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The value of historical and archaeological data in understanding patterns of long term coastal change

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The historical evolution of the coastline has been determined by the fluctuating relationship between land and sea. This process can be assessed to provide valuable information on trends that contribute to our understanding of past and current coastal change scenarios. These changes were initially dominated by the marine transgression following the last Ice Age, but the pace of sea level rise slowed and an equilibrium became established. This natural balance remained relatively stable until it was influenced by humans.

Where early archaeological material can be dated and contextualised within the landscape it provides evidence of the changing physical environment. Prehistoric structures act as datums that can be used to demonstrate how settlements were overwhelmed by rising sea level and they can indicate how populations reacted to the loss of land. In historical times, when sea levels were comparable to modern conditions, humans became more proactive along the coastline. Some of the alterations they made did not take into account weathering and as a consequence storm events could be destructive. These incidents were often recorded within historical, and artistic sources, that, along with the archaeological data, can be used to interpret the long-term impact of natural and human influences along the coast. Additionally, artistic representations can be used to make the story accessible to a wide range of people.

This paper will assess the under-used archaeological, historical and palaeo-environmental information within the English Channel and southern North Sea coast as data sources to provide insights into the impact of human activities along the coastline from the early Holocene, into the Anthropocene and to the mid-twentieth century. This research is being conducted within the Sustainable and Resilient Coastal Cities project (SARCC) and it concludes that while some human interventions have been positive, many have been counterproductive.

INTRODUCTION

Geological and geomorphological events laid the foundations for the contemporary coastline. The most dominant cause over the last eleven millennia has been the marine transgression. This was initiated by a sharp increase in global temperatures at the end of the last glacial epoch c.11.500 BP that accelerated the melting of ice sheets[1]. The increasing discharge of water caused rivers to swell and to transport vast quantities of fluvial material to the sea. Around 8,000 years ago, rising sea level inundated the land between Europe and Great Britain to open the English Channel[2]. As the sea continued to rise, hills were eroded by wave action and truncated to form cliffs while Pleistocene outwash gravel was carried by the currents to form beaches and spits. The rate of rising sea level slowed around 5,000 years ago and has since only risen by a few metres. This rise does not take into account isostatic movements caused by underlying geological faults or the rebound following the removal of the Devensian ice sheet that have caused the land to shift vertically at different rates in different places, resulting in variations of the relative sea level along north-west European coastlines[3].

The slowing of sea level rise during the last five millennia formed relatively stable coastal landscapes. As river sediments reached the sea, estuarine complexes developed, mudflats became established, deltas formed and barrier dune systems grew in balance with the changing coastal forces. Here, the marine sediments and colluvial material from eroding cliffs were transported by storms and currents to replenish beaches[4]. This was also a time that humans had increased interactions with the sea.

Evidence of Mesolithic (Middle Stone Age) human occupation from over eight thousand years ago can be found underwater and along the European intertidal zone[5]. With the onset of more sedentary Neolithic (New Stone Age) lifestyles around six and a half thousand years ago, human structures became more prolific. This was followed, around four and a half thousand years ago, by Bronze Age communities who introduced new technological innovations that enabled people to build more complicated structures and to actively exploit marine resources[6]. Salt marshes were increasingly used for grazing and sea salt extraction while landing stages were built on the water's edge to accommodate more sophisticated vessels. The arrival of the Romans two thousand years ago introduced an even more intrusive approach. They modified the landscape by constructing shoreline defences, ports and harbours, increasing salt manufacture and extracting coastal peat on an industrial scale.

By the Medieval and early modern periods, growing populations and social stability attracted more people to settle near the sea. Walls and dikes were built to reclaim and then protect land. Where the landscape was manipulated in a way that acted against rather than with the naturally evolving geomorphology, floods and storms could be devastating and frequently destroyed many hectares of low-lying coastline. By the nineteenth century, with industrialisation at the onset of the Anthropocene, technical advances and the use of increasingly robust construction materials emboldened coastal engineers to build larger harbours and installations out into the sea. They were confident that these could stand against the natural forces. It would appear that these engineers did not anticipate the indirect consequences that included the disruption of sediment flow, the loss of beaches, scour around structures and siltation[7].

1 Alley et al., 2000
2 Farr et al., 2017; Flemming et al., 2017; Harff et al., 2017; Sturt et al., 2013
3 Shennan et al., 2018; Kluiving et al., 2013
4 Brampton et al., 1998
5 Bailey et al., 2020; Flemming et al., 2014
6 Cunliffe, 2001
7 Momber et al., 2017

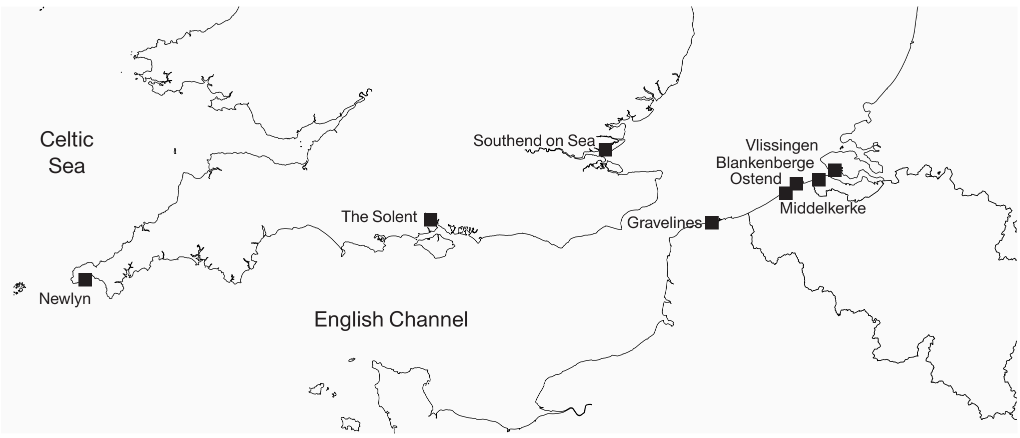
This paper will identify the sources of palaeo-environmental, archaeological and historical data, and show how we use them to demonstrate and interpret past change. Longer term data sources can show the results of rising sea levels along a coastline, while more recent historical imagery can demonstrate rates of change and the unfortunate consequences that occur when the impacts of that change are not anticipated. This is a practice that is becoming more common in the twenty-first century as Nature-Based Solutions (NBS) are incorporated to protect, restore or manage ecosystems[8].

8 Chester et al., 1919; Maes and Jacobs, 2015

The defence of our urban coastlines is an issue that is becoming more pertinent as the sea level rise is predicted to accelerate at unprecedented rates. Accordingly, we need to be prepared with innovative solutions if recent changes in the climate cause a break in past trends that result in increasing impacts along the coast. By drawing on long-term human datasets we can learn from the experiences of our forebears that will allow us to gain wisdom from hindsight.

SUSTAINABLE AND RESILIENT COASTAL CITIES (SARCC)

The SARCC project is an ongoing initiative, part funded by the EU through the European Regional Development Fund (ERDF), which aims to explore the viability of different NBS to protect urban centres from coastal threats. The project is looking to incorporate NBS into coastal management and policy making by identifying the additional benefits they offer when compared to traditional grey infrastructure. This includes an assessment of the long-term coastal evolution to provide a baseline against which change can be measured and to understand the processes that established the current position. Seven pilot sites have been chosen for assessment. These are located across the Channel and southern North Sea area from Newlyn and Southend on Sea in England, to Gravelines in France, Middelkerke, Ostend and Blankenberge in Belgium and furthest east, in Vlissingen, the Netherlands (Figure 1). This is the first time long-term processes have been investigated for this purpose and it has been found that the required data is limited. Accordingly, the pilot sites have been complemented by studies of areas that graphically demonstrate how the physical evidence and data sources can be used. The section below presents examples of this archaeological and historical evidence that has been assessed to interpret long-term change.



01

01 Location of pilot sites and the Solent study area mentioned in the text

STUDIES INFORMING THE SARCC PROJECT

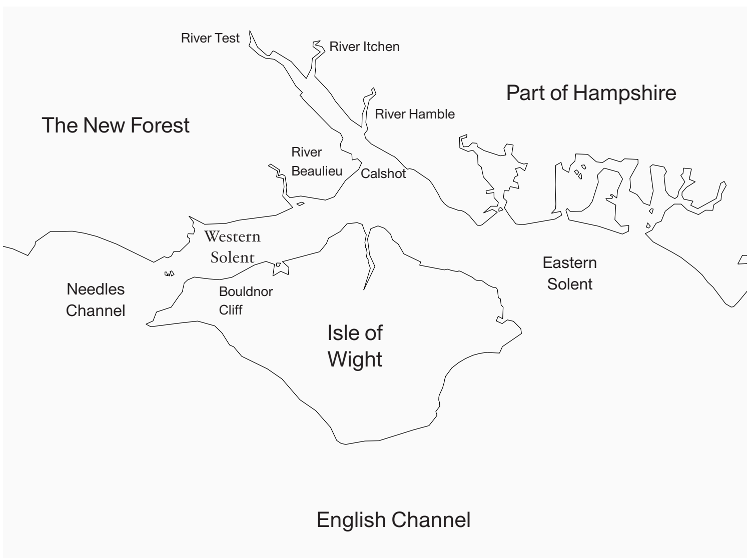
Early prehistoric structures can survive underwater where they have been protected in anaerobic sediments that were deposited as the sea level rose. Here, organic artefacts can remain for thousands of years in oxygen free, silt and peat layers. When these sites are found in situ, they can provide an archive of palaeo-environmental and archaeological information that informs us about past human occupation, the environment and the response of the coastline to sea level rise. Submerged landscapes have the potential to provide precise dates and index points for the height of sea level at a given point in time. This is a great asset, particularly when considering past and present rates of change at different locations along the coastline that are caused by eustatic and isostatic fluctuations.

Of the submerged landscapes in North West Europe, a particularly significant site has survived in the Solent, England. This is positioned in the middle of the SARCC project area. It contains an archaeological resource underwater at Bouldnor Cliff and in the intertidal zone, south west of Calshot. These old land surfaces are becoming exposed due to erosion caused by hydrodynamic changes that has resulted from natural and human influences (Figure 2).

THE FORMATION OF THE WESTERN SOLENT

A little over eight thousand years ago sea level rose into a sheltered floodplain along a low-lying valley in the western Solent. At the time, the area was 9-10m below current UK Chart Datum (CD). Sea level continued to rise and back ponding created stagnant pools that filled with vegetation, into which large trees fell after their roots were poisoned by salt water. The growing estuary spread over the ancient landscape and covered the organic material with alluvial silt. As the centuries passed, sea level continued to rise although the rate of change fluctuated. When it slowed or stopped, mudflats were vegetated, which then formed new organic layers of peat when sea levels rose again. This sequence of events occurred in many places across the northwest European continental shelf and is recorded in detail for the Doggerbank area in the North Sea[9].

9 Gaffney et al., 2009; Gaffney et al., 2017



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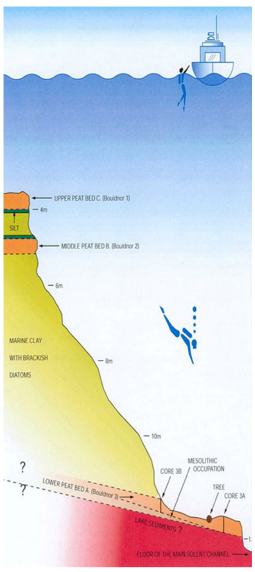


02 Location Map of the Solent showing Bouldnor Cliff, Calshot and Hurst Spit (Maritime Archaeology Trust).

03 Schematic cross section through the alluvial deposits at Bouldnor Cliff that have been truncated by erosion. The outcrops of peat have been dated to provide index points that have quantified the rate and change of sea level
(courtesy Isle of Wight Council).

At the underwater site of Bouldnor Cliff, along the south side of the western Solent, there is a 7m thick deposit of alluvial sediments, interwoven with layers of peat, that built up above the old valley floor. This has now been eroded to form a near vertical section that cuts through all the sequential layers. Dates have been taken from the tops of the peat horizons within the cliff to provide index points relative to the sea level at 8.7m 3.1m and 2.1m below CD. The depths dated to 6000-5920 cal BC (SEURC 11284), 4820-4435 cal BC (Beta140103) and 4425-4230 cal BC (Beta-140102) respectively (Figure 3).

On the Northern side of the Solent, similar layers of sediment were deposited on the old landscape. These are in shallower water where peat deposits found at 3.8m, 2.1m and 0.2m below CD, have provided dated index points at 5310 – 4940 cal BC (Beta 166478), 4490 – 4230 cal BC (Beta 16477) and 2571 – 2347 cal BC (SUERC 96363) respectively.

Collectively, the index points demonstrate a rise in sea level of 8.5m in approximately five and a half thousand years. Environmental and sedimentary evidence from each dated level has provided information that has enabled the evolution of the landscape to be reconstructed[10]. Diatoms and foraminifera samples from the cliff face were studied to characterise the deposited alluvium. Analysis indicated sediments had arrived from different places at different times. The varying sediment transport routes were studied to interpret changes to the coastline during the sea level rise[11]. Each modification had an impact that introduced new erosive regimes and forced people to adapt, but the most dramatic change to the coastline occurred when the estuary transitioned into a maritime strait.

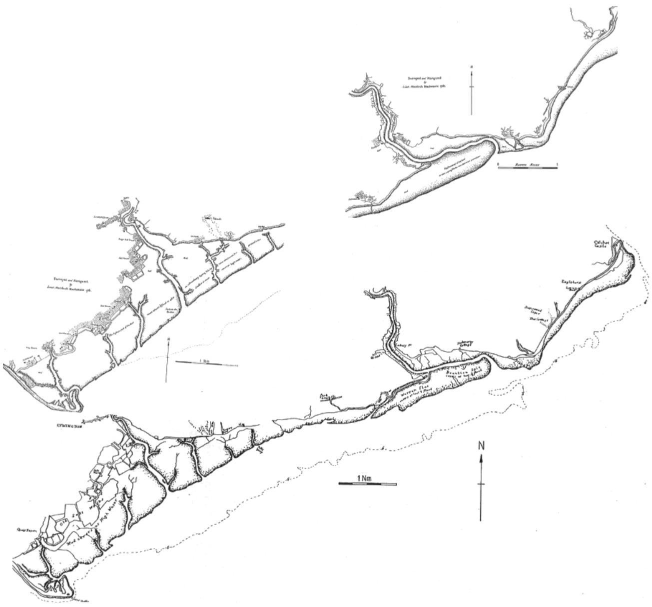
The formation of the open waterway occurred towards the end of the transgression, probably around three thousand years ago, however, the marine influence would have grown slowly at first as the high tides crossed the umbilical of land that connected the Isle of Wight to the mainland around the modern day Hurst Spit (see Figure 2). The movement of the tides, coupled with storms from the English Channel to the west, continued to remove the surface deposits and deepen the waterway. Sedimentary and geomorphological studies demonstrated that maritime conditions then become fully established in the western Solent approximately two and a half thousand years ago[12]. The new 'Hurst Channel' deepened and as it did so, tides were funnelled through the narrow passage, increasing the energy within the water column and the levels of erosion. Today it is over 60m deep and the currents continue to scour the seabed. The sedimentary regime in the western Solent has turned from accretion to erosion, with previous deposits being removed. The retreat of Bouldnor Cliff shows how this process continues to have an impact underwater while the recent collapse of the one hundred and fifty year old east wing of Hurst Castle, at the end of Hurst Spit, is a more visible example of coastal instability (Figure 4).

On the northern shores of the Solent, erosion has caused the destruction of saltmarsh and removal of sediment from the beaches. This is a relatively modern phenomena as charts from 1781 (Murdoch MacKenzie) and 1851 (Captain Sheringham) show an intertidal zone covered by mudflats at three quarters high tide (Figure 5). These have now been lost leaving the exposed Eocene geology, cut through with the

10 Scaife, 2011
11 Momber, 2011
12 Devoy, 1982; Dean, 1995; Ke and Collins, 2002; Hampshire County Council, 2014

04

04 The east wing of Hurst Castle, built in 1874 was undermined by the sea and collapsed in January 2021. The collapsed section can be seen in the centre of the image (Maritime Archaeology Trust)



05

05 Charts of the north west Solent from Hurst Spit in the west to Calshot Spit in the east (see figure 2 for comparison with modern map). The Murdoch MacKenzie chart of 1781 shows the mudflats along the coast that were exposed at three quarters high tide. Captain Sheringham, 1851, shows a further reduction in the size of the mudflats seventy years later (Maritime Archaeology Trust).

06

06 Looking west along the intertidal zone of the north-west Solent at low water spring tides in March 2021. The mudflats have been washed away, exposing the Eocene clay bedrock and mobile gravel banks (Maritime Archaeology Trust).

occasional infilled palaeo-channel and with gravel banks lying across the hard clay bedrock surface (Figure 6). Additional evidence of the changing shoreline is found in the archaeological record where freshly exposed artefacts and ecofacts can be dated to provide a *terminus anti quem* for the development of the covering deposits. The results indicated that the mudflats across the Solent have been stable for thousands of years, with the most extensive changes taking place over the last two hundred years[13]. Much of the recent loss of sediments has coincided with increased human interventions along the coastline.

13 Momber et al., 2011, Ke and Collins, 2002
14 Momber et al., 2021
15 Smith, 2015; Momber et al., 2011; Momber and Peeters, 2017; Momber, 2021

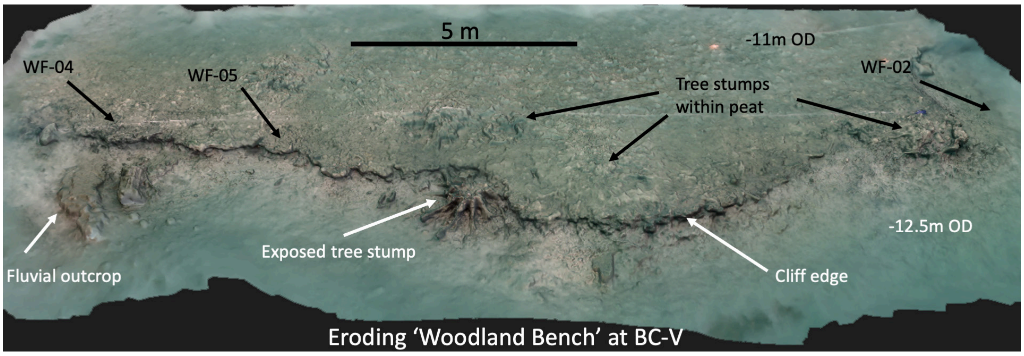
MARINE ARCHAEOLOGICAL SITES AS INDICATORS OF CHANGE

The base of the underwater cliff at Bouldnor contains archaeological evidence within a strip of seabed that is composed of compacted peat, trees and entwined root systems. This is within an eight-thousand-year-old, one kilometre long, linear 'woodland bench' 9-10m below CD (Figure 3). The strip of trees and the network of roots within the submerged land-surface are more resilient than the covering sediment, making them slower to erode (Figure 7). Well preserved archaeological artefacts left by the occupants of the old valley floor were discovered at several sites. Archaeological finds include old shoreline structures and the oldest boat building site in the world[14]. The presence of the material within its original depositional matrix, the excellent levels of preservation and the fast rates of degradation that occur once the artefacts are exposed, demonstrate that this is the first time the landscape had been uncovered since it was first protected. This, in turn, provides direct evidence for new erosion. The archaeological material has also provided insights into the lifestyles of people who lived by the water's edge and shown how they adapted to sea level rise. Discoveries of wheat within sedaDNA, along with the archaeological assemblage, demonstrates there was trade and there were common cultural connections with mainland Europe[15].

The removal of the mudflats along the north-west shores of the Solent have revealed a series of exposed archaeological sites. These date as far back as the Neolithic, the oldest being 3346 – 3090 cal BC (SUERC-86552) (Figure 8). The site was dry land when it was built but it is now 4m underwater during the highest tides. The structures are often associated with palaeo-channels and survive because these were sheltered inlets that filled with estuarine silt when they were inundated towards the end of the marine transgression.

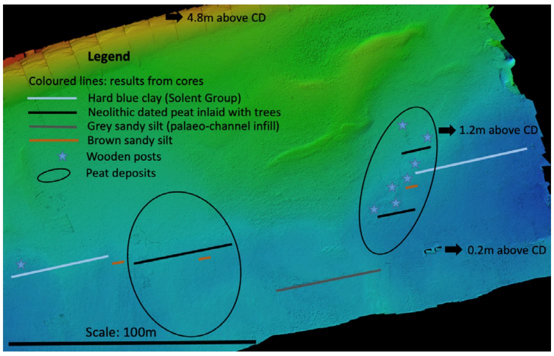
The beach has been surveyed, enabling the generation of a digital terrain model showing the archaeological and palaeo-environmental features (Figure 9). The areas of exposed trees, peat and ancient wooden posts reveal that it has eroded recently. Repeat surveys over the last couple of years are recording ongoing losses. The cause of the beach drawdown has yet to be confirmed but the area is located immediately in front of a relatively new seawall.

A Bronze Age basket-like construction, dated to 1502 – 1401cal BC (SUERC-96362), was recently found 300m to the west of the palaeo-channel and Neolithic posts. This structure was built when the sea level was a couple of metres lower. Today it is 0.25m above CD. At the time of construction it



07 3D photomosaic of the eroding 'woodland bench' in 2019. The view looks south to highlight the northern eroding edge of palaeo-landscape exposed against the deeper water. Some of the more resistant tree root systems, wooden features (WF) and geomorphological features are annotated (Maritime Archaeology Trust).

08 A worked post recovered from a site along the northern shores of the Solent. It is one of several posts that run along the edge of an infilled palaeo-channel (Maritime Archaeology Trust).



09 Digital Terrain Model of Thorns Beach. The light blue at the bottom of the screen is 0.1m above Chart Datum (1.9m below OD). The border between the blue and the green is 1m above CD. The green areas on the upper half of the beach are gravel banks. The interpretation of the sediments is derived from core samples along the linear transects indicated (Maritime Archaeology Trust).

would have been positioned around the mean tide level, being c.2.5m above CD, and covered by the sea for half the tidal cycle. It is not substantial enough to survive in open water so it would have been built in a sheltered intertidal creek where it was protected by the coastal mudflats and salt marsh (Figure 10).

Other archaeological structures that were built at a similar position relative to sea level can be found ten kilometres to the east. Here, there are a number of features including Bronze Age wooden posts, one of which dated to 1447 – 1301 cal BC (SUERC-82078). The posts are robust measuring 10 – 20cm in diameter and relatively densely packed in an area around 15m across. This indicates these are footings for a structure in the intertidal zone that could have elevated a platform or hut by a few metres so it would have been above high water. The structure is near a causeway, from which a post was excavated and dated to 1222 – 1047 cal BC (SUERC-82076). The archaeological evidence shows that the causeway was later rebuilt or repaired with new timbers that date to 42 cal BC – 60 cal AD (SUERC-77376) and then with more substantial timbers a century later in 23 – 140 cal AD (SUERC-82075) (Figure 11). The evidence shows repeated use at the same site during a period when sea level continued to rise. This is also an area that would have been sheltered from the open sea within mudflats if it were to survive rough seas. The mudflats would then have expanded to cover and protect the structures until more recent changes in water movement, and increased storminess stripped the cover from the beach and the features became re-exposed. The exposure of the relict landscapes and the archaeology therein, are not only useful to gauge past change, their appearance provides direct evidence of current shoreline erosion, and it provides a valuable human narrative of past adaptivity or abandonment as a result of sea level rise.

10

11

10 Bronze Age structure visible at very low tides. It is believed to be a basket. It dates to 1502 – 1401cal BC (Maritime Archaeology Trust).

11 Roman post, dated to 23 – 140 cal AD being excavated from a causeway through a channel between mudflats. The mudflats have now been lost to erosion (Maritime Archaeology Trust).

Across the Channel, an area under study is the coastline and hinterland of Flanders. The region has been heavily manipulated by human activities and it contains most of the SARCC pilot sites. When the sea level rise slowed, around 5,000 years ago, the balance changed from landscape inundation to progradation where new land was created by high levels of sediment deposition from the rivers and estuaries. Barrier bars grew to protect the land from the sea and river banks evolved into salt-marsh around the Rhine, Meuse and Scheldt estuarine complexes from the beginning of the 3rd millennium BC[16]. The process was replicated along the Belgium coast, where by the middle of the 2nd millennium BC, modelling by De Clercq shows how the land at the mouth of the Ostend valley extended a further 10km out to sea when compared with the contemporary coastline, while, coastal peat marsh stretched almost 20km inland[17].

Progradation of the coastal zone in the region continued until the end of the first millennia BC when sea level rise slowed. A stable equilibrium might then have been established if it were not for human influence. Peat extraction, primarily by the Romans, removed the surface deposits, drained the land, compacted the soil and lowered ground levels to reverse the earlier depositional processes. The peat was an important source of fuel and used in the process of marine salt manufacture[18]. Archaeological evidence shows how this was conducted on an industrial scale which included the breaching of natural barriers to help drainage and for the movement of water to the salt pans (Figure 12). Following the departure of the Romans, the salt industry faltered and land management practices declined. By 450 AD the sea had advanced into the depleted coastal peat lands and the estuaries opened into wide channels[19]. This reconfigured landscape was now less attractive for settlement. However, this was to change, as the natural build-up of fluvial sedimentation along the waterways and the expansion of salt marsh during the Medieval period reintroduced spaces for grazing and small scale dwellings. Insights into the occupation of the coastal marshes can be found in written sources and in the form of archaeological remains[20]. As early as 707 AD, contemporary records show that twelve marisci or grazing meadows in the saltmarshes by Aardenburg close to Sluis, were donated to the Abbey of St Peters near Ghent[21]. Archaeological evidence includes the remains of a house from the Middle Ages that was exposed in the intertidal zone seaward of the sea defences at Raversidje, Belgium[22]. The discovery of this dwelling provides a tangible source of evidence that the old landscape extended further offshore before the coast was later manip-ulated by human activity (Figure 13). The location was once a stretch of land called Testerep that was surrounded by a tidal creek. At the time, settlers adapted to the tidal inundations by living on dwelling mounds (Terpen), rather than building defences against the sea (Figure 14). By the eleventh century, large tracts of land were being taken over by monastic orders and during the next few centuries, there was a move from living in balance with the environment to one of modification. This included a programme of dike building to protect the pastures from floods. As the wetlands were steadily stabilised, drained and protected, more people were attracted to work the land. The growth in population led to more settlements and more reclamation that led to the narrowing

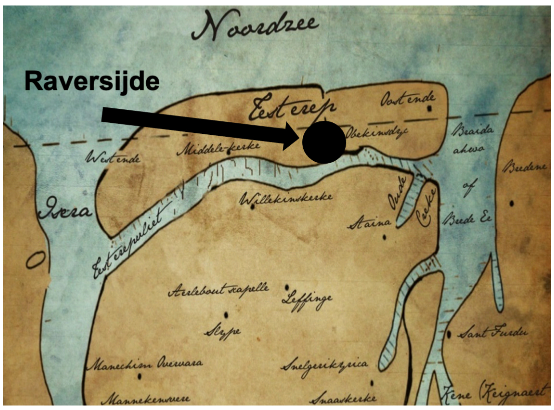
16 Vos and van Heeringen, 1997; Vos et al., 2011; Weerts, 2013
17 Ervynck et al., 1999; De Clercq et al., 2013; Baeteman, 2013.
18 Lascaris and De Kraker 2013
19 Ervynck et al., 1999
20 Mol, 2013; Tys, 2013
21 Tys, 2013
22 Missiaen, 2014a

12

12 Aerial photo of peat excavation remnants at the beach of Raversijde. Photo E. Cools, around 1970 (courtesy T Missiaen, D Evangelinos and I Jongepier).

13

13 Remains of a late medieval house discovered on the beach of Raversijde, picture taken in 1950's. Photo E. Chocqueel (courtesy T Missiaen, D Evangelinos and I Jongepier).



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14 Medieval map of 'Testerep' island which extended between Ostend and Westende, with the approximate location of the modern coastline denoted with a hatched line and the medieval Raversijde settlement indicated (courtesy T Missiaen, D Evangelinos and I Jongepier).

15 The ruins of the church of Verrebroek in the Scheldt polders following flooding in 1602. Image in public domain via Algemeen Rijksarchief Brussel, ARA in the following, Arenberg, LA n° 4413.

of estuarine waterways, which in turn raised the water level during high tides. Larger dikes were built for protection but, on many occasions, they proved inadequate to mitigate the impact of storm surges.

The collapse of sea defences was a relatively common occurrence in the 14th to the 16th centuries, causing extensive flooding in Flanders, the Netherlands and across the North Sea in the Thames Estuary. The Thames saw progressive reclamation of the salt marshes which included the building of dikes from the thirteenth century, many of which were subsequently breached. As with the Low Countries, a reason for the increase in tidal height and energy along the river was the narrowing of the river channel[23]. The reclamation of Canvey Island, Hoo, Coney Island and Foulness Island alone almost halved the available space for the sea to occupy at the mouth of the Thames during storm surges, increasing the effect of channelling; an issue that remains a challenge today. The areas reclaimed in the Thames were much smaller than their Flemish neighbours, but the consequences of overtopping of the dikes could be equally damaging.

In time, engineering solutions advanced and larger dikes were built. This gave people more confidence to move to the places with increased protection. However, in Flanders and the Netherlands, many of these areas were now several metres below sea level as a result of the earlier compaction, peat exploitation and drainage. Consequently, when the dikes did collapse, the impacts of floods were more devastating than the inundations that had occurred before they were built[24] (Figure 15).

Even where the natural forces were held back by stronger dikes, the inherent vulnerability was exploited by invading or occupying armies. This weakness was widely exploited during the 80 Years War of Dutch independence from Spain between 1568 and 1648 where defences were breached to flood strategic areas[25] (Figure 16). The damage took decades to repair, but with independence from Spanish rule a more strategic plan was put into place. Over the next three hundred years protection around the southern North Sea was largely successful, until the storm surge of 1953 that killed thousands and flooded almost ten percent of Dutch farmland. This tragic event precipitated the building of new coastal defences that have prevented further catastrophes. This is reassuring, but the continued building of traditional grey coastal defence infrastructures does not necessarily solve the challenge in the long term.

During the more recent decades of the Anthropocene, new approaches have been taken to protect the coast. Here, hydraulic engineers are becoming key enablers of change by incorporating NBS to create better environmental outcomes rather than just facilitating social and economic development[26]. The large-scale sand nourishment schemes that harness the natural forces of the tides and currents to stabilise the coastline[27]; the beach replenishment schemes that form part of the Belgian, 2011, Integrated Master Plan for Coastal Safety[28]; the creation of artificial reefs with encased oyster shells in deltas to facilitate sedimentation in the Netherlands and the revegetation of deltaic wetlands in the UK, provide positive examples[29].

The historical perspective explains the evolution of threats from flooding and why some areas are more susceptible to inundation. However, in the UK, while the recent publication of the National Flood and Coastal Erosion

23 Galloway, 2013
24 Vos et al., 2014
25 Missiaen, 2014b
26 Slinger and Vreugdenhil, 2020
27 Hermans et al., 2013
28 Vlaanderen 2011
29 de Vriend et al., 2014; Pontee et al., 2016

16

16 Historical representations of the calamities that befell Amsterdam following the breaching of the St Anthony Dikes in 1651. Image in public domain via Wikimedia Commons.

17

17 Reculver Church on the cliff edge. It was abandoned due to coastal erosion and has provided a well-illustrated reference point for coastal retreat. Aquatint engraving by William Daniell, 1824 (courtesy Prof. R McInnes).

Risk Management Strategy for England acknowledges that 'Coastal erosion is a natural and ongoing process that has been happening for thousands of years'[30], it does not advocate that we look to historical evidence to identify the causal relationship that links the past with the present. This would offer a useful narrative for stakeholders along low lying coastal regions, and river floodplains, in this time of increased storm and flood events, as well as providing scientific data points for coastal managers.

30 Environment Agency, 2020

THE VALUE OF VISUAL TOOLS TO CALIBRATE, MONITOR AND ILLUSTRATE PAST CHANGE

Archaeological artefacts and early historic or prehistoric landscapes are diagnostic features that can be used to help calibrate, current and past change. Unfortunately, these are invariably under threat once they are exposed so there is a need to retrieve data from sites before they are lost. A further challenge when presenting information from old land surfaces is awareness raising. Bits of old soggy wood or laminated clay and peat deposits seldom attract attention from the public or policy makers. However, imagery in the form of paintings, postcards, photographs, maps and charts can be very impactful. Accordingly, these are being used within the SARCC project to both measure change and to demonstrate long-term adaptations along the coastline that can enhance awareness and provide a baseline against which we can reference change.

Works of art being considered include oil paintings, watercolours, pencil drawings, engravings, aquatints or lithographs that can be studied to support understanding of a shifting coastline (Figure 17). These landscape paintings depict coastal environments, often encompassing a broad view of the shoreline including buildings, fixed structures, maritime activity and on occasion, foundered or wrecked vessels. This provides a range of images that can be used to help stakeholders visualise past events by comparing landscapes through time. Our project area has a legacy of painting that dates back to the 15th century.

Historical maps and charts are another valuable tool. They provide an important source of information to study coastal evolution from the late Middle Ages onwards, although the motivation behind the creation of maps and charts can affect their quality and objectivity. Therefore, it is important to investigate the history of each individual map and chart before using it for interpretation. This was a challenge particularly for the older maps that could be more qualitative than quantitative, but by the fifteenth and the sixteenth centuries major cartographical innovations and better instrumentation were introduced that improved accuracy.

In more recent times, during the nineteenth century onwards, modern photography processes advanced appreciably. The first publicly available cameras reached the market in 1888. The coastline proved to be a very popular subject at a time when tourists were taking holidays at the seaside. As a result, the postcard industry grew and photographic images along beaches became a popular theme. This happened in tandem with the growth in personal photographic collections as camera ownership became more viable. The new medium captured detailed and measurable views that are an important source of comparison with later and contemporary images. They provide data that can be used to both calculate and demonstrate change.

CONCLUSION

When fluvial drainage systems are curtailed, marine sediment pathways are interrupted and the shoreline is built upon, coastal stability can be compromised. Modern coastal infrastructure and hard sea defences contribute to these processes where they work against the natural forces that have evolved over millennia, rather than with them. This is demonstrated by the recent exposure of archaeological sites from the SARCC project area where ancient structures, that had been protected below sediments for hundreds or thousands of years, are providing direct evidence of new and evolving threats.

This paper has reviewed examples of coastal geomorphological evolution over the last eight thousand years in relation to human occupation. It has shown how archaeological information and visual representations provide insights into past natural and anthropogenic adaptations. Many of the historic changes made by humans such as the lowering of the land by peat or water extraction, the building of dikes and the creation of hard sea walls have interfered with natural processes resulting in increased impacts on the coastline and the coastal plain. A review of historical data sets can provide us with additional information to understand past, current and long-term patterns of change. This knowledge can provide a positive contribution when unlocking material that contributes to building an evidence-based narrative of coastal change. It will be particularly valuable where it can be used to calibrate and visualise changes. This can help stakeholders, coastal managers and decision makers consider solutions that would work in tandem with long term natural processes rather than in opposition.

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