THE TRANSFORMATION OF THE SUFFOLK COAST *c.*1200 TO *c.*1600: FROM ORFORD NESS TO GOSEFORD

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INTRODUCTION

THE WALKER WHO stands at the abandoned gun emplacement on the exposed shoreline at Bawdsey cliff and surveys the modern landscape to the north would be forgiven for assuming that little had changed here for centuries. A curving shingle beach and a line of Napoleonic Martello towers stretch out towards the hamlet of Shingle Street, beyond which the river Ore reaches the sea at North Weir Point at the end of Orford spit (see Fig. 26). Landward of the long shingle beach is a large area of low-lying arable land separating the sea from the inland villages of Hollesley and Alderton. Yet, despite the trappings of history and the semblance of continuity, this landscape largely acquired its present form during the early modern period. Before then it was significantly different. In *c.*1250 North Weir Point, Shingle Street and the arable expanses did not exist, and instead mudflats, tidal saltmarshes and navigable creeks dominated the area between the sea and the villages of Alderton and Hollesley. Between *c.*1250 and *c.*1600 the coastline between the rivers Ore and Deben was transformed so comprehensively that the knowledge of these medieval havens has been long lost.

This local example captures the ways in which the low-lying coastal zones of the North Sea basin have changed dramatically over the centuries, while also underlining that our knowledge of those changes is weak. If our knowledge of what happened is uncertain, then unquestionably our understanding of how and why such changes occurred must also be poor. The dynamics of coastal change are especially complex in East Anglia and Essex, where the shoreline geology of loosely aggregated soils and rock—sand, clay, alluvium and crag—is especially vulnerable to marine incursions and modifications. The modern landscape here is the product of a combination of the natural processes of erosion and sedimentation, and the human interventions of land reclamation and management of intertidal zones, occurring over many centuries. It forms part of the wider North Sea basin whose history has been shaped by the processes of storm, flood, erosion and deposition, and by communities managing the risks of both reclamation and inundation.[1]

In the twenty-first century these coastal communities face the formidable challenges of rising sea levels, increased erosion and inundation, and higher storm surge flooding. English Heritage's urgent response to these threats was to declare the mapping and recording of the archaeology of England's 'coastal zone' as a matter of national strategic importance.[2] It initiated a series of Rapid Coastal Zone Assessment Surveys (RCZAS) in the four counties considered most at risk from coastal erosion and change: Norfolk, Suffolk, Essex and north Kent. The scale of the threat, and the challenge, is reflected in the fact that over thirty per cent of land in Suffolk's coastal zone is reclaimed from sea or marsh, and is protected by >200km of sea and river banks.[3] English Heritage's energetic response had grasped the fundamental point that the future management of the vulnerable coastline of eastern England requires a full understanding of long-term coastal dynamics and the ways in which people have managed low-lying coastal areas in the past. Our understanding of this subject has advanced in the past two decades, thanks to a succession of case studies led principally by archaeologists and landscape historians.[4] To a lesser extent, climatologists and historians have paid attention to the changing frequency of storms over the centuries and their impact upon coastal communities.[5]

Despite these advances, there remain major gaps in our knowledge and understanding. First, the processes of erosion, deposition and reclamation are often studied separately, which means that the dynamic interconnections between them and their impact on coastal morphology over time have been relatively neglected. This is an important oversight, because erosion events are closely linked to deposition events, and the responses of human communities to both are varied.[6] Second, sea banks and river walls are major monuments in coastal lowlands and central to the management of tides and storms, but they have been largely neglected as archaeological features and a pervasive vagueness exists about their dating and age.[7] The RCZAS reports commissioned by English Heritage on the most vulnerable coastlines are openly uncertain on this point, especially for pre-1700 reclamations: as one candidly states, 'the date and precise sequence of drainage and reclamation along most of the Suffolk coast is unclear'.[8] Finally, places such as the Humber estuary, the Lincolnshire marshes, the Thames estuary and Walland and Romney marshes have received a good deal of attention, whereas the coast between Canvey Island and north Norfolk has received much less.[9]

The purpose of this article is to address some of these gaps by documenting the dramatic changes to the low-lying and unstable stretch of coastline between Orford Ness and the lower reaches of the river Deben (the historic port of Goseford).[10] Within this narrow study area are prominent examples of deposition (Orford spit), reclamations (the Butley and Deben rivers) and erosion (Bawdsey cliff). We consider the historical evidence for coastal and climate change and argue that the pace of erosion and accretion increased markedly between the mid-thirteenth and mid-sixteenth centuries due to a shift in the global climate system. The onset of these changes corresponded with a sustained phase of economic decline, which created stresses for local communities and accelerated the decline of the port of Goseford.[11] Yet the long-term processes of accretion—the accumulation of sediment in shingle barriers, spits, mudflats and saltmarshes—created new opportunities for land claims when the economy expanded again in the sixteenth century.[12] This subject demonstrates the high potential for combining documentary research with environmental science to improve our understanding of the processes of coastal change over many centuries rather than merely over several decades.

THE PROCESSES OF COASTAL CHANGE

An understanding of the transformation of this section of the Suffolk coast requires an elucidation of the two main physical processes driving coastal change. The first is the formation, breakdown and movement of shingle barriers and spits, and the second is cliff erosion, which supplies the sand and shingle needed to build them. The changing supply and transport of sand and shingle, and the particular ways in which these barriers and spits evolved, combine to determine the rates and types of sedimentation in the estuaries and lagoons behind them, resulting in differential rates of deposition over time.[13] Furthermore, complex feedback mechanisms exist between cliff erosion and the evolution of barriers and spits, so that, for example, the presence or absence of a protective beach at the toe of a cliff can significantly influence the rate of erosion. Shingle barriers depend on the supply and transport of sediments from cliff erosion in the direction of the prevailing longshore drift. Broadly speaking, the growth or decay of a coastal sediment feature is determined by the net movement of sediment into and out of the feature. The same applies to the development of mudflats and sediments in estuaries or lagoons.

Just as the dynamics of the Suffolk coastline are strongly linked to the processes that generate cliff erosion and the transport of sediment, so over the last millennium the principal

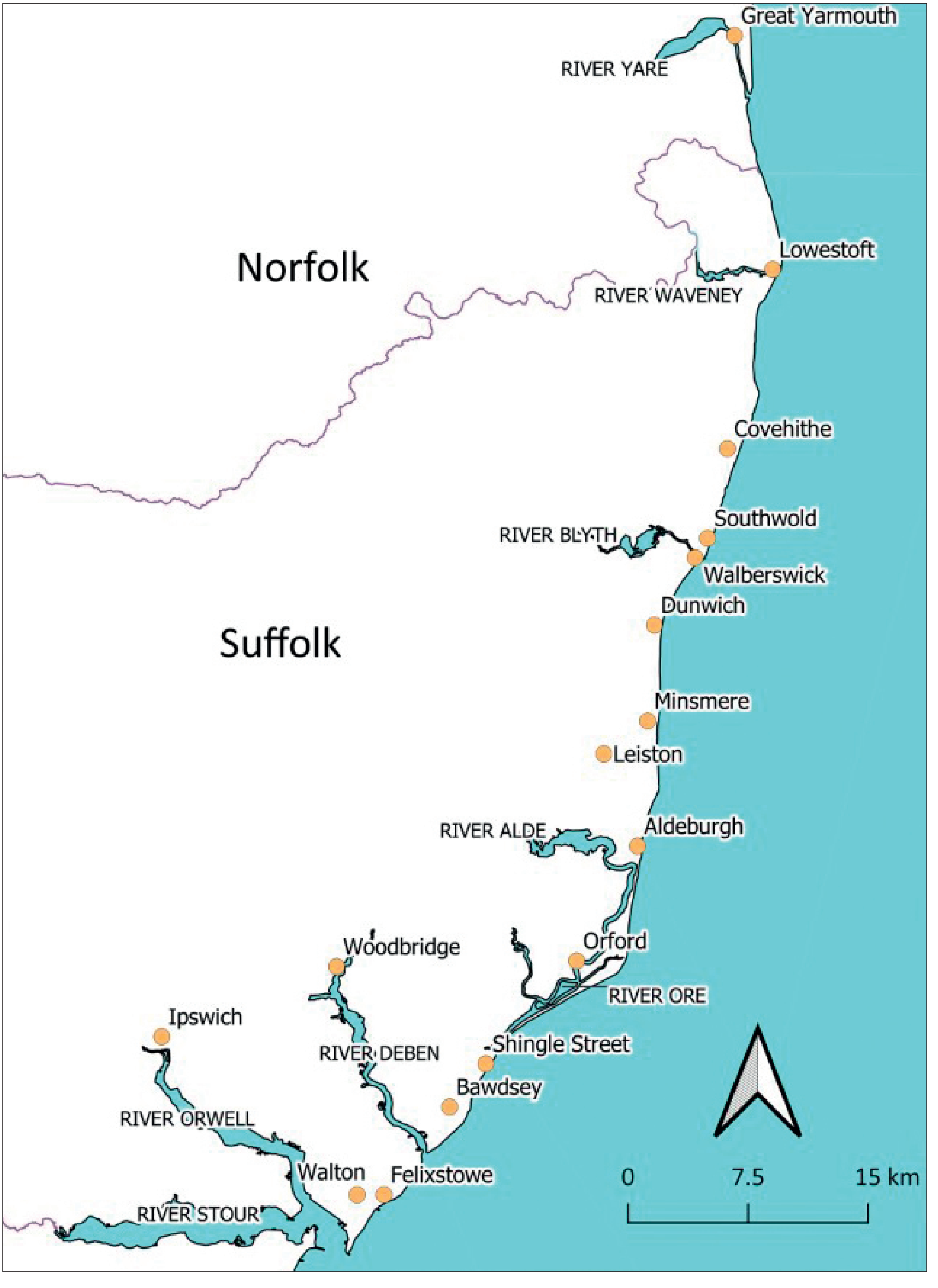


FIG. 26 – The study area and the modern Suffolk coastline.

influence on these processes has been storm surges and storm waves: the rise in relative sea level has had less effect locally.[14] This is because the direction and the magnitude of waves—their power and height—is the main influence on the volume and direction of sediment transport along this coast.[15] The passage of very low pressure systems into the North Sea drives storm surges which flood low-lying areas, breach shingle barriers, and erode beaches and cliffs, such as occurred in 1953 or the more recent 2013 event.[16] Intervening periods of lower wave energy tend to reconstruct breaches in barriers and to elevate beaches after normal winter storms. Another feature that can also influence the transport of sediment is the presence or absence, and the growth and decline, of offshore banks, because these alter the amount and direction of wave energy at a given point along the coastline.[17] For example, the northern extension of an offshore bank at Dunwich during the early twentieth century appears to have reduced wave energy at Dunwich cliffs, contributing to the rebuilding of the beach and the reduction in the speed of cliff erosion.[18]

The direction and size of waves, and the elevation and direction of storm surges, are ultimately controlled by the strength and direction of storm tracks from the North Atlantic Ocean. Storms that track over the north of England and Scotland are formed of low pressure systems, which create storm surges that travel south down the North Sea and are then followed by gales from the south and south-east as the low pressure system heads east. These storms generate large waves from the south-east that transport sediment north along the Suffolk coast. Conversely, storm tracks passing along the English Channel, or from the south, create large waves from the north-east, driving drift south along the coast. The dominance of northerly or southerly storm tracks over the British Isles is caused by variations in the jet stream position over the North Atlantic, and by the spatial patterns and magnitudes of northern Atlantic Ocean temperatures. In combination, these create low pressure systems that determine their route of travel over Britain. A measure of the pressure gradients in the North Atlantic, and by extension a measure of whether northern or southern storm tracks are dominant in the North Sea, is the North Atlantic Oscillation or NAO. During periods of positive NAO, the dominant storm tracks are from the north and followed by south to south-easterly gales, which transport shingle north along the Suffolk coast. During negative NAO, storm tracks from the south generate north-easterly gales with large waves, which transport shingle south along the Suffolk coast.

In addition to these natural forces, human interventions also alter the process of sediment transport and the patterns of drift and accretion along the coastline. Attempts to protect beaches and prevent cliff erosion by constructing groynes to alter the rate of longshore drift are well known. Similarly, reclamation works in tidal estuaries and behind shingle barriers have influenced the deposition of fine sediments. The main examples of such works are the embanking of the shallower intertidal marshes abutting the higher ground, then draining the trapped water to create pasture or arable land, and also the practice of warping, whereby measures are taken to encourage tidal flows to drop sediments onto marshes, such as the installation of wicker fencing on mudflats.[19] Changes to farming practice and land use inland can result in a substantial increase in the volumes of fine sediment washed into rivers and deposited in estuaries, and the contribution of river sediment loads to deposition in smaller estuaries with larger catchments can be significant.[20]

The reclamation of intertidal marshes incurred high costs through the labour and capital required to construct the protective sea banks and river walls, and also the various ditches and sluices within the land claim itself.[21] It involved high risks, too, because embankments reduce the space available for waves and storms to dissipate their energy, thereby increasing the threat of inundation and displacing tidal waters further up river to other vulnerable places.[22] Yet the rewards were the high returns from the productivity and value of the reclaimed arable or pasture land. Communities therefore required clear and sustained economic incentives if the costs and risks of reclamation were to be outweighed by the returns, which meant that the vast majority of land claims occurred during sustained periods of agricultural prosperity and profitability, such as the twelfth, thirteenth and sixteenth centuries.[23] The presence locally of a high-status and wealthy landlord, especially a perpetual institution such as a monastery, with the capacity to invest in and direct major infrastructure works, was another significant enabling factor.[24] Periods of agricultural recession, such as the century or so after the Black Death in 1348–9, lowered the rewards of reclamation and even discouraged the preservation of existing sea banks, resulting in widespread marine inundations and reversion of earlier land claims to intertidal marshes in coastal areas.[25]

CLIMATE CHANGE AND THE EAST ANGLIAN COASTLINE IN THE LATER MIDDLE AGES

Thus the evolution of the Suffolk coast in the past, present and future is a mosaic of features created over centuries and millennia by a complex and variable interaction of natural processes, climate change, and the cumulative and opportunistic activity of generations of coastal communities. A major element in explaining coastal change over long timescales is the variability in the air and water temperatures of the North Atlantic Ocean, a highly complex climatic phenomenon connected to remote changes in the global climate, because these are a major influence on the frequency, severity and direction of storm surges in the North Sea. For much of the twelfth and early thirteenth centuries, levels of solar activity were very high—a phase dubbed the Medieval Solar Maximum—contributing to higher mean air and ocean temperatures globally (Fig. 27). From the mid-thirteenth century solar energy fell, whose effects were exacerbated by a period of increased atmospheric sulphate and dust emissions from a series of large volcanic eruptions, including that of Samalas (1258) the largest in the Holocene. Consequently, global air and sea temperatures fell sharply, altering oceanic and atmospheric conditions in the north Atlantic and resulting in increased storm severity and frequency (Fig. 27).[26] A temporary resurgence in solar energy towards the end of the fourteenth century was followed by another long decline, albeit interspersed with some volatility in the sixteenth century, as global temperatures fell in the period dubbed the 'Little Ice Age'.

The effects of this change in the climate varied, but within the North Sea basin four main consequences are apparent. First, between *c*.1275 and *c*.1375 the mean sea temperature of the North Atlantic Ocean fell, but also fluctuated over short periods to an exceptional degree, cooling then warming dramatically, and the fluctuations were especially pronounced between *c*.1315 and *c*.1345. Second, fluctuations in precipitation were abnormally high in late thirteenth- and early fourteenth-century Britain, with phases of severe deficiency alternating with those of excess: compare, for example, the deluges of 1314–17 with the droughts of the late 1320s and early 1330s.[27] Third, the frequency and severity of storms increased, although the direction of storm tracks and the rate and direction of drift along the coastline were variable, because NAO alternated between negative and positive phases. Finally, severe storms continued throughout the fourteenth century, and peaked again in the sixteenth century, resulting in significant damage to the 'soft' eastern coastline (Fig. 27).[28]

The local nature and impact of storms can be pieced together through fragments of surviving historical evidence. A succession of major storms hit the whole of the North Sea basin in the 1280s and early 1290s during a phase of strongly negative NAO, including the great storms of 1286–8 which decimated Winchelsea in the English Channel and badly damaged Dunwich.[29] Another significant storm in East Anglia in 1307 was followed by a

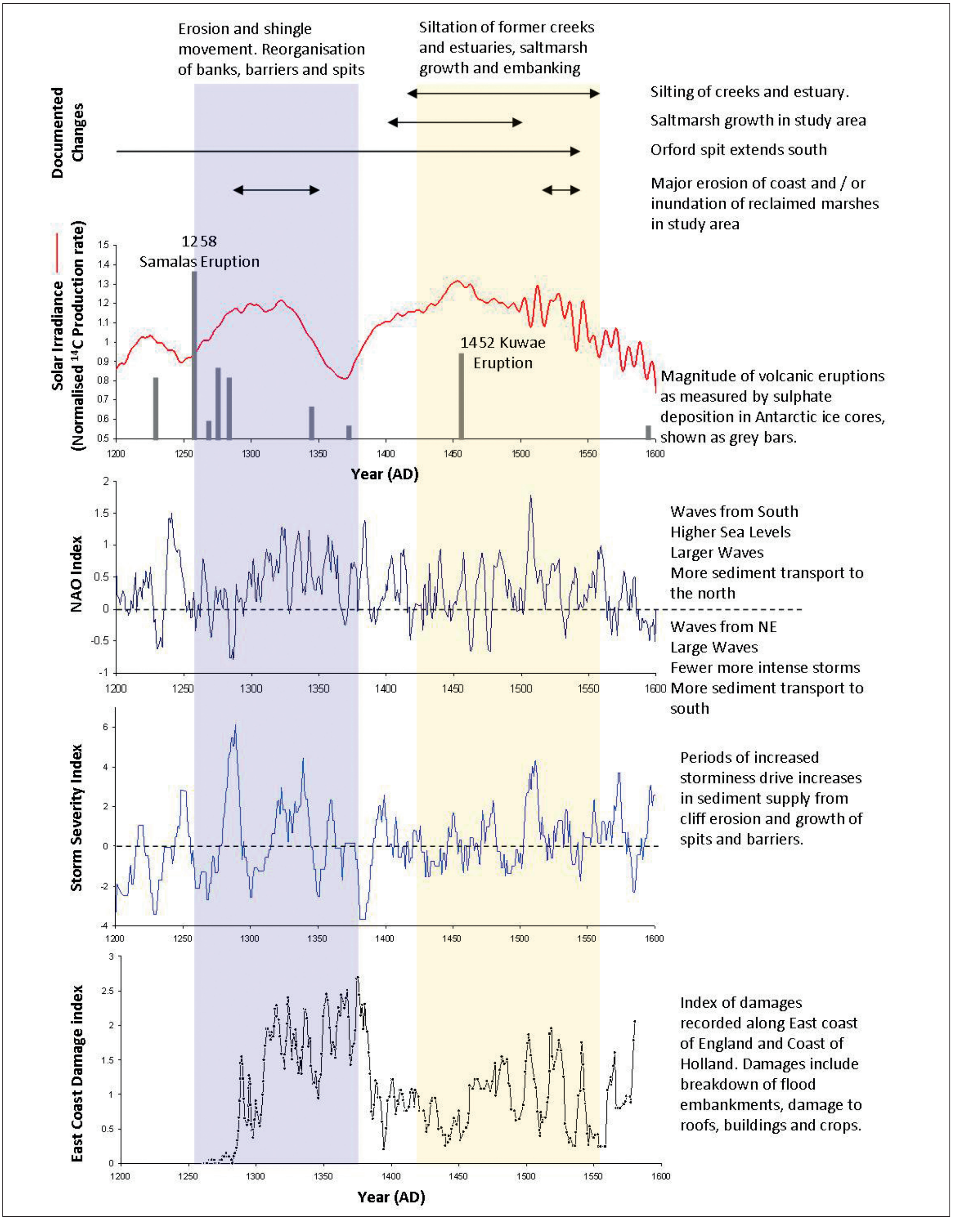


FIG. 27 – Time series of the drivers of coastal change and summary of major changes along the east coast and study site (*Sources: Solar Irradiance data from Wu et al., 2018; Volcanic eruption magnitude [grey bars in upper panel] refer to volume of sulphate emissions recorded in ice cores, Castellano et al., 2005; NAO Index derived from Cook et al., 2019; Storm Severity Index is based on documented North Sea storms, Sear 2018; East Coast Damage Index is compiled from Galloway, 2009, and De Kraker, 2005*).

series of minor storms during the early 1320s. Widespread storm activity recurred in the 1330s and early 1340s during a period of strongly positive NAO that drove shingle north along the Suffolk coast. It was precisely this period when the substantial royal borough and port of Dunwich was decimated, as the sea swept away *c.*600 buildings, permanently blocked its old harbour entrance and diverted the river Blyth's entry to the sea over one mile to the north.[30] Major losses of other sections of the coast are recorded during this period and Leiston Abbey had to relocate inland to escape the 'tempests of the sea'.[31] Storms and rising sea levels caused the flooding of peat diggings in eastern Norfolk from the end of the thirteenth century to create what are now known as the Norfolk Broads.[32] Heightened storm activity continued during the fifteenth and sixteenth centuries, characterised by phases of negative NAO (Fig. 27). The fifteenth century was also a period of sustained agrarian recession, which reduced the incentives for coastal communities to continue to maintain or repair sea defences. Consequently, even relatively minor storms could result in more frequent and widespread inundations and the widespread reversion of earlier land claims to saltmarsh.[33]

The major changes in the global climate after *c.*1250, and the associated increase in storm frequency and severity in the North Sea, help to explain the contrasting fortunes of many East Anglian ports in the later Middle Ages: the decline of Yarmouth, Covehithe, Dunwich and Orford, yet the rise of Lowestoft, Southwold, Walberswick and Aldeburgh.[34] The problems caused by erosion and a shifting harbour at Dunwich, and the opportunities this presented at nearby Walberswick, are well known.[35] The case of Lowestoft and Yarmouth provides a powerful example of how the combination of an unstable climate and a geologically weak coastline could either create new opportunities, or pose insuperable challenges to local communities. In the thirteenth century, Lowestoft was an unprepossessing village in north-east Suffolk, a mile or so inland, until *c.*1300 when the settlement was relocated to a new site on heathland next to the sea. A new market and fair were granted in 1308, house plots were laid out in rectilinear form between the high street and the cliff top, and terraces were created to provide access to the beach below, which presaged the growth of Lowestoft over the next century as a maritime town.[36] The explanation for the settlement relocation and the town planning around *c.*1300 is not clear, but it was probably linked to the shifting harbour of nearby Great Yarmouth. In the early thirteenth century, this had been located at the northern end of Yarmouth, but a shingle spit developed and deflected the mouth of the rivers Bure and Yare progressively southwards towards Kirkley Roads: the severe storms during the last quarter of the century, combined with the negative NAO, would have driven the spit and extended offshore banks southwards.[37] So the storms not only reduced the navigability of the river entrance to larger boats, but also shifted the mouth much closer to the newly relocated Lowestoft.[38] The problems of a silting and shifting harbour plagued Yarmouth throughout the fourteenth century, forcing its burgesses to spend a great deal of money on artificial cuts through the spit in attempts to persuade the sea to flow closer to their town.[39] The storms of the 1280s and early 1290s set in motion long-term and significant changes to the Yare estuary and its offshore banks, which prompted the relocation of Lowestoft to exploit the advantage. The example of Lowestoft and Yarmouth underlines the challenges and opportunities caused by accretion over short stretches of coast.

In addition to historical evidence for deposition, the analysis of sediment cores taken from Suffolk river estuaries and marshes provides important information about the chronology of coastal change. Indeed, the cores confirm major changes around the period of increased storminess at the end of the thirteenth century. Evidence for the maximum extent of mud deposition inland from the river Blyth dates to *c.*1250, whilst in the estuary of the Dunwich river, a major transition occurs from freshwater to marine sediments around 1250–1300, both consistent with the breakdown of the shingle barrier, most likely due to the storms of 1287–

8.[40] The influence of marine sediment at Dunwich reduced after 1540.[41] In the former estuary at Minsmere, maximum marine influence occurred around the late eighth century, followed by increasing freshwater influence as the shingle barrier developed, culminating in conversion to freshwater marshes by 1550.[42] In the larger river estuaries of the Deben, Orwell and Stour, the sediment records show a persistent accumulation of marine muds, confirming a continuous opening to the sea rather than complete blockage by spit or barrier growth such as afflicted the Dunwich river.[43] Further light can be shed on river sediment loads through careful reconstruction of agricultural activity in the river catchments in conjunction with the dating of floodplain sediments.[44] Demographic pressure meant that by *c.*1300 the area under the plough had reached an historic high, and in East Anglia arable land was being exploited intensively by reducing fallows, increasing labour inputs and sowing more leguminous crops.[45] This intensification of arable cultivation would have caused rates of floodplain sedimentation to increase exponentially, which in turn would have increased riverine sediment loads and sedimentation rates in Suffolk's coastal marshes and mudflats.[46]

The historical sources for reconstructing the evolution of low-lying coastal areas and the impact of storms during the later Middle Ages have yet to be fully utilised. There is much more historical source material available for these purposes than the archaeologist's staple fare of maps, air photographs, charters and field surveys.[47] On the one hand, standing royal commissions (such as 'walls and sewers', empowered to investigate the state of river walls and ditches), one-off royal commissions into specific events (such as the catastrophic loss of land and housing at Dunwich), charters, deeds and the archives of some major monastic houses have been skilfully exploited.[48] On the other hand, as yet much less use has been made of a range of other local sources to yield evidence about key features such as sea banks before the advent of maps and estate surveys in the seventeenth century. Manorial accounts can contain information such as income from reclaimed marshes, the costs of repairing sea and river banks, and the loss of income due to marine inundations. Manorial court rolls record a wide range of economic activities and the upholding of seigniorial privileges, yielding incidental information about livelihoods and landscape. From *c.*1400 manorial surveys provide a great deal of topographical evidence, because they describe in detail the abuttals of individual parcels of land that as a consequence can reveal the existence of reclaimed marshes and lost landscape features such as creeks and havens.[49] Of course, the survival of this type of information is random and not always straightforward to interpret. For example, medieval records describe (confusingly) both reclaimed marsh and tidal saltmarsh as *mariscus*. Similarly, *fossus* can mean both a ditch and an embankment or sea wall. The context is important in deciphering the meaning, and additional references to the provision of, say, wood for guttering and sluices indicates a reclaimed marsh behind a river or sea wall.[50]

The range, quality and quantity of extant pre-1700 local sources is greater in England than for any other country in the world and they offer a unique opportunity to reconstruct a partial view of coastal morphology and changes over time in the absence of any reliable maps.[51] The task of reconstructing the coastline is assisted by the information from geological surveys and from modern LiDAR (Light Detection and Ranging) mapping, which identifies those areas of the river and coastal fringe that lie close to or below sea level. Figure 28 uses the LiDAR map and other evidence to show land above and below sea level relative to the modern high tide mark, which is then used as a baseline for reconstructing the medieval coastline and identifying later changes. It shows graphically how substantial areas of the modern landscape in the study area are actually below sea level, but are protected from inundation by both natural barriers and extensive human-made embankments.

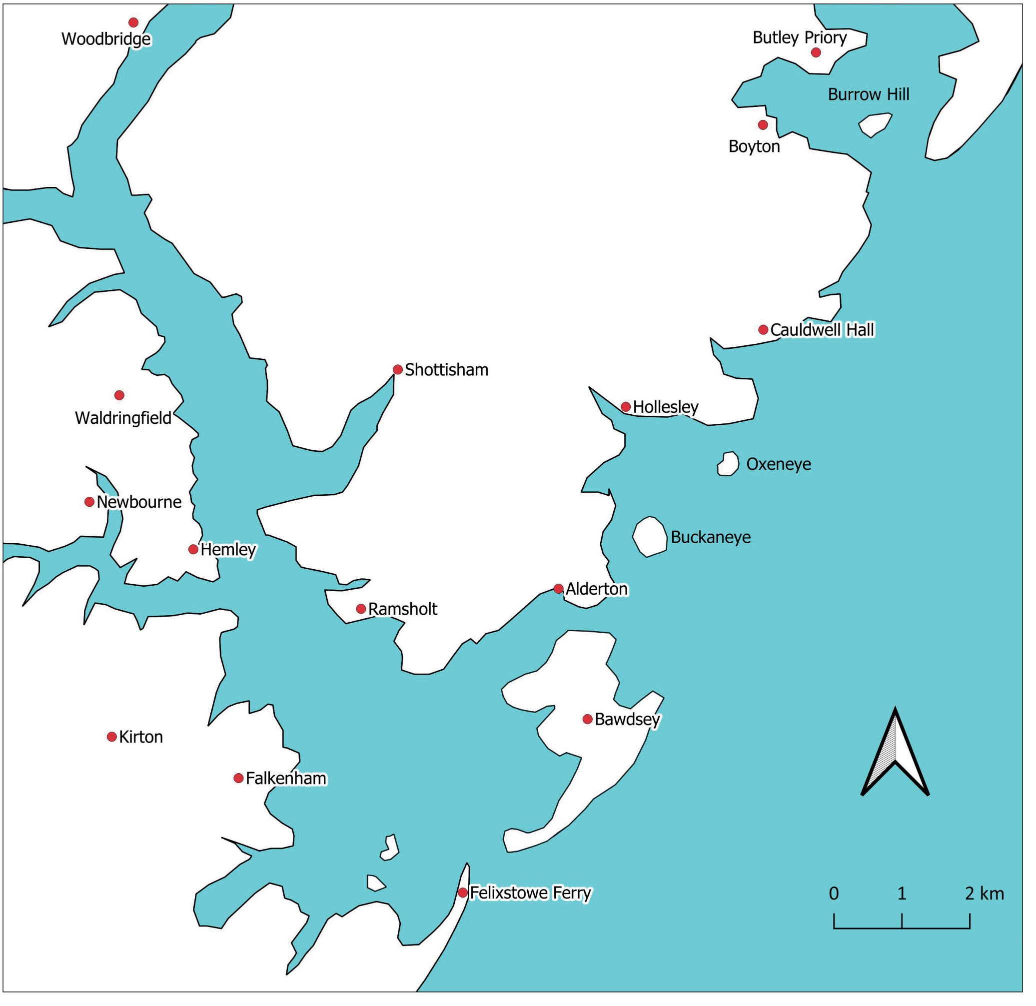


FIG. 28 – Land above the modern high tide mark in the study area.

CLIMATE AND COASTAL CHANGE: ORFORD NESS AND SPIT IN THE LATER MIDDLE AGES

The cuspate spit that deflects the river Alde from entering the sea at Slaughden in Aldeburgh and diverts it south past Orford Ness and eventually into the sea near Shingle Street is one of Britain's most famous coastal features. Its history bears testimony to the way in which humans have adapted to the natural forces of accretion. Yet reconstructing a tight chronology of its growth over time is impossible, because the evidence is too patchy and, in any event, it is an inherently unstable feature prone to regular breach and reformation.[52] Yet the snippets of available evidence suggest strongly that it was transformed during the late Middle Ages.

J.A. Steers concluded from the evidence of ridging on the spit itself and fragments of information from documentary sources that in the late twelfth century, the distal point of the spit had reached as far as Stoneyditch Point, just south of the newly founded borough of

Orford and some eight kilometres short of its current tip (Fig. 29).[53] The most reliable early source, John Norden's map of the area around Orford in 1601, shows that the river walls and marsh reclamations along the Ore between Aldeburgh and Orford itself were all well established, and there is explicit documentary confirmation of the reclamation of some saltmarsh between Orford borough and the spit in the late 1160s when the castle was under construction.[54] The wave energy in this upper section of the Ore river during the twelfth and thirteenth centuries would have been relatively low around the higher ground and on the spit's landward edge, creating conditions favourable to the construction of river walls and land claims upriver east and north of Orford. There is, however, no evidence before *c.*1400 for either the southwards extension of the spit beyond Stoneyditch Point, or the creation of the river walls south of Orford itself, or the reclamation of Havergate island. Indeed, the predominance of positive NAO, with its associated northwards movement of shingle and sand along the Suffolk coast, would have diminished the likelihood of any major growth in this period. Consequently, in the fourteenth century the Butley river flowed directly into the sea and was readily navigable: Butley Priory had funded the creation of a canal and wharf so that seafaring boats could reach as far as the priory.[55]

The heightened storm activity and phases of negative NAO during the fifteenth and sixteenth centuries (Fig. 27) would have resulted in greater cliff erosion and drift of sediment southwards along the Suffolk coast, and therefore created conditions that were highly favourable for an extension in the length and size of the spit. Norden's map indicates that by 1601 it had reached almost as far as Cauldwell Hall between Boyton and Hollesley (Fig. 29), which meant that the Butley river now flowed into the Ore rather than the sea.[56] The evidence from Norden is broadly consistent with the extant documentary evidence that the spit had extended between the thirteenth and sixteenth centuries.

The evidence that in the twelfth century Orford spit did not extend much beyond Stoneyditch point is also consistent with documentary evidence that medieval Hollesley was situated on the coast. At the time of the Norman Conquest in 1066, Hollesley must have been a strategically importance place, controlling access to the Butley river and other now lost anchorages in the vicinity, because the manor was granted to one of William I's most trusted henchmen, Roger Bigod, who was also granted the strategic manors guarding the gateways to Hamford Water and the river Stour (Dovercourt, in Essex), and to the Orwell and Deben rivers (Walton, Suffolk). The medieval manor of Hollesley had rights to wrecks and flotsam along the sea-shore, and items washed up along its coast are regularly recorded in its court rolls.[57] For example, a porpoise was cast up on the sea-shore 'on the land of the lords [*of the manor of Hollesley*] that is to say between Le Gulle and le Northe Coote'.[58] A rental of 1501 lists several fish-traps, stake-nets and ebb-weirs located on the land of Hollesley manor 'in the port called Orford haven in Hollesley'.[59] The 'Gulle' was a small maritime inlet and anchorage in Boyton, and in 1533 it was estimated to lie over two kilometres south of the then entrance to Orford haven.[60] The 'North Coote' was probably the small coastal hamlet that existed around Cauldwell Hall in the north-east of Hollesley parish until at least the 1520s.[61]

During the sixteenth century this section of coast between Orford Ness and Hollesley was undergoing rapid changes. A Hollesley court roll entry in 1528 notes that a cottage held by John Seresant located 'next to the shore of Orford Haven' had recently been 'swallowed and engulfed by the sea'.[62] Around the same time Butley Priory cited losses of arable land to the sea as an excuse for its financial woes.[63] In 1540 an inquiry concluded that fewer than half the number of boats were fishing within Orford Haven compared with the 1520s, because 'now the haven is so shorted by reason of the working of the sea'.[64] Another inquiry in 1584 noted that the deposition of sand and shingle had reduced the depth of the entrances to both the Ore and the Gulle even further.[65]

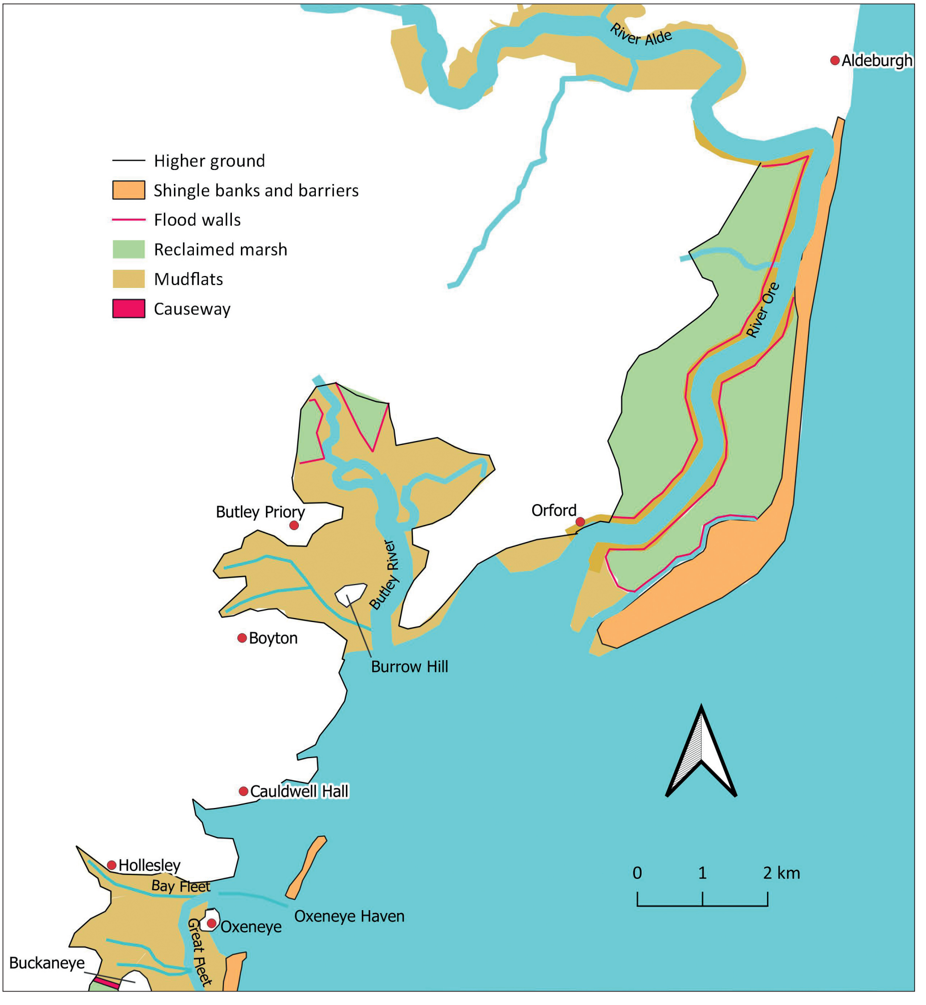
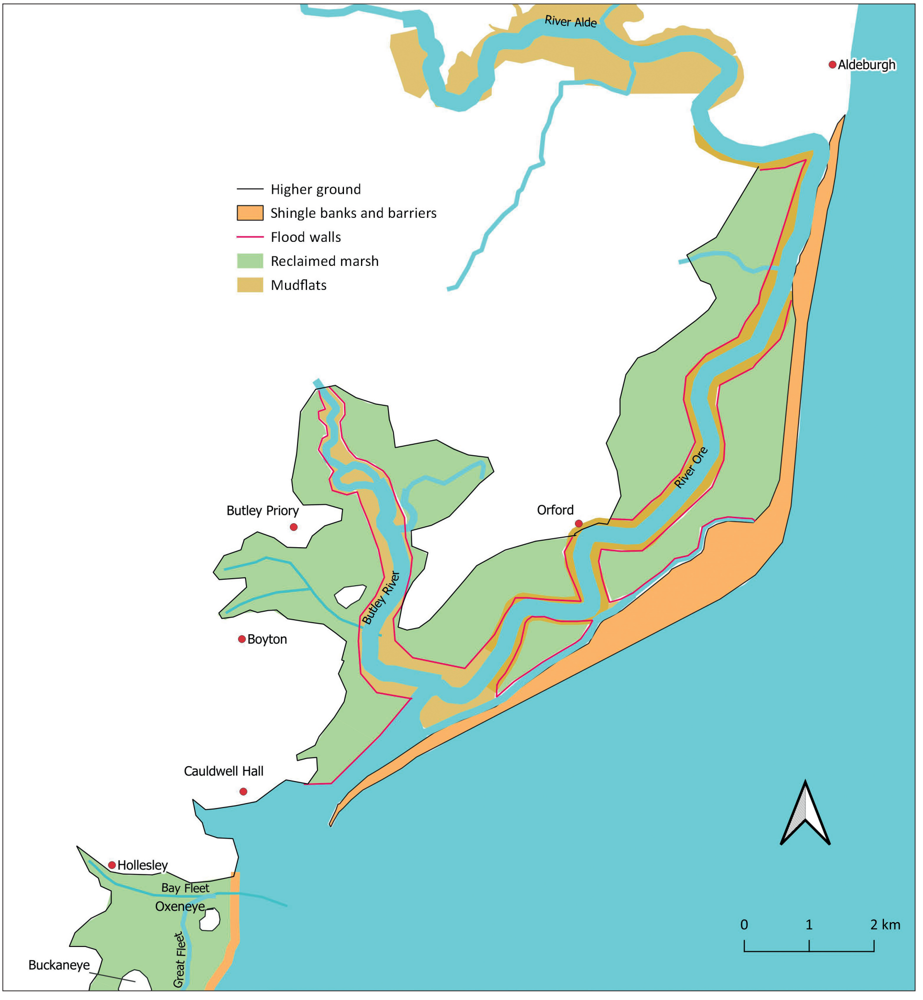


FIG. 29 – Conjectural reconstruction of Orford spit in *c.*1170 (ABOVE) and *c.*1600 (NEXT PAGE).

Thus the available historical evidence indicates that between *c.*1200 and *c.*1600 Orford spit had grown nearly six kilometres to reach a point just south of the Butley river. As a result, the Butley river no longer flowed directly into the sea, but joined the Ore just north of the latter's mouth. The spit had not yet reached as far south as Hollesley parish, which consequently still comprised the coastline (Figs 29 and 31). Of course, the continued extension of the spit over the ensuing centuries meant that Hollesley eventually became landlocked. Documentary sources also reveal that in the sixteenth century the entrances to the Ore and the Butley rivers were becoming shallower. The scientific data confirms that climatic conditions were most suited to the deposition of shingle along this coast, and to the growth of Orford spit, during the fifteenth and sixteenth centuries.



THE MORPHOLOGY OF THE COAST: HOLLESLEY TO GOSEFORD IN *c.*1250

As we have seen, in the later Middle Ages the north-eastern part of Hollesley parish constituted the medieval coastline (Fig. 29). The south-eastern part of the parish was not, however, directly exposed to the sea, but instead comprised pockets of reclaimed arable land amid tidal mudflats and saltmarshes, through which a creek called Bay Fleet flowed eastwards directly to the sea just north of Oxeneye island (marked on modern maps as 'Oxley' to the north of Shingle Street, see Fig. 30).[66] Hence medieval Hollesley possessed two havens—Bay Fleet to the south-east, and the 'North Coote' around Cauldwell Hall to the north-east—and was manifestly a maritime community. References in the extant records of royal courts from the 1330s and 1350s refer to the theft of hemp and sails, and of barrels of sprats and herring.[67] Wills from the fifteenth and early sixteenth centuries reveal bequests of small fishing boats and equipment.[68] Following one storm, nineteen casks of bitumen found floating on the sea were towed 'by water to the jetty (*usque pontem*) of Richard Braby'.[69] This was also an active

FIG. 30 – Conjectural reconstruction of the coast and river lines in *c*.1250 between Hollesley and the river Deben.

commercial community. The manor court of June 1337 records twenty-five brewers and fifteen bakers, a significant number for an ostensibly small place.[70] One resident in the 1320s was described as Matthew dil/ate Market and two cases of forestalling are recorded in the leet court of 1318.[71] There is no record of a formal grant of a weekly market to the manor, although a three-day annual fair was held on the feast of St Margaret and yielded between 5s and 15s annually for the manor.[72] It is feasible that such a large number of brewers and bakers were provisioning the passing maritime traffic in this busy little port.

The port of Goseford is the collective name given to a number of medieval maritime settlements that have long been associated exclusively with the lower reaches of the river Deben.[73] Yet the discovery of a sizeable haven south of Hollesley suggests that in the thirteenth century the port of Goseford comprised a series of havens over a larger geographical area, stretching from Hollesley in the north-east to Kirton Creek within the Deben in the south-west. Increased storm activity from the late thirteenth century caused the silting of the former, however, resulting in the shrinkage of the port of Goseford onto the lower Deben. Continued silting and further coastal change in the late fourteenth and fifteenth centuries added to the economic difficulties of Goseford and exacerbated its decline.

In *c*.1250 the area between Hollesley and Bawdsey mainly comprised a series of tidal saltmarshes, mudflats and creeks behind a long shingle bank (see Fig. 30). These creeks entered the sea to the north of Oxeneye island, which was attached to the manor of Bawdsey.[74] Indeed, it is still a detached portion of Bawdsey parish. The place-name element *-eye*, the LiDAR map, and geological surveys all confirm that Oxeneye was once an island formed of red crag.[75] In the thirteenth century a hamlet existed on the island, and its residents were known boat owners.[76] In 1579 Oxeneye island was estimated at forty acres.[77] There are various references to the existence of a haven; in 1302 it was mentioned in association with an act of piracy, and a Bawdsey survey of 1438 contains numerous references to 'the way leading to Oxeneyehaven'.[78] A navigable creek known as either 'Oxeneye Fleet' or the 'Greate Fleet' flowed north from the eastern reaches of Alderton to its confluence with the Bay Fleet, then out to the sea north of Oxeneye island.[79]

The historical evidence that tidal creeks flowed north from Bawdsey and Alderton to reach the sea at Oxeneye, rather than taking the direct route eastwards out to sea, forms the basis for deducing that a sizeable shingle bank, the forerunner of the modern Bawdsey beach, must have existed and prevented direct access to the sea. Geological maps identify an outcrop of red crag under what is now Shingle Street, which would have acted as a geological 'anchor' for the deposition of shingle and the formation of a sizeable bank.[80] Indeed, one late medieval description of the coastline between Orford and Bawdsey mentions the existence of 'a certain sandbank called Schinhil', and another identifies 'the singelen' lying near to 'the red cliff' (i.e. Bawdsey cliff) between Orford and Orwell.[81] As we shall see, this prominent feature was prone to changes in its width and composition during the fifteenth and sixteenth centuries.

In the thirteenth century the presence of a sizeable shingle bank between Oxeneye island and Bawdsey cliff would have created a natural barrier to the sea to its east and reduced the wave energy in the intertidal marshes and creeks to its west. This in turn would have created opportunities for some land claim of the higher saltmarshes in this sheltered area during the favourable economic conditions of the twelfth and thirteenth centuries.[82] A Hollesley account of 1306–7 mentions the existence of 'the new marsh' and that of 1308–9 records expenditure of 9s 6d for repairs to embankments and watercourses around 'the marsh next to the sea'.[83] Some piecemeal reclamations had also taken place along the rim of higher land around Bawdsey and Alderton (see Fig. 30).[84] A causeway linked the former island of Buckaneye, the site of much settlement in the Romano-British period, to Alderton along what is now 'Buckanay Lane'. A thin strip of land barely above sea level separated Oxeneye haven from Bawdsey's southern (Deben) haven, which today carries the main road from Alderton to Bawdsey. It was once a ford—surely, the original 'Goose ford' that gave its name to the wider port—but by *c*.1250 was almost certainly a causeway providing a dry route to and from Bawdsey.[85]

It is difficult to construct definitively the morphology of the lower reaches of the river Deben at the peak of Goseford's importance in the late thirteenth century. We can, however, state with confidence that its mouth was a good deal wider and deeper than subsequently, and that the river comprised a variety of small fleets and anchorages stretching from Bawdsey's Deben haven to creeks at Falkenham, Shottisham and Kirton (Figs 28 and 30). For example, both Falkenham and the lost hamlet of Guston in Kirton are mentioned explicitly as being part of the port.[86] The statement that the river mouth was wider and deeper at its medieval peak is based on snippets of evidence from the thirteenth century and unequivocal evidence that it has since suffered sustained erosion and silting. At the end of the thirteenth century the higher ground at the southern entrance to the river was dominated by the remains of a Roman fort (incorporated into the grounds of the priory of St Felix), the remains of Walton Castle and the chapel of Burgh.[87] In 1291 only two parochial churches in the whole of Colneis deanery were wealthier than the chapel of Burgh, which is suggestive of a thriving settlement around this cluster of high-status buildings on the south of the Deben mouth.[88] Burgh must have been a maritime community, accessed directly from the sea via the remnants of the Roman port off what is now the Dip in north Felixstowe, and also from the Deben itself along a creek that is still a feature of the modern landscape (see Fig. 30).[89] The lower reaches of the Deben mainly comprised saltmarsh, tidal creeks and mudflats. Piecemeal reclamations had taken place around the edges of the higher land, because in the late thirteenth century river walls protected Gulpher marsh and created a dry causeway to Holm Hill, both of which provided pasture for sheep.[90] Other minor reclamations are also recorded in Bawdsey and Ramsholt (see Fig. 30). There is no evidence for any large-scale, systematic reclamations at this date in this vicinity.

THE CHANGING MORPHOLOGY OF THE COAST: HOLLESLEY TO GOSEFORD *c.*1250 TO *c.*1600

The changes in the global climate from the second half of the thirteenth century and the consequential rise in storm frequency and severity in the North Sea resulted in major inundations in this area from the 1280s. The Hollesley manorial account of 1306–7 documents attempts 'to save the new marsh', presumably following the storm of 1307, and repairs to embankments and watercourses were still being effected in 1308–9.[91] These marshes may well have been among the 240 acres of arable land recorded as destroyed in Hollesley between 1290 and 1341 by marine inundations.[92] Another eighty acres of marsh had been lost in Boyton. In 1303, Butley Priory complained of debts partially incurred through losses of income from its lands around the Butley river following inundations of the sea.[93] Between 1290 and 1341, 240 acres of former arable in Bawdsey had been inundated, which was also the fate of sixty acres of arable in Ramsholt.[94] The same document recorded no such losses in Alderton, nor in any of the other parishes in the lower reaches of the Orwell and Deben rivers.[95] Local landholders would have had to decide whether to risk investing considerable sums of money in repairing the sea banks to restore the lost marshes during this period of economic uncertainty and extreme weather.[96]

A handful of manorial accounts for Walton (Felixstowe) in the 1280s document the destruction of a tidal mill at the hamlet of Gulpher, just inside the mouth of the Deben, in the storms of 1287–8, and subsequent repairs to river banks in this area.[97] Around this time, the priory of St Felix abandoned its original site on the south side of the Deben estuary and relocated inland next to Walton church, presumably because its original site was under imminent threat of falling into the sea, and between 1290 and 1341 marine inundations had reduced the revenues of the chapel of Burgh through the destruction of a large area of reclaimed marsh (almost certainly within the Deben) and led to the loss of tithe receipts from eighty acres of arable land (almost certainly from the shoreline).[98] The phase of positive NAO throughout the fourteenth century and associated southerly waves would have driven eroded material from the St Felix/Burgh headland northwards and extended the shingle bank around what is now Felixstowe Ferry.

What was the impact of this storm activity upon the morphology of the coast and the fortunes of the port of Goseford? There are three hints that Oxeneye haven was deteriorating rapidly from the late thirteenth century and no longer constituted a significant element within Goseford. The first is the changing spatial and temporal distribution of documented finds of coins in Alderton: 51 per cent of all finds (excluding Romano-British coins) originate from the period 1154–1307 with significant numbers clustered on the land to the north-east of the village, along what is now 'Buckanay Lane', and also on the eastern side of the ford between the two villages.[99] This is consistent with an active haven at Oxeneye and with the heyday of the port of Goseford. Similarly, the marked absence of coins in these areas dated after 1307 (just a single coin has been found at Buckaneye and only three from the site by the ford) is strongly suggestive of a rapid diminution in economic activity. Other coin finds in Alderton are concentrated to the south and west of the parish, i.e. on the Deben side, and date from well after the early fourteenth century, reinforcing the view that the port of Goseford was now focused on the Deben.[100]

The second hint is the timing and nature of institutional changes within the port. Documents from the thirteenth century usually refer to 'the port of Goseford', but then from *c.*1300 royal writs begin to associate Goseford closely and explicitly with Bawdsey, implying a strengthening of the role of Bawdsey within the port.[101] Similarly, from around the same time, Goseford and Bawdsey become synonymous in documents describing the origin of ships from the lower Deben.[102] The final hint is that since the mid-twelfth century, a fair had been held each September at Bawdsey, but in 1283 Robert de Ufford obtained a charter to extend its duration to eight days and another charter to hold a market each Friday. Both were to be held at the manor.[103] This was clearly a moment of significance, strengthening the commercial presence of Bawdsey within the wider port. The timing of these changes coincides broadly with the rise in storm and coastal damage from the late thirteenth century (Fig. 27). In other words, from the late thirteenth century climate change caused changes to the morphology of the coast that in turn reduced the viability of the anchorages in Oxeneye haven, and consequently the operational centre of the port shifted onto the river Deben and its administration became more narrowly associated with Bawdsey.[104]

The increased storminess after *c.*1450 (Fig. 27), coupled with the heightened incidence of negative NAO and associated southwards movement of shingle down the Suffolk coast, caused further changes. Oxeneye island and Bawdsey cliff must have suffered some erosion. A valuation of the manor of Bawdsey in 1434 noted that '160 acres of land, [*were now*] worth nothing yearly because they abut the seashore and are totally destroyed by the blowing sand, strong winds and daily flood and ebb tides'.[105] Yet the dominant process was deposition; the Bawdsey extent of 1438 identifies a road leading eastwards from the village (the modern East Lane) to the 'Newhaven', and another called Dalisway running north to the 'Newhaven' from Bawdsey cliff.[106] The 'Newhaven' was also described as the 'new port'.[107] The only explanation for the appearance of this new port is that sometime in the late fourteenth or early fifteenth century the sea must have carved a new entrance through the shingle bank south of Oxeneye island, probably corresponding with the partial or complete blockage of the original Oxeneye haven further north.[108] These changes were being driven by the same general forces driving the growth of Orford spit. Thereafter, continued deposition eventually blocked the Newhaven, and as a result an enormous and continuous barrier stretching from Bawdsey cliff to the northern end of Hollesley sealed off the former creeks and tidal marshes (Fig. 31).

The 'Goose Ford' was originally the fulcrum of the port of Goseford, but as Oxeneye haven silted, the port became more narrowly associated with the Deben side of Bawdsey. Two extents of Bawdsey in 1438 and 1579 both associate 'Goseford haven' exclusively with the Deben and Bawdsey Fleet.[109] Goseford centred on Bawdsey remained the main port on the Deben during the fifteenth century: for example, the tax on foreigners in England introduced in 1440 reveals twenty-five aliens, mainly Dutch, living in the villages within the port, compared with just two in Woodbridge.[110] Yet during the early fifteenth century, Goseford had suffered a sharp decline in its economic fortunes and was no longer the port it had been a century earlier. We now know that its economic woes were exacerbated by the relentless processes of coastal change.[111]

Heightened rates of erosion and deposition also altered the morphology of lower Deben. Continued erosion of the cliff face on the south side of its estuary eventually destroyed the chapel and settlement at Burgh, and the original sites of St Felix's Priory and Walton Castle. Deposition resulted in the growth of shingle banks on both sides of the mouth of the Deben. The coexistence in such close proximity of places liable to major erosion and accretion events is one of the complicating features of this coastline. The action of the sea gradually rendered the Deben estuary shallower and more challenging to shipping, paralleling the reduced access to the Ore. A document of 1587 surveying military fortifications along the coast described the mouth of the Deben as a 'barred haven so that none but small shipping shall come'.[112] The build-up of shingle banks around the river mouth would also have reduced the power of the ebb tide within the Deben, increasing deposits of sediment. At some point in the early modern period, Bawdsey Fleet ceased to be navigable, and the haven at Bawdsey eventually moved to its present location at Bawdsey quay. In 1844 Henry Davy observed that there is 'a haven for small vessels at the *mouth* of the river Deben' (our italics), which confirms that the haven was now located at Bawdsey quay.[113]

The changes within the Deben during the later Middle Ages are neatly illustrated by the fortunes of two hamlets situated within Kirton Creek, which thrived then declined with the fortunes of Goseford: indeed, they disappeared so long ago that their sites are now uncertain. The two hamlets, Guston and Struston, are recorded in the Domesday Book of 1086 in Colneis hundred and were located somewhere within Kirton parish.[114] They were situated within the large manor of Walton with Guston recorded as containing six freemen and seven bordars and Struston as containing five freemen and women and eight bordars. As each tenant equates to a household, these were clearly established settlements.

W.G. Arnott, the passionate historian of Suffolk's rivers, suggested that Struston was situated at the point where the modern Kirton to Newbourne road crosses Kirton Brook: today this place is marked by Brook Cottage.[115] Sixteenth- and seventeeth-century court rolls of Kirton make occasional reference to Struston green and Struston bridge without providing clues as to their exact location.[116] A late eighteenth-century map identifies Struston meadow and brook in the vicinity of the modern Brook Cottage.[117] Struston brook flows north-east from this point and within a few hundred metres enters the flood plain of Kirton Creek, close to the modern Broom Hill Cottage. The LiDAR map of this area shows that the high tide would have reached this point, and indeed Newbourne, so shallow-draught boats could have operated from both places before the creek was drained and embanked sometime around 1600. A modern bridleway links the main settlement of Kirton with Broom Hill Cottage and rights of way on the modern Ordnance Survey map delimit a triangular green, whose base abuts the place where the brook enters the flood plain.[118] It is possible that this area represented a maritime extension to the main settlement of Struston.

Arnott could not pinpoint the location of Guston, but regarded it as a maritime settlement of some importance on the south side of Kirton Creek until sometime in the sixteenth century. In the fourteenth century, Guston sailors contributed boats to royal navies.[119] It was effectively the port (albeit a modest one) of Kirton, located somewhere to the east of Struston. Fifteenth-century court rolls of Walton refer to Guston fleet, presumably another name for Kirton Creek, and ferries operated from Guston 'stone', presumably some form of jetty, to Ramsholt and to Shottisham Creek.[120] In 1785 the Kirton court rolls were still identifying a parcel of land 'lying in the hamlet of Guston'.[121] Guston as a hamlet is highly unlikely to have existed at this late date, however, and it does not appear on contemporary maps: its function disappeared once Kirton Creek was embanked and drained. The reference to a hamlet in 1785 is just a formulaic recital of the same words that appear time and again whenever this parcel of land was conveyed.[122] So where had Guston once stood? There is no doubt that it was situated in the far north-east of Kirton parish somewhere on the curve of higher land between Kirton Creek and the Deben above Falkenham marshes. In 1408 an incidental reference in the Walton court rolls described a way leading directly from Guston stone into Falkenham to the south, which places it at either the eastern end of Kirton Creek, or on the Deben itself.[123] The late eighteenth-century map definitively equates 'the road to Guston sluice' with the modern road between Corporation Farm and Sluice Farm.[124] On balance, Guston was located near the modern Sluice Farm on the banks of Kirton Creek (Fig. 30).[125]

References to medieval Guston are scarce, but in 1327 a ship involved in the Gascon wine trade was arrested in Goseford and described as '*la Godale* of Guston, 140 tons'. This was a sizeable boat and the nature of the reference closely associates Guston with the port of Goseford.[126] Furthermore, there are enough references from the period around *c*.1400 to indicate that it was still an active community. In August 1370 Richard del Fen, a serf of the manor of Kingston in Woodbridge, was reported as having left the manor to live instead 'at Guston in the parish of Kirton'.[127] In the 1390s and early 1400s new tenants occupied built messuages in Guston, in 1400 'the homage of Kirton and Guston' presented cases to the leet court of Walton, and in 1412 Robert Burrich of Guston paid for a marriage licence.[128] There are also indications of economic decline and decay around this time. In August 1386 the Walton court rolls record dilapidating houses in Guston and in 1390 the court was trying to force three men to occupy three empty tenements in the hamlet.[129] The earliest surviving leet court rolls of Kirton date from the late fifteenth century and do not mention Guston at all.[130]

These are slim documentary pickings, but overall they hint that Guston was contracting from the end of the fourteenth century, a chronology that corresponds closely with the decline of the port of Goseford.[131] The English economy in general was contracting sharply from the 1380s and the trade of Goseford was hit especially hard from this time.[132] Yet the Deben's mouth was silting at the same time, inhibiting the movement of shipping and gradually increasing the rate of sedimentation. Their fate was sealed towards the end of the sixteenth century when Kirton Creek was embanked and its valley converted to pasture.

THE MORPHOLOGY OF THE COAST AND ESTUARIES IN *c*.1600

Between 1250 and 1600 the two principal changes to the morphology of the coast within our case study were a marked increase in sedimentation, and a major phase of river wall construction in order to undertake large-scale reclamations of intertidal marshes (Fig. 31). The two processes were closely linked. The growth of Orford spit southwards, the extension of the great shingle bank to link Bawdsey with the coast north of Oxeneye, and the silting in and around the mouth of the Deben would have reduced the wave energy and weakened the ebb flows within Butley river, the Bay and Oxeneye Fleets, and the Deben itself. This would have gradually increased the deposition of marine and freshwater sedimentation and the cumulative impact of these processes meant that by *c*.1500 the havens and creeks were shallower than they had been in *c*.1200. Bawdsey's northern haven deteriorated badly and the port of Goseford's fortunes declined during the economic recession of the later Middle Ages. During the agrarian boom of the sixteenth and early seventeenth centuries, the economic incentives to reclaim intertidal marshes for agricultural use land rose sharply, but now the shallower waters and weaker tidal flows in this area made the task of embanking and reclaiming much less risky. As the examples of Struston and Guston indicate, maritime activities contracted and they were replaced by reclaims of high quality arable and pasture land (Fig. 31).

The scale of reclamations was also transformed. There is little evidence from the Middle Ages to indicate that these were anything other than piecemeal, relatively small, and

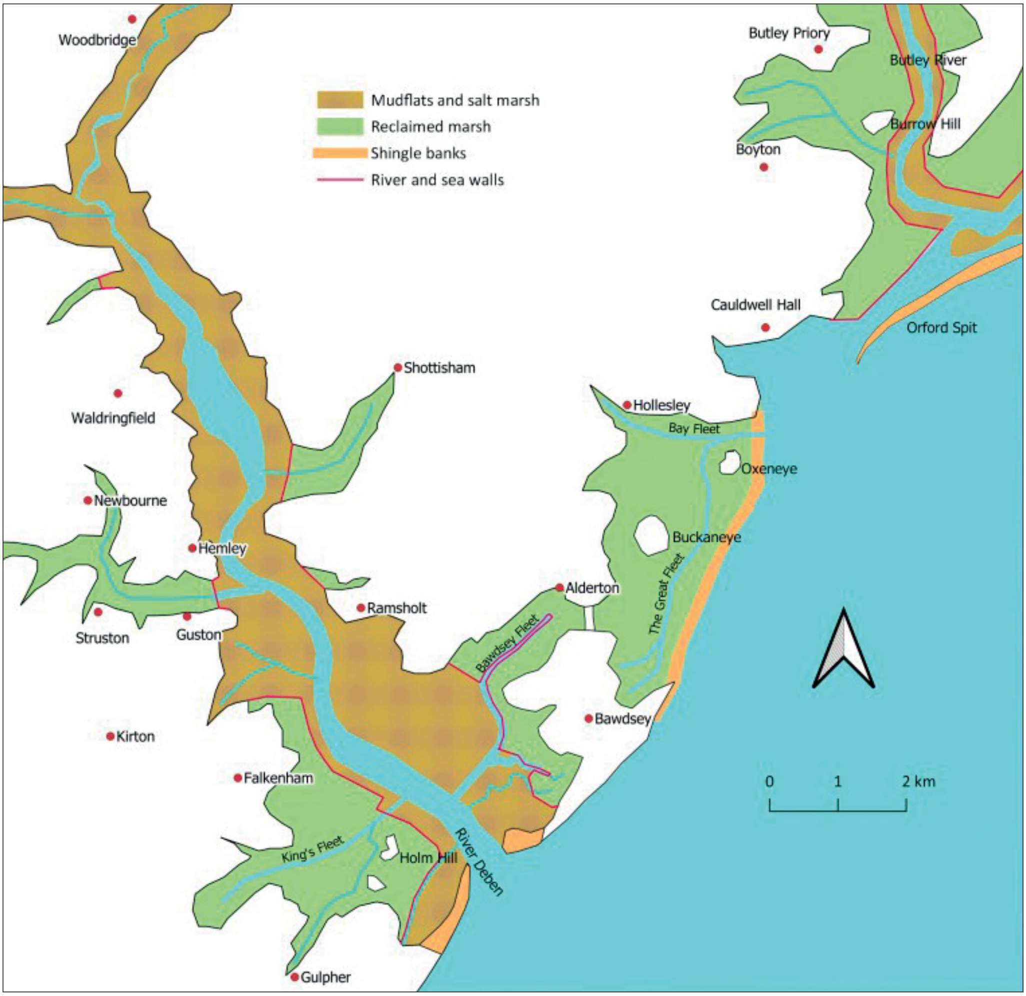


FIG. 31 – Conjectural reconstruction of the coast and river lines in *c*.1600 between Hollesley and the river Deben.

unsystematic, as a result of which they merely modified the marshland landscape rather than transformed it.[133] In contrast, the land claims of the sixteenth century were on a much larger scale whose cumulative effect was to transform the landscape, often led by major landlords such as Butley Priory (before the Dissolution) and the dukes of Norfolk.[134] Although little is known generally about the date of many of the 200+km of river walls and the associated draining of marshland along the Suffolk coast, documentary evidence confirms that most within the study area date from the sixteenth and early seventeenth centuries.[135] For example, the extensive Falkenham marshes were reclaimed at this time, the river Tang was embanked and sluiced some time before the 1560s, and John Norden's map of 1601 identifies 'new marshes' within the Butley river and shows the recent 'innyng' of Sudbourne Fleet in its north reaches (see Figs 29 and 31).[136] In 1568 oral testimonies relating to disputes over the marshes in the lower reaches of the river Ore confirm that in the 1540s and 1550s saltmarshes around Havergate island were being walled and 'made fresh'.[137]

The extension of the shingle bank north of Oxeneye island and the blockage of the Newhaven by *c.*1500 must have greatly reduced the flow of the sea and the wave energy in the old creeks and marshes, and so presented an obvious opportunity for their systematic reclamation in the sixteenth century. This would have entailed creating a sea wall behind the bank and an outfall into the sea for the waters from the Bay and Great Fleets, building river walls around the two fleets, and creating a series of ditches and sluices to enable rainfall and freshwater to run off the reclaimed marshes into the fleets (Fig. 31). Legal sources confirm that these activities occurred largely in the sixteenth century. In 1585 a dispute arose over Winstone's marsh, Whytinge marsh and Ten Acre marsh in Bawdsey and Alderton, and an inquisition established that within living memory these had been saltmarshes 'overflown with salte water at eny or most of the Tydes, eaten or gulled in with diverse Crickes [*creeks*] and fleettes and by that means of very little valewe'.[138] A succession of witnesses dated the 'innynge' of these marshes to the 1530s. For example, William Sawyer, aged 64, testified that as a child he carried food to his father working as a labourer embanking the marsh, and another witness, 71-year-old Richard Revell, attributed reclamations to Prior Mannyng of Butley, who was prior between 1528 and 1537: he was explicit that these reclamations were 'fresh made', i.e. not some recycling of earlier works.[139] Similar major infrastructure works had been undertaken in the 1540s in the south-east part of Hollesley parish. In 1587 a survey was made of 'all the groundes and marshe lande within the newe walle and Innynge made at the charge of the late Duke of Norff[*olk*] about anno 35 Henry 8' [*i.e. in 1543–4*] in Hollesley. The surveyors of 1587 noted the existence of old banks and 'innings' within the 1543–4 wall, which were probably the surviving piecemeal reclamations of the high Middle Ages.[140]

Hence during the 1530s and 1540s, at least two high-status local landlords led the major and systematic reclamation of the saltmarshes between Bawdsey and Hollesley, creating the foundations of the modern landscape and coast in this area. In 1601 an inquiry noted that some of the sea and river banks in this vicinity had been recently breached by the sea, which serves as a salutary reminder of the continued storminess of the period and the need for constant maintenance of river defences.[141] Our research shows that it is possible to date the construction of river and sea walls with reasonable accuracy though fragmentary evidence contained within a variety of historical documents. It also reveals that thirteenth-century reclamations of tidal marshes were piecemeal and unsystematic in the study area, whereas sixteenth-century reclamations were large-scale and systematic. The technical, institutional and economic contexts were broadly the same in both periods, yet sixteenth-century communities were the first to undertake major reclaims. The main variable was that the rate of marine deposition had greatly increased between 1200 and 1600, linked directly to the frequency, severity and direction of storm activity. Shallower estuaries, havens, creeks and intertidal marshes eased the task and reduced the risks of reclamation.

CONCLUSION

The modern Suffolk coastline is the product of a complex combination of natural forces, climate change and varied human responses over many centuries. It follows that any attempt to reconstruct its past should be a multi- and interdisciplinary endeavour involving archaeologists, landscape historians, historians, geographers and environmental scientists. To this end, this case study has attempted to demonstrate the potential for utilising a wide range of local historical sources and the benefits of collaborative ventures between historians and scientists for reconstructing coastal change over centuries, not just decades.

Scientific evidence indicates that between the mid-thirteenth and mid-seventeenth centuries, global temperatures cooled, interspersed with short bursts of warming. The resultant, highly complex, changes in the air and sea temperatures of the North Atlantic Ocean increased the severity and frequency of storms in the North Sea, especially between the 1280s and 1380s, then again in the sixteenth century. This increased storm activity heightened the erosion and movement of sediment along the Suffolk coast, and the shift to predominantly negative NAO during the fifteenth and sixteenth centuries meant that the transportation of shingle was mainly southwards.

The historical evidence from the study area corroborates the climatic evidence for increased storm frequency and severity after *c*.1250, as reflected in the erosion of vulnerable stretches of coastline, and the inundation and loss of earlier marshland reclamations. The long downturn in agrarian fortunes between 1300 and 1500 meant there was little economic incentive to repair breached defences or to initiate new reclaims. Yet the historical evidence also encourages shifting attention away from eye-catching erosion events towards the importance and the consequences of the gradual accumulation of on- and offshore shingle over a long period of time. During the late Middle Ages the extension of spits and barriers between Orford Ness and the Deben estuary resulted in increased sedimentation in tidal rivers and creeks. This had the obvious effect of reducing the accessibility of both the Ore and the Deben to shipping, and the much less obvious effect of creating shallower riverine waters. In *c*.1250 reclamations of intertidal marshes between Orford Ness and the Deben estuary were piecemeal, unsystematic and small scale. By *c*.1600 the coastline had been transformed by large-scale and systematic reclamations. The technical know-how to construct large sea and river defences had certainly existed in *c*.1250, high-status landlords possessed the resources to fund such major enterprises, and the economic incentive was high: the main difference between the thirteenth and sixteenth centuries is that the rate of marine deposition had increased considerably, which made marine reclamations much easier at the later date. This study has confidently dated the extensive construction of sea and river banks, and systematic reclamations, along this stretch of coast to the sixteenth century. As a result, by 1600 its contours, and those of the Butley and Deben rivers, are readily recognisable to the modern eye.

The interplay between natural processes and human responses is exemplified by the fortunes of the port of Goseford, which in *c*.1250 was an important and thriving maritime community covering a cluster of anchorages between Oxeneye haven in the east and Kirton Creek in the west. Oxeneye haven then began to deteriorate and silt, as a result of which the port became associated more narrowly with Bawdsey and the Deben. Goseford under the leadership of Bawdsey reached the peak of its importance in the 1340s, when Edward III rewarded its shipmasters for supporting his military activities against the French crown with the right to provision the newly acquired garrison at Calais. Thereafter the fortunes of the port declined, especially in the early fifteenth century.[142] The most obvious explanations are economic and military, but it is now apparent that complex changes to the coastline added to its difficulties. Oxeneye island was partially eroded, its haven became blocked and its creeks sealed off from the sea by the creation of the large shingle barrier now known as Bawdsey beach. Then, as the Deben side of Goseford also silted, so other small communities such as Guston lost their maritime gateways.

Two final observations are worth making. The first is that scientific discoveries about long-term climate change have presented a new set of questions and opportunities for historians to consider. Historians are able to provide important evidence that confirms, informs and can even direct the work of scientists in this area in a genuinely interdisciplinary manner. The second is that major changes to the coastline occur quickly during periods of sustained climate change and economic recession. In 2021 spiralling government debt due to a global pandemic reduces the future affordability of major spending on coastal defences, despite rapidly rising sea levels and a warming global climate. The lesson from history is that storm severity, frequency and direction, rather than rising sea levels *per se*, are the main drivers behind coastal change, but they also trigger highly complex changes in the patterns of erosion and accretion whose outcomes are not readily predictable. Human incentives and imperatives drive reclamations in some periods, but not in others: changes in the global climate increase sedimentation in some periods, but not others. Coastal communities have always lived with such unpredictability and associated risks, and with the ebb and flow of reclamation and inundation. Adapting to the force of the sea has meant accepting inundation as well as defending reclamations. After all, to some extent 'nature-induced' catastrophes are what humans make of them.

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NOTES

1 Rippon 2000, 268–9; Bankoff 2013.
2 Fulford *et al*., 1997.
3 Hegarty and Newsome 2005, 78–9.
4 See, for example, Allen 1997; van der Noort and Ellis 2000; Rippon 2000; Gardiner 2002; van der Noort 2011. Also the RCZAS reports produced for English Heritage, Wessex Archaeology 2000; Hegarty and Newsome 2005; Albone *et al*. 2007; and Gascoyne and Medlycott 2014.
5 Bailey 1991; Sear *et al*. 2008, 2011; Galloway 2009, 2013.
6 Van der Noort 2013, 36–43.
7 Allen 1997, 6, 18–22; van der Noort 2011, 122; Galloway 2013, 178.
8 Hegarty and Newsome 2005, 81. See also Wessex Archaeology 2000, 48–9; Albone 2007, 106–7; Gascoyne and Medlycott 2014, 15–17, 62–289.
9 See, for example, Allen 1997, 22–9; van der Noort and Ellis 2000; Rippon 2000, 152–207; Gardiner 2002; Galloway 2009; Simmons 2013, 2017.
10 For the medieval port of Goseford, see Wain 2016.
11 Wain 2016, 295–7.
12 A general point made, but not developed, by Green 1961, 26–7.
13 Hamilton *et al*. 2019, 155; Sear *et al*. 2016, 18–35; Brew *et al*. 1992, 71.
14 Burningham and French 2017, 84; Sear *et al*. 2008, 14; Hamilton *et al*. 2019, 155; Shennan *et al*. 2018, 150.
15 Wallingford 2016, 65; Burningham and French 2017, 86–7; Brookes and Spencer 2014, 589.
16 Brookes and Spencer 2014, 589–90.
17 Pye and Blott 2006, 455–8.
18 Sear *et al*. 2013, 100–9; Burningham and French 2017, 84.
19 Allen 1997, 1–5, 17–18; van der Noort 2011, 115–23.
20 Crossley *et al*. 2020.
21 Allen 1997, 6–11.
22 Allen 1997, 1–5; van der Noort 2011, 118.
23 For a summary, see Rippon 2000, 46–53, 152–99; for Suffolk, see Bailey 2007, 73, 92.
24 Rippon 2000, 249–56.
25 Galloway 2012; Galloway 2013, 186–96, 203.
26 Campbell 2016, 198–208.
27 Campbell 2016, 204–5; Stone 2014; Pribyl 2017, 98–101, 118–30, 163–4; Slavin 2019, 33–9.

28 Pye and Blott 2006, 453–5; Sear *et al.* 2008, 14–19; Galloway 2009, 173–5, 180–3; Galloway 2013, 184, 186–7.
29 Bailey 1991, 191–6; Bankoff 2013, 8–9, 20–3; Galloway 2013, 182–6; Eddison 1998; Sear *et al.* 2011, 116.
30 Bailey 1991, 195–7; Sear *et al.* 2011, 114–16.
31 Bailey 1991, 192–3; Galloway 2013, 189–92.
32 Bailey 1991, 198–9; Williamson 1997, 86.
33 Allen 1997, 12–16; Galloway 2009, 180–1; 2013, 184–6, 192–4, 203, 206; Galloway 2012.
34 Bailey 2007, 281–4.
35 Bailey 1992; Sear *et al.* 2008, 2011; Ayers 2021.
36 Butcher 2016, 80–113.
37 Green 1961, 22–4.
38 Saul 1975, 38–9, 77.
39 Saul 1982, 83; Butcher 2016, 141–3.
40 Brew *et al.* 1992, 68–71; Sear *et al.* 2016, 36.
41 Sear *et al.* 2016, 28–30.
42 Lloyd *et al.* 2013.
43 Brew *et al.* 1992, 71.
44 Macklin *et al.*, 2010, 1571–2.
45 Campbell 2000, 231–75, 309–85; Bailey 2007, 73–9.
46 Macklin *et al.*, 2010.
47 Allen 1997, 18–22; Hegarty and Newsome 2005, 81, 84.
48 Smith 1943, 166–89; Bailey 1991, 194–8; Allen 1997, 20; Galloway 2013, 201–4.
49 Bailey 2002, 37–43, 105–15, 167–92.
50 Rippon 2000, 201.
51 Boer and Carr 1969, 17–32; Simmons 2017.
52 Boer and Carr 1969, 33–8.
53 Steers 1926, fig. 2, 125–7.
54 Potter *et al.* 2002, 18, 21.
55 Myres *et al.* 1933, 261–3; for an alternative interpretation of the water channel to the priory, see Fenwick and Harrup 2009, 4.
56 BL, Cotton MS Augustus I i 64; SA/I, EE5/11/1; Steers 1926, 124–31; Steers 1953, 152–6; Newton 2011, 292–4.
57 Wrecks and flotsam appear in the fourteenth-century court rolls, Arundel Castle Archives, M1022. The manorial custom concerning wrecks and flotsam is recorded in 1501, BL, Add. MS 23950. See also Arnott 1952, 73–4.
58 SA/I, HB10:431/33, m. 4.
59 BL, Add. MS. 23949.
60 Boer and Carr 1969, 28.
61 One Thomas Clerk held a croft called Caldwell croft, SA/I, HB10:431/33, court held Lent 1528. The hamlet may well have been called Caldwell and located to the east or south-east of Caldwell Hall on land now lost to the sea.
62 SA/I, HB10:431/33, m. 2, Lent 1528.
63 Myres *et al.* 1933, 226–7.
64 SA/I, EE5/7/13; Fenwick and Harrup 2009, 90–3.
65 Boer and Carr 1969, 31–3.
66 TNA, MPA1/1/1.
67 TNA, JUST 3/64/3.
68 See, for example, the wills of John Sarle (1497), SA/I, IC/AA2/3:221; John Combyrlond (1469), SA/I, IC/AA2/186; Richard Mome (1501), SA/I, IC/AA2/4/24; and the Harwer family, notably William (1533), SA/I, IC/AA2/11/141, and his father Jeffrey, SA/I, IC/AA2/179.
69 SA/I, HB10:431/33, m. 2.
70 Arundel Castle Archives M1022, m. 25. By way of comparison, in the 1330s the market towns of Brandon and Lakenheath in west Suffolk averaged 17 and 30 brewers per court respectively, Bailey 1989, 261–2.
71 Arundel Castle Archives M1022, m. 18, July 1318; m. 21, July and September 1326.
72 TNA, C/132/38/17; TNA, SC6/998/22 to 24.
73 Arnott 1950, 54–60.

74 Wain 2018, 40.
75 Briggs and Kilpatrick 2016, 9; Geology of the Woodbridge and Felixstowe District, sheets 208 and 255, British Geological Survey, 2002.
76 In the 1327 lay subsidy returns for Bawdsey, three taxpayers possessed the locative surname 'de Oxeneye', Hervey 1906, 111–2; in 1311 one Henry de Oxeney owned a ship called 'La Custance of Goseforth', TNA, KB27/226/178; Wain 2018, 39.
77 BL, Add. MS 32134, f. 6v. This indicates that modern Oxley farm—which is located on a small area of land just above sea level—is all that is left of the medieval Oxeneye island: it probably comprised its western end, and the eastern section must have been eroded by the sea before the shingle barrier grew and sealed the remnants of the island in the marshes.
78 *Calendar of Patent Rolls, 1301–7*, 81; BL, Add. MS 23948, ff. 1-3, 14, 17, 39.
79 BL, Add. MS 8987, f. 136.
80 Geology of the Woodbridge and Felixstowe District, sheets 208 and 255, British Geological Survey 2002.
81 Briggs 2020, 324.
82 For other examples of this phenomenon, see Rippon 2000, 159, 199; Galloway 2013, 176. Conversely, when a protective shingle bank is destroyed in a storm, the resultant flooding can be devastating, Gardiner 2002, 103–4.
83 TNA, SC6/999/4.
84 The 1438 extent of Bawdsey records the existence of Trewlode Marsh, Newemarsh (40 acres), Haskessade and the Marsh of the Priory, BL, Add. MS 23948, ff.3, 7–8, 41–3. The map of 1589 locates these marshes around the fringes of the higher land in north Bawdsey and east Alderton, as represented in Fig. 30. Since the economic incentives for reclamations had virtually disappeared after the arrival of the Black Death in 1349, the marshes named in the 1438 extent were most likely to date from the boom of the twelfth and thirteenth centuries.
85 Newton 2011, 297, suggests that the name Goseford derives from the Norse *-fjorthr*, which would refer to the river Deben. This interpretation is at odds with our discovery that the port of Goseford extended beyond the Deben to Oxeneye, with a ford/causeway between Alderton and Bawdsey as its fulcrum. Keith Briggs, (pers. comm.) is clear in his forthcoming book that the placename evidence supports the *-ford*, not the *-fjord*, derivation.
86 *Calendar of the Fine Rolls, 1399–1405*, 206; Arnott 1950, 56–8.
87 Fairclough and Plunkett 2000, 450–2.
88 *Taxatio Ecclesiastica*, 119. A settlement in this location is depicted on the Gough map, though unfortunately its name is badly faded: the evidence suggests that the name is 'Burg'.
89 Fairclough 2011, 267–8 notes fragmentary archaeological evidence for a landing place where the modern remnants of this creek meet the high ground near the golf clubhouse. We speculate that this creek was navigable in the thirteenth century, providing riverine access to Burgh, and that a narrow shingle bank connected Burgh with what is now Felixstowe Ferry.
90 TNA, SC6/1007/4 to 7.
91 TNA, SC6/999/4.
92 *Nonarum Inquisitiones*, 63.
93 Myres *et al.* 1933, 185.
94 *Nonarum Inquisitiones*, 79–80.
95 *Nonarum Inquisitiones*, 63–5, 79–80.
96 For an outline of the fortunes of the English economy on the eve of the Black Death, see Miller and Hatcher 1995, 418–29.
97 Bailey 1991, 199.
98 Fairclough and Plunkett 2000, 425, 436, 451–2; *Nonarum Inquisitiones*, 63.
99 For the economic heyday of Goseford, see Wain 2016, 582–7.
100 Excluding the Romano-British and Iron Age coins, a total of 136 coins have been found in Alderton of which 70 (51 per cent) are from the period 1154 to 1307; data from The Portable Antiquities Scheme/The Trustees of the British Museum.
101 Wain 2018, 588–90.
102 For example, Henry de Oxeney's ship 'La Custance' is described in 1311 as 'of Goseforth' then in 1323 as 'of Baudeseye', TNA, KB27/226/178 and TNA, CP40/242/265f. Also 'La Fraunceys of Baudreseye' in 1327, and in 1326 'La Fraunceys of Goseford', *Calendar of Memoranda Rolls*, 128; Gras 1918, 406. In 1345 'La Godyer of Goseford' and in 1360 'La Godyer of Baldersey', William Scott named as master on both occasions, TNA, E101/25/9 and TNA, E372/206/83f. In 1401 John Staverley was master of 'La Trinite of Baldereseye' and again in 1403 of 'La Trinite of Goseford', *Calendar of Charter Rolls, 1399–*

1402, 347, and *Calendar of Charter Rolls, 1402–1405,* 209.
103 Letters 2003, 323.
104 Wain 2018, 585.
105 TNA, C19/66/43 mm. 27, 29.
106 BL, Add. MS 23948, ff. 7, 17, 34. Similarly in the extent of 1579, BL, Add. MS 32134, ff. 43, 71.
107 BL, Add. MS 23948, ff. 4–5, 7–8.
108 Wain 2018, 41; BL, Add. MS 23948, ff. 7–8, 34.
109 BL, Add. MS 23948, f. 4; BL, Add. MS 32134, ff. 7, 9, 54.
110 TNA, E179/180/92 part 2, mm. 15, 16, 17, 20, data from the England's immigrants database. Alderton recorded ten, Bawdsey two, Felixstowe five, Falkenham two, Kirton two, Walton two, and Hollesley and Newbourne one each.
111 Wain 2016, 595–7.
112 TNA, SP12/206 f. 53r.
113 BL, Add. MS 191130.
114 Rumble 1986, 7:88, 7:89, 7:103 and 7:105.
115 Arnott 1946, 32.
116 SA/I, HB 8/1/70, court held 7 January 1604 includes a copyhold conveyance describing a tenement on the way leading from Struston green to Struston bridge, and other courts around 1500 mention Struston field (September 1495, May 1535); see also SA/I, HB 8/1/71, court held July 1601.
117 SA/I, HD 1487, f. 9 and tab. XVI.
118 OS Explorer 197, Ordnance Survey 2015.
119 Arnott 1950, 57, 64.
120 Arnott 1946, xv, 32; Arnott 1950, 57, 83; SA/I, HA 119/1/3/5/1/7, court held 28 March 1463, 'the Lady of Manor granted at Michaelmas last past to lease to William Redgrave all rights of Ferry and of boat passage from Guston Stoon to Sutton Melleflet with all profits for 4 years at 2s yearly'.
121 SA/I, HB 8/1/70, court held May 1785.
122 It was described in exactly the same way in court rolls from March 1538, August 1627 and November 1679, SA/I, HB 8/1/70, and again in the 1590s, SA/I, HB 8/1/71; for the absence of any hamlet in contemporary maps, see SA/I, HD 1487/1 and SA/I, HA 119/435/26.
123 SA/I, HA 119/1/3/5/1/1, m. 105, court held May 1408.
124 SA/I, HD 1487, f. 9 and map XVI.
125 Around coordinates LAT 52 022706 LONG 1 326001.
126 The entry also lists five other boats before 'la Godale' – 'la Eleyne' (120 tons), 'la Laurence' (80 tons), 'la Seintmariecogge' (80 tons), 'la Margarete' (80 tons), 'la Margerie' (80 tons*)* – without assigning them to a place: if the scribe meant that all six were from Guston, then its importance within Goseford is greatly enhanced; *Calendar of the Memoranda Rolls,* 128.
127 CUL, EDC 7/14/B/5.
128 SA/I, HA 119/1/3/5/1/1, m. 61, court held February 1396; m. 78, court held May 1400; m. 102a, court held November 1406; m. 118, court held August 1412.
129 SA/I, HA 119/1/3/5/1/1, mm. 20, 39.
130 SA/I, HA 119/50/3/119, six rolls of courts between 1462 and 1486.
131 Wain 2016, 595–7.
132 For a detailed analysis of the difficulties of the economy in the 1380s and 1390s, see Bailey 2021, 234–82.
133 For these categorisations see Rippon 2000, 46–53.
134 Myres *et al*. 1933, 260, 263.
135 Arnott 1950, 35–8; Arnott 1952, 7, 73–5, 80; Hegarty and Newsome 2005, 81–7.
136 Arnott 1950, 15, 37–8; Hegarty and Newsome 2005, 81–4; Fenwick and Harrup 2009, 83; SA/I, HD88/996; the period after 1550 was also significant in the embankment and reclamation of the south Lincolnshire coast, see Simmons 2017, 47–8.
137 SA/I, HB 83/988/6.
138 TNA, E134/27&28Eliz/Mich15; see also the extent of reclamation by the late sixteenth century in BL, Cotton MS Augustus I i 64.
139 TNA, E134/27&28Eliz/Mich15; Page 1907, 99.
140 TNA, E178/2182, m. 7.
141 TNA, E178/2222.
142 Wain 2016, 594–7.

BIBLIOGRAPHY

Calendar of the Close Rolls, Henry IV, 1, 1399–1402. 1927. London.

Calendar of the Close Rolls, Henry IV, 2, 1402–1405. 1929. London.

Calendar of the Fine Rolls, 1399–1405. 1931. London.

Calendar of Inquisitions Miscellaneous (Chancery), 1308–1348. 1916. London.

Calendar of Memoranda Rolls (Exchequer), Michaelmas 1326–Michaelmas 1327. 1968. London.

Calendar of the Patent Rolls, 1301–1307. 1898. London.

Collections by David Elisha Davy, son of David Davy, of Rumburgh Hill, Suffolk for a parochial history of Suffolk. Vol. XXXVII. BL, Add. Ms. 19113.

Nonarum Inquisitiones in Curia Scaccarii. 1807. London.

Taxatio Ecclesiastica 1291. 1802. London.

Albone, J., Massey, S. and Tremlett, S., 2007. *The Archaeology of Norfolk's Coastal Zone: results of the National Mapping Programme*. English Heritage Project No. 2913.

Allen, J.R.L., 1997. 'The geoarchaeology of land-claim in coastal wetlands: a sketch from Britain and the northwest European Atlantic–North Sea coasts', *Archaeological Journal*, **154**, 1–54.

Arnott, W.G., 1946. *The Place Names of the Deben Valley Parishes*. Ipswich.

Arnott, W.G., 1950. *Suffolk Estuary. The Story of the River Deben*. Ipswich.

Arnott, W.G., 1952. *Alde Estuary. The Story of a Suffolk River*. Ipswich.

Ayers, B., 2021. 'Medieval Suffolk and its North Sea world: archaeological approaches and potential', *Proc. Suffolk Inst. Archaeol.*, **45**, 44–62.

Bailey, M., 1989. *A Marginal Economy? East Anglian Breckland in the later Middle Ages*. Cambridge.

Bailey, M., 1991. '*Per impetum maris*: natural disaster and economic decline in eastern England, 1275–1350' in B.M.S. Campbell (ed.), *Before the Black Death. Studies in the 'Crisis' of the Early Fourteenth Century*, 184–208. Manchester.

Bailey, M. (ed.), 1992. *The Bailiffs' Minute Book of Dunwich 1404–1430*. Suffolk Records Soc., 34. Woodbridge.

Bailey, M., 2002. *The English Manor, c.1200–c.1500*. Manchester.

Bailey, M., 2007. *Medieval Suffolk. An Economic and Social History*. Woodbridge.

Bailey, M., 2021. *After the Black Death. Economy, Society and the Law in Fourteenth-Century England*. Oxford.

Bankoff, G., 2013. 'The 'English lowlands' and the North Sea basin system: a history of shared risk', *Environment and History*, **19**, 3–37.

Boer, de, G., and Carr, A.P., 1969. 'Early maps as historical evidence for coastal change', *The Geographical Journal*, **135**, 17–39.

Brew, D.S., Funnell, B.M. and Kreiser, A., 1992. 'Sedimentary environments and Holocene evolution of the lower Blyth estuary, Suffolk (England), and a comparison with other East Anglian coastal sequences', *Proceedings of the Geological Association*, **103**, 54–74.

Briggs, K., 2020. 'Two coastal terms of continental origin: 'shingle' and 'dene'', *Notes and Queries*, **67(3)**, 323–6.

Briggs, K. and Kilpatrick, K., 2016. *A Dictionary of Suffolk Place-Names*. Nottingham.

Brooks, S.M. and Spencer, T. 2014. 'Importance of decadal scale variability in shoreline response: examples from soft rock cliffs, East Anglian coast, UK', *Journal of Coastal Conservation*, **18**, 581–93.

Burningham, H. and French, J.R., 2017. 'Understanding coastal change using shoreline trend

analysis supported by cluster-based segmentation', *Geomorphology*, **282**, 131–49.
Butcher, D., 2016. *Medieval Lowestoft: the origins and growth of a Suffolk coastal community.* Woodbridge.
Campbell, B.M.S., 2000. *English Seigniorial Agriculture, 1250–1450*. Cambridge.
Campbell, B.M.S., 2016. *The Great Transition. Climate, Disease and Society in the Late Medieval World*. Cambridge.
Castellano, E., Becagli, S., Hansson, M., Hutterli, M., Petit, J.R., Rampino, M.R., Severi, M., Steffensen, J.P., Traversi, R. and Udisti, R., 2015. 'Holocene volcanic history as recorded in the sulfate stratigraphy of the European Project for Ice Coring in Antarctica Dome C (EDC96) ice core', *Journal of Geophysical Research,* **110**, D06114.
Cook, E.R., Kushnir, Y., Smerdon, J.E., Williams, A.P., Anchukaitis, A.J. and Wahl, E.R., 2019. 'A Euro-Mediterranean tree-ring reconstruction of the winter NAO index since 910 C.E.', *Climate Dynamics*, **53**, 1567–80.
Crossley, L., Langdon, P.G., Sear, D.A., Dearing, J.D., Croudace, I.W., 2020. 'Palaeoenvironmental determination of biogeochemistry and ecological response in an estuarine marine protected area' in J. Humphreys and R.W.E. Clark (eds), *Marine Protected Areas*, 667–83. London.
Eddison, J., 1998. 'Catastrophic changes: a multidisciplinary study of the evolution of the barrier beaches of Rye Bay' in J. Eddison, M. Gardiner and A. Long (eds), *Romney Marsh: environmental change and human occupation in a coastal lowland*, 65–87. Oxford.
Fairclough, J., 2011. 'Felixstowe Roman port', *Proc. Suffolk Inst. Archaeol.*, **42**, 253–76.
Fairclough, J. and Plunkett, S.J., 2000. 'Drawings of Walton castle and other monuments in Walton and Felixstowe', *Proc. Suffolk Inst. Archaeol.*,, **42**, 419–59.
Fenwick, V. and Harrup, V., 2009. *Untold Tales from the Suffolk Sandlings*. Butley.
Fulford, M., Champion, T. and Long, A., 1997 *England's Coastal Heritage – A survey for English Heritage and the RCHME*. London.
Gallloway, J.A., 2009. 'Storm flooding, coastal defence and land use around the Thames estuary and tidal river *c*.1250–*c*.1450', *Journal of Medieval History,* **35,** 171–88.
Galloway, J.A., 2012. ''Tempests of weather and great abundance of water': the flooding of the Barking marshes in the later middle ages' in M. Davies and J. A. Galloway (eds), *London and Beyond. Essays in Honour of Derek Keene*, 67–86. London.
Galloway, J.A., 2013. 'Coastal flooding and socioeconomic change in eastern England in the later Middle Ages', *Environment and History,* **19**, 173–207.
Gardiner, M., 2002. 'The late medieval 'antediluvian' landscape of Walland Marsh' in A. Long, S. Hipkin and H. Clarke (eds), *Romney Marsh: coastal and landscape change through the ages*, 101–20. Oxford.
Gascoyne, A., and Medlycott, M., 2014. *Essex Historic Grazing Marsh Project*. Essex County Council.
Gras, N.S.B., 1918. *The Early English Customs System: a documentary study of the institutional and economic history of the customs from the thirteenth to the sixteenth century.* Cambridge, Mass.
Green, C., 1961. 'East Anglian coast-line levels since Roman times', *Antiquity*, **35,** 21–8.
Hamilton, C.A., Kirby, J., Lane, T.P., Plater, A.J. and Waller, M.P., 2019. 'Sediment supply and barrier dynamics as driving mechanisms of Holocene coastal change for the southern North Sea basin', *Quarterly International,* **500***,* 147–58.
Hegarty, C. and Newsome, S., 2005. *The Archaeology of the Suffolk Coast and Inter-Tidal Zone*. Suffolk County Council and English Heritage.
Hervey, S.H.A. (ed.), 1906. *Suffolk in 1327, being a Subsidy Return.* Suffolk Green Books, 9 (2). Woodbridge.

HR Wallingford, 2016. *Bawdsey - Coastal Process Assessment*. HR Wallingford Report No. DDR5548-RT001-R03-00 for The Crown Estate.

Kraker, de, A.M.J., 2006. 'Flood events in the southwestern. Netherlands and coastal Belgium, 1400–1953', *Hydrological Sciences Journal*, **51**, 913–29.

Letters, S. (ed.), 2005. *Gazeteer of Markets and Fairs in England and Wales to 1516*. Kew.

Lloyd, J., Larcombe, P., Zong, Y. and Woods, A, 2013. 'Relative sea-level changes and coastal evolution of the Minsmere coastline, Suffolk, during the Late Holocene. Unpublished conference paper.

Macklin, M.G., Jones, A.F. and Lewin, J., 2010. 'River response to rapid Holocene environmental change: evidence and explanation in British catchments', *Quaternary Science Reviews*, **29**, 1555–76.

Miller, E. and Hatcher, J., 1995. *Medieval England. Towns, Commerce and Crafts, 1086–1348*. Harlow.

Myres, J.N.L., Caroe, W.D. and Ward Perkins, J.B., 1933. 'Butley Priory, Suffolk', *Archaeological Journal,* **90**, 177–281.

Newton, S., 2011. 'The battle of Newmouth and the lost Viking history of Sudbourne, with a postscript on the place-name Orford', *Proc. Suffolk Inst. Archaeol*, **42**, 292–99.

Noort, van der, R., 2011. *North Sea Archaeologies: a maritime biography, 10,000BC–AD 1500*. Oxford.

Noort, van der, R. and Ellis, S., 2000. 'The Humber estuary: managing the archaeological resource in a dynamic environment' in K. Pye and J.R.L. Allen (eds), *Coastal and Estuarine Environments: sedimentology, geomorphology and geoarchaeology*, 419–27. London.

Page, W. (ed.), 1907. *The Victoria History of the County of Suffolk*, *II*. London.

Potter, V., Poulter, M. and Allen, J., 2002. *The Building of Orford Castle. A Translation from the Pipe Rolls, 1163–78*. Orford.

Pribyl, K., 2017. *Farming, Famine and Plague. The Impact of Climate in Late Medieval England*. Berlin.

Pye, K. and Blott, S.J., 2006. 'Coastal processes and morphological changes in the Dunwich-Sizewell area, Suffolk, UK', *Journal of Coastal Research*, **22**, 453–73.

Rippon, S., 2000. *The Transformation of Coastal Wetlands*. London.

Rumble, A. (ed.), 1986. *Domesday Book: Suffolk, I*. London.

Saul, A., 1975. 'Great Yarmouth in the fourteenth century. A study in trade, society and politics'. Unpublished DPhil thesis, University of Oxford.

Saul, A., 1982. 'English towns in the late Middle Ages: the case of Great Yarmouth', *Journal of Medieval History,* **8**, 75–88.

Sear, D.A., 2018. *Storms Database*. http://www.dunwich.org.uk (last accessed 20 August 2020).

Sear, D.A., Bacon, S.R., Murdock, A., Doneghan, G. and LeBas, T.P., 2008. *'Dunwich 2008 Project Report'*. GeoData Research Report No. UC1064.

Sear, D.A., Murdock, A., Baggaley, P., LeBas, T.P. and Gubbins, G., 2013. '*Dunwich Project 5883: final report'*. English Heritage.

Sear, D.A., Bacon, S.R., Murdock, A., Doneghan, A., Baggaley, P., Serra, C. and LeBas, T.P., 2011. 'Cartographic, geophysical and diver surveys of the medieval town site at Dunwich, England', *International Journal of Nautical Archaeology,* **40**, 113–32.

Sear, D.A., Bacon, S.R. and Langdon, C., 2016. *Touching the Tide: Dunwich land based archaeological survey.* http://www.touchingthetide.org.uk/assets/Documents/Touching-The-Tide-Coring-Project-2016-FINAL.pdf.

Shennan, I., Bradley, S.L. and Edwards, R., 2018. 'Relative sea level changes and crustal movements in Britain and Ireland since the last glacial maximum', *Quarterly Science*

Review, **188**, 143–59.
Simmons, I.G., 2013. 'Rural landscapes between the East Fen and the Tofts in south-east Lincolnshire 1100–1550', *Landscape History*, **34**, 81–90.
Simmons, I.G., 2017. 'Fen and sea: medieval and early modern landscape evolution in south-east Lincolnshire before 1700', *Landscapes*, **18**, 37–54.
Slavin, P., 2019. *Experiencing Famine in Fourteenth-Century Britain*. Turnhout.
Smith, R.A.L., 1943. *Canterbury Cathedral Priory. A Study in Monastic Administration*. Cambridge.
Steers, J.A., 1926. 'The Suffolk coast: Orford Ness', *Proc. Suffolk Inst. Archaeol.*, **19**, 117–40.
Steers, J.A., 1953. *The Sea Coast*. London.
Stone, D., 2014. 'The impact of drought in early fourteenth-century England', *Economic History Review,* **67**, 435–62.
Wain, P., 2016. 'The medieval port of Goseford', *Proc. Suffolk Inst. Archaeol.,* **43**, 582–601.
Wain, P., 2018. 'A lost Suffolk settlement', *Suffolk Review,* **70**, 39–41.
Wessex Archaeology, 2000. *Historic Environment of the North Kent Coast: rapid coastal zone assessment survey*. Kent County Council.
Williamson, T., 1997. *The Norfolk Broads: a landscape history.* Manchester.
Wu, X., Yang, H., Waugh, D.W., Orbe, C., Tilmes, S. and Lamarque, J.-F., 2018. 'Spatial and temporal variability of interhemispheric transport times', *Atmospheric Chemistry and Physics*, **18**, 7439–52.

Abbreviations

BL	British Library
CUL	Cambridge University Library
SA/I	Suffolk Archives, Ipswich
TNA	The National Archives, Kew