CASE STUDY 3D – SOLENT AND ISLE OF WIGHT, UK

Case Study Area: Solent and Isle of Wight, UK

Main geomorphological types: Soft chalk and weak sandstone clifflines, coastal landslide systems, shingle and sandy beaches, tidal estuaries, dunes, saltmarsh and mudflats

Main coastal change processes: Cliff erosion, coastal landsliding, beach erosion, sea flooding.

Primary resources used: Art, Archaeology, historic photographs, maps and charts.

Summary: The Solent and Isle of Wight coastlines are very varied and include exposed as well as sheltered frontages. They offer an excellent range of sites suitable in terms of illustrating historical coastal change processes. The area also has an extensive and unique archaeological and palaeoenvironmental record demonstrating these processes over the last 10,000 years.

Recommendations: Coastal managers should use these resources when predicting future rates of erosion, they provide thousands of years' worth of data to assist in the understanding of the rate and scale of change. Further work is required in order to model these changes across the region, combining the rich archaeological record with art, photographs and maps.

Coastal managers face an ongoing battle to moderate impacts from the sea in the face of a changing climate and pressures from human use of the coastal zone. The challenges that lie ahead are forecast to increase while resources are being forced to go further.

The Solent and Isle of Wight is one of six UK case study areas for the Arch-Manche project. This case study report introduces the study area and why it was chosen as part of the project, the results of the archaeological and palaeoenvironmental study are then presented along with the results of the art, photos, and maps and charts studies. The analysis of these results and the potential for demonstrating the scale and rate of sea level change are then presented.

Within the Solent area the archaeological and palaeoenvironmental resource and the available art resource have been researched, scored and analysed. The extents of the detailed study areas are shown in Figure 3D1. The areas considered for archaeology and palaeoenvironment have been selected to provide a representative range of types of evidence across a range of periods spanning from the Palaeolithic through to more modern coastal heritage. The art, photograph and map and chart case study area encompasses a broader stretch of the coastline to reflect the various coastal morphologies and features which have been depicted over time.

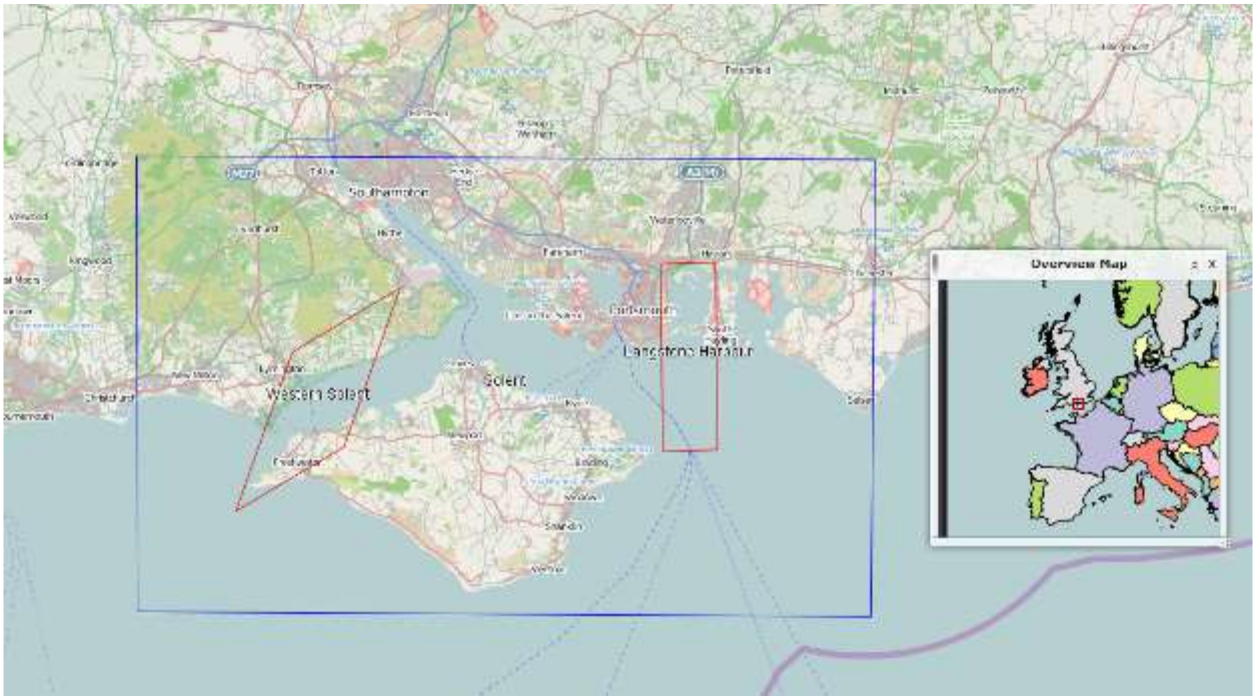


Figure 3D1: Map of the Solent and Isle of Wight Case Study Area. The art area is depicted in blue and the archaeology areas in red.

3D.1 Introduction to the Solent and Isle of Wight Study Area

The archaeological and palaeoenvironmental study areas cover the western Solent from the Needles to St Leonards, and Langstone Harbour. Both sites contain evidence of a changing landscape from the Palaeolithic to modern times.

The western Solent study area embraces the largest and best known of the two major spits in the Solent region, namely, Hurst Spit. The spit lies at the mouth of the western Solent where it projects some 2.1 km towards the Isle of Wight. The study area also encompasses the distinctive chalkland coastal topography at Alum Bay and the Needles.

This study area was chosen as a 'cross boundary' example where two administrative entities, on the opposite sides of a relatively narrow stretch of water, share a common interest in coastal behaviour. It is here that an array of archaeological and palaeoenvironmental features may help to define the nature, scale and pace of coastal processes that are still actively widening and deepening the seaway channel.

Langstone Harbour has been subject to detailed archaeological and palaeoenvironmental investigation, a large multi-disciplinary project was carried out over 5 years in the 1990's which sought an understanding of natural change and the course of human activity. The project revealed intermittent human activity commencing in the Mesolithic (Middle Stone Age) and adapting, at various times, to a rising sea-level. These changes were accompanied by a retreat of the shore from mudflats and saltmarsh. The area was selected in order to combine this data with recent studies to gain a more detailed picture of the changing landscape over time. As a result a 4D evolution model has been created and is presented below.

The three selected art study sites lie within the Hampshire Basin, at Portsmouth in Hampshire, and at Ventnor and Yarmouth on the Isle of Wight. The Hampshire coastline extends for a distance of approximately 30 miles (48km) along the central south coast of England and abuts the Solent; the Isle of Wight coastline extends to a total of 65 miles (110km). The study sites are Portsdown Hill overlooking Portsmouth Harbour in Hampshire, Ventnor on the south coast of the Isle of Wight and Yarmouth on its north-west coast. The particular geomorphological interest of the Solent and Isle of Wight study sites relate to understanding coastal evolution and coastal landsliding problems.

The study area coastline has a complex geological and geomorphological history with, as a result, a wide variety of landscape types. Although parts of the coastline are heavily developed, for example the great maritime ports of Southampton and Portsmouth, together with some of the seaside resorts and coastal towns bordering the eastern side of the Isle of Wight, much of the coastline is undeveloped and has been designated for its landscape, environmental and geological importance.

3D.1.1 Geology and Geomorphology

The coastlines of Hampshire and of the Isle of Wight lie within the Hampshire-Dieppe Basin; its geological structure arising from the Miocene Alpine mountain-building phase that took place approximately 30 million years ago. This resulted in a ‘syncline’ or downfold being created to form a Basin. The rocks on the Isle of Wight were uplifted, folded and compressed, and subsequently eroded and weathered. As a result of these structural movements, some of the strata now rest in a near vertical position, meaning that a wide variety of rock types, dating from the Cretaceous onwards, are exposed around its coastline. The steepest arm of the Isle of Wight monoclinal fold dips almost vertically to form the central downs, which cross the Island from west to east. The southern limb of the monoclinal fold dips gently from the central downs towards the south coast behind the town of Ventnor.

The ancient geological structural faults that first moulded the landscape were reactivated during the Tertiary to form the Hampshire Basin. These were overlain by the Lower Eocene London Clay which in turn were covered by groups of sands, gravels and clays laid through the Tertiary, in the Eocene and Oligocene. These formations have been moulded over the deep routed faulting bedrock and can be relatively easily reworked or eroded (Dix 2001, Bridgland 2001).

The eastern part of the Solent sits on a relict palaeo-channel that evolved during the Pleistocene. The Solent is the lower extent of a river system that drained the Hampshire Basin. The channels that emptied into the Solent were created over the last 2 million years and have been subject to repeated climate swings. A series of fluvial gravel deposits have been left behind, the youngest being close to the modern day coastline. As a result of the mountain-building phase, basement geological fractures and subsequent changes in sea level over the last 10,000 years, parts of the Hampshire and Isle of Wight coastlines are particularly susceptible to coastal instability problems promoted by erosion and high ground water levels.

3D.1.2 Summary of the Archaeology and History of the Study Area

Two areas were selected for archaeological and palaeoenvironmental investigation: the western Solent and Langstone Harbour. This section provides a summary of the archaeology and history of each area, the western Solent is presented first, followed by Langstone Harbour.

3D.1.2.1 Summary of the Archaeology and History of the Western Solent Study Area

The western Solent study area stretches from the Needles (on Isle of Wight) and Hurst Spit (in Hampshire) east to Hamstead (Isle of Wight) and the Beaulieu River (Hampshire). This study area was chosen as an example of where two coasts on the opposite sides of a relatively narrow strait share an array of archaeological and palaeoenvironmental features, which helps to define the nature, scale and pace of coastal processes that are still actively widening and deepening the stretch of water. The western Solent study area has been significantly affected by changing sea levels during and since the last glacial period. This has left a trail of gravel deposits along the shoulders of the Pleistocene river valleys of this region. The following text provides a historic context for the western Solent and identifies areas where future work could help understand the nature and scale of coastal change.

Early Prehistory (Palaeolithic and Mesolithic)
The earliest pertinent evidence of human activity comes from Pleistocene terrace gravels deposited at various altitudes along and below the upland boundaries of the western Solent lowland. Bridgland (2001, 16-19) cites four specific gravel terraces that may be dated by the presence of associated human artefacts. These deposits all rest on benches on the northern shoulder of the western Solent valley. These are the gravels of Setley Plain (*c*.42m OD); Old Milton (*c*. 35m OD); Taddiford Farm (*c*. 28m OD) and Stanswood Bay (*c*.22m OD).

Maps provided by Allen & Gibbard (1993) and Bridgland (2001) show the course of these elevated terrace gravels shadowing the northern coastline of the western Solent. Here they appear to conform to an ancient Pleistocene valley that long pre-dates the formation of the Solent seaway.

The highest and oldest of these gravels to yield datable human artefacts is the Setley Plain deposit. For this, Bridgland proffers a date of some 400,000 years BP (Oxygen isotope stage 11-10). This is based on implement typology and analogy. For implements in the Old Milton gravel, parity with oxygen isotope stage 8-7 is proposed. This would signify a date around 300,000BP. Implements within the Stanswood Bay gravel have yet to be assigned a conclusive date but a date within oxygen isotope stage 9/11 has been proposed (Bates, 2001).

The old terraces cutting through Dorset and Hampshire have proven to contain a rich source of Palaeolithic flint tools whereby reflecting the value of the waterways as routes for early waves of hominins. The youngest gravel lens is found across the north shores of the Solent, below the Pennington marshes between Lymington and Milford on Sea. It was laid down *c*.120,000 years ago towards the end of the Ipswichian (OIS 5e) and sits at a height that equates to current OD.

At lower levels within the western Solent valley, some palaeoenvironmental evidence is available from submerged contexts in the coastal zone. These resources include some deposits off the Isle of Wight coast at Newtown where elephant and bison remains have been recorded (Munt, 1987). Further palaeochannel deposits yielding interglacial fauna have been identified on the New Forest shore at Stone Point, Lepe (Brown *et al*, 1975).

It is the environmental changes of the early and mid Holocene that are of particular importance to the management and protection of the Solent coast. These events mark the genesis of the coastal processes that are still eroding and modifying the coastline today. The presence of Mesolithic habitation sites in the intertidal and sub-tidal zones offers a particularly valuable opportunity to establish the long term behavioural history of this shoreline. Current investigation into the submerged habitation site at Bouldnor has established a date of circa 8,000 BP for the existence of brackish conditions prior to the formation of the open sea-way. At this time habitation was still possible at a level of -11m OD.

Elsewhere on the floor of the western Solent, further evidence of Mesolithic activity can be detected. This evidence has been produced by fishermen recovering flint tools from the seabed, with recoveries from Pitts Deep and Pennington being particularly notable. These finds, and some associated deposits of peat, come from levels that are higher and arguably later than the dated occupation site identified at Bouldnor. This upward trail of submerged Mesolithic occupation sites now offers a valuable means of fixing and dating the retreat of the shoreline in the western Solent.

Later Prehistory (Neolithic, Bronze Age and Iron Age)
There is no doubt that the coastal landscape of the western Solent continued to submerge during the 3rd millennium BC. Explicit evidence comes from the mouth of Newtown harbour where a Neolithic wooden trackway was built across the coastal marshland, the feature has been dated by radiocarbon to 4160±70BP 2920-2500 *cal* BC (GU-5341). In the mouth of the Western Yar, another Neolithic trackway, laid in a similar environment, has been dated at 4220±60 BP 2920-2620 *cal* BC. Depths ranging from -2.9 to -1.6m OD place these structures well below current sea-level. If these structures were to extend further underwater their depth could provide further index points for change in sea level.

At Fawley, peat that had accumulated just above the tidal limit has been recorded at a level of -2.5mOD. This deposit has been dated approximately at 3600 BP. Other coastal Neolithic sites of potential value include the find-spots of flint artefacts at Newtown, Hamstead and Saltmead. At Colwell Bay, Bronze Age tools have been recovered from the intertidal zone but it is uncertain whether these were associated with a submerged landscape.

Towards the close of the 1st millennium BC, Iron Age activity developed within and around the hill fort at Buckland Rings near Lymington. This site overlooks the Lymington River at a point where an entrenched enclosure has been constructed on the river bank at Ampress. At present little is known of the date and function of the Ampress enclosure although it may be associated with Iron Age navigation of the river. Sediment archives occupying the margin between Iron Age occupation on the river bank and the accretion of river silts could offer particularly valuable information on past nature of this coastland and its contemporary sea level. At Exbury, on the east bank of the Beaulieu River, another defended enclosure offers similar potential.

Roman Period
At present, the nature of the Roman coastline of the western Solent is very poorly understood. Intertidal survey to pursue salt-working sites of this period would be particularly helpful in establishing the sea level of this period.

At Yarmouth Roads an anchorage of this period has been identified in a water depth of 9-16m (Tomalin 2006). A scatter of Roman pottery at this location suggests that very little change has taken place in the nature of this particular area of seabed during the past two millennia. Historic anchorages have also been identified at Lymington River and Hurst Roads.

Medieval Period (500AD – 1485AD)
Since the Middle Ages the Isle of Wight has been important from both a commercial and military standpoint. There has always been a strategic need to protect this offshore domain from the unwelcome interests of potential invaders. As a result, the coastline of the Solent has seen the construction of a succession of military defensive structures.

The medieval town and port of Newtown (Francheville) was critically damaged by French attack in the 14th century. It is thought that the town had developed an anchorage and waterfront within the confines of Newtown Harbour but after the French raid of 1377 it never recovered its prosperity. The sacked town diminished to a shrunken medieval settlement and it eventually ended its days a 'rotten borough', it status dismissed during the Parliamentary reforms of the 19th century.

The intertidal and sub-tidal archaeology at Newtown is of interest because it offers a very rare opportunity to examine an unbroken record of sediment accretion in a Solent creek. This is a location that has escaped all effects of navigational dredging. It has also escaped development interests since the 14th century. This location has the potential to offer a sediment archive covering several millennia.

Like Newtown, both Yarmouth and Lymington are medieval port towns. Both owe their development to the maritime aspirations of Anglo-Norman entrepreneurs. At both towns the nature of the medieval waterfront is not clearly understood although it is likely that the remains of the quays and jetties of this period now lie within areas that can be subject to reclamation, development or the construction of sea defences. Lymington also maintained a thriving medieval shipbuilding industry and this could bring a further array of helpful archaeological evidence to the low-water boundary of the contemporary shoreline.

Waterfront archaeology offers the potential of securing absolute dates for past shorelines. It can also reveal a wealth of information on the past coastal environment. Timbers of waterfront structures may offer tree-ring evidence of climate as well as dating. Navigational dredging is common at both Lymington and Yarmouth. Although destructive, these activities can offer opportunities to recover new evidence concerning the past environmental conditions that have accompanied the shoreline development of these historic towns.

Post-Medieval Period (1485AD – 1901AD)

During the post-medieval period the coast of the western Solent maintained its strategic importance. This is demonstrated by substantial fortifications at Hurst Castle, Yarmouth Castle, Fort Victoria and Fort Albert. The Tudor forts at Hurst and Calshot are sited on spits that are particularly vulnerable to changes brought on by coastal processes and sea level rise. By their very nature, these massive spits are subject to shifts in their configuration. These changes pose a threat to the cultural monuments on the spits and to a trail of leeward coastal habitats that depend on the spit's protection.

An important aspect of the 'built heritage' for the study of sea level change are the salterns. These were constructed at levels that related to the tidal cycle where rising seawater was allowed to enter through embanked enclosures. Salterns can offer further opportunities to examine the limits of past tidal regimes. In Hampshire the salt industry was particularly intense in the vicinity of Lymington and Pennington where many abandoned salterns still survive. Other historic structures of the coastland are chapels, houses and tidal mills. The latter may offer some evidence of past tidal levels.

A further potential source of environmental information may lie within each seabed 'footprint' provided by a contemporary shipwreck. The discovery of a 16th century Iberian merchant ship on the floor of Yarmouth Roads has revealed a preservative environment associated with the benign accretion of a protective blanket of sediment since its loss (believed to be) in 1567. This wreck was randomly discovered as a result of a specific archaeological survey. Its presence is now a reminder that a very substantial archaeological and palaeoenvironmental potential is still concealed within the vast area of the Solent floor that has escaped any kind of scientific examination.

Modern

Some of the most visible archaeological sites and remains from this period are defensive military structures such as pillboxes, gun emplacements and decoy sites. Current changes in the coastline have been observed at Hurst Spit where storm events have exposed and revealed ancient wooden structures associated with an earlier configuration of the spit (Figure 3D.2).

Figure 3D.2: Damage caused by the storms in January 2014

3D.1.2.2 Summary of the Archaeology and History of Langstone Harbour

Langstone Harbour today includes an area of around 1900 hectares, at low tide there are only 200 hectares of the harbour underwater, meaning that 1700 hectares of mud are exposed, demonstrating the shallow nature of the harbour.

Peats in the Broom Channel at a depth of between -10.5 and -12m below OD were discovered within cores related to a housing development (Mottershed 1976). But other than these the main evidence for the evolution and development of Langstone comes from work associated with the Langstone Harbour Archaeology project undertaken in the 1990s. During this project there were two dates gained from tree remains that were embedded within small peat deposits from Baker's Rithe and Russel's Lake areas. From the former a peat deposit from a depth of -1m OD provided a date of 2310 – 1950 Cal BC, and from the latter at a depth of -0.5m OD a date of 3350 – 2010 Cal BC. These Neolithic dates for peat deposits are evidence of the complex development of the harbour over time.

During auger work related to the excavation of the Langstone logboat in 2002 a substantial peat deposit was encountered at a depth of around – 2m OD off the north west coast of Long Island. This peat is currently undated, but its substantial thickness of up to 2m indicates this is likely to be a different peat to those identified during the Langstone Harbour Project (Allen & Gardiner 2000; Scaife 2003).

Langstone Harbour in Early Prehistory

During the interglacial periods of the Middle and Upper Pleistocene the climate was warm enough to accommodate early human settlers of the Lower and Middle Palaeolithic. Lithic evidence left by these peoples is not uncommon in Britain and the finds are predominately from reworked fluvial deposits displaced as landscapes were remoulded (Wenban-Smith & Hosfield 2001). The Solent region has been recorded as containing more Palaeolithic sites than anywhere else in the country (Wymer 1991). In Langstone Harbour flint tool finds from this period are recorded from Long Island and from the intertidal mud on the west side of Hayling Island.

The changes associated with the Holocene also correspond with the human re-colonisation of Britain around 13,000BP (11,000BC). During this period the marine landscape of the Solent was developing from one containing freshwater river systems running through incised valleys to increasing marine conditions caused by rising sea level. The area was also home to expanding Mesolithic populations.

Early Mesolithic sites are limited in numbers but increase as we move further into the Mesolithic. At Langstone Harbour there were fourteen areas of Mesolithic activity recorded in the intertidal zone but no evidence of any 'base camp' assemblages (Allen and Gardiner 2000,203-4). There are records of flint recoveries from each of the four islands in the harbour in addition to a cluster of finds from Farlington Marshes and others on the west coast of Hayling Island. These discoveries demonstrate a relatively limitied lithic 'tool kit', but they do provide an indication that former Mesolithic landsurfaces may be encountered within the harbour.

Later Prehistory (Neolithic, Bronze Age and Iron Age)

The slowing of the rise in sea level by the Neolithic saw water levels across the Solent region at around -6m OD. After this period the slower rises continued, with a further development of peat deposits in the Bronze Age which are around -4m OD. Associated archaeological and palaeoenvironmental deposits associated with buried prehistoric landsurfaces are found within the tidal river and estuaries of the Solent, including Langstone Harbour (Allen & Gardiner 2000; Long & Scaife 1996; West 1980).

Evidence from Langstone Harbour demonstrates that in the late Neolithic and Early Bronze Age the landscape had freshwater rivers existing within the former deeply incised channels. The area was now part of the coastal plain, and extensive peat blankets were formed in the valley flood plains.

With more permanent settlement the character of the archaeological record changes, in particular there is greater variety of finds, and importantly the presence of pottery and metal work remains. Evidence from the Neolithic period is dominated by flint tools and scatters related to their production, but by the Bronze Age levels of occupation are increasing and a wide range of evidence has been recovered from within the harbour.

During the mid to late Bronze Age Langstone Harbour had slow meandering streams running through low lying grassland with localised salt marsh. The maritime influence on the environment was growing. Artefacts from this period include metal work, a large flint collection and an extensive pottery assemblage. A number of the pottery vessels are believed to be related to cremation burials; pottery in the harbour is often found in association with small pits or hearths. Allen and Gardiner (2000) suggest that part of the harbour was used as an open flat cemetery with the cremation burials within it. However, further foreshore fieldwalking appears to be providing more evidence of hearths which could indicate more mixed use of the area.

The islands in the north of the Harbour are particularly rich in Bronze Age material, indicating this area of the harbour was dry land during this period. There is also material from Farlington Marshes and the west coast of Hayling Island. An interesting feature consisting of timber posts from the north coast of Hayling Island has been dated to the Bronze Age and may represent the remains of a trackway.

Environmental changes resulted in the harbour becoming wetter and more maritime by the Iron Age. The relatively small rises in sea level had greatly expanded the rivers, moving towards harbour conditions. Maritime trade and transport also developed significantly and by the Iron Age (800-700 BC) there was a comprehensive trade network between Britain and continental Europe. Pottery and coins from Europe have been discovered at a number of coastal settlements around the Solent (Trott and Tomalin 2003).

Most Iron Age evidence from the harbour is related to salt working, this includes briquetage and pottery. There are particular concentrations on the west coast of Hayling Island, North Binness Island and on the fringes of Farlington Marshes. There is a complete salt production site in Creek Field on Hayling Island which includes ‘boiling pits’ and flues. There is little other direct evidence of Iron Age activity within the harbour, however, on Hayling Island there is Tournebury Hill Fort in addition to an Iron Age Temple (King & Soffe 1994).

Roman Period

In the early Roman period it was neighbouring Chichester Harbour that was the most important of the three Solent harbours, with Fishbourne Roman Villa located at its head. However, there is evidence of a range of Roman occupation around Langstone Harbour demonstrated by villas, roads and saltworking.

Roman pottery finds from Langstone Harbour span all the main centuries of Roman occupation. The types of form and fabric are indicative of small scale rural farming communities, with only a small amount of imported pottery being discovered. While there has not been any evidence so far discovered for extensive settlement directly on Langstone Harbour, the material culture suggests that saltworking, brick or tile manufacture and oyster farming could all have been carried out. In particular saltworking appears to have been important with records from as early as AD410 which mention the superior quality of the salt from around the shores of Hayling Island (Allen & Gardiner, 2000: 217). Finds from around the harbour appear to demonstrate a continuity of salt making in locations that were used in the Iron Age.

Medieval Period

By the early fifth century the Roman Empire was in decline, trade between Britain and continental Europe had practically collapsed. From the mid-fifth century, groups of Germanic peoples began to arrive in southern and eastern England and contacts with the continent began to increase.

During this post Roman period it appears that the population returned to building methods which utilise timber, and hence do not generally leave such a visible archaeological record. However, there are a number of finds from Langstone Harbour which show continued use of the harbour throughout this period.

The Langstone logboat was excavated from the north west shore of Long Island in 2003 and has been radio carbon dated to AD500 (HWTMA 2003). The boat had been abandoned on salt marsh deposits; beneath the boat pieces of wood which had been split and some with tool marks were discovered, which demonstrates human activity in the marsh environment. Not far from the location of the boat several pieces of wattle work hurdle have been found with one of these dating to Cal AD 790-1030. Further organic remains dated to AD980 – 1180 were discovered protruding from the water at an extreme low tide, and subsequently investigated by divers. This was the Sinah Circle, which is believed to be related to oyster fishing activity.

The Domesday survey indicates Hayling Island was used extensively for agricultural activities in this period, while neighbouring Portsea island had few inhabitants. In Langstone Harbour Medieval activities were focused on fishing, oyster farming and saltworking. There are a large number of timber structures located on the west coast of Hayling Island which are thought to be related to fishing, although they have not been dated, they are assumed to be Post Medieval in date.

Post-Medieval Period

In terms of use of the inter tidal area in this period, Langstone does not witness large scale land reclamation between the 5th and 15th centuries which is often seen in other areas of the country (Galloway 2009; Fulford et al 1997:136). This may be due to the coastal saltmarshes being relatively narrow; it is not until the 17th Century that areas are reclaimed.

Saltworking continued to be a significant industry until the late 18th century when it went into decline. The industrialisation and urbanisation of Britain during the nineteenth century led to dependency on sea trade as never before. During this period the west side of Langstone Harbour was developed with housing and maritime facilities, although this was confined within Portsea Island. Within the harbour some saltworking was still undertaken. The need to develop a secure route for shipping from Portsmouth, via Chichester, to London saw the construction of a canal in 1822 which cut across the top of Hayling Island and entered Portsmouth via Milton Lock.

Modern

In Langstone Harbour large areas remain protected due to their environmental significance, this has ensured that development has not encroached on the harbour. The harbour is used for a range of recreational activities, but also maintains commercial shipping, particularly through aggregate wharves and associated vessels.

War related activity is reflected within the archaeological record which includes many pill boxes and decoy lighting sites, in addition to craters where bombs were dropped. Langstone was a centre for construction and diversion during the two World Wars. Mulberry harbours were built here; the remains of one remain to the north east of the harbour entrance. The islands in the harbour were used as air raid decoys to divert planes away from Portsmouth.

3D.1.3 Archaeological, Palaeoenvironmental and Coastal Heritage Resources Consulted for the Project

A general overview of the Solent's history and archaeology is provided by The Book of the Solent – Solent Science (Drummond & McInnes 2001). This is supported by other general histories of the New Forest provided by the Forestry Commission and the New Forest National Park Authority that provide context for the north coast of the western Solent study area.

The Isle of Wight was one of the first areas in England to undertake detailed study of intertidal and coastal archaeology and in 1998 carried out a coastal audit. This resulted in the county Historic Environment Record (HER) containing large numbers of coastal sites and the potential and diversity of the coastal heritage resource being relatively well understood. The success of the IoW coastal audit led to an English Heritage supported program of Rapid Coastal Zone Assessments (RCZAs) in other areas of the country.

The western Solent has benefitted from a Rapid Coastal Zone Assessment (Wessex Archaeology 2010a and 2010b). The RCZA reviewed a wealth of existing literature and databases, before conducting fieldwork to identify more sites and better understand others. A wide range of smaller desk based assessments and archaeological reports also exist for the New Forest coastal area, providing valuable context for human activity and settlement in the area.

The main resources consulted during the Arch-Manche project for the western Solent area have been from the work carried out by the Maritime Archaeology Trust (MAT), particularly at the site of Bouldnor Cliff (Momber et al 2011). Work carried out by the MAT in Langstone Harbour has also been consulted alongside the 1990's Langstone Harbour Project (Allen & Gardiner, 2000).

On the northern shore of the Western Solent a substantial area of inter-tidal mudflat and salt marsh has accrued along a front approximately 10km long. Recent studies by have shown that these areas which were once sediment sinks are diminishing rapidly. Areas of mudflats are being lost by up to 5m per year (Ke and Collins 2002:422) and the Channel Coastal Observatory recorded an 83% loss since 1946 (Cope *et a*l 2008).

Other resources consulted for the area are the Hampshire Field Club papers and occasional papers accessible at the University of Southampton and National Oceanography Centre libraries (Anderson, 1933; Draper 1968; Hack 1999; Bates 2001; Nichols & Clarke 1986) and PhD thesis' (Dyer 1969; Scaife 1980; Dean 1995). Archaeological data sources include English Heritage National Record of the Historic Environment (NRHE), county based HERs and various journals (Momber 2000; Long & Tooley 1995). The Solent - Thames Regional Research Framework contributory section for the Solent has an Upper Palaeolithic and Mesolithic resource assessment for the Isle of Wight (Loader 2007). Internet sources consulted including (West 2008; Cope et al 2008)

During the summer of 1997 the submerged forest that lay underwater in the Solent was subject to attention as part of the European Community L'Instrument Financier pour l'Environment (LIFE project entitled Coastal Change, Climate and Instability (Dix 2000; Scaife 2000a; Tomalin 2000a). This work was a particular relevant source of information as one of the main objectives of the project was to assess the value of archaeological and palaeoenvironmental evidence as a means of measuring the scale and pace of coastal change.

Historic sources include the numerous academics who have traced the evolution of the 'Solent River' back into the Pleistocene, during which river systems abraded a path through the southern part of the Hampshire Basin (Fox 1862; Everard 1954; Alley *et al* 1993). The primary source of information being the east-west-tending fluvial deposits laid down in close association with one another as the river migrated during successive glacial cycles. In more recent times seismic and coring investigations in Southampton Water and the Eastern Solent have helped to define a channel identified as the Solent River (Hodson and West 1972; Dyer 1975). The area is rich in gravel deposits and in peat formed during the preceding Flandrian Transgression, many of these deposits correspond with progressive inundation reflecting the Solent River's clearly defined geomorphological development as sea levels rose (Long and Tooley 1995).

Work by Velegrakis and the School of Ocean and Earth Sciences at the University of Southampton, identified a series of south-flowing palaeovalleys which had breached the old submerged chalk monocline prior to the Flandrian Transgression (Velegrakis *et al* 1999; Velegrakis 2000). This evidence refuted the notion of a Solent River passing from west to east to the north of the Isle of Wight during or following the last glacial epoch. The research showed that rather than there being a single river flowing east, there would have been a number of south-trending channels draining the lands to the north, forming separate waterways east and west of the island.

High-resolution multi-beam survey was conducted in the western Solent in conjunction with Submetrix/SEA Ltd in June 2001. The system was used was the Interferometric Seabed

Inspection Sonar (ISIS) 100 (Momber and Geen 2000). The georeferenced survey gave a highly accurate position and recorded a large expanse of elevated seabed which corresponded to the location of the peat deposits. Dive surveys were then able to integrate with the bathymetric model of the seabed and comparisons made. In the north east Solent, to the seaward end of Keyhaven Marshes around Hawker's Lake by Hurst Spit, not-withstanding the ongoing erosion witnessed on the seabed, comparison suggested that the submerged shelf upon which the peat sat mirrored the areas that had once supported mudflats only 200 years earlier.

3D.1.4 Art History of the Study Area

This section presents the background to artistic representations within the area including key schools and individual artists. This provides the background to the broader consideration of individual artworks within the study area.

The coastlines of Hampshire and Isle of Wight started to receive attention from artists and writers in the late eighteenth century who were visiting the region in search of picturesque scenery (Wyndham, 1793; Rowlandson, 1793; Tomkins, 1796; Pennant, 1801; Gilpin, 1804). The French Revolution and the Napoleonic Wars prevented travel in Europe and resulted in antiquarians and artists paying greater attention to the landscapes of the more remote parts British Isles such as this region.

One early writer and artist, William Bernard Cooke, having crossed to the Isle of Wight, described the Island in the following way: "the two sides of the Island present each a peculiar character, as distinct, and as strongly opposed as their aspects. The northern side is marked by all that is lovely, rich and picturesque; the southern side, commonly called 'the back of the Wight', abounds in bold wild rocks, precipitous projections, ravines, fearful chasms and other features of the opposing and even of the sublime. In parts it is true these opposite characters are greatly mingled – a circumstance that only adds to the effect produced upon the observer, and together with the constant alteration of marine and inland views contribute still more powerfully to distinguish the Isle of Wight as the 'Garden of England" (Cooke, 1808).

Gentry and other patrons of the arts living along the Hampshire and Isle of Wight shorelines became influenced by the 'Picturesque' style as exemplified by the works of such artists as Claude Lorrain, Nicholas Poussin and Salvator Rosa whose works they saw on the Grand Tour. They now increasingly purchased copies of finely illustrated topographical accounts of travels of their own region by such eminent authors and illustrators as Tomkins (1796), Pennant (1801), Gilpin (1804), Englefield (1816), Raye (1825), Rowe (1826), Brannon (from 1821) and Woodward (undated).

Mid-to-late eighteenth century landscape art in Hampshire and on the Isle of Wight is dominated by three important watercolour artists who were all painting here at about the same time, John Nixon, Thomas Rowlandson and, slightly later, Charles Tomkins. John Nixon was an amateur landscape painter and caricaturist who toured Britain, Ireland and the continent widely in the 1780s and 1790s often working with other important artists. He provided drawings for Thomas Pennant's 'Journey from London to the Isle of Wight' (Pennant, 1801) as well as for the European Magazine.

The leading artist of the Georgian period, Thomas Rowlandson visited Hampshire and the Isle of Wight in about 1784 with a colleague artist, Henry Wigstead, but returned in 1791 to undertake a more comprehensive tour producing numerous fine watercolour drawings.

'A Tour of the Isle of Wight' was published by Charles Tomkins in 1796 (Tomkins, 1796), the text being accompanied by eighty delicate sepia aquatints of coastal and inland views. The tour includes an extensive description of the journey from London to the Isle of Wight as well as interesting views along the central Hampshire coastline. Tomkins' aquatints compared favourably to the rather coarse copperplate engravings in Sir Richard Worsley's 'History of the Isle of Wight' (Worsley, 1781). A patron of the arts on the Isle of Wight, Earl Yarborough, commissioned Charles Tomkins to paint a further series of fifty-eight watercolour drawings of Isle of Wight scenery in 1809. Nearly all the watercolours from Tomkins' 1809 tour are illustrated elsewhere (McInnes, 1993). Together with the work of Rowlandson and Nixon the illustrations by Tomkins provide a unique insight into life in coastal Hampshire and on the Isle of Wight during the late eighteenth and early nineteenth centuries before the impact of the Victorian development.

The nineteenth century was a remarkable period for Hampshire and Isle of Wight art, with some nine hundred works being exhibited at the Royal Academy and other principal London exhibitions. A vast number of paintings and watercolours were produced in Queen Victoria's reign alone and for every fine painting that was exhibited there were perhaps one hundred that were not. Art and drawing was part of the upbringing at that time and thus there were hundreds of good paintings by Hampshire and Isle of Wight artists, as well as visiting artists, unlisted and unknown to exhibition catalogues.

During the early nineteenth century several fine sets of aquatints and engravings of works by such artists as John Dennis, Frederick Jukes, Richard Bankes Harraden, Barth and King, and Richard Livesay were published. As Hampshire and the Isle of Wight became more accessible, with improved rail communications, further fine books were published, illustrated with beautiful colour and black and white plates of both coastal and inland scenes including Charles Raye's 'Picturesque Tour of the Isle of Wight' (1825), Frederick Calvert's 'The Isle of Wight illustrated' (Calvert, 1846), William Westall's 'Views of Carisbrooke Castle and Environs' (Westall, 1839) and the three volume publication on 'Hampshire' by Mudie (Mudie, 1840).

Some of the finest views of Hampshire and the Isle of Wight coast were the ten aquatint engravings produced by William Daniell towards the end of his 'Voyage Round Great Britain' in 1825 (Daniell & Ayton,1814). By the time Daniell had toured the British Isles and reached the Solent he had perfected his style and his delicate views are some of the most important taken in that period. Whilst most of his views are of the Isle of Wight, his 'View from Portsdown Hill' and 'Distant view of the Needles and Hurst Castle' are particularly fine.

Many of England's most celebrated artists visited and painted the Hampshire shoreline including Thomas Rowlandson, Thomas Hearne, John Linnell, David Cox Snr and J. M. W. Turner. John Bullar completed his 'A companion in a tour of Southampton' with numerous views of the environs in 1819 (Bullar, 1819) later followed by 'Views of the Principal Seats and Marine and Landscape Scenery in the Vicinity of Lymington' by R. A. Grove in 1832 (Grove, 1832) and 'A Handbook for Lymington and the New Forest' by Richard King (King, 1845).

Between 1800 and 1820 wealthy families constructed marine villas in secluded locations around the Solent and South Wight shorelines or they improved earlier residences. Designs published by fashionable London architect Robert Lugar in his 'Villa Architecture' (Lugar, 1828) included a view of Puckaster Cottage, Niton, one of a number of cottages ornés constructed in this area. This style was encouraged by the prominent Regency architect, John Nash, who resided at East Cowes Castle. The owner of Puckaster Cottage was Mr James Vine, who commissioned a series of watercolour drawings from Joshua Cristall, first President of the Old Watercolour

Society. He was also host to J. M. W. Turner, Sir Edwin Landseer and many other artists. Two important visitors to the Island encouraged the development of its art. The first was Turner, who stayed on the Island on at least two occasions in 1795 and 1827. His first visit is recorded in the sketchbook number TBXX14 and contains numerous views of the Undercliff, Blackgang and Bonchurch.

The Isle of Wight artist, engraver and author, George Brannon, and his sons, Alfred and Philip, who worked on the Isle of Wight during the early and mid-nineteenth century, and are recognised as having made a significant contribution to Isle of Wight art and culture. The publication 'Vectis Scenery' (Brannon, 1821-1876), which was commenced by George Brannon in 1821, has provided us with an impression of the Island landscape through the eyes of a local resident over a period that spanned extraordinary changes in terms of the Island's landscape, coastal scenery and economy, particularly during the first half of the reign of Queen Victoria.

Brannon's 'Vectis Scenery' included, over its lifetime (Brannon, 1821-1876), a vast range of illustrations of Island towns, inland and coastal scenery as well as country houses and churches. In 1821 Brannon published the first complete volume of 'Vectis Scenery' and continued for almost forty years until his death in 1860. Alfred, his second son, took over the business at the age of forty-two, but within a few years sales of the book reduced dramatically, possibly due to the increased popularity of photography. Undoubtedly the most talented and versatile member of the Brannon family was Philip, one year younger than Alfred. He was a fine artist, engraver, teacher, a successful architect, civil engineer and inventon. 'Vectis Scenery' was just one of the publications by the Brannon family. Others included 'A Picture of the Isle of Wight' (Brannon, 1850a), 'Graphic Delineations of the Isle of Wight' (Brannon, 1841), 'Voyage round the Isle of Wight' (Brannon, c.1860) and the 'The Pleasure Visitor's Companion' (Brannon, 1850b). Philip Brannon also produced guides to Southampton, the New Forest and Bournemouth.

Both the Hampshire and Isle of Wight coastlines have a rich resource in terms of landscape paintings, watercolour drawings and engravings. On the Hampshire coast prolific artists included George Arnold ARA (fl. 1807-28), William Bellers (fl. 1762-73), George Chambers (fl. 1852-62) together with such well known names as J. C. Barrow, John and Robert Cleveley, Alfred Clint, James Francis Danby, A. V. Copley Fielding, Edwin Hayes, John Linnell, Dominic Serres, William Shayer and Alfred Vickers. In addition, a fine selection of albums of drawings, such as those of Philadelphia Mitford, exist in private collections or within the historic yacht clubs and local museums. Those artists with a coastal or Naval upbringing or training can be distinguished for the quality and accuracy of their works. These include, for example, E. W. Cooke and J. W. Carmichael. The Navy regarded drawing as an essential skill for officers; Richard Livesay was one of a number of drawing masters at the Royal Naval College, Portsmouth, having succeeded the eminent artist John Christian Schetky.

While Bonchurch developed in the east Wight, a similar writers and artist's circle was developing in the west Wight centred on Farringford, the Tennyson's home. Their neighbours included Julia Margaret Cameron, George Frederick Watts and Valentine Cameron Princep. Princep was the son of a distinguished Indian civil servant who lived at Holland Park in London, a noted gathering place for leading Victorian artists and writers. Princep was closely associated with G. F. Watts, Dante Gabriel Rossetti, Burne-Jones and others of the period.

The artist Helen Allingham, was introduced to Lord Tennyson through her husband William, a poet. Helen was also made aware of the beauties of the Island by an acquaintance, Thomas Carlyle, who had rented a villa at Ventnor for several seasons. Helen's interest in cottage architecture was fulfilled on the Isle of Wight where she painted over a hundred and ten watercolours on successive visits, mainly on the Farringford estate or in the vicinity of Freshwater. On several visits to Farringford she met the important Victorian watercolourist Myles Birket Foster and they painted together for a number of years. In February 1862 Birket Foster and his family moved to Bonchurch, renting Winterborne (now an hotel) for a period of recuperation from tuberculosis. Whilst living there, he produced at least ten fine watercolours of the cliffs and beach at Bonchurch or in The Landslip, and a number of these have been illustrated elsewhere (McInnes, 1989, 1999, 2004).

The natural landscape and in particular the sea cliffs of the south-east corner of the Isle of Wight were captured in detail by followers of the Pre-Raphaelite School, John Brett, John William Inchbold and Frederick Williamson. Brett took a house in Upper Bonchurch and produced views of the Undercliff scenery demonstrating the remarkable coastal geomorphology of the area in painstaking detail. He was, without doubt, the foremost landscape painter of the outer Pre-Raphaelite circle and he worked exclusively in watercolour until he was fifty but from then onwards turned solely to oils. The son of an army officer, he studied at the Royal Academy Schools before travelling abroad to Switzerland where he was deeply affected by the sight of the Alps. Here he met John W. Inchbold who was also a Pre-Raphaelite follower and who later worked on the Isle of Wight, painting a fine view of the Niton Undercliff in a style similar to that of Millals.

A further four artists who painted almost continuously in Hampshire and the Isle of Wight deserve special mention. Alfred Vickers was a Londoner, who exhibited views regularly between 1832 and 1869. His sketchy style of working in oil has been likened to that of the French artist, Eugene Boudin, and his exhibited Hampshire and Isle of Wight works numbered thirty-three in total. William Shayer also loved the scenery of the New Forest as well as crossing regularly from his native Southampton to paint coastal views or scenes of smuggling or gypsy folk. Julius Godet made an annual pilgrimage from London to the south coast from 1853 until 1879 with his work being accepted at the Royal Academy or Suffolk Street exhibitions in every one of those years. Finally, Miss Harriet Gouldsmith's works are worthy of note. Between 1826 and 1831 she was a prolific exhibitor of small oils of the coastal scenery and fisherfolk at Ventnor Bay and Luccombe, producing thirteen works for the Royal Academy and elsewhere over that period.

Marine painters including Charles John De Lacy, Thomas Sewell Robins, Edward Duncan, John Wilson Carmichael and George Chambers produced scenes of shipping and craft in the Solent waters. Charles and George Gregory, father and son, were also prolific local artists, although they did not exhibit regularly. Arthur Wellington Fowles painted yachting and regatta scenes off Cowes and Spithead in particular often depicted against the background of the Isle of Wight coastline. In 1850 he gave up his employment to concentrate on working as a marine painter, which he continued for the rest of his life. He painted a number of important scenes capturing races and regattas including important craft such as Cambria sailing off Ryde.

An increasing demand for visitor's guides to the Isle of Wight necessitated a change from the relatively expensive books by the Brannon family, Roscoe, Barber and others. These were replaced by cheaper guides, often illustrated with chromo-lithographs or woodcuts. Later, artists were commissioned to paint watercolours of local scenes for reproduction in the first colourplate guides and for picture postcards. This resulted in a wealth of attractive watercolours being produced at the end of the last century by Henry Wimbush, Alfred Robert Quinton, William Wells Quatremain, Alfred Heaton Cooper and Newport art teacher Fanny Mary Minns. The publishers A. & C. Black's pencil sketches series followed later with a delightful Island volume by Dorothy Woollard (Woollard, c.1915).

3.1.5 Art Resources Consulted for the Project

In order to investigate the art resources available to assist an understanding of long term coastal change a review has been made of works of art held by the principal national, local and private collections for the study area comprising the coastlines of Hampshire and the Isle of Wight. These collections are detailed in Section 2.1 .

As part of the research it was necessary to contact museum and gallery curators and search available publications, as well as undertaking research on the Internet, taking advantage of new resources including the Public Catalogue's Foundation volume (Ellis, 2004) and the BBC *Your Paintings* website.

In addition to searches of on-line databases and images held by national and local collections an assessment has been made of art from the study area contained in important publications and, in particular, catalogues of exhibitions at principal London galleries and also in the study area itself. The literature sources relating to works exhibited are comprehensive and comprise reviews of the artists and their works (e.g. Graves, 1901), together with catalogues and dictionaries published by the museums themselves and interested publishers (e.g. the Antique Collectors' Club). The published works of this kind do, therefore, represent a considerable resource of assistance to this study (Wood, 1978; Russell, 1969; Archibald, 1980; Lambourne *et al*., 1980; Mallalieu, 1984; MacKenzie, 1987).

More specifically in relation to local collections covering the Hampshire and Isle of Wight coastlines, the work of Dr Raymond Turley, formerly of Southampton University Library, is particularly relevant (Turley, 1975; Turley, 1977). With respect to the Isle of Wight coastline, an attempt was made to list both those artists that had exhibited works at the principal London exhibitions together with other artists who had exhibited locally or were active in the period 1770-1920 (McInnes, 1993); this list was updated substantially as part of The Crown Estate – Caird Fellowship 2008 (McInnes, 2008a).

A sample of historic photographs, maps and charts were assessed. These were obtained through online searches and several maps were provided by Professor Robin McInnes. The primary resources consulted for historic photographs were the Carisbrooke Castle Museum online library and the online collection from the Britain from Above project.

3D.2 Current Environmental Impacts, Threats and Coastal Management Approach

This section considers the current environmental impacts and threats along the Solent and Isle of Wight coastline and reviews the current coastal management issues and approaches.

3D.2.1 Review of Key Contributors to Coastal Change

The coastline of Hampshire and the Isle of Wight, facing the English Channel, are impacted upon by Atlantic storm waves from the south-west, as well as waves generated within the Channel itself and, indeed, within the Solent. This coastline has, historically, experienced rapid rates of coastal erosion resulting in instability problems, breaching and sea flooding. The coastline supports a high population density, with major cities, towns and smaller settlements, as well as important infrastructure located in vulnerable locations.

Climate change induced coastal change including sea level rise, will be likely to promote worsening conditions, particularly more rapid rates of coastal erosion and the reactivation of coastal landsliding, as well as increased flooding by the sea over the next decades. The low-lying coastlines of Hampshire are particularly vulnerable for flooding, for example the city of

Portsmouth, which is densely populated, as well as the towns of Cowes and Yarmouth on the north coast of the Isle of Wight.

Elsewhere, rising sea levels are inundating important salt marsh and mudflat habitats, which also form a natural type of coast protection for the creeks and estuaries bordering the Solent. Due to 'coastal squeeze' almost complete loss of saltmarsh is predicted on the Hampshire shore of the western Solent. Other natural and semi-natural habitats are associated with the gravel spits and the transitional margins of the higher (inner) saltmarsh and reed swamp areas. Some of these are essentially artificial, such as the saline lagoons within Pennington Marshes. These are the surviving relics of the Solent's historic salt-producing industry. Current rates of diminution are accelerating. This trend towards net loss almost certainly correlates with the commencement of erosion and the 'dieback' of *Spartina anglica*.

On the open coastline along the south of the Isle of Wight rapid rates of coastal erosion are being experienced, and these are expected to continue and increase, whilst, along the south coast of the Isle of Wight, the Undercliff, which is north-western Europe's largest coastal landslide complex, can be expected to face increasing challenges as a result of both coastal erosion and increased ground water levels as a result of changing weather patterns.

The archaeological study area of Langstone Harbour has a long history of submergence and coastal erosion, in particular to the mudflats caused by the die back of *Spartina* Grass. Relative sea-level rise will have a huge impact on the harbour given the high rate of downwarping in this region.

Similarly the western Solent archaeological study area is impacted by erosion. At Bouldnor cliff erosion is seen on land as high as 50m giving way to a slumping and retreating cliff-line where new and soft landslides are removed by the sea. On the other side of the Solent the saltmarsh around Lymington is being rapidly eroded and Hurst Spit, a cuspate shingle foreland protecting the entrance to the western Solent has witnessed notable changes due to an increased rate of transgression.

Cause and effect relationshops in this area are complex, this involves the consideration of sediment loading, sea level rise, the wave climate and hydraulic regime, as well as the impact of anthropogenic development and remodelling of the foreshore.

3D.2.2 Summary of Current Coastal Management Approach

To address the issues outlined above, shoreline management plans have been prepared for the whole of the study area coastlines, and an effective coastal monitoring programme has been in place for over ten years. Good communication between adjacent coast protection authorities, local authority planning departments, and other stakeholders is achieved through the Standing Conference on Problems Associated with the Coastline (SCOPAC), a coastal network, the Solent Forum and the Southern Coastal Group.

As noted above Hurst Spit is being affected by an increased rate of transgression, the site is important for coastal defence as it protects the western Solent and shelters the salt marsh to the north. After declining in volume the area is now being managed and maintained through regular shingle recycling. It is thought that coastal protection works from the 1940's in Christchurch Bay interrupted the movement of shingle which maintains the site's stability. This led to many breaches and as well as shingle replenishment and monitoring a rock breakwater and revetment were built in the late 1990's. Despite this, erosion is still impacting the site and the saltmarsh to the north are also eroding, the seaward edge is believed to be eroding by up to 2m/year (SMP).

3D.3 Archaeological and Palaeoenvironmental Scoring

This section outlines the results of the archaeological and palaeoenvironmental scoring from the study area, followed by a discussion of the results. The scoring methodology applied is detailed in Section 2.2.

3D.3.1 Results of the Archaeological and Palaeoenvironmental Scoring

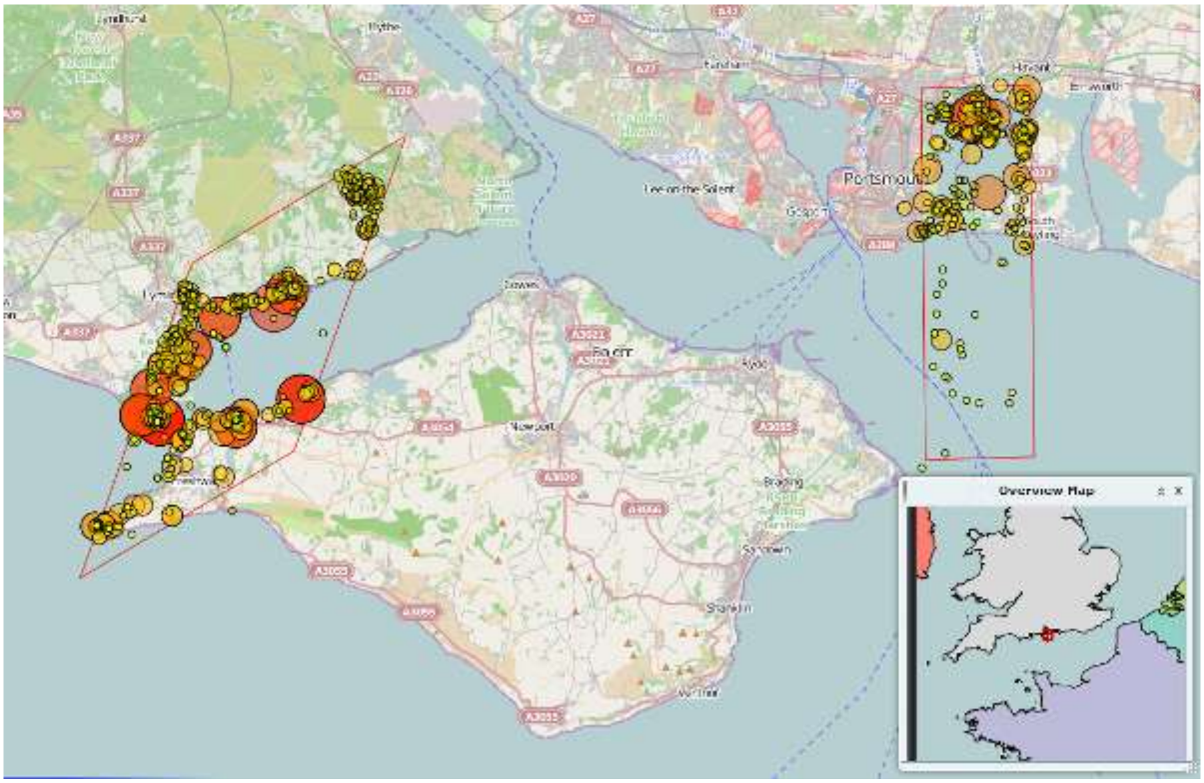


Figure 3D.3: Map showing the distribution of archaeological and palaeoenvironmental sites within the Study Areas

Within the study area data was obtained from the local Historic Environment Records (HERs), the National Record of the Historic Environment (NRHE), the United Kingdom Hydrographic Office (UKHO) and the English Heritage Peat Database. Where data from the HER indicated sites of particular interest, further research was in order to understand the full nature and extent of the site. Each data set went through a process of cleaning, in order to prevent the duplication of sites. A total of 817 sites and records were assessed.

The highest scoring sites are listed in the table below, the total score has been normalised to give each site a score out of 100.

APE uid	Site Name	Site Type	Period	Score – Sea Level	Score – Environ mental	Score – Temporal Continuity	Total Score	Coastal Context
600	PITTS DEEP - Submerged Peat Deposits	Submerged Landsurface	Prehistoric	High	High	High	100	Marine
707	BOULDNOR CLIFF	Submerged Landsurface	Mesolithic	High	High	High	100	Marine
604	HURST SPIT - Hurst Castle	Coastal Defence	Medieval	High	High	High	100	Above HW

324	RUSSELLS LAKE - Prehistoric Forest	Submerged Landsurface	Prehistoric	High	High	High	100	Marine
339	BAKERS RITHE - Prehistoric Forest	Submerged Landsurface	Prehistoric	High	High	High	100	Marine
712	HAWKERS LAKE - Submerged Peat	Submerged Landsurface	Unknown	High	High	Medium	88	Marine
714	OXEY MARSH - Submerged Forest	Submerged Landsurface	Unknown	High	High	Medium	88	Marine
716	PENNINGTON MARSHES - Peat	Submerged Landsurface	Unknown	High	High	Medium	88	Marine
717	PYLEWELL LAKE - Peat	Submerged Landsurface	Unknown	High	High	Medium	88	Marine
718	RIVER YAR - Peat	Submerged Landsurface	Unknown	High	High	Medium	88	Estuary
719	TANNERS HARD - Submerged Forest	Submerged Landsurface	Unknown	High	High	Medium	88	Marine
705	HURST CASTLE SPIT - Core Samples	Other	Prehistoric	Medium	High	High	88	Sandy foreshore
265	WRECK - Long Island Logboat	Wreck	Early Medieval	Medium	High	Medium	77	Inter-tidal
271	LANGSTONE HARBOUR - Sinah Circle	Marine installation	Early Medieval	High	Medium	Medium	77	Marine

Table 3D.1: Highest ranking archaeological and palaeoenvironmental sites within the Solent study area.

Figure 3D.4: Map showing distribution of highest ranking archaeological and palaeoenvironmental sites within the Solent study area.

Scores for sea level change

	High	Medium	Low
Number of sites	13	179	625

Scores for environmental change

	High	Medium	Low
Number of sites	13	20	784

Scores for temporal continuity

	High	Medium	Low
Number of sites	6	197	614

Table 3D.2: Detail of the ranking across archaeological and palaeoenvironmental categories for the Solent case study

3D.3.2 Discussion of the Scoring Results

The western Solent area includes a wide range of archaeological and palaeoenvironmental site types. Of particular interest are the number of prehistoric finds, sites and peat deposits.

A relatively large number of sites have been recognised for their 'medium' potential for providing information on past sea level. Submerged landsurfaces feature heavily in the higher scores. These include multiple finds from the Bouldnor area where stratified Mesolithic material has been found underwater at a height relevant to a contemporary sea level. Stratified organic material can be used to date sea-level at particular periods. This is illustrated by the dated peat deposits in a submerged landscape at Bouldnor as well as evidence of dated submerged forests off the islands of Langstone Harbour.

Some features of later date also score highly. This includes the medieval castle at Hurst Spit. The interpretation of these sites in relation to sea level can provide information on the use and the development of the marine zone and on human responses to changes in sea level or specific natural events. The Hurst Spit site also has the potential to inform on environmental changes as it contains datable palaeoenvironmental evidence.

A large number of submerged landsurfaces and peat deposits scored highly, in particular for the evidence they provide on environmental change, this reflects the often long and helpful timescale offered by these sediment archives. The high scores awarded to submerged landscapes and palaeoenvironmental deposits reflect their particular value in helping to inform on past sea levels and coastal change.

3D.4 Archaeological Fieldwork

The main archaeological and palaeoenvironmental fieldwork was carried out in the western Solent and in Langstone Harbour. Smaller surveys were also carried out on the Hamble River, Burrow Island (Portsmouth Harbour) and East Winner Bank wreck (eastern Solent). This section outlines the field studies undertaken and the main results. The western Solent will be presented first, followed by Langstone Harbour and then the smaller studies.

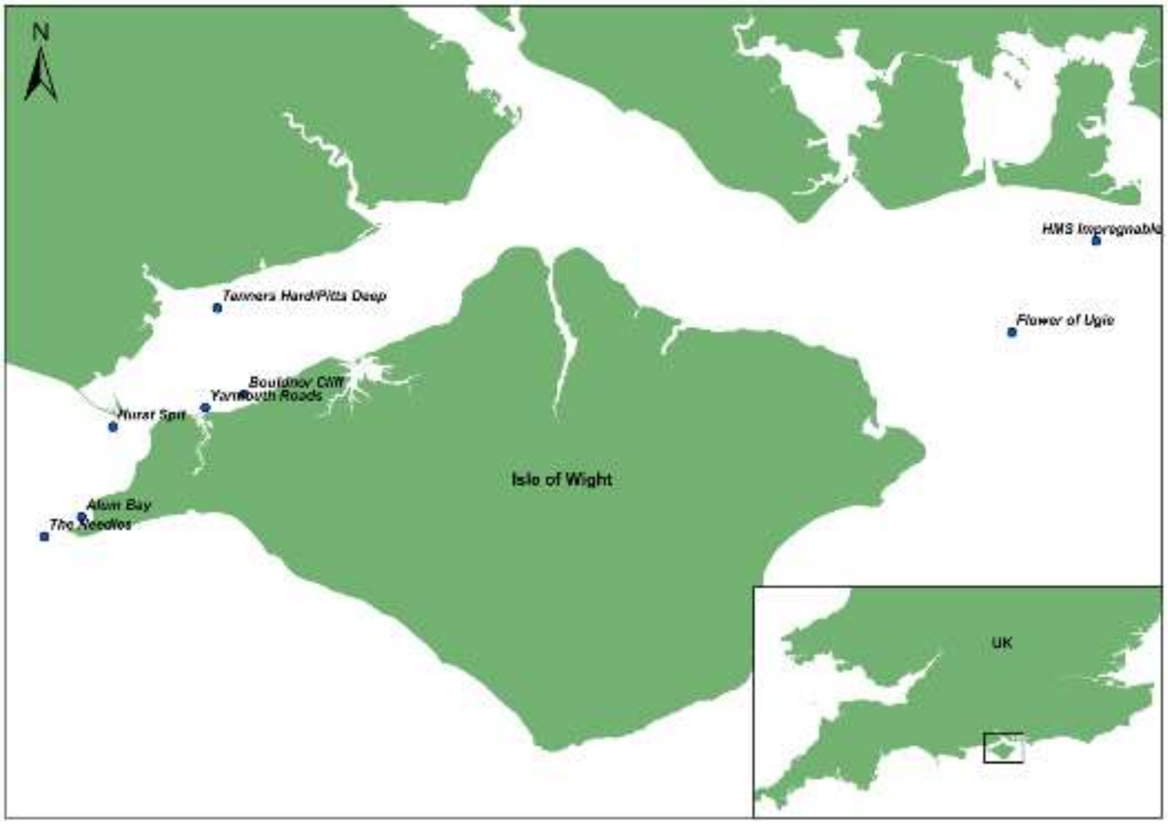


Figure 3D.5: Location of dive sites in the Solent, UK

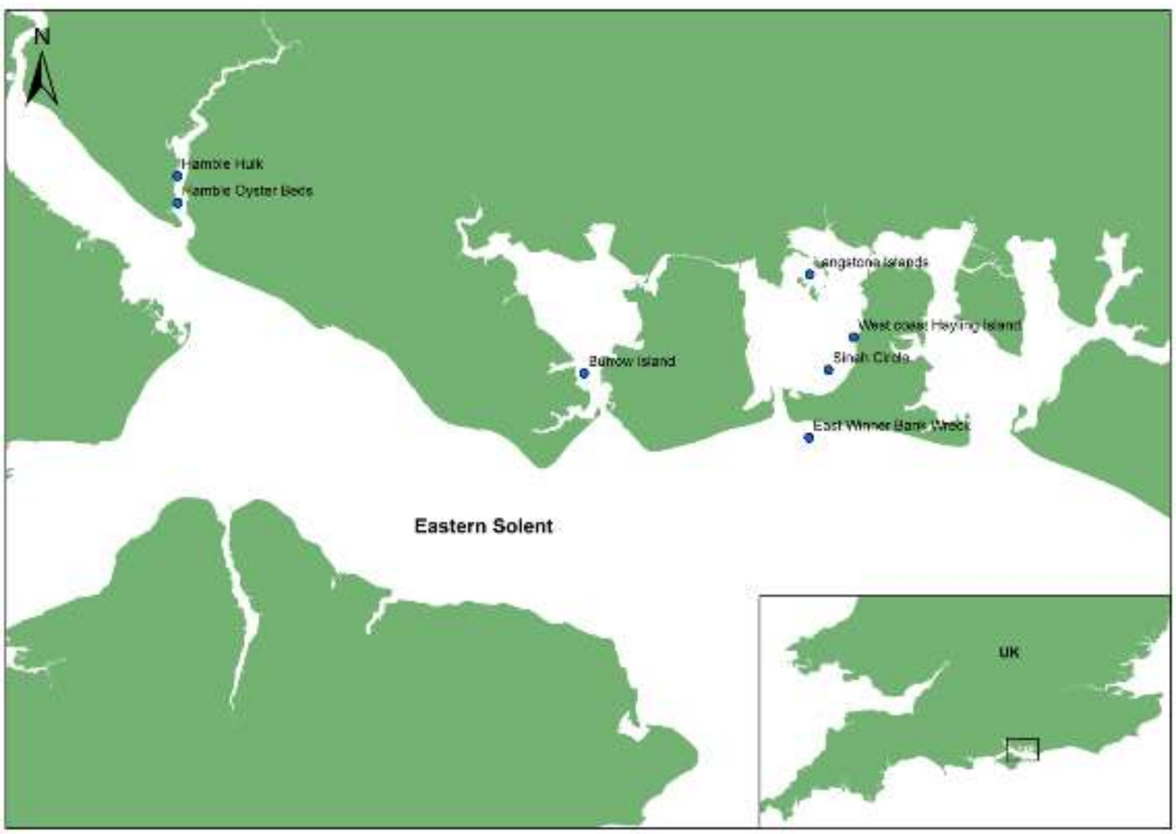


Figure 3D.6: Location of intertidal sites in the UK

3D.4.1 Western Solent

The western Solent is an interesting coastline to study as it has been completely reconfigured over the last 8,000 years during the rise of sea level. The process has not finished and a stable equilibrium has yet to be reached. It demonstrates how the long term evolution of a coastline can influence future patterns of change with important implications for ongoing management policies.

The underlying geological controls have been outlined in 3D.1.1 above. Dominant features along the coastal fringes are the Cretaceous Chalk structures. These have been folded to form rolling downs and sea cliffs which run from the Isle of Wight to Dorset in the west and extend below sea level to the east (Figure 3D.7). North of the chalk ridge the rocks dip gently towards the Solent. Here, the sedimentary sequences are younger and generally less consolidated than the chalk thereby succumbing more readily to weathering (Moore *et al* 2010). However, undulations in the landscape are also the result of geological factors where deep-rooted basement faults cause moulding of the plastic Mesozoic and Tertiary strata (Nowell 1995, Melville & Freshney 1982). This causes irregular rates of uplift and down-warping over relatively short distances. Some of the faulting has manifested itself as an anticline that runs along a northwest axis across the Solent from Newtown Creek to the New Forest while to its west there is a syncline or basin below what is now Yarmouth Roads. Hard limestone outcrops are in concordance with the anticline while the syncline is dominated by soft Eocene clays. The reshaping of the surface morphology along the western Solent coastline has been controlled by these varying geological features with different susceptibilities to erosion.

Figure 3D.7: White chalk cliffs on the south west side of the Isle of Wight

Key Research Questions

Palaeoenvironmental and archaeological remains can be used as indicators to record the scale and pace of past change within coastal units as a result of sea level and environmental fluctuations. The archaeological fieldwork and geomorphological studies conducted in the western Solent aimed to gather data that could answer the following research questions:

- What are the long term patterns of geopmorphological adaptation along the coastline as a result of sea level change?
- What are the current coastal and submarine processes?
- What can the palaeoenvironmental data collected from the western Solent tell us about the past environment?

- What can the archaeological data collected from the western Solent tell us about human adaptation to change and provide lessens from the past?
- Can monitoring discreet areas of the seabed show rates of erosion?
- How can this information be used in conjunction with previous survey work to inform on the changing landscape over time?

The fieldwork aimed to collect data from key areas of the western Solent that could build on past research to show current change and vulnerabilities. Work was focused on the prehistoric and landscape features at Bouldnor Cliff, Tanners Hard and Hurst Spit, while the wreck sites within Alum Bay reveal data on more recent seabed changes. These sites provided data on the north, south and west of the western Solent. The formation of the Solent has removed most prehistoric landscape evidence from the east of the study area.

The key aim of the fieldwork was to gather information on sites, finds and deposits which can inform on the changing landscape over time. The key objectives were to:

- Establish whether the submerged landscapes off Tanners Hard in the Solent were continuing to erode.
- Establish whether the submerged landscapes off Bouldnor Cliff in the Solent were continuing to erode.
- Sample palaeo-environmental material from the seabed to ascertain the date and process of past environmental change.
- Sample palaeo-environmental material from the seabed to aid understanding of the formation of the Solent and consequential impact on coastal processes.
- Monitor seabed changes around the wreck sites of Alum Bay to provide data on micro-scale changes occurring with the bay.

Long term patterns of geopmorphological adaptation along the coastline as a result of sea level change

The Holocene began when the Younger Dryas came to an end c.11,500 years ago and the climate warmed. The sea was 30-40m below current levels. Analysis of ice core GISP2 from Greenland shows a rise in temperature of 5º to 10º C in just a few tens of years (Taylor *et al* 1997; Alley 2000; Alley *et al* 1993). This increase in temperature caused relatively quick melting of the permafrost and ice sheets.

The millennia that followed the Younger Dryas were formative years for the western Solent basin (Momber, 2004). About 8,500 years ago sea level was around 15-18 m below Ordnance Datum (OD) and the Isle of Wight was part of mainland Britain. The Solent River ran down Southampton Water and veered east at Calshot. Tributaries from Beaulieu and Newtown plus waterways running through Portsmouth and Langstone Harbours joined the river as it headed south to the Channel. The area around Yarmouth Roads remained separated from the Solent River system by elevated land that mirrored the geological anticline running north-west through Newtown Creek. To the west there was another shoulder of land that ran along the line of Hurst Spit to Sconce Point. The Lymington River drained south between Hurst and Newtown, passing along the course of the Western Yar to Freshwater on the further side of the Isle of Wight (Figure 3D.8). The area of the western Solent formed a basin around the river floodplain with fresh water lakes and mires (Momber 2011a; Tomalin 2000b).

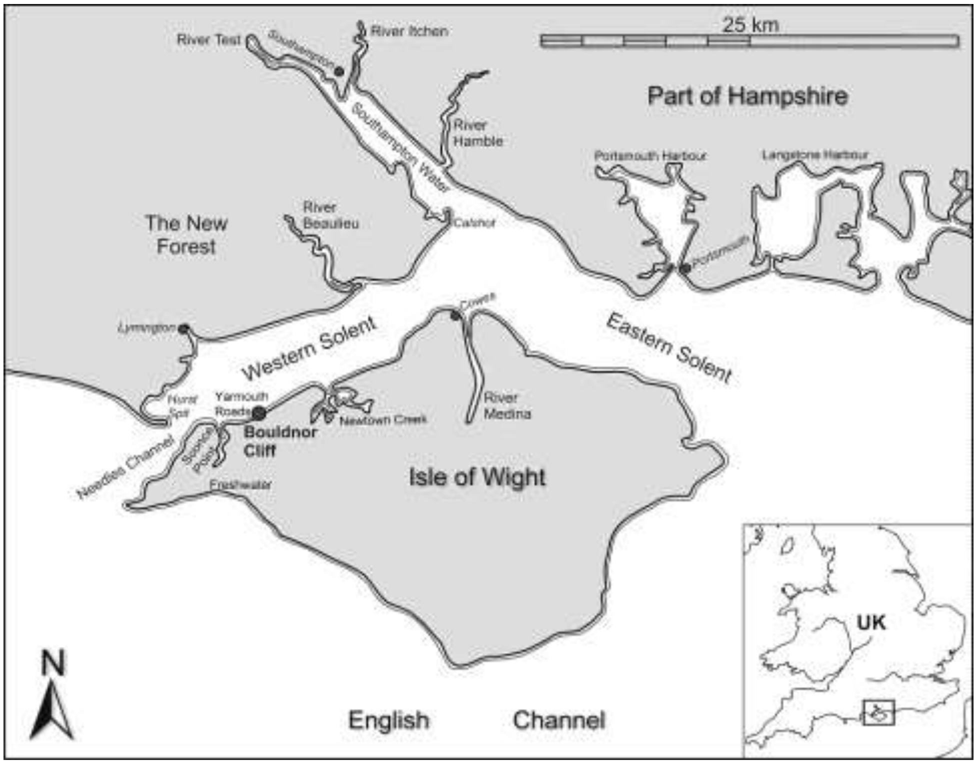


Figure 3D.8: Map of the study area showing the places mentioned in the text.

Five hundred years later, at 8,000BP the sea level had risen to 10.7m below Ordnance Datum (Momber et al 2011 p32). This had now flooded the west Solent basin and a wet fen environment was developing around an estuarine lagoon. The transition between a 'well watered' freshwater fenland to a brackish environment took a quite a few decades. The pollen record shows how it was accompanied by an increase of alder and grasses, ultimately resulting in colonisation by saline tolerant plants and the formation of saltmarsh.

As the sea water continued to flood into the Solent there is a strong presence of deep water planktonic and continental shelf foraminifera. Arrival at the site could be due to a sea level surge or reworking of older deposits. This also coincides with an expansion of the diatom *Paralia sulcata* that arrived with deeper water following a flooding event (Scaife 2011). The saltmarsh soon gave way to the formation of mudflat. Over the next 2,000 years the sea level rose a further five and a half meters during which time the mudflats continued to deepen (Momber *et al*. 2011). By the time water levels had reached 5m below OD, the flooded basin overtopped the land to the east and the Lymington River joined the Solent estuary.

The new expanded estuary continued to develop for the next 300 years or so laying down another metre of mudflat sediment. This deposit was then colonised by saltmarsh; evidence for which has been found along the north and south of the modern Solent, and on the Christcurch Bay side of Hurst Spit. At that time, around 6,000 years ago, the rate of sea level rise was slowing but the estuarine conditions in the western Solent prevailed. Studies conducted through the University of Southampton looking at the morphodynamics and evolution of the saltmarshes have concluded that these peats formed within an inner estuarine or bayhead deposit in the western Solent (Ke & Collins 2002, 435). Furthermore, a date has been speculated for the final submergence of the peat and the opening of the Solent to Christchurch Bay at somewhere before 2500 years BP. The figure is based on the assessment of dated peat samples from similar heights in the region (Devoy 1982; Dean 1995; Hampshire County Council 2014). 3,800 year old samples from peat deposits 2.5 metres below Ordnance Datum have subsequently been recovered from the south of the Needles Channel, east of Hurst Spit that show fully marine conditions were not introduced into the Solent until after this time (Momber 2011b). This means the area had not been overtopped and the western Solent waterway had yet to form (Figure 3d.9).

Until the Solent managed to break through its western end, the coastal zone between the New Forest and the Isle of Wight was sheltered and formed a sedimentary sink. It was an area dominated by mudflats and saltmarsh. This provided protection for the coastline and preserved the buried landscapes beneath it. When the Solent finally became an open channel new currents were introduced that started to remove the sediment and the protection it afforded the coastline. This new process has, and is still having, a very erosive impact above and below water. The fieldwork conducted as part of the Arch-Manche project has helped us to understand the rate and scale of erosion as well as contributing to our understanding of the geomorphological processes.

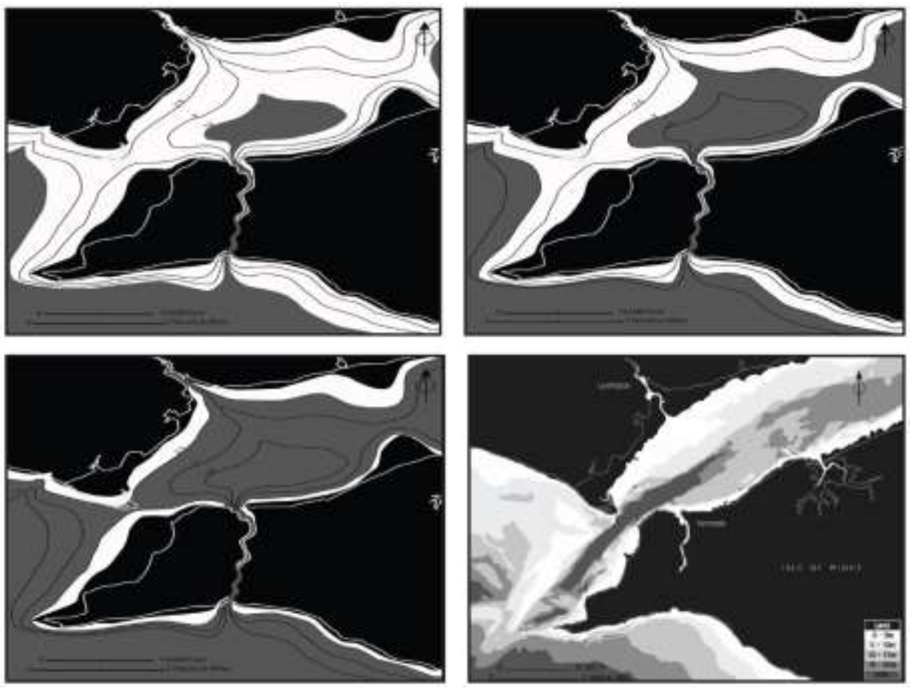


Figure 3D.9: Images showing the development of the western Solent. About 3,500 years ago, the breaching of the final land link to the island transformed a salt marsh into a channel that would eventually extend over 10km long and up to 60m deep. The strong tidal currents introduced when the channel was formed continue to erode the Solent shoreline today.

Current coastal and submarine processes

One of the most striking consequences of the new western arm of the Solent was the Hurst Deep. This is a furrow that has been excavated to almost 60m below OD off the reverse end of Hurst Spit. It runs for around 5 km towards the Needles in the south-west. Tracking 5km beyond the Hurst narrows in the opposite direction, the seabed quickly shallows again rising to less than 20m below OD off Bouldnor Cliff. It can therefore be seen that the central point off Hurst spit is roughly equidistant with shallow water to its east and west. The Deep is very localised and occurs where the currents are strongest. It would appear the channel off Hurst is controlled by the morphology of the spit which forces the water into a confined space causing scour (Dyer 1975). Consequently, its formation can be attributed to recent marine tidal attrition.

It is probable that the erosion around the Hurst Deep will be amplified as the sea level rises and the amount of water through the channel increases. The enlarged volume of water will add to the forces through the narrows. The Spit itself is now being defended with artificial recharge following storms by the sea defences and castle at its tip, therefore, it is protected from the forces. This is not the case for the other side of the Hurst narrows which is only 1.2km to the south east (Figure 3D.10). Here the Eocene clays and fine sands of the Headon Hill Formation at Fort Victoria Country Park are being washed away by the sea (Figure 3D.11). This area is likely to see an acceleration in erosion as the sea level rises.

Prior to coastal erosion, the hill would have extended further into the Solent. Before the breach it would have joined with the submerged land that still remains underwater to the north where it has been protected by the shelter of Hurst Spit. However, once that first bit of land was breached and the channel was opened, tidal scour has widened and deepened the water course at an exponential rate.

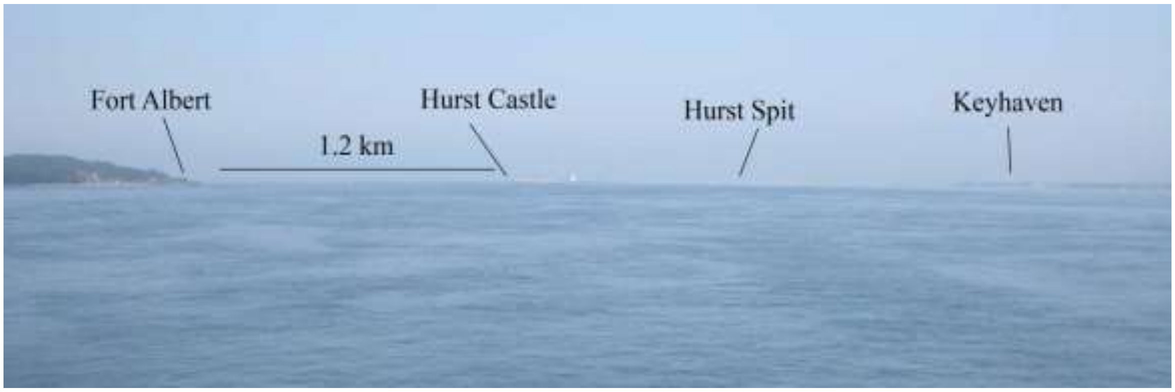


Figure 3D.10: A 3,800 year old palaeo-landsurface lying just 0.5m below Chart Datum remains protected on the east side of Hurst Spit (this side of the Spit in the image). The hill at Victoria Country Park, adjacent to fort Albert is receding. The width of the channel is only 1.2m while the depth is close to 60m. The spit and hill have protected the land causing the tidal forces to scour the 60m Hurst Deep. The forces acting in the channel will increase as sea level rises increasing threats to the coastline.

Figure 3D.11: Active erosion and rotational sliding forming a cliff along the north edge of Victoria Country Park.

Another significant geological soft spot is the 60m high cliff at Bouldnor which is the northwest face of a truncated hill a little over two 2km east of Yarmouth. The hill is composed of soft Oligocene Marls forming an angle of repose in the order of 15° to 20°. It is being steadily trimmed by the Solent and resulting in rotational sliding as indicated by fallen trees lying on the beach and expanses of bare rock face caused by mudslides (Figure 3D.12). The hill would have previously extended further northwest across the Solent towards the New Forest. Reduction of the current cliff at Bouldnor is clearly visible and rapid. This will have been accelerating as sea levels rose and it is also worth noting that the highest point on the hill at Bouldnor lies at the top of the cliff. This shows that the hill is still rising at the point where it is severed by erosion inferring that the pre-eroded hill would have been higher. The notion of a prominent hill extending across the western Solent valley towards the mainland before being eroded by the sea is unavoidable.

Figure 3D.12: Fallen trees below Bouldnor Hill resulting from cliff erosion

A record of recent movement of coastal features has been collected by historic chart comparison studies covering the last 200 years and the monitoring of the salt marsh over the last 50 years. This has shown a distinct regression of the coastline and declining saltmarsh along the north west Solent (Figure 3D.13) (source data from: http://www.channelcoast.org and New Forest District Coastal Group, 2007).

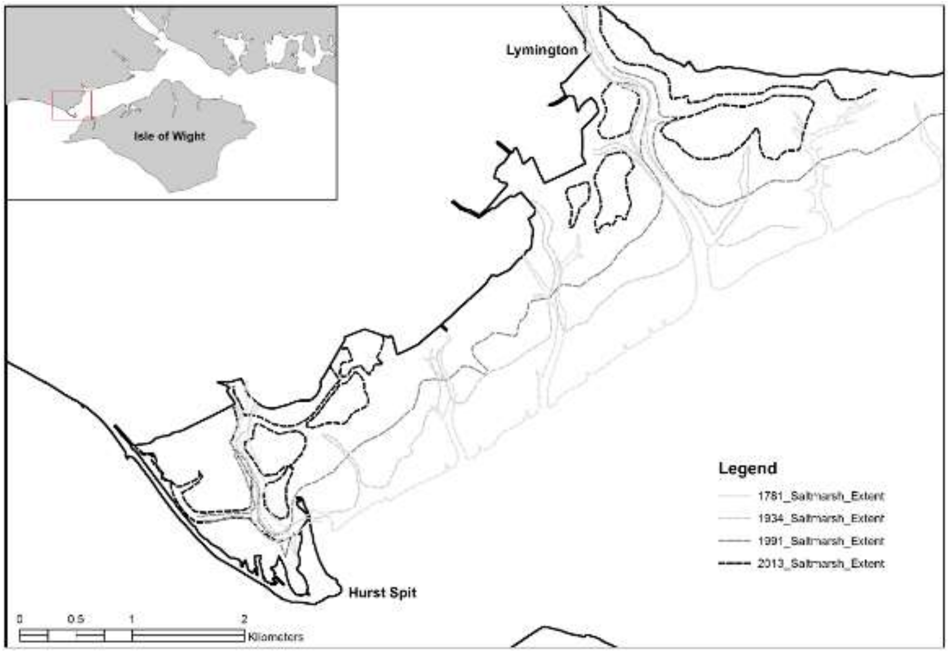


Figure 3D.13: Saltmarsh and mudflat regression from 1781, 1934, 1991 and 2013 based on the analysis of historic maps (see section 3D.7 below).

The removal of the mudflats has revealed a widespread deposit of peat and trees underwater at 2.5-4m below OD. These deposits have dates ranging from around 4,000 to 6,300 years BP. Much of the older deposit in 4m of water is very well preserved, however, now that it is uncovered it is eroding fast and subject to virulent degradation by crabs and wood boring organisms (Figure 3D.14). The landscape represents a shallow submerged bench that absorbs wave energy before it reaches the shore. The fresh, but aggressive loss of material testifies the long term stability of the submerged land surface inferring that it has been uncovered for the first time. This in turn implies that the mud flats have been stable for 6,000 years and the current regression is a modern phenomena that is invariably a result of human actions in the last 200 years. The loss of the mudflats and underlying land surface is increasing the threat to the coastline. Similar recorded submerged landscapes are seen along the southern shores of the eastern Solent (Tomalin *et al* 2012).

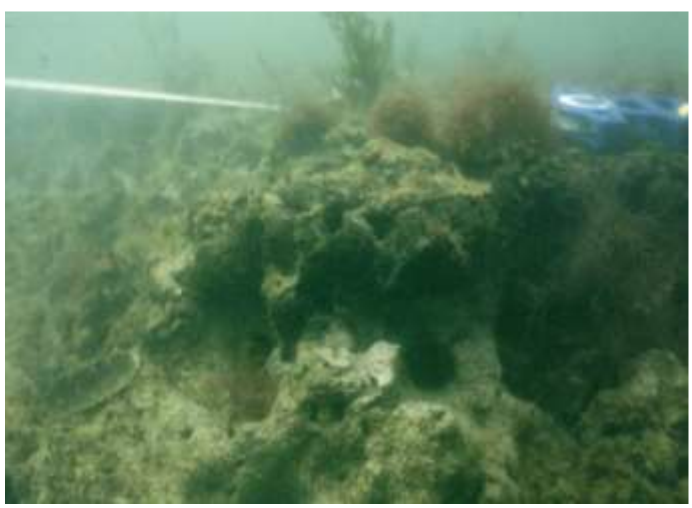


Figure 3D.14: Erosion and degradation accentuated by marine boring is evident within the relatively recently exposed submerged landscapes in the north-west Solent.

On the opposite side of the Solent, below Bouldnor Cliff, the relict landscape is less expansive due to the impact of the tidal channel that has scoured a linear 8-9m high cliff (Figures 3D.15 and 3D.16). It runs for around 1km below the water, parallel with the shore and the main channel at around 3-400m offshore. The top of the cliff reaches 4m below OD. This area has survived because it lies in a bay within the lee of Yarmouth, however, it continues to erode and as it does so, it both reduces protection for the coastline and exposes the palaeolandsurface that is eroding from the base of the cliff. This area has been monitored during the course of Arch-Manche fieldwork.

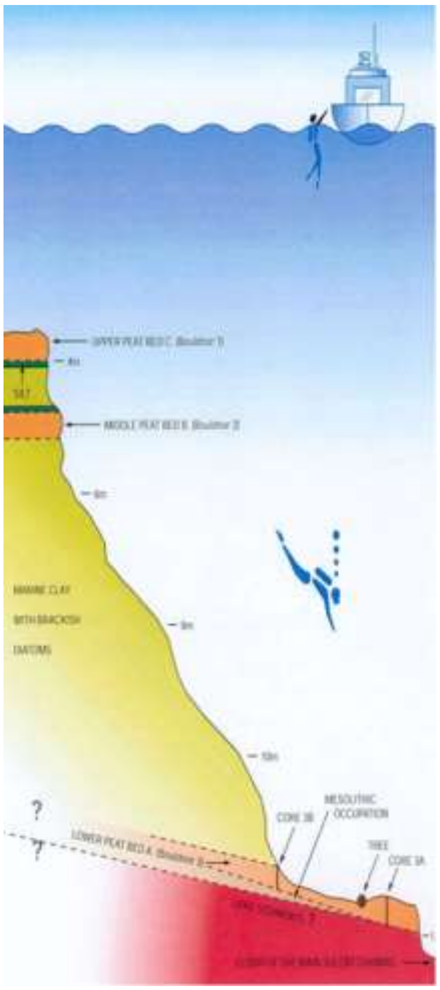


Figure 3D. 15 (left): Schematic across Bouldnor Cliff showing the sediment layers and relict submerged land-surface at the base of the cliff (Courtesy of Isle of Wight Coastal centre).
Figure 3D.16: (right) The 8-9m high submerged cliff at Bouldnor runs for 1km along the edge of the Solent channel parallel with the shore.

The investigations in the Solent have shown that by characterising areas of long term erosion, coastlines under ongoing stress can be identified. To improve our understanding of the changes there is a need to calibrate the rate and scale of erosion in the long and short term if we wish to anticipate future scenarios. The long term issues have been considered above while short and medium term changes have been addressed by the diving fieldwork conducted in the western Solent during 2012 and 2013.

3D4.1.1 Fieldwork Methodology

The fieldwork was conducted to monitor the seabed and collect samples that would address the key research questions outlined above. The fieldwork included:
Diver survey - The diving fieldwork involved the use of professional divers and suitably qualified volunteers over fieldwork seasons 2012 and 2013. All diving was conducted to UK HSE diving standards. The diving took place at Bouldnor Cliff, Tanner's Hard, Hurst Spit and Alum Bay from the certified dive vessel *Wight Spirit.*

Monitoring landscapes – On the prehistoric landscape sites the objective was to relocate the historic datum points and monitoring pins to calibrate rates of erosion over the past 10 to 15 years. When the datum pins were relocated, baselines were run between them and offset measurements were taken between the pins and well defined points on the cliff edge and to trees routed to the land surface. The measurements were taken at set distances along the baseline and the monitoring pins to replicate previous survey.

Monitoring also utilised bathymetric survey. A survey conducted in 2003 defined the lines of the submerged cliff and highlighted areas susceptible to erosion by marine boring crustaceans where reworked archaeological artefacts had been found on the seabed (Figure 3D.17).

A further survey was conducted at BC-V where the original survey grid was re-established with baselines and offset measurements were made to the eroding edge of the palaeo-landsurface in 11m of water.

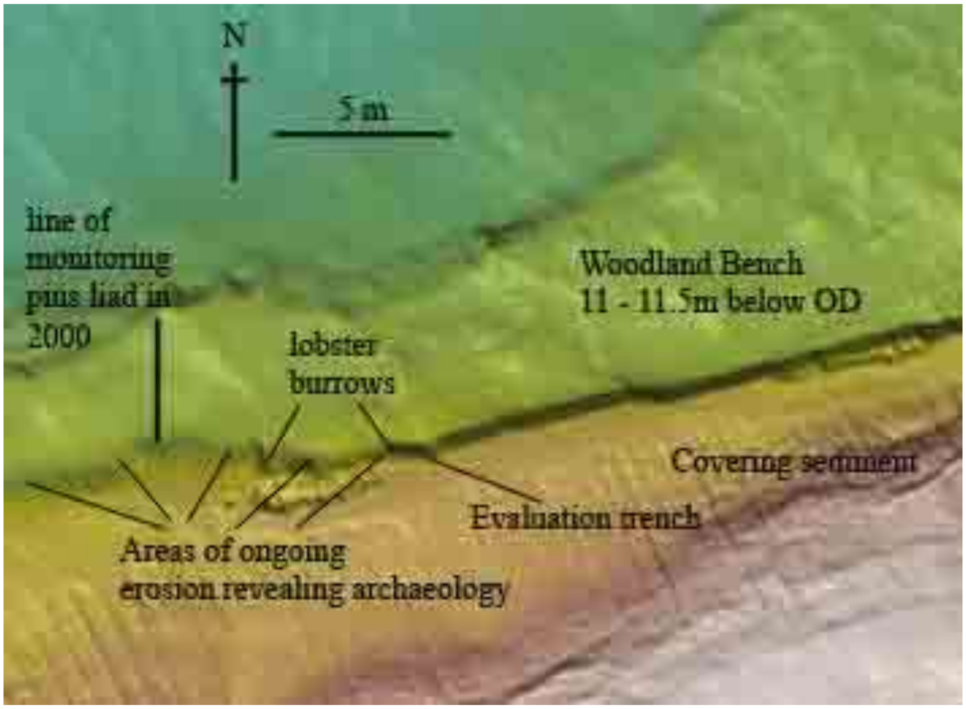


Figure 3D.17: Annotated bathymetric survey conducted in 2003.

Sampling landscapes – Sediment samples were collected from Bouldnor Cliff and Hurst Spit to assess palaeoenviromental changes and for radiocarbon dating. The samples were collected by divers using marine grade stainless steel monolith tins on Bouldnor Cliff and by taking cohesive bulk samples on Hurst Spit. Hand saws were employed to help remove the tins from the outlying sediment and the samples were protected by being wrapped in industrial-strength cling film at the point of extraction. These tin sizes are manageable for divers to handle but large enough to retain a cohesive sample (Figure 3D.18). Bulk samples were also removed from an evaluation trench at BCII following clearing of the alluvial clay to access the sandy clay archaeological layer beneath. Sandbags were filled upon completion and packed into the trench to backfill it to protect the surrounding seabed.

Figure 3D.18: Sample being recovered by divers from prehistoric landscape site.

The samples brought to the surface during diving fieldwork in 2012 and 2013 were processed once on shore by experienced staff or they were kept in cold storage at 6 degrees centigrade at the British Ocean Sediment Core Research Facility (BOSCORF) where they were sub-sampled by specialists to determine their suitability for palaeoenvironmental analysis. Selected samples were subject to radiocarbon dating.

Excavation – an evaluation trench measuring 1m by 2m was created by removing a slab of clay from an eroding section of the submerged landscape. The area below was sub-sectioned into 0.25 by 0.5 m areas and lithic material was recovered from individual sections. Sampling in the trench was limited to a single 30cm spit within the sandy silt deposit.

The excavation trench was also extended at BC-V. Here, the covering peat and humic sediment was removed from above timber that was vulnerable to erosion and loss. Conventional trowels and brushes were used to clear the sediment and work around the artefact before recovery.

Rescue artefacts – Artefacts which have been exposed through erosion of their protective sediments were recovered from the seabed before they were lost. The location of the finds were plotted with reference to the site grid.

Monitoring shipwrecks – diver survey of the Alum Bay 1 and 2 shipwrecks consisted of direct measured survey of areas of exposed wreckage in relation to established datum points. Additional evidence was gathered through photographic and video survey of the sites.

3D4.1.2 Results of work at Bouldnor Cliff II (BC-II)

Monitoring

Inspection of the seabed in 2012, 10m to the west from the evaluation trench excavated in 2003 revealed a large area of scour that extended into the base of the cliff. Previous survey had recorded a fallen oak tree at this location but it was now gone (Figure 3D.19). It would have been removed by the strong tides or been snagged and pulled from the bank by fishing gear. The underlying palaeolandsurface was now exposed (Figure 3D.20). This consisted of a sandy silt deposit that was covered by a horizon of peat, which, in turn was covered by a layer of estuarine mudflat deposit. This sequence of horizons was recorded in 2003 as part of an English Heritage project and dated by radiocarbon dating to around 8,000 years old. The base of the peat and sandy silt deposit contained archaeological material.

Figure 3D.19: 60 cm wide, eight thousand year old, oak tree on seabed at BC-II recorded in 2003. It is now gone and the area has become more vulnerable to erosion.

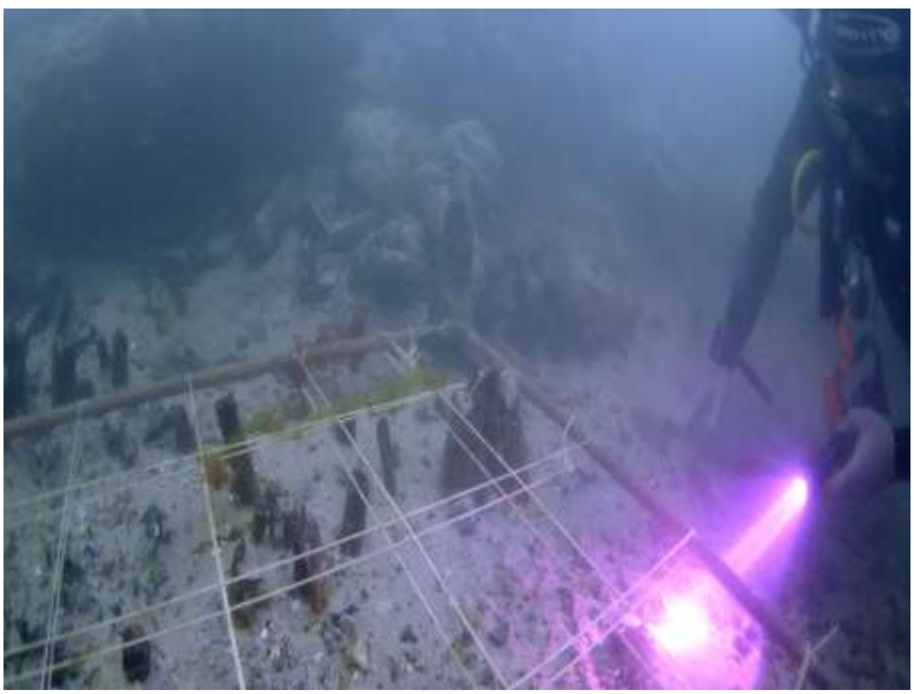
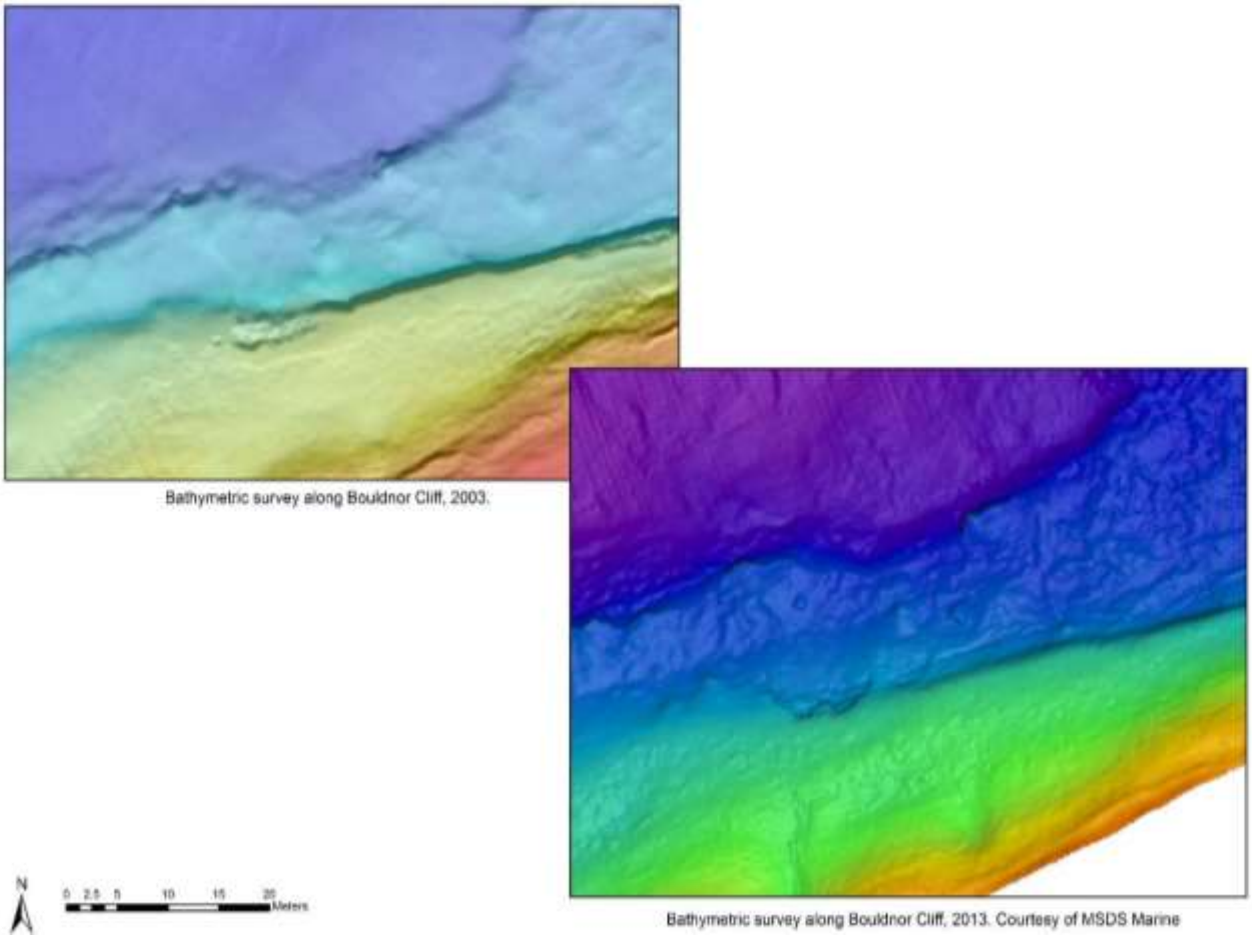


Figure 3D.20: Area of seabed inspected and surveyed at BCII. This has become exposed since previous survey in 2003. Tree roots and flints can be seen in planning frame. The surface is now 11m below OD and is 8,000 years old.

To determine the extent of erosion, the area was re-recorded and compared to the 2003 survey (completed in 2004). A number of the original datum points were relocated and the survey grid was re-established. Comparative measurements were taken from the survey baselines to the base of the cliff (Figure 3D.21). The erosion was recorded at around 3 m in 10 years although it should be noted that this was the location where a tree had since been removed.

Figure 3D.21: The darkened area within the survey grid had been subject to greatest erosion since 2003/4. Erosion of 3-4m was recorded.

A main cause of the receding submerged cliff line is scouring and collapse. The fine sandy silt deposit that lies under the peat is easily winnowed away by the tide and is attractive for crustaceans who burrow into it. Once the sandy silt is removed, the peat and silt above is undermined. It soon breaks and collapses, falling onto the seabed in front of the cliff. From here, it is steadily washed away by the tides. Comparison of bathymetric surveys conducted in 2003 and 2013 can be seen in Figure 3D.22. It shows that the area investigated was already beginning to fracture and separate from the cliff in 2003.



Bathymetric survey along Bouldnor Cliff, 2003.

Bathymetric survey along Bouldnor Cliff, 2013. Courtesy of MSDS Marine

Figure 3D.22: Two bathymetric surveys conducted of the same area show plans 10 years apart. The different colours represent different depths. The colours change at 1m intervals although the hues differ between the two survey images. In the 2003 survey, the light blue area running from left to right in the centre of the image is the 11m deep submerged land surface. It is covered with trees inlaid within a matted peat deposit. The same layer is dark blue in the 2013 survey. The colours to the south, at the bottom of the image, represent the sediment within the covering cliff; the trees and peat extend underneath the cliff to the south. Here, the water gets shallower as the cliff gets higher. The area surveyed by divers is located at the bottom of the cliff and along the southern end of the submerged land surface: in the lower middle left of the images. The mottling evident in the yellow level on the 2003 survey is the area that has since collapsed. The loss of material can be seen when compared to the cliff edge at the same location in the 2013 survey.

Sampling at BC-II

Inspection of the seabed during the first dives on the site in 2012 resulted in the discovery of 43 pieces of worked or burnt flint. These were found in 11m of water at the foot of the cliff. The ensuing survey pinpointed their position to an 8m long section in the area where erosion was greatest (see Figure 3D.21). Here, the freshly exposed sandy silt horizon was being scoured by lobsters and the tidal currents. At the western end of the exposure, a deeply scoured undercut contained several flints (Figure 3D.23), although the concentration of discoveries was greatest 2m to the east (Figure 3D. 24).

Figure 3D.23 (left): An undercut running 1.1m beneath the peat cover. It is located at the western end of the survey area.
Figure 3D.24 (right): Loose worked flints recovered by divers following their discovery on the seafloor at Bouldnor Cliff. A limited amount of marine growth demonstrated that they had not been exposed for long.

Palaeoenvironmental evidence including, pollen, diatoms and foraminifera was also extracted from the site to characterise the changing climate and ingress of marine conditions at the time of human occupation. Pollen and diatom analysis was conducted by Rob Scaife. Pollen was extracted using standard pollen extraction techniques (Moore and Webb 1978; Moore *et al* 1991) on samples 2ml in volume, diatoms were prepared by digestion of humic/organic material using hydrogen peroxide, then drying on microscope cover-slips, mounting, then subject to examination at high-power magnification. Samples for foraminifera evidence were processed and analysed by Jan Gillespie after a process of soaking in Calgon 10%, washing, drying and examining at high-power maginification.

The results from the deposits at BCII showed a clear palaeoenvironmental sequence. Mesolithic activity, including flint working and the processing of hazelnuts in oak/hazel/alder woodland alongside a stream, the deposition of flint gravel, the development of alder-dominated fen woodland, its replacement (probably as a result of rising water level) by an alluvial reedswamp and, finally a full marine transgression. The samples from along the cliff at site BCV identified 3 local pollen sequences. Overall oak and hazel are the most important constituents throughout with only small numbers of birch and pine.

Other trees include elm, holly, ash and yew though taxa are less well represented in the pollen spectra and may have been relatively important constituents of the local woodland. There then comes a poorly developed palaeosoil and old land surface which was sealed by development of the overlying peat. Oak and hazel woodland prevailed on drier soils adjacent to a wet fen or slow-flowing river and lime was starting to colonise the habitat with a peaty humic soil developing. Increasing rainfall/humidity and increasing relative sea level during the early Atlantic period (Chromozone II) resulted in destruction of the on-site and near-local woodland. Rising sea level caused conditions suited to peat formation through the raised groundwater table, but this was ceased by the final marine/brackish transgression. Change to the marine conditions is also supported by evidence in the diatom and foraminifera record. The samples which came from the context are shown to be detrital fen peat and did not contain foraminifera or diatoms, this is followed by a salt-marsh deposit that developed following gradually wetter conditions and is evidenced by a foraminifera assemblage consisting of a typical mudflat fauna (*Haynesina germanica, Ammonia beccarii and Elphidiu? Excavatum). Trochammina* was recorded below this level indicating a transition from marsh to mudflat.

Excavation and artefact recovery at BC-II
The initial phase of diver survey identified an area where the covering clay had separated from the submerged cliff and was in the process of collapse. This was adjacent to an area where the concentration of archaeological discoveries was greatest so it was removed for the next phase of investigation.

The second phase of fieldwork in 2012 and 2013 was an evaluation trench, excavated to confirm that the flints were coming from within the cliff. A section that had been exposed by erosion was identified and cleaned (Figure 3D.25). The face was then protected from collapse with sand bags. This allowed the 2m wide capping of alluvial/mudflat clay to be removed without destabilising the deposit below. It was removed with ease as it had already broken away from the bottom of the sloping cliff. The clay was removed to reveal a layer of wood rich peat. The peat layer was divided into sections then carefully removed in 30cmx20cm blocks, flints were noted in the base of the peat. The peat samples were recovered in zip lock bags that could be carried to the surface by the divers in safety. The surface below the peat consisted of a fine sandy silt deposit with inclusions of vegetation and flint lithics.

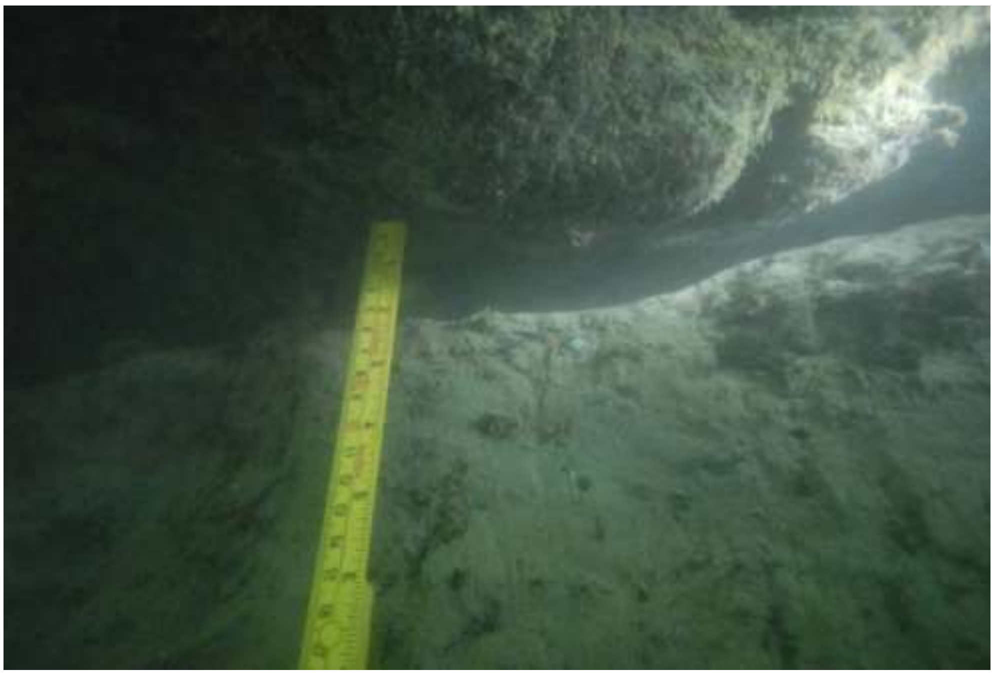


Figure 3D.25: Interface between the peat deposit and the underlying fine sandy silt. The sandy silt deposit is the main source of worked flints.

A 1m x 2m, east – west orientated surface was cleared below the peat. It was sub-sectioned into 0.5x.25m units and the surface deposits were slowly cleared by hand-fanning, towelling and brushing. Lithics that became exposed were recorded then recovered (Figure 3D.26).

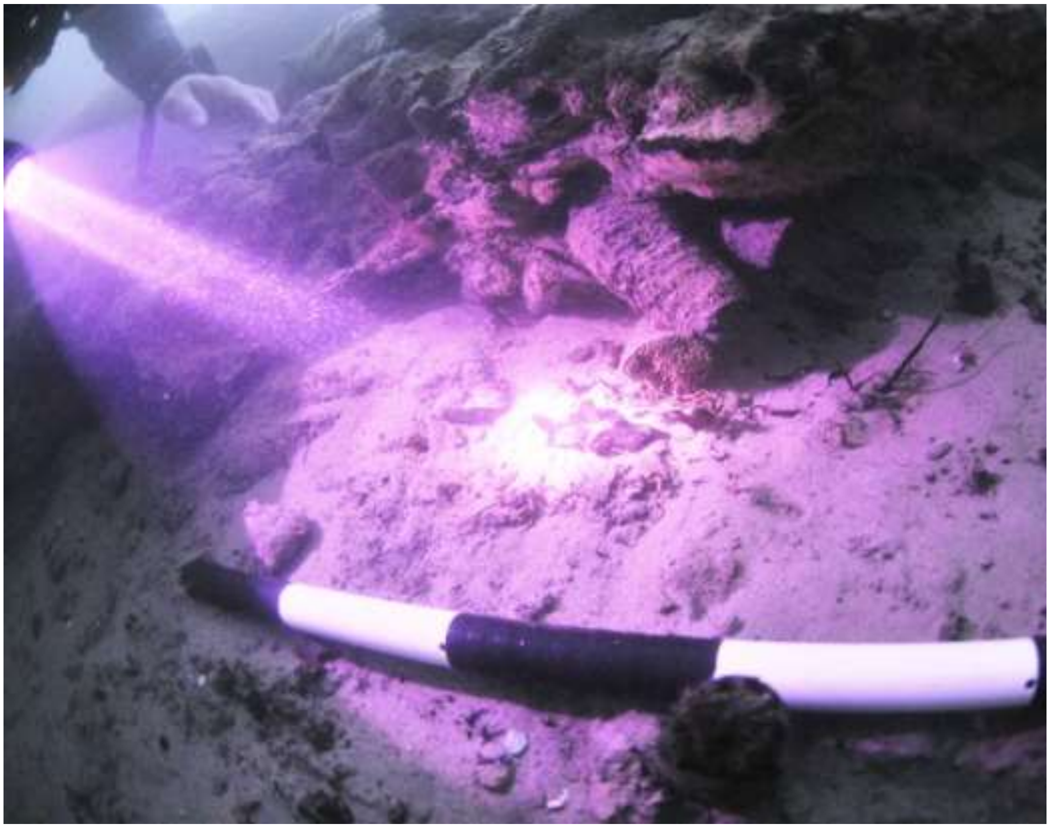


Figure 3D.26: The surface of the fine sandy silt matrix shown shortly after it was exposed but before sampling and excavation. The torch light is illuminating an oak leaf found in-situ and a black flint flake is visible immediately to the left of the beam.

The sediment was excavated to reveal worked and burnt flints. The flints were distributed fairly evenly across and within the sandy silt. Studies from 2003 identified the sandy silt layer as a sand bar deposit that built up adjacent to a fresh watercourse over the course of a few years or decades. This had undergone periods of stability that would have enabled activity on its surface. The flints could have been deposited during these periods. They might have also been subject to an amount bioturbation although the distribution is fairly even and the pattern is widespread across the deposit. In addition, the time period between deposition, development of peat and then burial under mudflat deposits following inundation would have restricted the window of opportunity for too much movement.

The deposit appeared homogenous and was excavated for 30cm which brought it close to the seabed level at the foot of the cliff. Here, more flints were recorded but this time there were several distinct clusters (Figure 3D.27). These flints would probably have been deposited on the land-surface before it was covered by the sandbar. The clusters were not large and could have gathered together naturally. There is a need to understand the wider context before we can qualify the relationship between the flints, however, the extensive vertical distribution through the sandy silt and into the peat demonstrates continual activity on the site during a period of marked environmental change.

Following the excavation, the site was backfilled with sand bags and re-covered with the capping alluvial clay that had been removed at the outset.

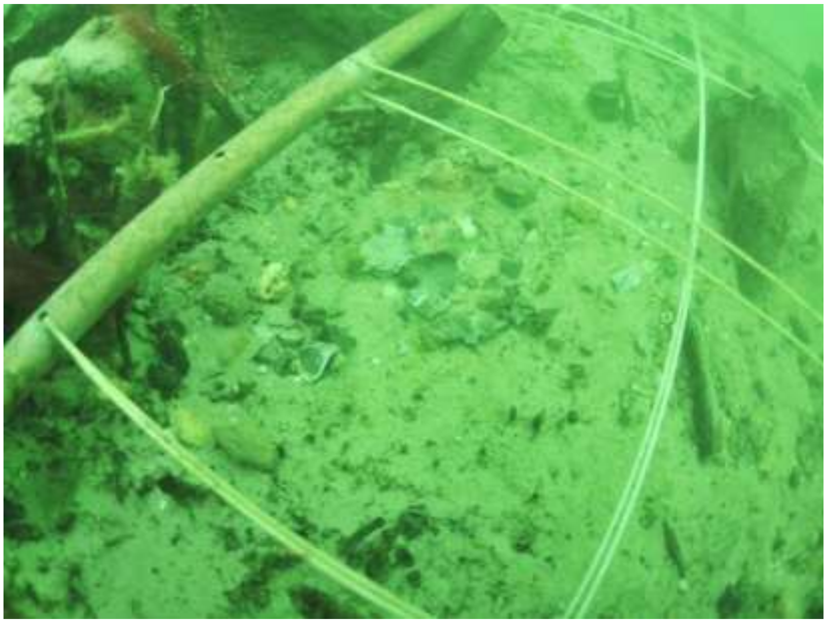


Figure 3D.27: Three clusters of flints were noted at the base of the evaluation trench. The cluster shown at the centre of this figure was located along the southern edge of the trench.

Artefacts

In total, 124 flints were recovered during the excavation (Figures 3D.28 and 3D.29). These were largely burnt flints, flakes, bladelets and cores. The struck flints were in very good condition and showed no signs of abrasion. The collection is comparable to that recovered in 2003 (Tomalin 2011), but it has yet to be fully analysed.

Figure 3D.28 (left): A selection of flakes and bladelets recovered during the fieldwork in 2012/13.
Figure 3D.29 (right): A selection of cores recovered during the fieldwork in 2012/13.

In addition to the 43 pieces of worked or burnt flints recovered from the seabed and 124 flints recorded in the evaluation trench in 2012, a further 35 flints pieces were identified and brought to the surface in 2013. Furthermore, a bovine trichlea/ankle bone was discovered within the depression scoured beneath the peat outcrop to the west of the site (see Figure 3D.30). The trichlea was found out of context but it was too large to belong to a modern cow, but the right size for an auroch. Collagen from the bone was dated to 6220 - 6020 Cal BC; 2 Sigma calibrated result, 95% probability (Beta-366541). During preparation it was noted that the collagen levels were low which could be caused by heating. If the auroch have been heated and possibly cooked, this would not contradict the archaeological findings to-date, however, signs of burning have not been detected on the bone, nor have cut marks. Either way, the discovery of the single bone indicates that there could be a great deal more evidence within the eroding cliff. Further investigation would be needed to answer these questions.

Figure 3D.30: Caudal view of the Auroch trichlae that was recovered from the eroded landscape at Bouldnor Cliff-II.

3D4.1.3 Bouldnor Cliff V (BC-V)

Bouldnor Cliff V lies 400m to the west of BC-II. It is a location that contains worked wood and is believed to be a site of wood working activity that could have included boat building. It lies on the northern edge of the peat platform where a cliff in the order of 1.5 m drops to the floor of the seabed and then dips gently into the Solent. The edge is subject to ongoing erosion by the tide and by crustaceans that burrow into it and destabilise the softer sediments. The site was revisited to record evidence of continued degradation and to look for further exposures of archaeological material.

Monitoring

A site grid was set up at BC-V in 2007 and west-east running baselines were laid between 1m long galvanised steel datum points. A 25m baseline was used to gather baseline data between the grid and the edge of the cliff to the north.

In 2012, the grid was re-established and offset measurement were repeated along the baseline. The rate of erosion along the cliff edge varied from negligible to 2m. The areas subject to the greatest amounts of erosion were in the east and west (Figure 3D.31). These were also the areas where most of the archaeological material had been identified.

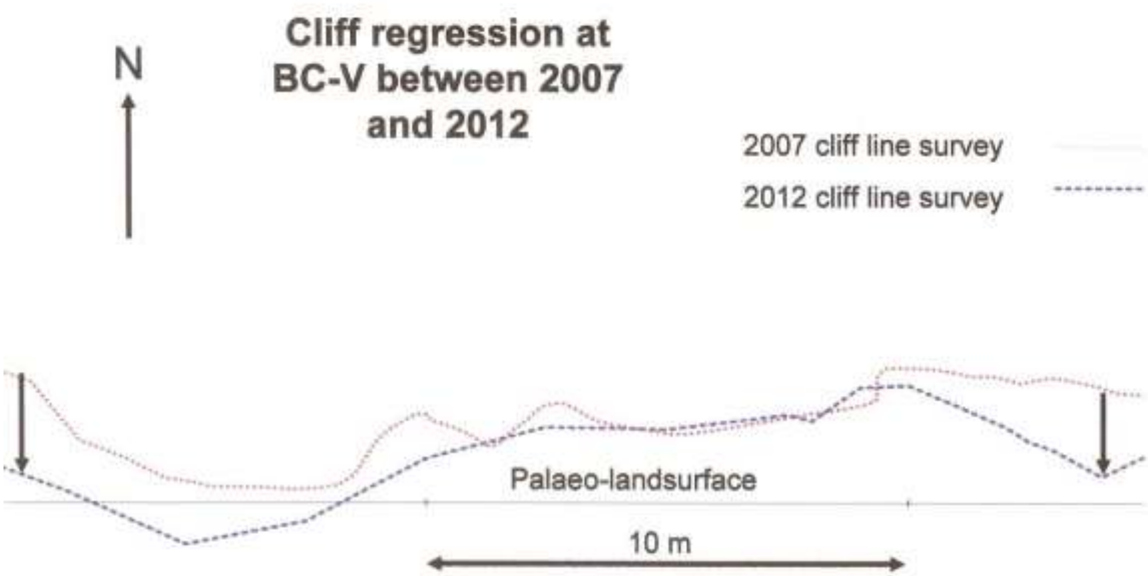


Figure 3D.31: Erosion monitoring plan of BC-V. Losses of 2m of sediment were recorded in the east and the west although the site was relatively stable in the middle.

Sampling

Sample collection at BC-V was limited. Material that is eroded from the northern edge of the shelf is quickly lost into the Solent allowing very limited opportunities for its rescue and recovery. However, during diver inspection in 2014, a new exposure of worked timber within a matted peat horizon associated with the archaeological horizon was recorded. It was eroding from the eastern end of the site, 18m west of the postulated wood working site. Pieces of protruding timber were recovered for recording and assessment (Figures 3D.32 and 3D.33).

Figure 3D.32: Undersides of split and worked timber from BC-V. The samples recovered in 2014 are at the top of the picture.

Figure 3D.33: Opposite side of the two split timbers recovered in 2014. The flat side is down.

Excavation and Artefact Recovery at BC-V

Approximately three square metres of seabed were excavated between 2007 and 2001. The site of excavation was 2m back from the edge of the cliff. This was an area where the palaeo-landsurface of peat was sitting above a humic surface that contained archaeological material. 25 pieces of archaeological timber were recovered from this area. Amongst these timbers was one large timber which proved to be a plank which had been tangentially split, the technique was, and still is, used for boat building and other structural woodworking and has been observed in assemblages of timber from the Neolithic to the Bronze Age but is unknown in the Mesolithic. It is not known if further material exists although exposures of similar worked wood have been found within 20m of the location.

In 2012, inspection of the excavated trench revealed the area in the south was receding and a timber feature was becoming exposed (Figure 3D.34). The timber was excavated and recovered (Figures 3D.35 and 3D.36). A smaller piece of worked timber was also identified in the base of the archaeological horizon, 0.5m to the north. This was also recovered (Figure 3D.37).

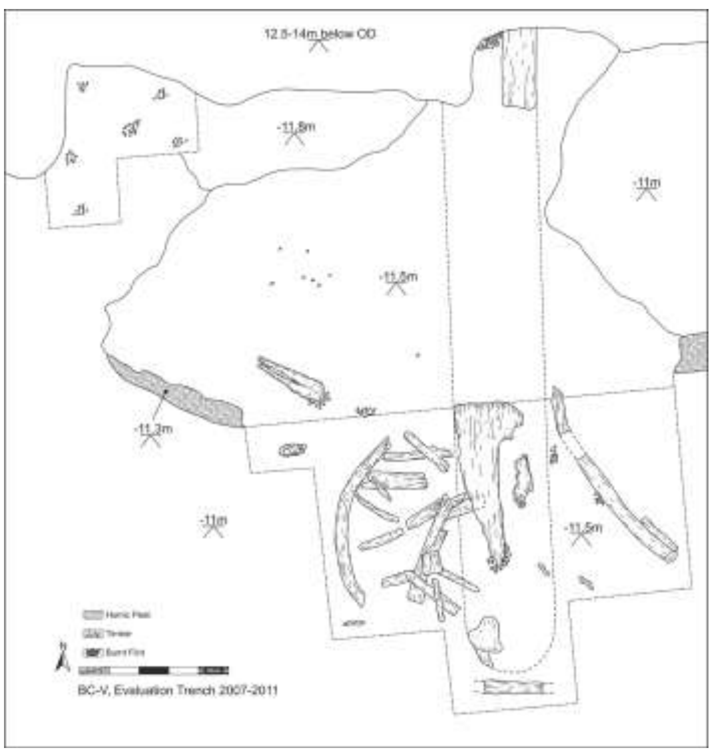


Figure 3D.34: Plan of the wood working site at BC-V. The exposed timber recovered in 2012 was first noted in 2011. It is recorded on the above plan as the southernmost piece of timber.

The timber rescued in 2012 was recorded in-situ then carefully recovered to the boat. The timber was chopped from the roots and was found laid on its side perpendicular to the line of the proposed log boat that was being worked on site. Four such pieces of timber that had been cut down in this way have been found at the site. They are of varying size and two are shown with the 2012 recovery in Figure 3D.35. The timber measured 1.1m long and had a distinctive cut, 0.7m from its base (Figure 3D.36).

Figure 3D.35: The 1.1m long timber recovered in 2012 was found lying perpendicular to the hypothesised log boat where it would have provided support at its southern end. The smaller pieces of timber, were harvested by Mesolithic people in a similar way. They were found in the same assemblage of timbers at BC-V.

Figure 3D.36 (left): Close up of the distinctive cut o.7m from the base of the recovered timber.
Figure 3D.37 (right): A smaller piece of fashioned and worked timber was recovered from the floor of the trench extended in 2012. It contains well defined cut marks but its function is yet to be determined.

3D4.1.4 Pitts Deep and Tanners Hard

The terrestrial landscape at Bouldnor once extended across the valley floor into the New Forest (Figure 3D.38). Tracts of submerged prehistoric landscape still remain in the north west Solent. The area has been a source of many prehistoric artefacts and is an integral part of the old Solent cultural landscape.

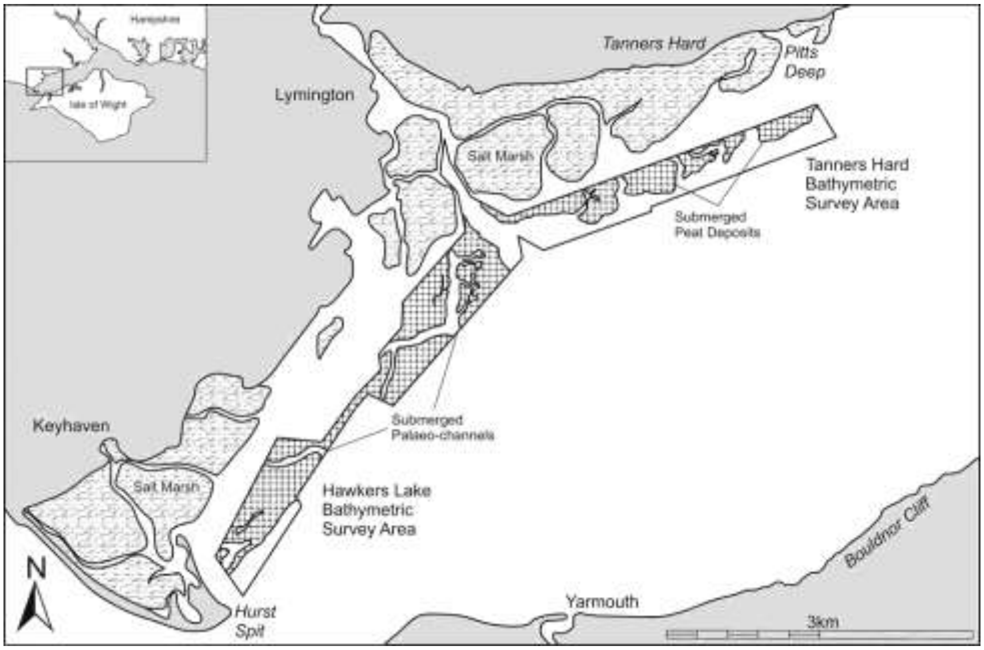


Figure 3D.38: Peat deposits in north west Solent are signified by the hashed boxes. The data was collected by Bathymetric survey.

Monolith samples taken from Tanners Hard in 2000 were subject to palaeo-environmental analysis and radio carbon dated. The samples were taken from a well-defined section along the submerged cliff. The base of the upper peat platform which sat at a depth of -4m OD was dated to 5510 +/- 70 BP (2 sig cal BC 4470 to 4240) (cal BP 6420-6190) (Beta-166477) (Figure 3D.39). The lower peat, beneath the silt at a depth of -7.7m, provided a date of 6170 +/- 60BP (2 sig cal BC 5290-4940) (cal BP 7240-6890) (Beta-166478).

Figure 3D.39: Section at the top of the 1.5m high cliff off Tanners hard. The peat deposit is 0.2m thick.

Monitoring survey at Tanners Hard

In 2000 a grid was set up on the edge of a 1.5m high cliff 1.5km south of Tanners Hard on the New Forest coast of the north west Solent. A key datum was a railway wheel laid 5m south of the cliff edge (Figure 3D.40). The peat deposit was 0.2m thick all the way to the edge of the cliff. The cliff at this point dropped vertically for a distance of 9m. Its angle of repose reduced to the east and west of the vertical section.

Figure 3D.40: The railway wheel that is used as a sinker and monitoring point for cliff erosion.

The 2012 inspection and survey was conducted at the same spot. The large circular sinker positioned 5m south of the north facing cliff edge in 2000 was relocated and its position relative to the cliff edge was recorded. The measurement was taken from the centre of the wheel, as it was in 2000, and recorded as 3m. This demonstrated erosion of 3m. However, the erosion was greatest along the edge of the cliff. The vertical drop recorded in 2000 had now been reduced to a slope of about 45 degrees and the peat along the cliff edge has thinned with patches of silt showing through. The erosion could be natural but the evidence suggests it has been trimmed by fishing activity where lines scrape along the edges of the cliffs.

The baseline was relocated and the measurements concurred with the direct distances recorded from the railway wheel. Monitoring pins were placed to the west of the sinker in a new survey area at Pitts deep at 7m offset from the cliff edge. Offset measurements were taken to two peat edges north of the cliff.

The loss of the mud flats along the north west Solent are having a direct impact on the coast line. A visit to Pitts Deep, which lies 1 km to the east of Tanners Hard, following the storms in January 2014 revealed extensive erosion of harbour structures that date back to the 16th century. Material had been removed for the first time since the harbour was built (Figures 3D.41 and 3D.42). This level of destruction will be ongoing if the saltmash continues to erode. The submerged landscape provides a shallow water breakwater that reduces the energy of the waves. Once it is gone, the erosive forces along the shore will increase.

Figure 3D.41: The loss of mudflats from the north west Solent have reduced protection for the coastline. Erosion of infill deposits from this post medieval jetty at Pitt's Deep during the winter of 2014 now make the cultural site and the shoreline much more vulnerable.

Figure 3D.42: Layers of wattle that would have been laid beneath the jetty infill are now exposed and eroding. These probably date to the 18th century although Pitt's Deep was known as a harbour when the first charts were drawn up of the area in the Elizabethan Period (17th century).

3D4.1.5 Hurst Spit

Hurst Spit is situated at the entrance to the Solent. There is a distance of 1.2km between the tip of the spit and the soft eroding cliffs behind Fort Victoria Country Park where the seabed plunges into the 60m depths of Hurst Narrow (see section - *Current coastal and submarine processes* – above). Where Hurst Spit reaches out in the mouth of the western Solent it has protected a palaeo-landsurface that bridges over half the distance between the mainland and the Isle of Wight.

Diving survey in 2012 identified a submerged peat deposit to the west of Hurst Spit. This is an area that is exposed to the predominant westerly storms. The spit has migrated to the east across this palaeo-landsurface so the date and character of the land can provide information that can inform the processes of change that led to the current geomorphological configuration of the spit and formation of the Solent. In 2012 and 2014 the peat deposit to the west of the spit was inspected and samples were collected for palaeo-environmental analysis and dating.

Sampling

A peat sample was located 0.5 km from the end of the spit (50º 42’ 26”N, 01º 33’ 38” W), from an outcrop of submerged land on the western side from the shingle spit at c.4m below OD. A section of the protruding deposit was recovered with a hand saw (HS01). Its orientation was labelled, it was sealed in a zip lock bag and recovered to the surface for further analysis and sub-sampling. Two samples were taken; one from near the base of the peat and the other from near the top. Unfortunately, the covering sediment was missing and the amount of the surface lost by erosion was unknown. This compromised the accuracy of the dates as an index points for sea level rise, however, when complemented with palaeo-environmental analysis of pollen, diatoms and foraminifera, the relationship to sea level rise within the changing environment could be resolved.

Results

The sediment samples raised from the submerged land off Hurst spit were subject to palaeolenvironmental investigation and radio carbon dating. Well preserved pollen and spores where recovered from the sample (HS01) which gave two radiocarbon dates of 3690+/-30BP (2190 to 1980 Cal BC) (*Beta*-366543) and 3780+/-40BP, (2290 to 2140 Cal BC) (*Beta*-366542). The pollen report, produced by Dr Rob Scaife, concluded that the area the sample had been recovered from was once wooded, and the dominance of hazel pollen suggests that the on-site vegetation comprised relatively dry woodland with sufficient moisture to enable humic accumulation. Oak is present and would certainly have been growing within the overall hazel woodland. It is possible that ash and lime may also have been growing on nearby well drained soils as they are generally poorly represented in pollen assemblages unless the sample site is in close proximity to their growth (Andersen 1970, 1973). A very limited herb pollen flora is attributed to the ground cover of the site, especially enchanter’s nightshade and sedges (Figure 3D.43). Evidence of acid heathland communities was nearby and a wet *sphagnum* mire community is seen to develop in the upper levels of the peat. Interestingly this acid plant community reflects the sand Tertiary lithology lying north of the chalk ridge and is comparable with the heathland of adjacent Headon Warren on the Isle of Wight. Samples taken from three submerged peat beds at Bouldnor Cliff also demonstrated the expansion of Sphagnum in the western Solent in the uppermost of the peat beds (Scaife 2011) where there is a similar change to a more acidophilous *Sphagnum* community. A late prehistoric radiocarbon date of 5580+/-60BP (4525-4330 Cal BC), (Beta-140102) from underlying sediments demonstrates that this change occurred during the late-prehistoric period. *Sphagnum* may have developed over quite a substantial area of the low lying and now submerged western Solent as demonstrated at these two sites with similar ages. Other than a single record of Chenopodiacea in the upper level of the sample it is concluded that there are no indications of impending saline conditions although transgression must have taken place at a later date. Analysis showed that the sample did not contain any diatoms or foraminifera, which is indicative of a terrestrial land surface without a maritime influence.

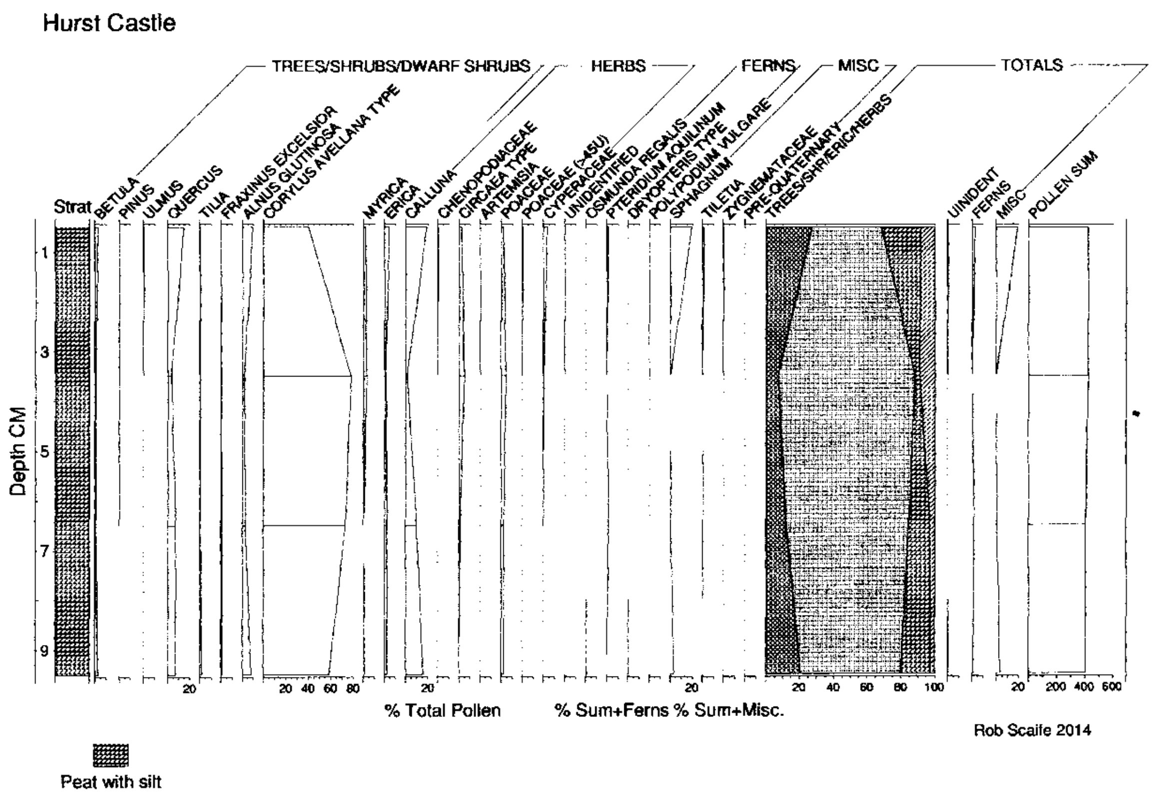


Figure 3D.43: Pollen diagram from Sample HS01, off Hurst Spit, Hampshire.

Interpretation
The sample was recovered from immediately to the west of the spit and represents a landscape without the immediate influence of marine conditions. The environmental characteristics compare favourably to the changes seen in the upper peat deposits within the western Solent. These were formed on top of an earlier mud flat and prior to further inundation, however, they occurred a couple of thousand years later. The sites from within the Solent were recovered from a depth of -4.1m below OD off Bouldnor Cliff with a date of 4525-4330 Cal BC (Beta 140102) and in -4.0m below OD in Tanners Hard dating to 4470-4240 Cal BC (Beta166477).

The sample from Hurst Spit (HS01) is from a similar depth to those in the Solent which is unusual as it was dated to over 2,000 years later. It was formed during a period when sea level was rising, so, when compared with the western Solent sea level curve, it should have been inundated. However, it was dry land. Another sample from the east of Hurst Spit (HSE1) was dated to 1900–1690 Cal BC (Beta-270797), which was only 2-300 years later. It came from a landscape that was 2.5 m below Ordnance Datum (OD). The difference in heights could be accounted for by a fall in sea level between 4,000 and 2,000 BC (which is contrary to the sea level curves along southern Britain), or compaction (that is probable and could contribute to it being in a deeper depth, but the sample was recovered from next to a tree bowl that was round rather than oval, whereby suggesting compaction was limited), or it could be caused by a larger tidal range in the Solent caused by funnelling along the Estuary. Today, the funnelling effect of the Solent and Southampton Water on the tide between the open sea and Southampton, which lies towards the top of the estuary, is around 0.6m. If the high tides were 0.6m higher in the Solent 4,000 years ago, the saltmarsh or mudflat would have developed at a similarly elevated height. If the western Solent was still an estuary when the land on the east side of the modern-day Hurst Spit was formed, as dated by sample HSE1 to 1900–1690 Cal BC (Beta-270797), the funnelling effect would explain the relatively high salt marshes in the Solent. If the Solent was an open waterway, this discrepancy would not exist. This infers that the Isle of Wight was still connected to the mainland at this location around 3,800 years ago.

The evidence from the relative dates and depths of the earlier land surfaces is significant enough to hypothesise a late formation of the Solent, but it would still be beneficial to calculate the extent of compaction to refine our understanding of relative sea level. This is also important to the assessment of coastal stability along the spit. The issue of stability relates to the migration of the spit over underlying landscapes. If a spit or beach is being forced uphill, it will invariably meet more resistance and travel more slowly. However, if it is pushed along a flat surface or downhill, it will be less stable and be more vulnerable.

Diving fieldwork in 2014 included a further inspection of the peat deposits along the west of Hurst Spit, 900m from the reverse end (50º 42’ 28”N, 01º 33’ 50” W). At this location, a wide expanse of peat was evident. This was inlaid with tress and vegetation. The deposit was at a depth of 5.5 to 6m below OD. The peat overlays soft clay sediment that is at least 1.3m thick. Following ground-truthing by divers, the peat deposit was identified on bathymetric data supplied by the Channel Coastal Observatory (Figure 3D.44). The peat deposit is truncated in the west along a cliff that mirrors the line of the spit and continues towards the spit in the east (Figure 3D.45). The spit is known to have migrated to the east in historic times. As it has moved, it would uncover land to the west that was once protected. Hordle Parish Saltern, which was shown on the east side of the spit on the Murdoch MacKenzie chart of 1781, appeared on the west side of the spit following a large storm in 1989. This meant the spit moved around 100m in 200 years. Therefore, it is probable that the spit migrated east away from the peat deposits that are now exposed underwater. It should also be noted that the peat creates a dipping seabed which travels steadily upslope towards the current beach at a gradient of approximately 1:10. It is possible that the peat has suffered greater erosion to the west, although, long term horizontal erosion has formed a submarine cliff. If this does represent a slope, it means the beach complex including the spit has ascended to the crest of the relict hill.

The evolution of Hurst Spit has been dependent on the long term geomorphological processes that formed the western Solent. This has dictated its past response to maritime forces and it is influencing its response to current and future storm events. This information is fundamental when assessing the long term management of the spit.

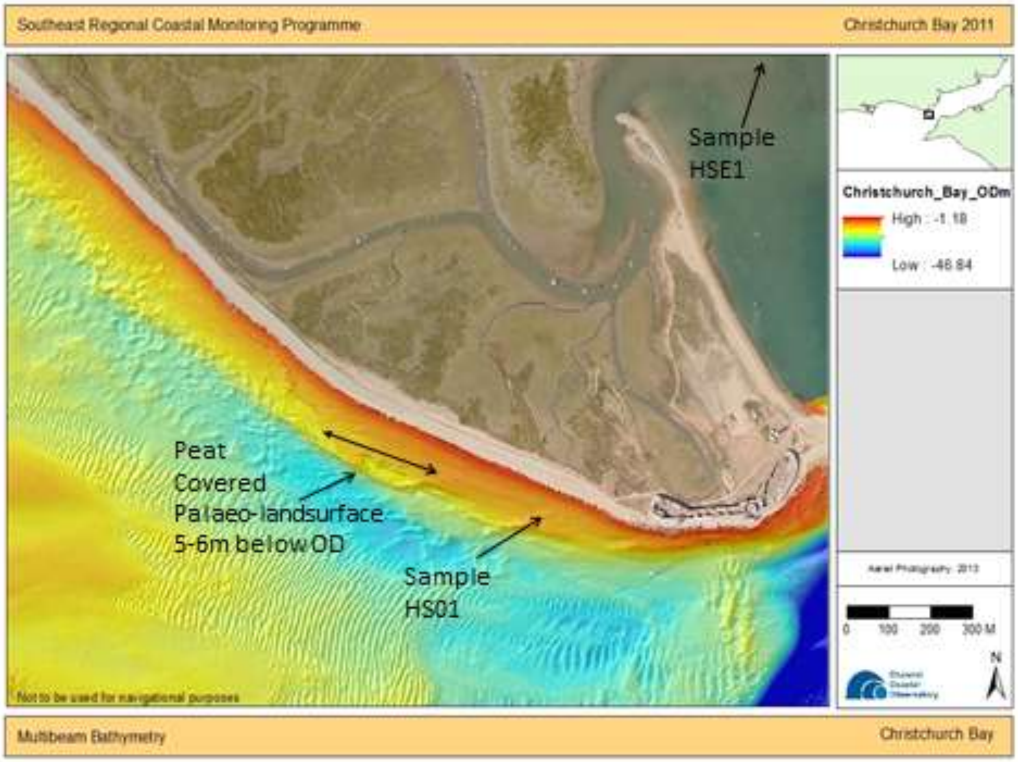


Figure 3D.44: Bathymetric data showing the seabed west of Hurst Spit. Image kindly provided by the Channel Coastal Observatory.

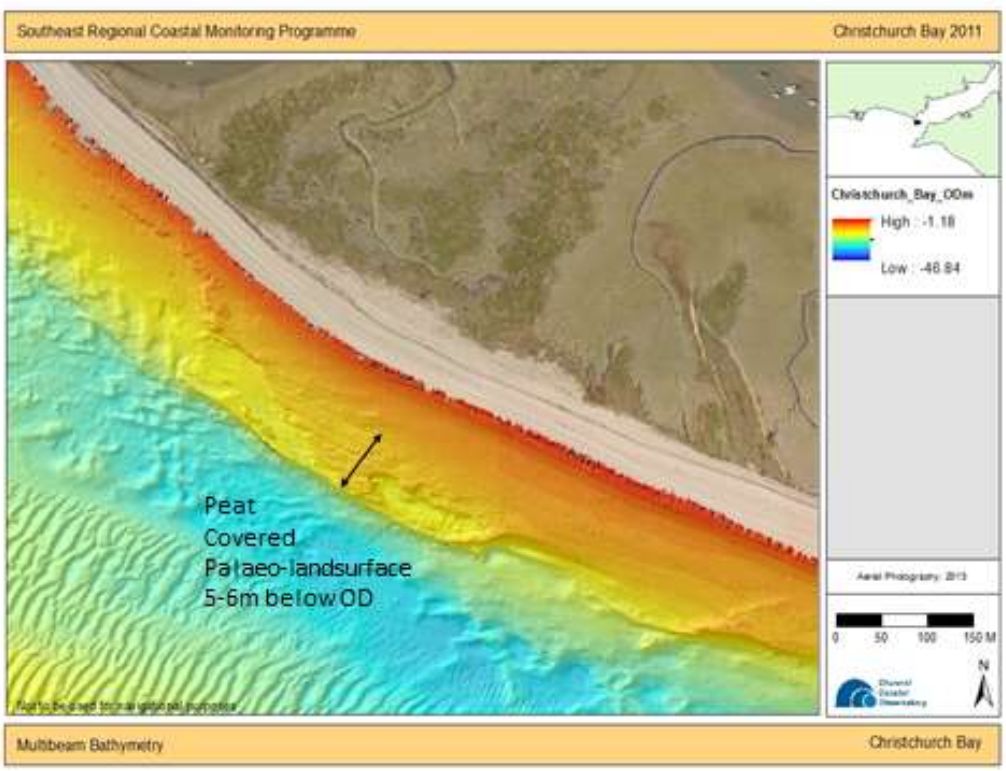


Figure 3D.45: Close up of the bathymetric data highlighting the peat deposit on the seabed west of Hurst Spit. The peat forms a slope from east to west. Image kindly provided by the Channel Coastal Observatory.

3D4.1.6 Wrecks of Alum Bay

Alum Bay itself is located on the north west coast of the Isle of Wight (Figure 3D.46). Needles Point and its famous surrounding rocks are the most westerly point of the island and are located at the extreme western end of Alum Bay. The coastline of the bay forms steady curve, bounded by high chalk cliffs prone to rock-falls and landslips along the southern edge with bands of coloured rock along the eastern side. Alum Bay is bordered to the north-west by the Needles Channel.

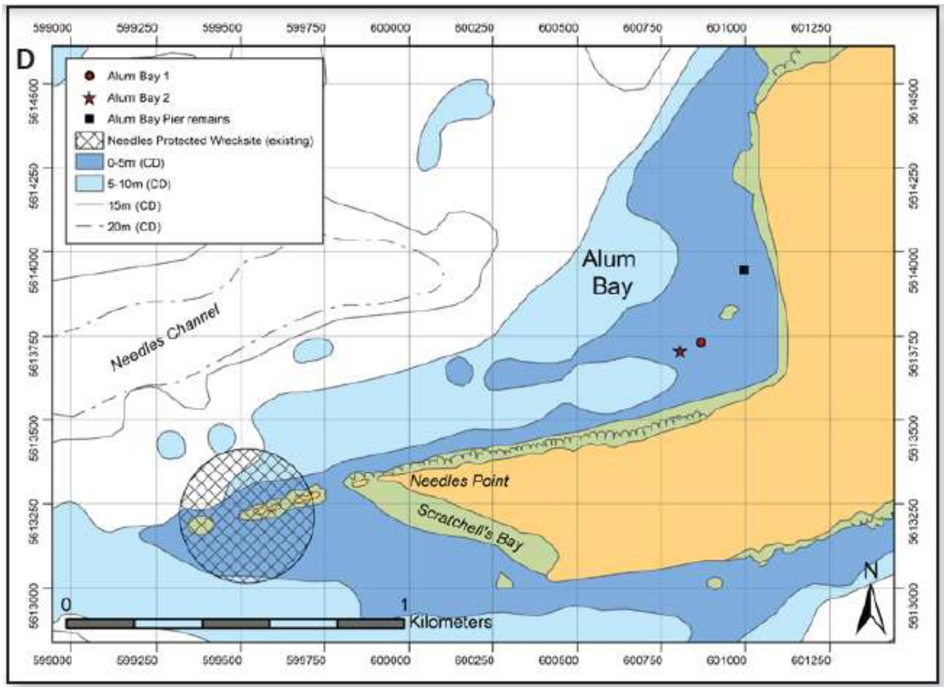


Figure 3D.46. The location of the wrecks within Alum Bay

3.1.1 Geology and Seabed

Alum Bay lies within the Greater Poole and Christchurch Bay region as defined by the South Coast Regional Environment Characterisation (SCREC). Christchurch Bay is a relatively shallow embayment, defined by Hengistbury Head in the west and Hurst Spit and The Needles in the East. The underlying geology of the area is of Wealdon Beds to the south of a line running between The Needles and Purbeck, a thin strip of Lower Greensand/Gault and Upper Greensand lies to the north of this. The remainder of the area to the north is comprised of Bracklesham Beds, Barton Group and Solent Group (cf. Velegrakis, 2000: 23-25 & Figure. 3D.47). Alum Bay lies just at the intersection of these and the chalk outcrop that traverses the centre of the Isle of Wight (Figure 3D.47). This has resulted in the famous coloured rocks along the eastern cliff of Alum Bay and the notable contrast between those and the chalk cliffs and stacks of the southern edge of the Bay and the Needles proper (Figure 3D.48).

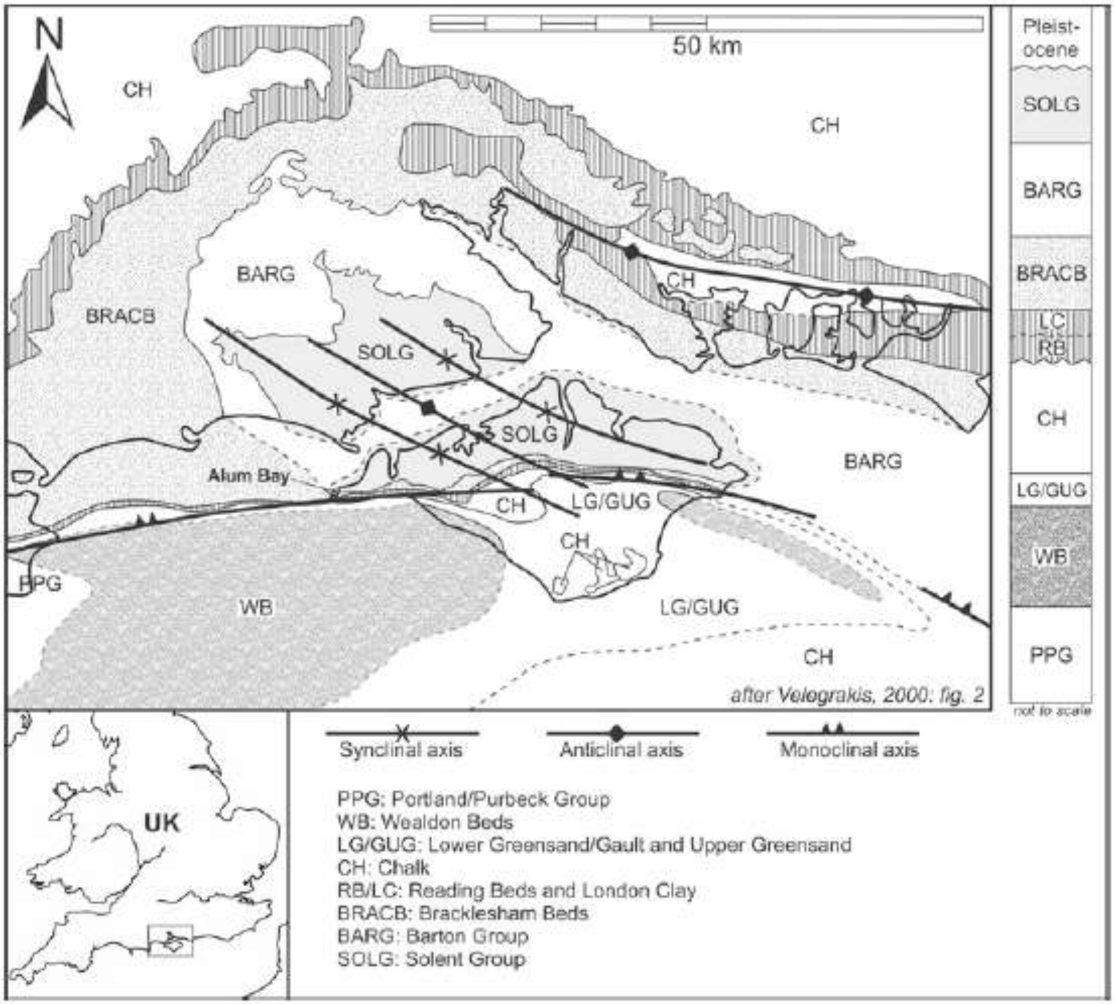


Figure 3D.47: The geological context of Alum Bay (after Veligrakis, 2000).

Figure 3D.48: The Needles, Needles Point and Alum Bay looking east from the Needles Channel. The inner reaches of Alum Bay can be seen where the cliff geology changes from white chalk to coloured sands.

In the south of Alum Bay, the Reading Beds and London Clay dip steeply (SCOPAC: Western Solent, E5&6) and all strata in Alum Bay are soft and easily eroded, comprising clays, sandstones and occasional grit and pebble horizons. There is ongoing erosion of the high chalk cliffs that line Alum Bay, although little quantitative work has been undertaken on the scale and pace of change (SCOPAC: Western Solent, E5&6). Erosion occurs as the cliffs are undercut and destabilised through marine erosion, leading to infrequent, localised rock falls, depositing debris on the cliff base and beach, which is then gradually removed by marine processes before the cycle is repeated (Figure 3D.49). The erosion of these cliffs has been cited as being an important source of gravel and course sands for local beaches while finer sands, silts and clays derived from the cliffs are thought to be susceptible to rapid suspended transport offshore. The seabed in the area is a thin layer of sandy-gravel, overlaying bedrock. Within the SCREC, the seabed at Alum Bay is described as 40-50% gravel and 50-60% sand, this comprises poorly-sorted granules with a mean diameter of 2-4mm.

Figure 3D.49: High chalk cliffs characterise the shoreline along the southern side of Alum Bay and are subject to on-going erosion resulting in significant landslips (Photo: Ine Demerre)

Observation during fieldwork within Alum Bay indicates that the seabed around the two wreck sites consists of sandy silt which overlies the bedrock. A seabed sample was taken from the area of Trench 3 during the 2010 fieldwork, prior to the excavation and removal of sediment from this area. The sample extended between two of the vessel’s frames to the depth of the outer hull planking. As such, the sample encompasses the sediment overlying the wreckage following its deposition.

Assessment of the sediment has identified four distinct layers all comprised of sand. Each of these layers is c.25mm thick and very distinct in nature. From top to bottom these layers are described as follows:

1. Upper mobile yellow sand.
2. Beige sand.
3. Very dark-grey sand.
4. Mid-grey sand.

It has been possible to correlate the assessment of the recovered seabed sample from AB1 with existing diver observation of the sediment composition made during survey and excavation of AB1 and survey of AB2. This indicates that sediment disposition, prior to any excavation or disturbance has been broadly similar across both sites, resulting in a thin layer of sediment covering both sites.

Tidal and Sediment Regime

Alum Bay is exposed to tidal currents and modified open sea, including swell and waves. Maximum significant wave heights of up to 2.3m might occur at a 1 in 50 or 1 in 100 frequency. The general tidal patterns in the Solent are complex (see Bruce, 2008) and the relationship between the tidal streams in Alum Bay and those in the western Solent and Needles Channel no less so. In the Needles Channel, north-easterly tidal flow peaks at 3.7 knots, 5 hours prior to high water (Portsmouth) springs (Bruce, 2008: 10) and the south-westerly tidal flow at 3.3 knots, 3 hours after high water (Bruce, 2008: 26).

The sediment regime in the surroundings of Alum Bay is twofold. Offshore, the over-riding regime is one of the south-westerly transport of sediment from the western Solent and Hurst Spit along Hurst Channel and the Needles Channel. This is partly related to the tidal regime in the area. Tidal flow is broadly asymmetric, with a concentration of the ebb tide into a shorter time period than the flood tide, with a correspondingly higher potential for sediment transport in a seaward direction. The potential for sediment transport against this general regime has also been noted and in the case of coarse sediment transport this is seemingly the result of high wave energy coupled with a storm surge (SCOPAC: Western Solent, F1). Meanwhile, fine sediment may be transported in a north-easterly direction during the longer flood tide. Inshore, within Alum Bay, there is a net littoral drift from southwest to northeast leading to the transport of flints, sand and gravel from Alum Bay towards Totland (SCOPAC: Western Solent, LT4) and net offshore loss of fine sand in Alum Bay has been suggested (Brampton *et al*., 1998).

In comparison to the rest of the Isle of Wight, Alum Bay has received far less study and is correspondingly less well understood. Survey, monitoring and reporting of beach profiles to advise on sediment erosion/accretion has taken place around the Isle of Wight as part of the Southeast Strategic Regional Coastal Monitoring Programme (see Crocombe, 2008; Case, 2009a; 2009b). However, the Totland 1 cell (containing the western half of Alum Bay) has either not been included in the topographic survey so far undertaken through this programme (Crocombe, 2008: 12) or the survey has been delayed (Case, 2009a: 21; 2009b: 18). Some data is available for the Totland 2 cell (containing the eastern half of Alum Bay). Where monitoring of beach material has taken place, it has revealed an overall loss of material between 1996 and 2002 (Bradbury *et al*., 2003). Analysis of the northern half of Alum Bay between 2003-2004 illustrates an accretion in the cross-sectional area of the beach caused by a steepening of the profile (Crocombe, 2008: 19, 150-2). The northern half of Alum Bay has been classified as being in ‘retreat’ at the mean high and low water marks with a classified *foreshore change parameter* of -6 (Crowcombe, 2008: 19). It has been suggested within the context of the work of SCOPAC that future increases in rates of sea-level rise and winter rainfall would have the potential to accelerate the landslides on the cliffs within Alum Bay, with an increase in the supply of sediments to the sediment transport system just outlined, as a result.

On-site Sediment Levels

As part of the Arch-Manche project diver survey was undertaken to record sediment levels in the vicinity of the two areas of historic shipwreck (Alum Bay 1 and Alum Bay 2). Observation since 1993 on Alum Bay 1 and 2001 on Alum Bay 2 suggests that the level of sediment has changed at either site, in different ways and that any observed changes tend to be quite localised in nature. In general, it may be stated that the levels of sediment at both sites have remained relatively stable over the last decade or so, although there has been an observed reduction in sediment, and associated exposure of wooden structure, at the site of Alum Bay 1. However, there has been no dramatic exposures of 'fresh' structure or significant accumulations of sediment.

At the site of Alum Bay 1, there has been a slight reduction in sediment cover over the archaeological remains, this is more pronounced around the hawse-hole structure that protrudes from the seabed at the northern end of the site (Figure 3D.50). There, the hawse pipes have become far more visible than in previous decades and wooden material has become exposed and degraded away. Meanwhile, the photographic archive from Alum Bay 2, located slightly further towards the Needles Channel, suggests that sediment has accumulated on the site since 2001, obscuring the exposed framing timbers at the northern end of the site (Figure 3D.51). It may also be noted that the low laying nature of Alum Bay 2 means that it has been particularly prone to changes in sediment levels, with small increases greatly obscuring the site.

This general observation seems at odds with the overall sediment regime model for Alum Bay and the surrounding areas (above), which indicates that there should be net sediment loss within Alum Bay, rather than the relatively stable levels of sediment that seem to be present over the last decade or so. A possible explanation might be that while fine sediment is being transported in a generally north-east direction from Alum Bay towards Totland, similar sediment is accumulating around some areas of the two wreck structures as a result of sediment movement from the south-western end of Alum Bay within the overall north-easterly trend. The reef that lies to the north of both sites may be having an impact within this process by reducing sediment transport to the north. It should also be noted here, that the period of archaeological diver observation on the two sites has taken place over a much longer time frame than the limited investigation into sediment movement within Alum Bay itself. Broadly speaking, Alum Bay 2 appears to be better protected, at the time of writing, than Alum Bay 1; the former being subjected to slowly increasing levels of sediment, while the latter is seemingly subject to slow reductions in sediment levels.

Figure 3D.50: Changes to sediment levels at the site of Alum Bay 1 in the area of the hawse holes. Top: 1993, Middle: 2001, Bottom: 2003 (photo Roland Brooks). Overall sediment levels seem to be gradually falling in this area of the site, leading to the exposure and subsequent destruction of wooden structural material.

Figure 3D.51: Changes to sediment levels at the site of Alum Bay 2 wreck in the northern area of the site where framing timbers are most exposed. Top: 2003, Middle: 2003, Bottom: 2013 (photo Roland Brooks). Overall sediment levels seem to be gradually increasing in this area of the site, affording the wooden remains protection from marine organisms and erosion.

3D.4.2 Langstone Harbour

Fieldwork was carried out in Langstone Harbour in September 2012 and June 2013. A large archaeological project was carried out in the harbour in the 1990's with further work carried out by the MAT in 2002-2004. This work demonstrated the rich archaeological resource of the area and how modern erosion is exposing more material off islands located in the north of the harbour over time. Work as part of the Arch-Manche project aimed to re-survey some of the areas previously investigated and undertake further intertidal survey and sampling.

Key Research Questions

The archaeology ranking criteria demonstrated that archaeological and palaeoenvironmental remains can inform on past coastal change through the information they contain on past environments, or their location relative to changes to the coastline. The fieldwork conducted in Langstone Harbour over the two seasons of investigation aimed to gather information to answer the following research questions:

- What can the archaeological and palaeoenvironmental data collected from Langstone Harbour tell us about the past environment?
- How can this information be used in conjunction with previous survey work to inform on the changing landscape of the harbour over time?

The fieldwork aimed to collect a variety of different types of data from key areas of the harbour that had been identified as important by previous studies. These included the islands present in the north of the harbour, which are known to be the last vestiges of the prehistoric landscape prior to inundation; the west coast of Hayling Island, where numerous finds and wooden features have been identified; the channels of the harbour itself; and the location of the Sinah Circle.

The key objectives of the fieldwork were to:

- Establish whether further sites, features, deposits or finds of archaeological interest currently lie exposed off the coasts of Long Island, North Binness Island and Bakers Island;
- To gather detailed survey data on archaeological exposures to aid understanding of the landscape over time;
- To further investigate a palaeochannel and associated peat deposits which had been identified through augering off the west coast of Long Island;
- Determine whether other palaeochannel features lie buried below the current foreshore levels;
- Locate and investigate 'flint walled building' and associated complex of banks on Bakers Island; and
- Recover material for analysis and dating where it has the potential to add to understanding of coastal change.

Fieldwork Methodology

The following methods were used;

Walkover surveys – these were carried out in order to identify sites, features and finds which may have eroded or been exposed at the fieldwork sites. Positions were taken using a Real Time Kinematic (RTK) GPS along with a photograph. Artefacts were recovered if at risk of loss and archaeologically significant.

Monitoring of previously recorded sites – sites recorded during the 1990's Langstone Harbour Project and the 2002-2004 survey work were revisited to determine whether they were still in-situ or had been eroded. Positions were recorded with the RTK GPS system and photographs taken.

Landscape survey – the RTK GPS system was also used to survey the current edge of two islands in Langstone Harbour, focussing on the base of the small cliff which marks the extent of erosion.

Photographic survey – Photographs were taken of all the sites in Langstone Harbour, these and the associated index sheets are stored on the MAT servers.

Sampling – samples were recovered from the timber structures off Hayling Island and sent for radiocarbon dating along with samples from the auger survey.

Positioning - A Leica 1200 Real-Time Kinematic (RTK) GPS system was used to record the precise position of sites and areas of landscape. The RTK system provides accuracy to within +/- 15mm. Data collected can be imported into GIS for further processing, management and analysis. For archiving purposes, all basic data is retained in the form of a simple .txt file to ensure full future access to the original data collected during the survey.

Auger Survey - This was carried out off the west coast of Long Island with the aim to track the buried palaeochannel identified during previous excavations in the area. The survey was carried out using hand augers, both a gouge and dutch head were used (Figure 3D.52). Samples were assessed on site, with examples being recovered for further analysis and dating. The relative depths of the different soil types were noted when analysing the samples, so as to build a geological/stratigraphical sequence of the sediments.

Figure 3D.52: Auger Survey off Long Island, Langstone Harbour

Marine Seismic Investigations - As on land, reflection seismic measurements at sea involve the use of a sound source, towed behind a vessel or mounted to the hull, to generate acoustic waves that travel through the soil. Part of the acoustic signal is reflected from the seafloor but the remainder penetrates the seafloor and is reflected when it encounters boundaries between layers with different elastic properties. The recorded reflected acoustic waves result in a continuous record of the sub-seafloor stratigraphy.

Several physical parameters (frequency, output power, pulse length) determine the capability of the chosen technique. High frequencies provide higher resolution, but are limited in amount of penetration below the seafloor whereas lower frequencies provide lower resolutions but better penetration. Increasing output power allows for greater penetration but in the case of a hard seabed or very shallow water this will yield strong multiple reflections (i.e. seafloor echo) and lower signal to noise ratio. Finally, long pulse lengths yield more energy and result in greater penetration but will decrease the resolution. Shorter pulses correspond to broader bandwidth frequency response, thus increasing the resolution.

Figure 3D.53: Marine Seismic survey in Langstone Harbour. Upper left: Installation of the transducer pole onto the RIB. The pole is attached to a tilting system that fits over the inflatable hull. Upper right: transducer pole tilted horizontally during transit; GPS and motion sensor are on the right. Lower left: Data acquisition on board the RIB in Langstone Harbour. Lower right: close-up of the SES acquisition unit.

In Langstone Harbour a parametric echosounder was used. This source, which is mounted onto a pole attached to the side of the boat emits two signals with a different frequency (Figure 3D.53). The high-frequency signal (100 kHz) allows a very detailed image of the sea floor. The lower-frequency signal (between 6 and 14 kHz) penetrates deeper, resulting in an image of the underlying structure. The fast pulse rate (20-25 pulses per second) resulted in a high lateral coverage. During the measurements the echosounder was attached on a long iron pole fastened to the side of the ship. A motion sensor was used to filter out the wave movement. Positioning was done using a DGPS antenna with an accuracy of ±1 m.

Fieldwork Results

The map below (Figure 3D.54) presents the main areas targeted by fieldwork.

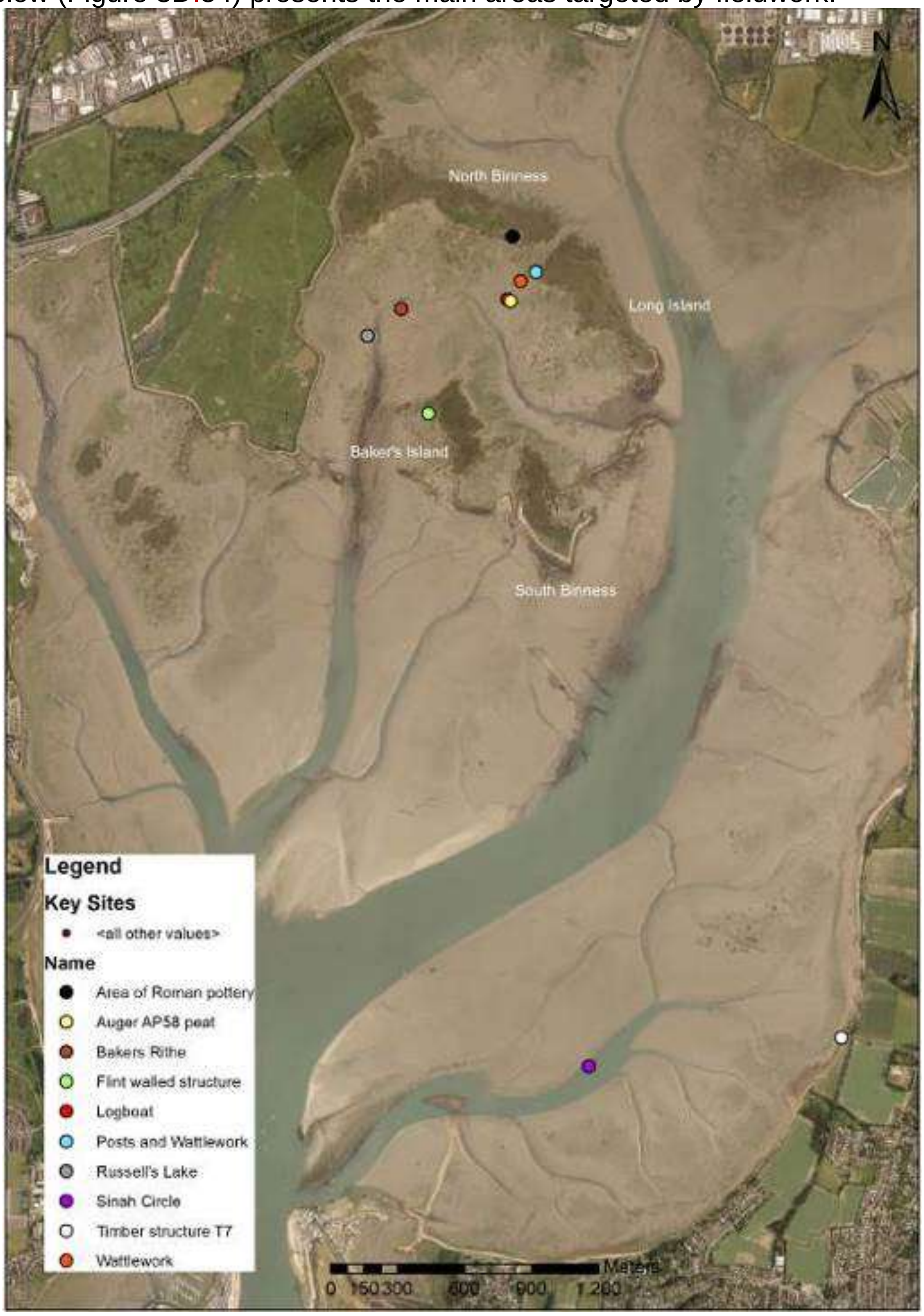


Figure 3D.54: Location of key fieldwork sites in Langstone harbour.

Walkover Survey and Monitoring Previously Recorded Sites

Walkover survey was carried out on the west coast of Hayling Island and around the four islands in the north of the harbour. Any sites and finds were photographed and the position was recorded using the RTK GPS system.

On the west coast of Hayling Island the focus of the fieldwork was on several timber structures identified through the 1990's Langstone Harbour Project. These were thought to be fish traps, which if dated could provide important information on relative sea level at the time of construction.

With the help of students from the University of Southampton, one site, T7, was selected for detailed investigation and dating. This site was thought to be a fish trap with a possible medieval date (Allen & Gardner, 2000:80). The site was planned and two samples recovered for dating. Radiocarbon results gave a date of AD cal 1650-present. This alongside other historical evidence including historic maps suggest that this structure and the other similar structures along the west coast of Hayling Island are extensions of the field boundaries into the intertidal area of the harbour. It was common practice to graze livestock in a saltmarsh environment.

Even though these structures are more modern field boundaries, they are able to provide detailed information on coastal change. Analysis in combination with historic maps and photos, demonstrates that there has been a rapid loss of salt marsh environment with areas where livestock would have grazed becoming mudflats. These structures can therefore provide information on the changing environment of Langstone Harbour over the last 300 years.

Figure 3D.55: Location of site T7 on the west coast of Hayling Island, the aerial photo (courtesy of the CCO) has been overlaid with a 1st edition OS map. The site corresponds with the field boundaries.

Sites off Long Island were also re-visited. This included an area of wattlework discovered in 2002 which was dated to 790-1030 Cal AD. Searches around the area were not successful in finding any of these remains, these may have since been eroded. Slightly further north and closer to Long Island another area of wattlework and timber posts recorded in 2002 were re-located (Figure 3D.56).

This area of four posts and wattlework lies on the very edge of Long Island. This feature consists of four posts arranged in a square with an area of wattle work on the northern side. There is also an area of flint nodules to the east of the structure which may be associated.

Figure 3D.56: The four post structure and wattlework off Long Island.

The timbers appear to be square in section, indicating they are likely to have been worked or sawn into shape. Two timbers are larger, these are on the eastern side of the feature, the western timbers are smaller. The south east timber measures 20cm x 10cm in section, the height above the foreshore was 0.30m, the north east timber is 10cm x 10cm and 0.29m high, with the western timbers measuring around 8cm square, the SW being 0.24m high and the NW 0.21m. The wattle remains lie less than 2 metres to the north of the timber posts. The western edge of the structure lies at 0.65m OD, with the eastern edge slightly lower at 0.61m OD.

The areas where wattlework has been discovered are now predominantly mudflats, suggesting that in the early Medieval period this area may have been a much different environment, possibly saltmarsh for grazing livestock. Another site further south in the harbour dates to a similar period, the Sinah Circle. Both sites can provide information on the late Saxon/early Medieval environment.

The Sinah Circle is a circular timber feature located within Sinah Lake in the south east corner of the harbour. The site is submerged other than on exceptionally low tides, one of which was experienced in March 1993, when the site was first noticed by local fisherman Mr Arthur Mack who indicated the tide was the lowest he had seen for 40 years. The waterlogged environment has aided the preservation of the site which consists of upright wooden posts with wattle woven in between in a circular form measuring 6 metres diameter.

Sinah Circle is important in terms of the information it can provide on coastal change. If the structure was related to oyster farming as is the current interpretation, then its position in relation to high and low water as well as accessibility would have been important. Based on later oyster beds from the 19th Century, such structures are generally located in the intertidal zone, they are positioned so that they retain a small amount of water at low tide to keep the oysters alive, but can still be accessible.

The last time the site was exposed was during an extreme low tide in 1993. This would indicate that mean sea level has risen since the Sinah Circle's construction. Mean high water springs in Langstone Harbour are 4.8m above Chart Datum/2.1m above Ordnance Datum (OD), Mean Low Water Springs are 0.8m above Chart Datum/-1.9m OD. Sinah Circle is located at -2.7 to -3m OD (Figure 3D.57). This indicates that generally at low water there is still at least 0.8m of water above the structure. Allen & Gardiner (2000:202) suggest that Langstone became a harbour by the Late Iron Age, and that the location of the Sinah Circle at -2.7 to -3m OD suggests that it is a marine structure as opposed to being built at a time of lower sea level. If it is related to oyster farming as suggested in the publication, then with at least 0.8m of water above the site during low water springs would make it difficult to access, therefore suggesting that there has been a small rise in sea level since this time.

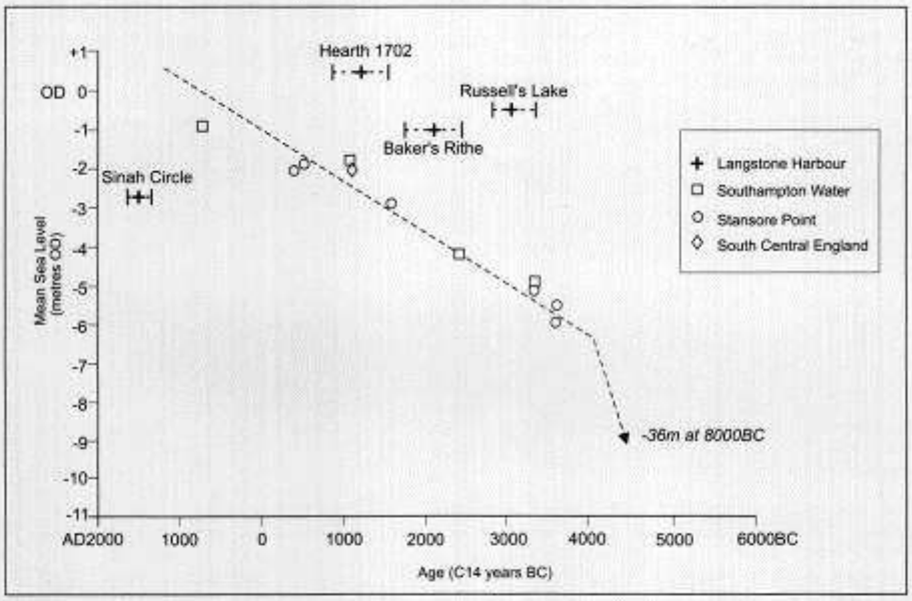


Figure 61 Mean sea-level changes (after Long and Scaife 1996, fig 17) with data from Southampton Water (Long and Scaife 1996) and Stansore Point (Long and Tooley 1995), and central southern England (Devoy 1982; 1987b, and Tooley 1990), and Langstone Harbour (this volume). Age errors of c ± 100 years and altitude errors of ± 0.5m should be assumed for each index point. Drawn by S E James

Figure 3D.57: Mean Sea Level Changes (Allen & Gardiner, 2000:202)

Further work is required in order to establish the function of the structure. If it is related to oyster farming then its position in relation to mean low water suggests that the structure can reveal more detail of the rise in sea level over the last 1000 years.

Another site which was re-visited was a small flint walled structure on Baker's Island. The island also contains the remains of WWII decoy structures which are now being affected by erosion. The islands were used as air raid decoys to divert planes away from Portsmouth.

Figure 3D.58: WWII decoy structures on Baker's Island. Structure on the beach are now being eroded.

.

The flint walled structure is marked on 19th century maps as 'old walls' and lies at the south west end of an elongated enclosure formed of a bank and ditch (Figure 3D.59). The building and 'field system' complex has been interpreted as either oyster beds or salterns, with an assumed Post Medieval date. As this site is potentially closely linked to activities which can demonstrate sea level change it was subject to more detailed survey in 2012.

Figure 3D.59: The remains of the flint walled building are highlighted in red, the associated banks can also be seen. Aerial photo courtesy of the CCO 2013.

Although the site was surveyed more detailed analysis is required in order to determine the date and nature of this site. Arthur Mack, a local fisherman informed us that historic records describe three families who lived on the island grazing sheep, the records also mention masonry buildings dated to the 16th Century AD. It is possible that this relates to the remains found on Bakers Island however, the oldest maps found of the area which date to the 18th Century, prior to the reclamation of Farlington Marshes, do not depict any structures on the islands.

Landscape Survey

The RTK GPS was used to record the edge of the small cliffs off Hayling Island and on Long Island. This data can be used to monitor erosion of the area over the coming years. In order to understand past changes it has been possible to compare the current high water mark with that recorded on the 1st Edition OS Map of Langstone Harbour from 1878 (Figure 3D.60). There has been up to 50m of erosion off Long Island and notable change on Bakers Island, however in some places there seems to be sediment accumulation, such as the northern edge of North Binness Island. There has been some work carried out by the landowners (RSPB) to build up the shoreline of the islands for nesting birds, further work is required to understand the nature and extent of this work.

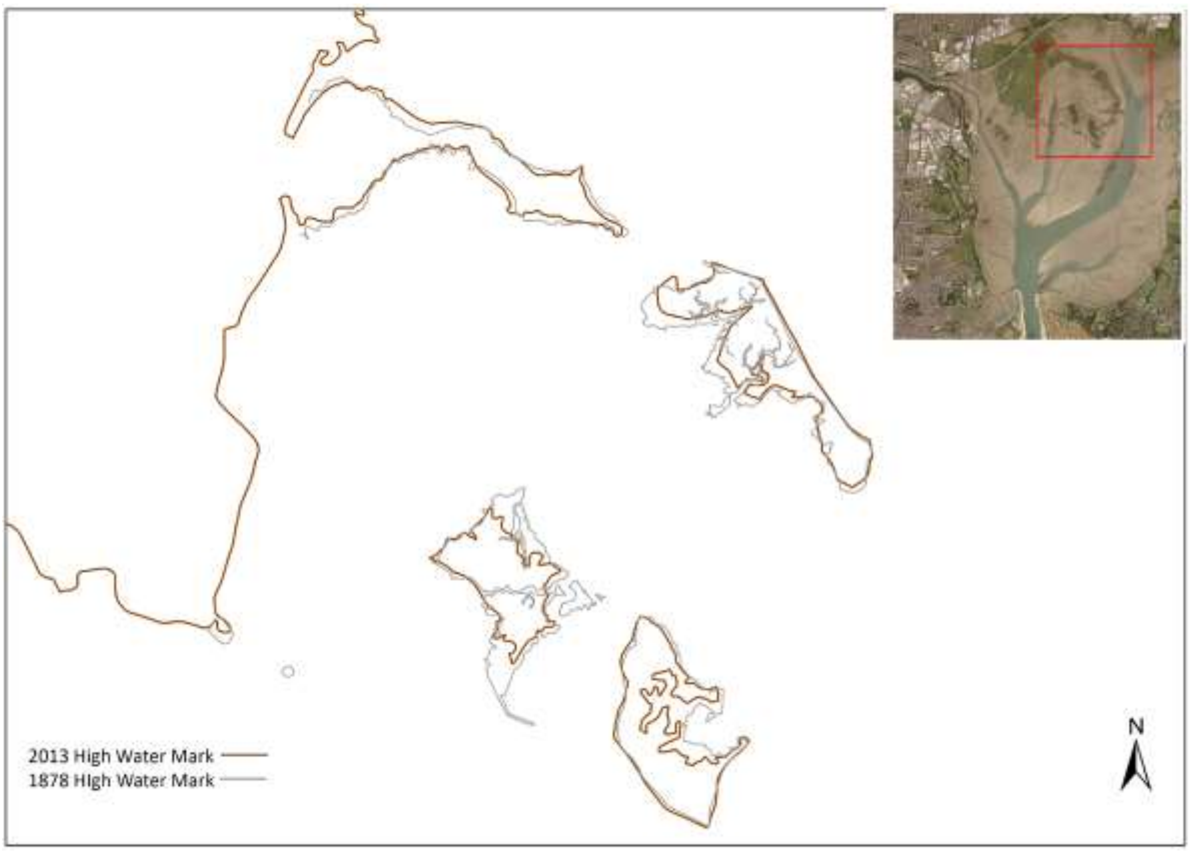


Figure 3D.60: High water mark from 1878 to 2013 around the islands, Langstone Harbour.

As well as assessing the change in the high water mark, it has also been possible to look at changes in the extent of saltmarsh in the harbour. A study in 2007 analysing saltmarsh change in central Southern England, demonstrated that between 1956 and 2001 around 71% of saltmarsh was lost from Langstone harbour (Baily and Pearson, 2007). It therefore seems likely that the harbour would have contained substantially more saltmarsh when structures like the wattlework and the Sinah Circle were built, meaning that it is likely to have been accessible at low water. The rapid reduction in salt marsh is demonstrated in Figure 3D.61. The extent of saltmarsh in 1946 and earlier would have made these sites more accessible by foot during low tide, today they are in a predominantly mudflat environment.

Figure 3D.61: The black lines show the extent of saltmarsh in 1946, the white shows the extent in 2005. Data courtesy of the CCO.

The precise cause of this rapid loss of saltmarsh over the last fifty years is unknown, dieback of Spartina is thought to have caused much of the saltmarsh loss in the Solent. Sea level rise, eutrophication and dredging may also play a part (Langstone Harbour Board 2009).

Auger Survey

The auger survey that was conducted off the coast of Long Island (Figure 3D.62) was able to re-locate the palaeochannel from the approximate area of the log boat survey which had been recorded in previous investigations. This palaeochannel was detected in four separate cores, and several of the other cores had potentially associated deposits relating to the development of the palaeochannel. Unfortunately, the penetration of the cores only reached 2.3m and although 14 cores were taken, the location of these cores were not able to capture high resolution detail on the path of the palaeochannel and there was little time to revisit the site in order to extend the survey area.

Figure 3D.62: Location of the Auger Survey, Langstone Harbour

The underlying geology of the area in the northern part of Langstone Harbour, where the survey took place, is chalk (Allen & Gardiner, 2000, 9), and although none of the auger cores went deep enough to reach this bedrock, it is not surprising that the base deposits contained chalk inclusions. The interpretation sequence is therefore based on deposits that lie on top of this geology; this sequence is as follows:

Unit 1: Base Deposit – The base deposit is a grey, silty clay that contains chalk inclusions from the bedrock. This deposit was recognised during the Langstone Harbour Project, and is thought to be either periglacial or post-glacial (Allen & Gardiner, 2000, 53).
Unit 2: Silty Clay – The next unit is composed of blackish, silty clay. It could well represent the bottom of the channel or the deposits that were formed prior to the channel being formed. It is likely to be Holocene in date, as a similar deposit is mentioned in the Langstone Harbour project, an alluvial, organic-rich, silty clay (Allen & Gardiner, 2000, 11).
Unit 3: Peat – The peat unit represents the Palaeochannel that was found during the survey. It is one of many that are known to have existed in the area, although their exact locations are not entirely known.
Unit 4: Sandy Clay – This unit is a sandy alluvial clay that could represent deposits on the edge of the palaeochannel. It was found close to, but not necessarily on top of the peat.
Unit 5: Greenish Black Clay – The greenish black clay is a post-channel alluvial deposit, probably from after the Harbour was inundated and no longer a coastal plain but a large intertidal basin.
Unit 6: Yellow Clay – The yellow clay unit is the archaeological horizon that is only found on the islands, and is known from the Langstone Harbour Project. It represents the last remnants of the

land surface (known to contain archaeological material particularly from the Mesolithic to the Bronze Age and later) that is being eroded away as the islands are subjected to coastal erosion. This is the layer in which archaeological artefacts might be found.
Unit 7: Silty Clay – This silty clay unit has shell inclusions, and sits under the top soil; it is most likely from modern fluvial actions.
Unit 8: Silty Clay – The top surface of the survey was a water logged silty clay that is undoubtedly modern and formed by current fluvial actions.

The auger survey did encounter a palaeochannel, which shows up as a peat horizon in samples AP02, AP06, AP58, and AP 57. The surrounding deposits, therefore, mostly likely represent the clay alluvial deposits laid down prior to the channel formation, silty clays afterwards, and sandy deposits from the edge of the channel. The palaeochannel would have been active after the last ice age but before the Harbour was inundated. No archaeological artefacts were found within the sample.

The sample that was taken from core AP58 at a depth of 76-81cm, was radiocarbon dated to-1500 Cal BC (Bronze Age). This ties into the period where the rise in sea level saw systematic flooding of the harbour area apart from the main channels that still exist today. The discovery of this palaeochannel lead to the second season of fieldwork using geophysical survey in order to try and detect further palaeochannels across the harbour as a whole.

Marine Seismic Investigations
The results from the geophysical survey of Langstone Harbour conducted in June 2013 are presented below. The survey was divided into five areas:

Baker's Island:
The geophysical survey recorded a dense network of 45 east-west, 7 north west-south east, and 38 north-south profiles in order to investigate the suspected area of submerged forest near Baker's Island (Russell's Lake and Baker's Rithe). These profiles revealed in high detail a network of channels of varying size present in the area. The data also showed a number of small, but marked surface features, some of which could have related to tree stump and timber remains. These remains were not located in the submerged forest area, suggesting that the 'forest' area could be much more widespread than originally presumed. The interpretation of the data was severely affected by the presence of shallow gas across the area. This meant that the palaeochannels identified could not be mapped in a coherent way.

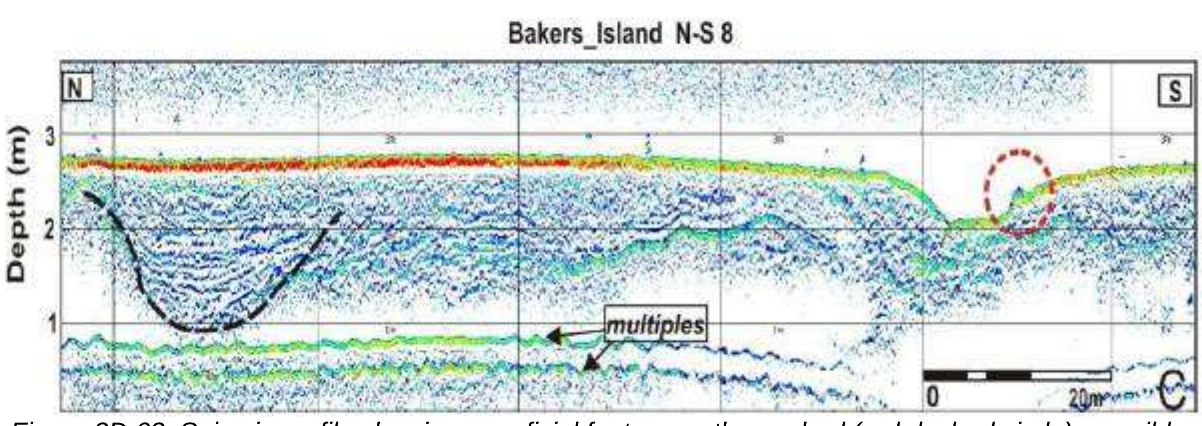


Figure 3D.63: Seismic profile showing a surficial feature on the seabed (red dashed circle), possibly related to a seabed channel. A small buried palaeochannel is also observed (black dotted line).

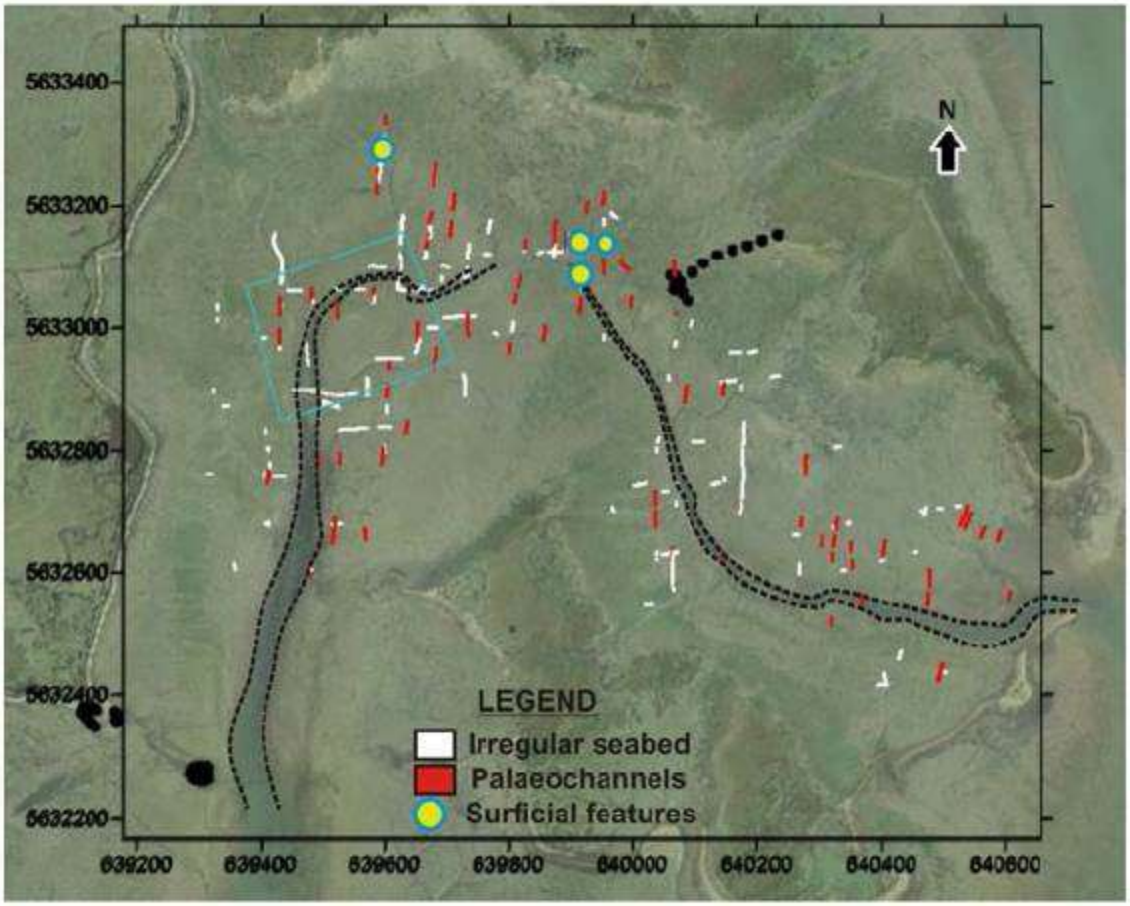


Figure 3D.64: Spatial distribution of irregular seabed, buried palaeochannels and marked surficial seabed features observed near Baker's Island. The blue rectangle marks the submerged forest area observed from previous investigations. The black dots in the northeast and southwest represent shallow core sites (it was not possible to reach the latter by boat).

Langstone Channel:
A small network of 8 north-south profiles and 11 east-west profiles were recorded in the Langstone Channel over the approximate location of the anomaly recorded in the 1996 Chirp survey of the harbour (Allen & Gardiner, 2000).

Again the survey was affected by the presence of shallow gas pockets, but a good penetration was achieved in the deeper part of the channel. Some large palaeochannels were observed at this location in high detail, though a coherent map of the buried palaeochannels was not possible because of the gas. The survey also potentially relocated the anomaly from the 1996 survey.

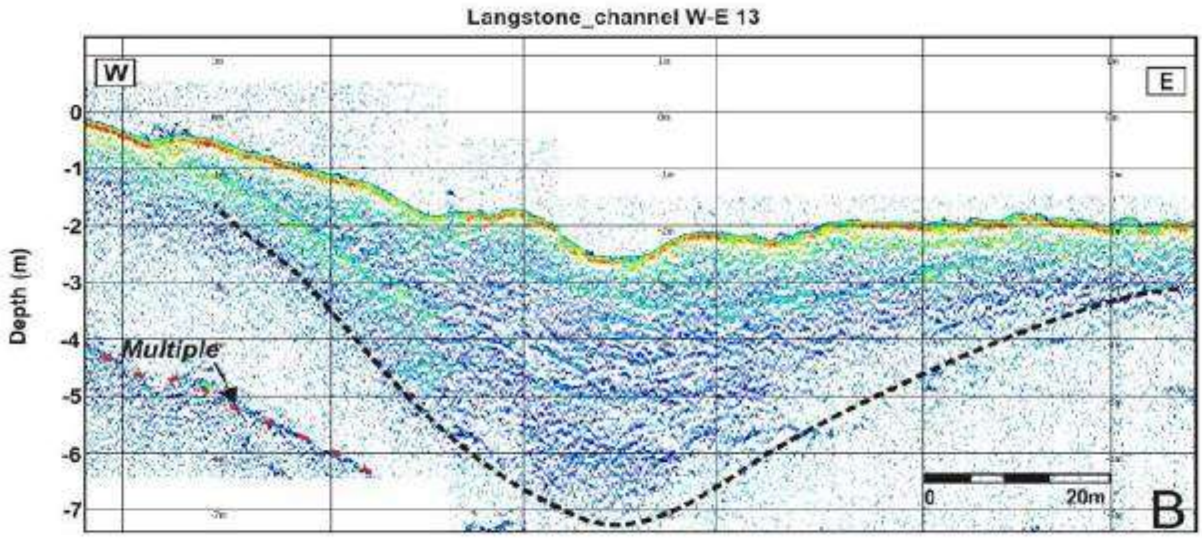


Figure 3D.65: Seismic profile in Langstone Channel showing a large buried palaeochannel and scour-related bottom features.

<u>Mesolithic Spot:</u>
The survey recorded 8 north-south and 13 east-west profiles over the approximate location of an area of Mesolithic finds identified in an earlier survey. The shallow gas pockets that are present throughout the harbour again affected the survey, in this case only allowing for one small palaeochannel to be observed in the data. Despite these problems, the survey was also able to identify a number of small features on the seabed, in the region of 10-40cm high. However, the identity and origin of these features is unknown.

<u>Feature T2:</u>
The feature T2 was identified during the Langstone Harbour Project and was covered by 14 north-south and 10 east-west profiles during this survey. Whilst again, being hindered by gas pockets, the survey did identify some locally buried palaeochannels, as well as the gently dipping Tertiary strata of the underlying geology. Unfortunately, the timber remains of T2 could not be clearly identified in the data.

<u>Sinah Circle:</u>
The approximate location of the Sinah Circle was covered with 10 north west-south east and 12 south east-north west profiles. Whilst again the survey was hindered by the presence of gas pockets, several palaeochannels, three distinct superficial features, and the Tertiary strata were identified in the profiles. The superficial structures are likely to represent timbers, and hence could prove that the Sinah Circle is still extant on the seabed.

The geophysical survey enabled the identification of numerous palaeochannels, and other features, across several different areas of the harbour. Unfortunately, the presence of shallow gas deposits across the areas surveyed means that these channels cannot be coherently mapped. However, the information about the location and the depth of the channels identified has been used with the other results and the work carried out in the 1990's in order to develop the 4D model demonstrating the evolution of the harbour from the Mesolithic to the present day, see Section 3D.7 below.

3D.4.3 Hamble River Survey

After the exposure of a series of wooden posts on the foreshore on the lower part of the River Hamble in 2011 a survey was carried out. Initial survey and desk based assessment established that the site represented a former oyster pond, the assessment was carried out with the use of historical mapping and aerial photographs, demonstrating the value of combining these resources. The site was selected as a case study site for Arch-Manche as the remains could provide information about the changing sediment levels on the River Hamble and the site was re-visited in 2012 to assess potential change.

Key Research Questions

The aim of the survey was to identify the extent of the features and structures on the foreshore and to create a site plan. This could then be compared with historical maps and monitored in future in order to understand the scale and rate of potential sediment change on the foreshore of the River Hamble.

Fieldwork Methodology

Fieldwork was carried out in spring and summer in 2011 and the site was re-visited again in 2012, some elements of the site are a relatively long way down the foreshore and can only be accessed for a period of two hours either side of low tide. Although the intertidal zone of the River Hamble is generally comprised of estuarine mudflats, the area immediately surrounding and including the site is relatively firm. Consequently, access to the site is safe and straightforward with none of the problems of sinking into the mud associated with other intertidal sites on the river. This allowed the maximum use to be made of the limited time on site accorded by the tidal regime.

GPS Survey

A rapid survey of the extant structural features of the site was conducted using a *Leica 1200* SmartNet GPS system. Use of this system allowed structural features such as posts and plank shuttering to be positioned to with +/- 1cm accuracy within the British National Grid. The rapid nature of this survey technique allowed the entire site to be surveyed by two people within the period of a single tidal window. The centre point of each post was recorded, in addition to its shape and extent. The extent and arrangement of any associated plank shuttering was also recorded. In addition to this, a topographic survey of the area of the wooden structure and the foreshore in the immediate vicinity was recorded to provide a benchmark record of foreshore mud levels for subsequent surveys. Finally, the edge of the slipway that runs along the northern side of the oyster pit was also recorded to allow future geo-referencing.

In May 2012 a repeat topographic survey of the site was conducted. This survey was again undertaken with a *Leica 1200* SmartNet GPS system with the intention of establishing if there had been any change in the levels of foreshore sediment at the site since the initial survey in March 2011.

Measured Surface Survey

A traditional, measured survey of the features visible on the surface of the site was completed. This allowed detailed recording of individual structural elements, particularly those along the southern side of the site. Additionally, searches were conducted along the southern edge of the site and in the vicinity of the single post located to the north of the slipway, during the GPS survey, to establish if any other structural features were visible. These areas had been identified during the GPS survey as being highly likely to contain additional structure. Where such features were visible, a small area around them was cleaned in order to allow them to be fully surveyed. Due to tidal restrictions, no survey work was conducted at the most eastern, riverward end of the site.

In addition to the offset survey, three 1m square areas for targeted detailed survey were established along the southern edge of the site around three the post tops. This allowed these features and any associated structure to be recorded in more detail than had been possible during the rapid GPS survey. These areas were surveyed with offsets from the edges of the areas, in addition to the use of planning frames. A further 1m area was established around the solitary post to the north of the slipway.

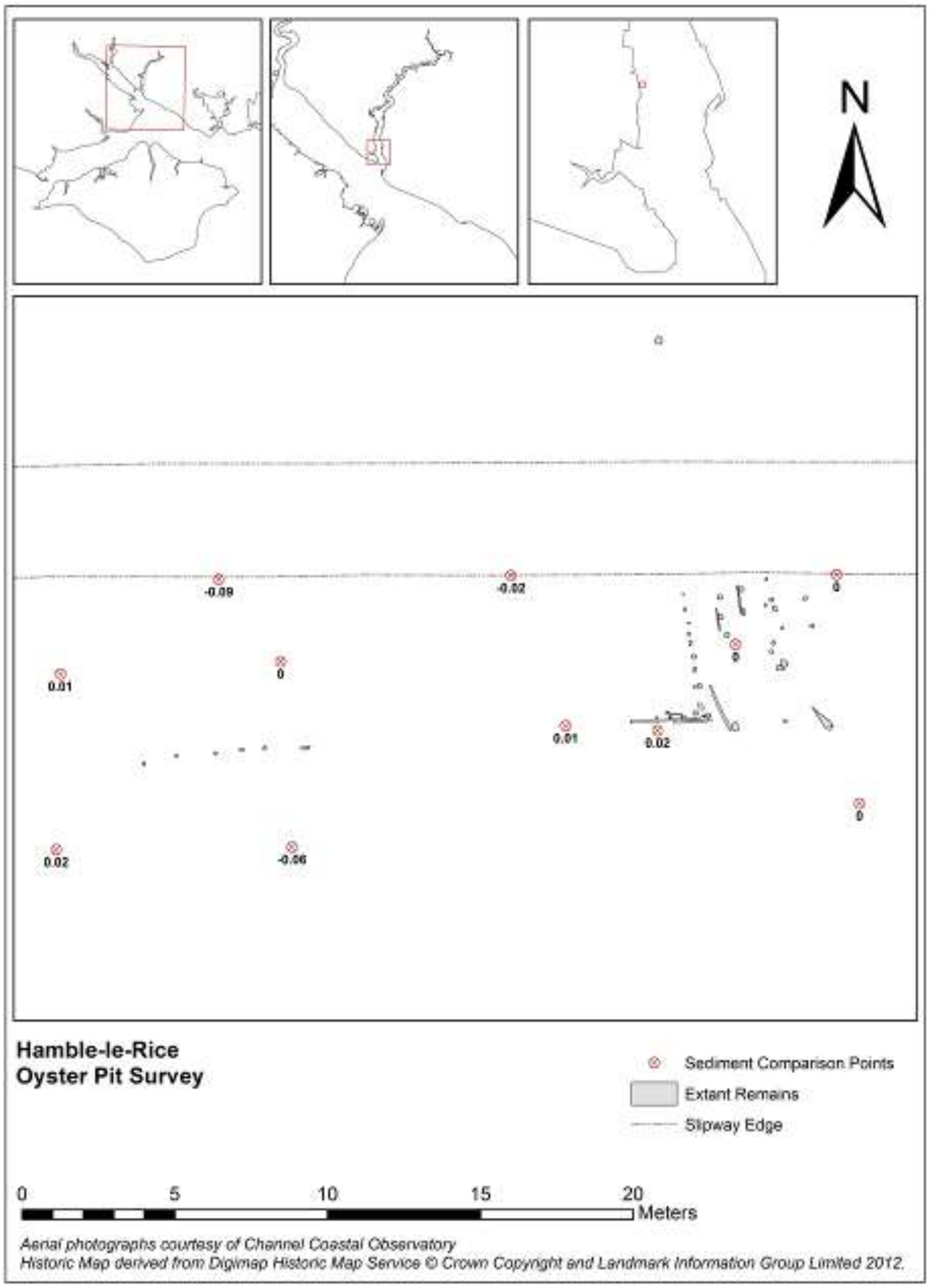


Figure 3D.66: Hamble River Oyster Pit site plan and sediment levels.

Fieldwork Results

The GPS survey established that the structural remains located on the site are generally 'L' shaped, with the long arm running west-east for 22.5m, roughly parallel to the edge of the slipway but 5-6m to the south of it. The short arm of the structure, forms a return for 5m to the north as far as the slipway. No structure was located to the north of the slipway apart from a single large post-top. A series of four, distinctive, north-south alignments of posts are located between the eastern edge of the main structure and the river. These are spaced between 0.8m and 1m apart.

A limited topographic survey of the foreshore was undertaken in the immediate vicinity of the structural remains for the purpose of future monitoring of sediment levels. Processing of this data revealed that along the southern edge of the site, the western end lies 1.04m higher than the south-eastern corner of the main structure, with a further 0.5m drop across the eastern extension of the site. Discussion with the local Parish Council Chairman following the initial exposure of the site indicated that the oyster pit remains had not previously been seen above the level of the foreshore mud. Local people were aware that foreshore sediment levels appeared to be falling over a period of time stretching back some forty years. No record of this change in sediment level at a small scale site such as the oyster pit exists. It was with this in mind that the initial topographic survey was conducted and a repeat survey carried out in 2012.

The survey results illustrate that there has been no appreciable, significant reduction or appreciation in sediment at the site over the fourteen month period between surveys. There have been small, extremely localised changes at a single point. However, given the level of accuracy of recording using the RTK system, these changes may be relatively small. It is intended to record measurements at the same locations in the future in order to begin to extend the recorded dataset over a more meaningful period of time.

Research into available historic maps held by the Ordnance Survey indicated that the visible foreshore remains directly correlated with the location of an 'Oyster Pond' between 1868 and 1909. The dimensions of the two sets of records, one historical and one archaeological, bear further comparison by way of confirming such an identification. The historic mapping shows the straight, eastern (riverward) end of the structure as c. 12m in length and the length of the entire structure as c.25m. This tallies closely with the overall length of the archaeological site which has been recorded as 22.5m along the southern edge. This would potentially allow 2.5m for the curved landward end, shown on the OS maps. The presence of a relatively modern slip makes ascertaining the width of the site harder, as it clearly cuts the remains in two. However, the distance from the south-east corner of the extant remains, to the single large post located on the north side of the slipway is 12.5m, which correlates extremely well with the historic dimensions. This serves to confirm that the archaeological remains do represent the 'Oyster Pond' marked on the OS mapping and, furthermore, suggests that the single post located on the northern side of the slipway is also likely to be part of that structure.

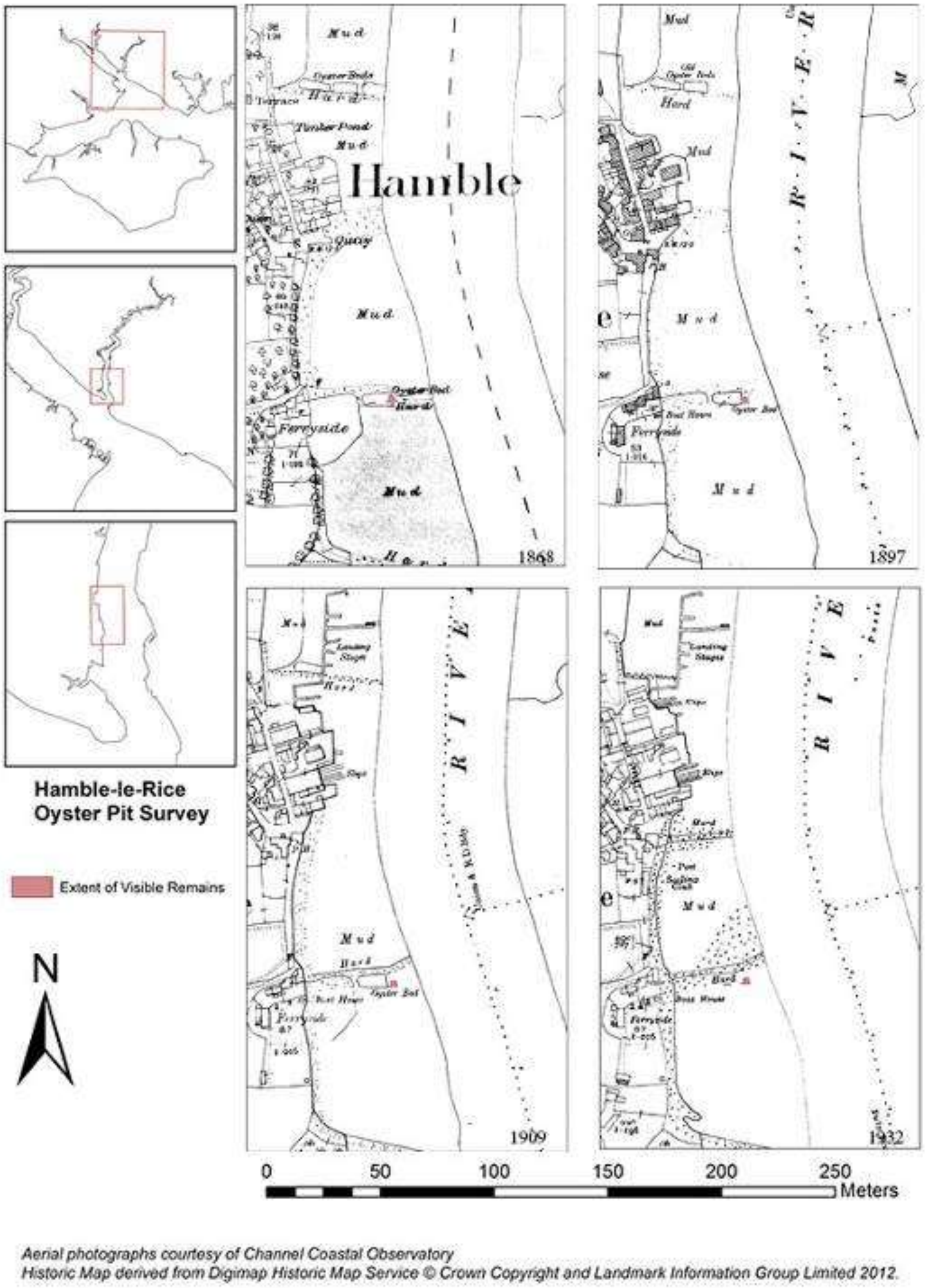


Figure 3D.67: Comparison of Ordnance Survey maps depicting the Oyster Pit from 1868, 1897, 1909 and 1932.

3D.4.4 Burrow Island Survey

Burrow Island, also known as Rat or Little Island, is situated on a spit advancing from Forton Lake into Weevil Lake and contains the ruins of Fort James. This fort was planned by Sir Bernard de Gomme as an element of the Gosport defences, and was built in 1678 at the same time as the Gosport lines (Pastscape 2007:Fort James). By 1707 however it was already falling into disrepair, and in 1742 its two guns were recovered; it was rendered obsolete by the extension of the Gosport defences to Priddy's Hard in the second half of the 18th Century (Pastscape 2007:Fort James).

Suggestions of a Norman Castle preceding the construction of Fort James also survive, though they are somewhat disputed. A letter dating from 1828 refers to the walls of a castle present upon the island being taken down; a further letter from 1847 mentions the ruins of "Borough Castle" associated with King Stephen, being used as a "burial place for convicts" (Pastscape 2007:Fort James).

After being contacted by a member of the public regarding the erosion of the island and resulting exposure of archaeological material the site was chosen as a small case study for the Arch-Manche project.

Figure 3D.68: Erosion on the small cliff of Burrow Island, recorded in 2013. MAT

Key Research Questions

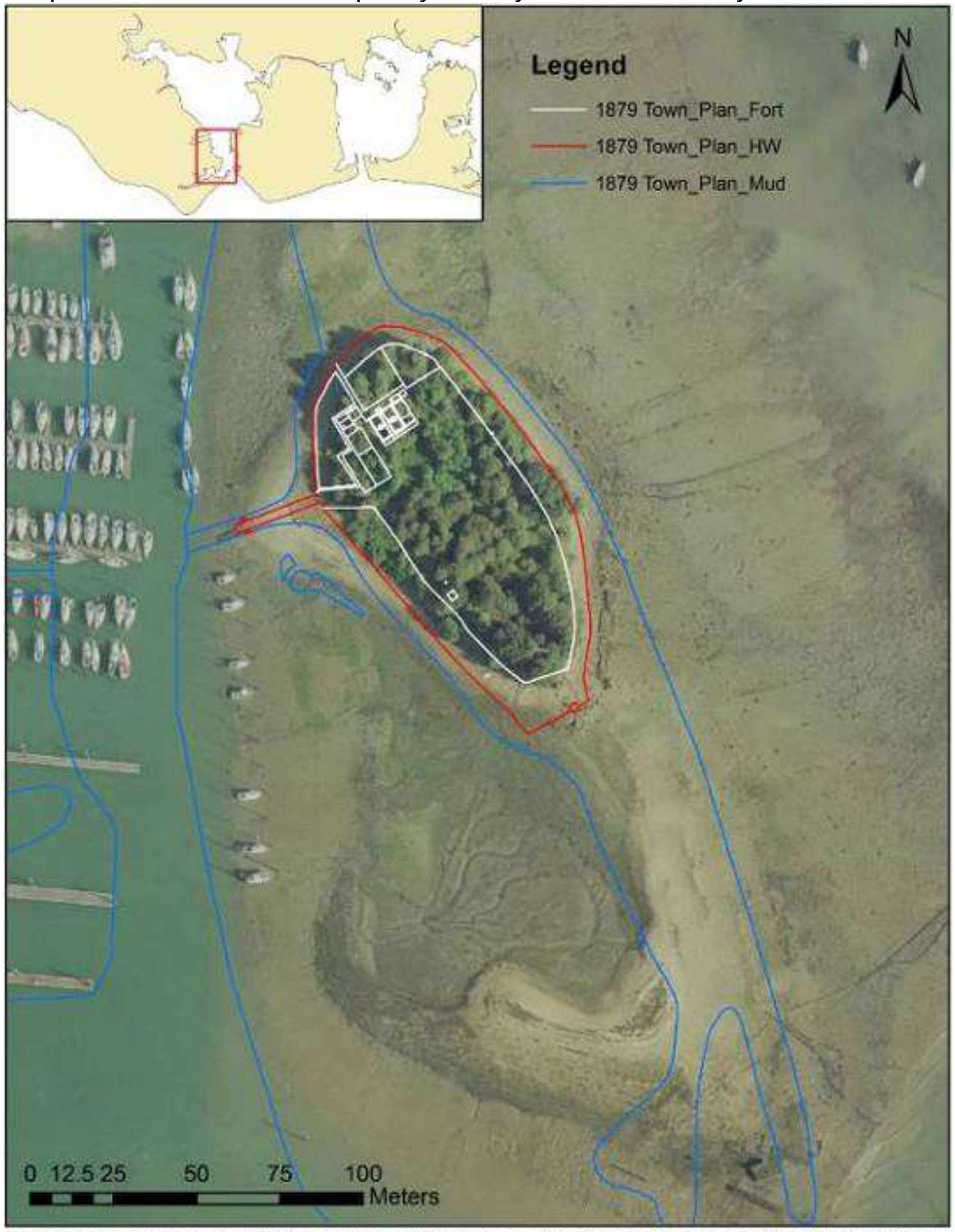
The aim of the fieldwork was to understand how the archaeological material and heritage features on the island could be used to help understand the rate and scale of erosion affecting the sites and whether these could be used in coastal management.

Fieldwork Methodology

During the fieldwork the main methods used were a walkover survey and photographic record, although a Leica 1200 Real-Time Kinematic (RTK) GPS system was also used to mark the position of any particular features of interest.

Fieldwork Results

Although further fieldwork would be required to complete a full topographic survey of the site, significant amounts of information were gained through comparison of archaeological survey results and modern aerial photographs of the island with a town plan from 1879. The historic plan shows the high water mark, the extent of the mud and an outline of the fort, this has been digitized and overlain on the modern aerial photography (Figure 3D.69). Through this it is possible to see that the shingle spit extending south from the island has shifted north westwards and the old pier has been almost completely destroyed and is now only visible at low water.



Aerial photographs courtesy of Channel Coastal Observatory. Historic map data derived from Digimap Historic Map service Crown Copyright and Landmark Information Group Ltd 2012.

Figure 3D.69: Comparison of the 1879 town plan showing the remains of the fort, the high water mark and the extent of the intertidal mud, with a modern aerial photograph.

3D.4.5 East Winner Bank Wreck Survey

Fieldwork was carried out after being alerted to the appearance of a previously unknown shipwreck on the East Winner bank, off Hayling Island in early March 2014, following a period of severe winter storms. The wreck was visited on 16th and 29th April 2014 during a low-water spring tide of 0.7m and 0.6m respectively (Chart Datum Portsmouth). The East Winner is a large sandbank located off the south-west corner of Hayling Island that firmly demarcates the eastern seaward side of the entrance channel into Langstone Harbour.

The situation of the East Winner within the surrounding sediment regime is described within the 'Portsmouth Harbour Entrance to Chichester Harbour Entrance' section of the Sediment Transport Study published by the Standing Conference on Problems Associated with the Coastline (SCOPAC). The tidal flow in the Langstone Harbour channel is dominated by the ebb tide when tidal rates can reach 1.5 knots (Bruce, 2008: 44-45). This has had the noted effect (SCOPAC: LT7) of flushing sediment seaward from the Langstone harbour channel to be deposited along the western side of the East Winner. The SCOPAC project also notes that there has been a previous suggestion that the East Winner bank itself is partially fed through the westward movement of sand from the Chichester tidal delta. Although the mechanics of this are not proven, the overall sediment transport pathway within Hayling Bay is considered to be from east to west, allowing for deposition of material onto the East Winner (SCOPAC: O1).

The circulation of sand on the East Winner itself is also covered by SCOPAC (O3) based on the previous work of Harlow (1980). This has noted that the East Winner bank is covered by ripples, sand waves and low dunes; analysis borne out by aerial photos and observation while on site. Such features are noted by SCOPAC as characterising high sediment mobility, but in this instance operating within a closed system because of the inability of sediment to move in a westerly direction across the Langstone Harbour channel. Accordingly, a system has been proposed (SCOPAC: O3) of net transport in an offshore direction by tidal currents on the western face of the bank and onshore transport on the eastern flank as a result of wave action. Study into the overall shape and volume of the East Winner by Whitcombe (1995) has highlighted the fluctuating expansion and regression of the bank caused by shifts in the alignment of the outer Langstone Harbour channel.

The exposure of this wreck highlights the dynamic nature of this sand bank, shipwrecks can be useful monitoring points in understanding changing sediment levels, it was therefore decided to use this site as a small case study in the Arch-Manche project.

Key Research Questions

Initial fieldwork aimed to record the extent of the site and particular features which may help identify and date the wreck. A second visit to the site aimed to assess the rate and scale of change in the sand bank as it began to re-cover some of the wreck and expose new areas. The overall aim was to understand whether this site could provide detailed information on the changing sediment regime in this part of the Solent.

Figure 3D.70: Aerial view of the East Winner Bank Wreck taken after the storms of January 2014.

Fieldwork Methodology

Access to the site is limited to a period of around 1.5 hours, straddling low water. This results in a reduced window of around 45 minutes when the water is at its lowest and conditions for working on the site are optimal. Even at that point, significant areas of the site continued to be underwater during the normal spring tide conditions of 0.6m (CD) during which the site was visited. Accordingly, successful work on site required limited objectives that could be effectively completed within the access window. Site visits were therefore concerned with documenting the characteristics of the site in as much detail as possible through recorded observations of the extant features, in conjunction with the creation of an extensive photographic and video record. The latter included the use of a pole-mounted camera in order to record overhead images of the site; proving especially helpful in identifying features that were not visible at ground-level (Figure 3D.70).

This work has served to establish a basic set of information about the site and the vessel itself that can be further informed through subsequent visits. In particular, the creation of a traditional site-plan was considered to be of relatively low-priority because of the amount of time required to complete it. Instead, focus was placed on recording the detail of the vessel's dimensions and constructional features in order to create a description of the site. It can be reiterated that such a description is not reliant on an overall site-plan but on the careful observation and recording of the archaeological detail present on the site.

Fieldwork Results

The extant remains are 21m in length and of variable width between two and four metres depending on the elements exposed. The visible remains are in a good condition overall and photos from the initial exposure in February/March 2014 illustrate that the wood was very 'fresh'. Since then, there has been a gradual build-up of sand and weed on exposed surfaces. The rapid period in which this has taken place suggests that although exposed, the site is afforded some protection from biological decay. Some evidence for gribble is present on the upper ends of the frames, and around the stern post indicating that there have been previous incidences of exposure limited to just the extremities of the wreck. Across the two week period in which site visits were made a large amount of new material was exposed at the northern end of the site.

The disposition of the exposed remains indicate that the hull of the vessel is orientated in a roughly north-south direction. The presence of the stern-post and associated rudder gudgeon indicates that the stern of the original vessel lies to the north and the exposed remains therefore represent the portside of the vessel. Four inaccessible upright posts lie to the west of the site that seem likely to represent the centreline of the vessel, although this is not confirmed. There is no surviving indication of any mechanical propulsion of any sort and so the vessel is considered to have been a sailing vessel. The curvature of the visible framing timbers suggests that the entire bottom of the vessel is likely to be preserved *in situ* under the sand to the west of the extant remains. Visible surviving hull elements are comprised of floor timbers, futtocks (first to third), top timbers, ceiling planking and outer planking. The partial remains of a beam is located in the centre of the site. Preserved fastenings and fixtures include treenails, copper bolts and a rudder gudgeon, additionally, a number of holes indicate the location of former fastenings.

A lump of coal was found immediately to the south of the wreck structure and its rounded appearance indicates a relatively long period in the sea. The presence of the coal may be purely incidental, but it does not occur naturally on the East Winner bank and its close vicinity to the site may therefore represent the remains of the former cargo, or stores, from the wrecked vessel.

Further work is required to identify the vessel and it is proposed that further work should be carried out with historic maps in order to further understand the nature of the East Winner Bank. More specifically to the immediate surroundings of the shipwreck, the site can also be used as a means to monitor changes to this area of the East Winner bank. Ongoing monitoring of the site, facilitated by further photography and site recording can provide micro-scale information on environmental changes to such sites and how their exposure and resulting vulnerability varies over time. Comparable schemes are in place for fully submerged sites in the eastern Solent, including the *Flower of Ugie* (see Whitewright, 2011) on the Horse Tail sand. Data from the East Winner site therefore has potential to contribute to a wider understanding of the impact of sediment processes, at a site specific and intra-site scale, within the eastern Solent.

3D.5 Ranking Artistic Depictions

The focus on artistic depictions of the study area has been on historic paintings, however several historic photographs, maps and charts were also assessed in order to highlight the potential of this resource. The results of the ranking for each of these is presented below followed by a discussion.

3D.5.1 Historic Photograph Ranking

A ranking system was developed for historic photographs, the development of the system and proposed methodology is set out in Section 2.2. The ranking system has been applied to a selection of historic photographs within this case study area.

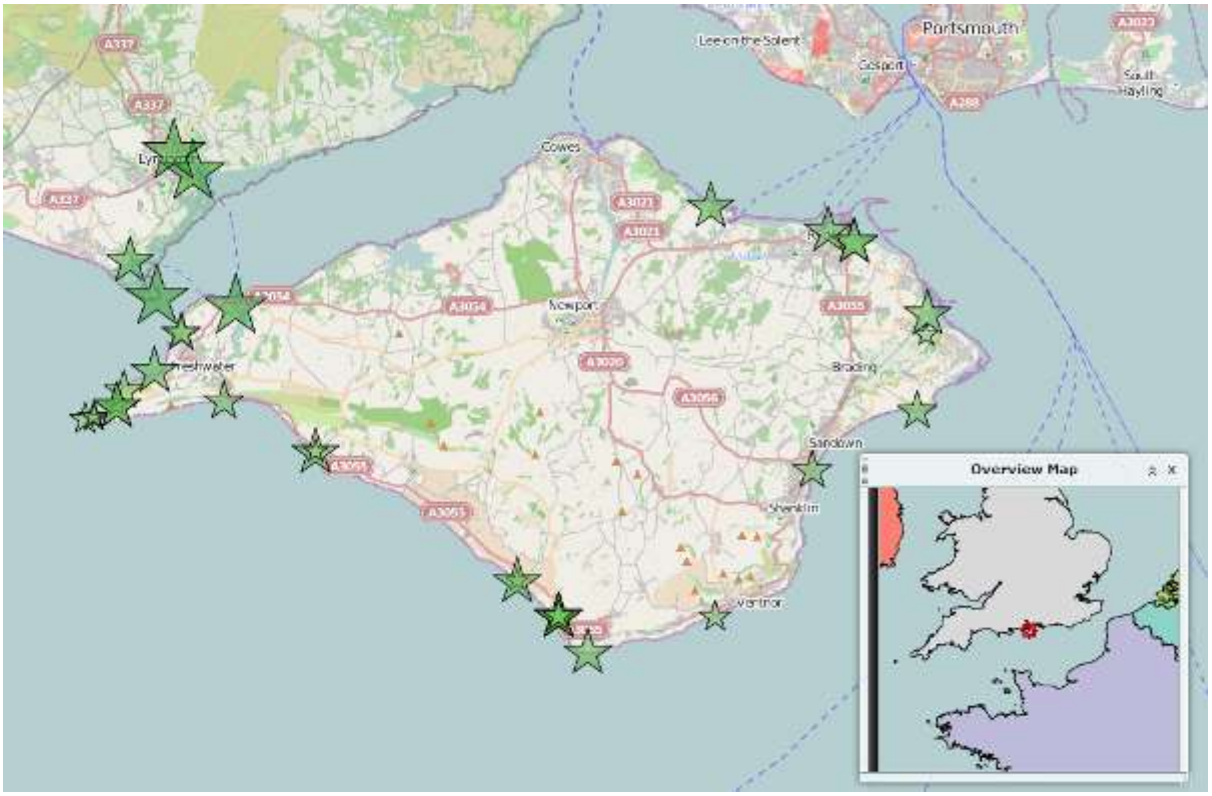


Figure 3D.71: Location of historic photographs assessed in the Solent study area.

All of the historic photos assessed were found through online searches. Many more images exist for this area, this study is not intended to be exhaustive, it simply aims to highlight the potential for historic photographs to provide information on coastal change. One of the primary resources used was the Carisbrooke Castle Museum Image Library which was launched in 2011, providing a digital resource of some of their collections.

Image Id No	Title	Year	Score Heritage View	Score Non Heritage View	Physical Image State	Total Score
1200	Lymington River and the Solent	1952	High		Good	100
1201	Hurst Castle & Lighthouse	1953	High		Good	100
69	Yarmouth Harbour	1910	High		Good	100
116	Royal Lymington Yacht Club	1950	High		Good	100
70	Chale and Blackgang	1900		Medium	Good	77
72	Blackgang Chine	1900		Medium	Good	77

74	Blackgang Chine	1900		Medium	Good	77
76	Brooke Shore	1900		Medium	Good	77
78	Eastern Beach at Ryde	1900	Medium		Good	77
79	Eastern Beach at Ryde	1900	Medium		Good	77
87	St Catherine's Lighthouse	1920	Medium		Good	77
82	Blackgang Chine	1900		Medium	Good	77
85	Woodside beach, Wooton	1900	Medium		Good	77
83	Blackgang Chine	1900		Medium	Good	77
88	St Helen's Old Church, St Helen's	1900	Medium		Good	77
95	Atherfield	1886		Medium	Good	77
111	Alum Bay Pier		Medium		Good	77
113	Keyhaven	1950	Medium		Good	77
114	Alum Bay Pier	1920	Medium		Good	77
117	Totland Bay	1950	Medium		Good	77
96	Ryde Esplanade	1910	Medium		Good	77

Table 3D.3: Highest scoring photographs from the Solent study area.

3D.5.2 Maps and Charts Ranking

A ranking system was also developed for maps and sea charts, the development of the system and methodology is set out in Section 2.2.

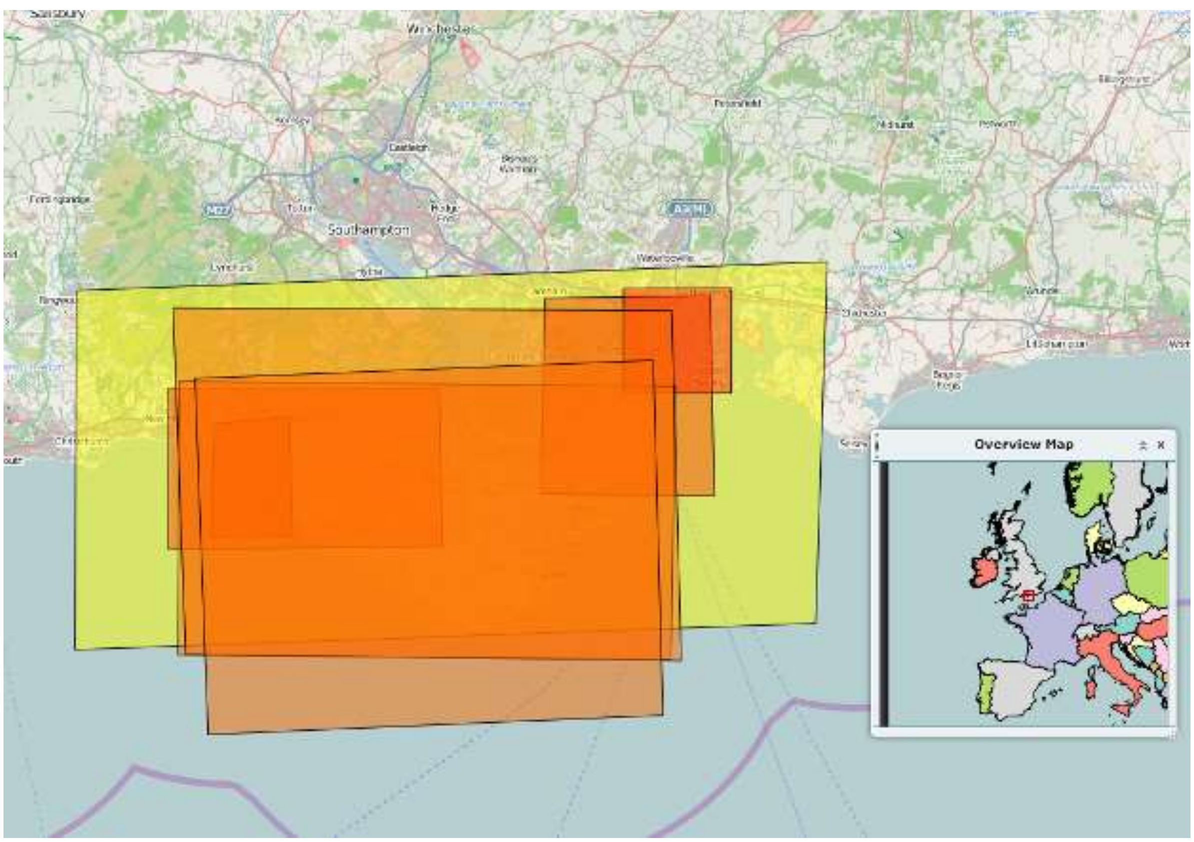


Figure 3D.72: Location of the maps and charts assessed in the Solent study area.

Map Id No	Title	Year	Score Chronometric Accuracy	Score Topographic Accuracy	Score Detail in non-coastal area	Score Geometric Accuracy	Total Map Score
148	Hurst Spit to the Isle of Wight	1934	93.3	77.8	100	83.3	88.6
146	England South Coast	1848	100	100	66.7	66.7	83.3
145	Portsmouth Harbour	1791	100	77.8	66.7	50	73.7
147	Isle of Wight to Hampshire	1791	86.7	94.4	33.3	66.7	70.3
36	Isle of Wight	1816	60	77.8	66.7	50	63.6
34	Map of the Isle of Wight	1862	86.7	50	66.7	50	63.3
37	Isle of Wight	1812	60	69.4	66.7	33.3	57.4
35	Early Map of the Isle of Wight	1600	6.7	20.8	33.3	0	15.2

Table 3D.4: Results of the maps and charts ranking in the Solent study area.

3D.5.3 Art Ranking

Thirty-eight works of art from the Solent and Isle of Wight art case study area were assessed. Artists tended to paint attractive or dramatic coastal locations as well as meeting specific demands of their patrons. On the Hampshire and Isle of Wight coastlines they were drawn to the expanding shipping ports and seaside resorts either on account of their locations or because of the interest in the activities of fishermen working along the shoreline. The result has been that many of the sites of key geomorphological and coastal risk management interest have been painted by artists particularly during the nineteenth century.

The ranking system has identified ten key paintings representing three study sites which are examined in more detail below:

Study site Number	Location	Artist	Date	Score type	Score period	Score style	Score enviro.	Total Score
D1	Portsdown Hill, P'mouth	William Daniell	1824	Aquatint	Early	Topog.	Detailed View	55
D1	Portsdown Hill P'mouth	William H. Bartlett	1848	Steel engraving	Mid.	Topog.	Detailed View	62
D1	Portsdown Hill P'mouth	William Turner	1854	Water-colour	Mid.	Topog.	Very Detailed View	51
D2	Yarmouth from the West	S. Barth & J. King	1813	Copper Plate engraving	Early	Topog.	Detailed View	37
D2	Yarmouth from the West	Robert Brandard	1848	Steel plate engraving	Mid	Topog.	Detailed View	62
D2	Yarmouth from the West	Charles Robertson	1891	Water -colour	Late	Topog.	Very Detailed View	77
D3	Ventnor Cove	Charles Raye	1825	Aquatint	Early	Topog.	Detailed view	48
D3	Ventnor from a Hill above the Cove	William Westall	1842	Steel engraving	Mid.	Topog.	Very detailed view	62
D3	The Beach, Ventnor	Rock & Co	1863	Steel engraving	Mid.	Topog.	Detailed view	55

Table 3D.5: Results of the art ranking in the Solent study area.

A more detailed explanation of each site and the interpretation of the individual artworks is provided in the study site descriptions below. The assigning of scores to each artwork suggests names of those artists who have depicted different aspects of the study site coast across the timeline 1770-1920. These artists include William Daniell, William Westall and Charles Robertson; they can be relied upon in terms of the accuracy of their depictions of the Solent and Isle of Wight coastlines.

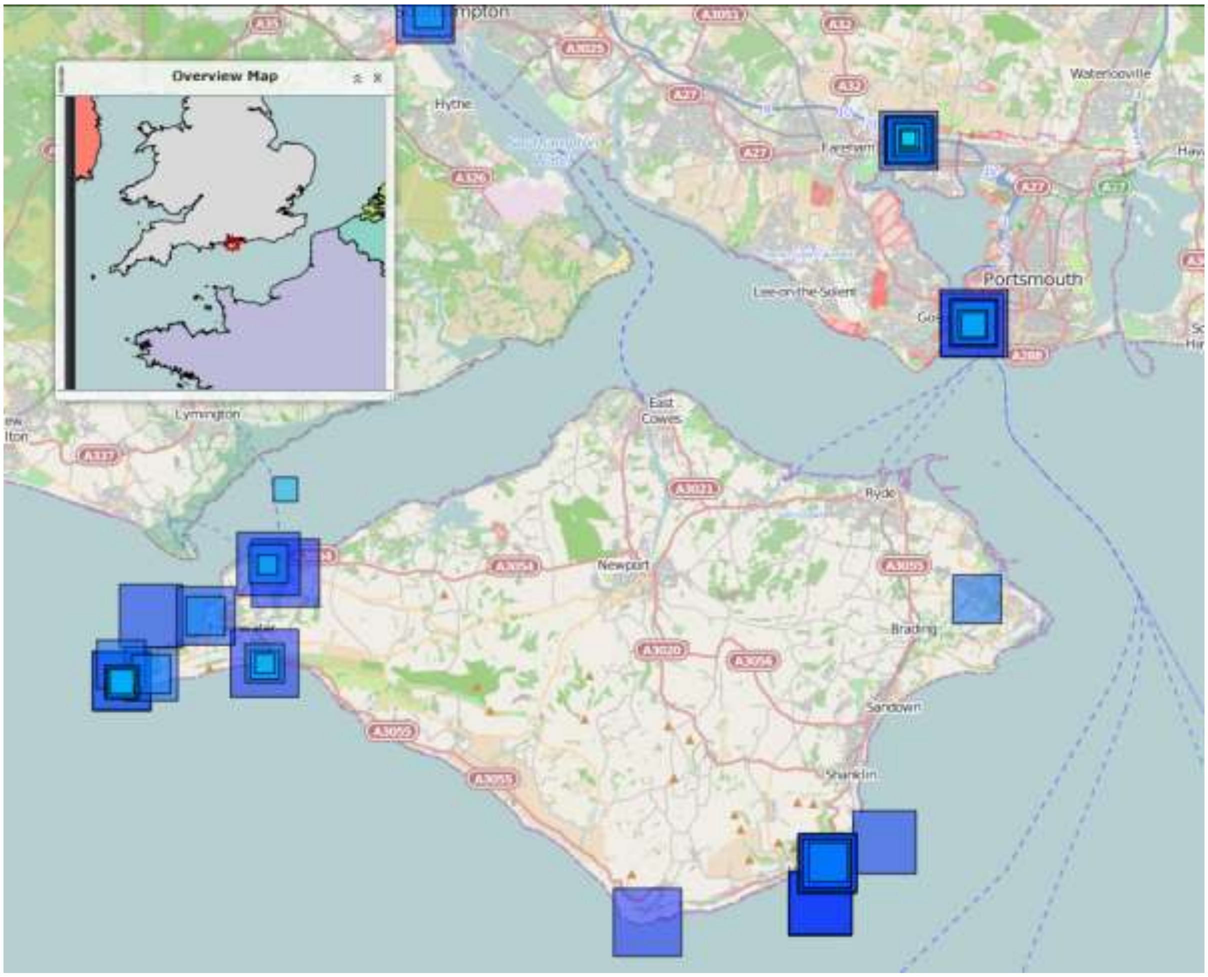


Figure 3D.73: Location of artworks assessed in the Solent/IOW study area.

3D.5.4 Discussion of Ranking Results

A total of 38 historic photographs were assessed, these ranged in date from 1886 to 1953. The highest scoring photographs contained easily identifiable features and could be compared with the present day. Because of the dynamic nature of this coastline historic photographs can be a valuable resource with many containing depictions of the cliffs, harbours and particularly of sites like Hurst Spit and the Needles with recognisable heritage features nearby, including castles, forts and lighthouses. These can be compared to the modern situation and from this an accurate idea of the rate of coastal change since the date of the photograph can be gained.

Eight maps were assessed, these ranged in date from 1600 to 1890. Although generally the more recent maps scored higher, some maps from the 1700's which were of a smaller scale also scored highly. These smaller scale maps provided detailed descriptions of the tidal areas and channels. Maps which ranked highly have been used to model changes in the landscape, particularly of the saltmarsh off Lymington and in Langstone Harbour the maps have been used in the 4D evolution models, see Section 3D.7 below.

The highest scoring artwork, a detailed watercolour of Yarmouth, by the artist Charles Robertson, gained 77 points whilst several coastal aquatints and engravings scored between 55-62 points. These are followed by oil paintings from the early and mid-nineteenth century which, with the exception of the Pre-Raphaelite artists and their Followers, generally provided less detailed information, and hence scored fewer points.

As the aim is to illustrate how art can inform us of long-term coastal change it is fortunate that within the higher scoring artworks there are examples, which include locations affected by coastal landsliding and marine erosion (Ventnor), flooding and environmental change (Portsmouth Harbour and Yarmouth). These differing physical processes and their impacts on coastal residents, assets and infrastructure could not have been easily matched to the most informative works of art without the provision of the ranking system.

Through the site studies the value of various artworks has been tested at sites of differing geomorphology. The combined approaches of desk-based research, museum and gallery searches and field visits have confirmed the added value of art from the period 1770-1920 to support other coastal surveying and monitoring technologies (e.g. space-borne, air-borne, ship-borne and terrestrial). It is important to remember that artists in the late Georgian and Victorian eras worked for very demanding, wealthy clients who often sought exact views of the coastal landscape to remind them of their visit. Before the days of photography precise images were, therefore, a prerequisite in most cases. The examination of the works of many artists painting the Hampshire and Isle of Wight coastlines testifies to their considerable artistic skills in capturing accurately the coastal topography.

Some of the artworks examined in these case studies show significant coastal change over time as well as telling the story of human intervention on the coast. Other artworks show very little change over the last two hundred years and this information is of equal interest to the coastal scientist. Importantly the artworks also illustrate, in many cases, the nature of the natural undeveloped coastline and suggest what conditions might be experienced if coastal defences were not maintained in the future. This is particularly significant as along certain coastal frontages it will not be possible to continue to defend the coast as has been the case in the past for physical or environmental reasons.

The results of the ranking have drawn attention to three sites, which differ geomorphologically from those examined already in East Anglia, East Kent and at Hastings. This case study assists in fulfilling the Arch-Manche ambition of selecting a range of coastal locations painted by artists that include the full range of environments to be found across the southern North Sea – Channel region.

3D.6 Art Field and Research Studies

In order to identify the most suitable artworks that could be studied in more detail at the field study sites a national search was undertaken involving an extensive review of landscape paintings, watercolours and prints held in public and some private collections. Following ranking of the artworks six examples have been the subject of more detailed analysis involving site visits.

3D.6.1 Key Research Questions and Fieldwork Approach

Having established, through the art ranking system that the images are likely to be true representations of the conditions that would be seen at the time they were painted, the research questions to be answered through examination of the artworks at the case study sites are:

- What information can the historical images provide to support understanding of long-term coastal change?
- How can the potential of this resource be used most effectively by the end-user?

Along the study area coastlines there are a range of physical conditions to be found including eroding cliffs, cliff instability problems, beach change and flooding of low-lying land by the sea. In order to reflect these varying conditions art images have been selected from three study sites, at Portsmouth on the Hampshire coast, and two sites on the Isle of Wight at Yarmouth on the north-west coast and at Ventnor on the south coast. Site D1 examines the coastal zone at Portsmouth when overlooked from Portsdown Hill, an elevated location looking southwards over the harbour, the city and to the Solent and Isle of Wight beyond. The key issue here is flood risk management, but the artworks also show how the city gradually developed on an open low-lying section of coast.

Figure 3D.74: A view of the entrance to Portsmouth Harbour from the south looking inland. The chalk cutting on the south face of Portsdown Hill (Case Study Site D1) can be seen in the distance. Photograph courtesy of The Wight Light Gallery.

The second study site is at Yarmouth on the Solent shoreline of the Isle of Wight. Here the historic town is at risk from flooding and important designated environments are at risk from inundation as a result of sea level rise. These issues are highlighted by the three selected artworks. Finally the coastal town of Ventnor is examined. Ventnor is situated within the largest coastal landslide complex and the case study explains how art has help to understand the nature and extent of the landslide system using historical evidence that has since been lost as a result of coastal erosion.

Each site considers the potential of the artwork to be used as a qualitative or quantitative tool to support our understanding of long-term coastal change and coastal management more widely.

Figure 3D.75 (left): A view of Yarmouth on the north-west coast of the Isle of Wight (Study Site D2). Photograph courtesy of Andrew Butler.
Figure 3D.76 (right): The town of Ventnor on the south coast of the Isle of Wight lies within the Undercliff landslide complex (Study Site D3). Image courtesy of The Wight Light Gallery.

Where it has been practical to gain access and relevant to the study, present day photographs were taken in the field to try, as far as possible, to match the views painted by the eighteenth, nineteenth and early twentieth century artists. It also provided the opportunity to assess the conditions of the cliffline and beach and changes that may have taken place over time. In terms of work in the field each of the locations has been visited and photographed in varying weather conditions. Inspections were timed to coincide with low water and a walk-over survey was made along the beach and base of the cliff returning along the cliff top. This ensured that thorough comparison could be made between the geomorphological conditions depicted in the artwork and the present day situation.

3D.6.2 Art Field Data Gathering Results

The selected Solent and Isle of Wight sites were chosen to reflect a range of geomorphological types – coastal landslides, estuaries and saltmarsh. Site inspections have confirmed that the locations selected do provide a good representation of these coastal geomorphological conditions against which the value of historical artworks can be tested.

The fieldwork element has been largely visual in terms of identifying the location of the paintings and making judgements, on site, of the role that art can fulfil as a qualitative or quantitative tool to support coastal risk management. The field inspections allowed a more accurate appraisal to be made of current physical conditions rather than relying upon written accounts and reports particularly as storm events can cause significant alterations over relatively short time periods.

The approach adopted for each case study has been the examination of one particular artwork and to make an assessment of what it tells us about changes over time from field observation. However, for some of the study sites it has been found that several artists painted the view from the same or a similar spot. This helps us to establish a chronology of coastal change through the nineteenth and twentieth centuries.

D.1. Portsdown Hill to Portsmouth Harbour, Hampshire

Location

This view by William Daniell (Figure 3D.77) illustrates the relatively undeveloped Portsmouth Harbour with Porchester Castle and the Isle of Wight beyond in 1824. It is interesting because it shows some of the islands and creeks of what is now a densely populated city in a largely natural state. The study site is the view from Portsdown Hill looking south over the harbour and the city towards the Solent and the Isle of Wight.

Why was the study site selected?
This site was selected to illustrate the role that historical artworks can play in informing us of the conditions that existed before coastal defences and other developments took place. An understanding of the natural conditions that prevailed in terms of evolution and coastal processes is a key consideration when developing a coastal risk management strategy for the future.

Geomorphological setting
The study site is located within the Hampshire Basin and comprises relatively soft rocks from the Cretaceous and Tertiary periods. Portsdown Hill stands as a ridge of chalk downland extending east to west behind the city of Portsmouth, which developed on Portsea Island. The sheltered Portsmouth Harbour lies to the west of Portsea Island whilst the large tidal bay of Langstone Harbour lies to the east.

Figure 3D.77: 'View from Portsdown Hill, Portsmouth' by William Daniell RA. 1824

Key coastal risk management issues for the frontage
Flood risk will increase because of rising sea levels threatening the coast and increased winter rainfall and summer flash flood events. Sea level will rise by approximately one metre in the next 100 years. Higher storm surges and tide levels will reduce the ability of drains to discharge into the sea, potentially increasing fresh water flooding in low lying areas. Greater frequency and intensity of short duration rainfall events will put pressure on drainage systems (surface

water and combined) and lead to localised flooding. 64.6% of the city of Portsmouth is at risk from flooding, which includes nearly 27,000 properties (Environment Agency, 2010).

Portsmouth is at risk from both surface water flooding, and tidal flooding. The most significant flooding event of recent years in Portsmouth occurred in the year 2000/01 when 114 properties flooded internally and 20 residential roads flooded. Tidal flooding presents the more significant risk as large portions of Portsea Island are below sea level, leaving nowhere for flood water to naturally drain after a flood event. In the face of climate change, flood risk is expected to rise as more severe storms will increase pressure on the existing urban drainage network (Environment Agency, 2010). The East Solent Coastal Partnership of local authorities has commissioned modelling studies in order to better understand flood and coastal erosion risks in the area (East Solent Coastal Partnership, 2013).

Observations on the artwork

The main road from London to Portsmouth passed over Portsdown Hill, a route used by many early writers and artists visiting the south coast and the Isle of Wight in the late eighteenth and nineteenth centuries. The view from Portsdown Hill over Portsmouth is spectacular and would have provided the first view of the sea for many travellers; as a result artists paused there and often painted the view. These included, in the eighteenth century, Thomas Jones (1870s), John Thomas Serres (1778) and in the nineteenth century William Daniell RA (1824), Wlliam James Callcott (1840s), William Henry Bartlett (1848) and William Turner of Oxford (1854). Following ranking the works by Daniell, Bartlett and William Turner have been examined further.

The view by Daniell is typical of his meticulous observation and eye for detail and he described the location in his famous publication '*A Voyage Round Great Britain'* (Daniell & Ayton, 1814).
"..an excursion was made to Portsdown Hill, the lofty and narrow ridge from whence was taken the annexed view, looking down on the harbour of Portsmouth. The aspect of that grand naval emporium, at this distance, is perhaps more impressive than any which would exhibit to a beholder in its immediate vicinity. On the tongue of land to the right is Porchester Castle. Farther in the distance is Gosport, backed by the Isle of Wight, of which the portion here visible extends from Brading harbour and St Helens road near Ryde. In the harbour Portsmouth are seen some objects strongly characteristic of a time of peace; they are ships laid up in ordinary. Altogether the prospect in this direction is surpassing for its grandeur and variety…"

Daniell's view looks down over Porchester Castle, the Roman fort, towards Gosport and Portsmouth with the Isle of Wight beyond. Twenty-four years later the prolific artist and engraver, William Henry Bartlett, produced a very fine steel engraving from the same location. The extent of the estuary is very clearly delineated and demonstrates the detail that could be achieved through engraving on a steel plate. The shape of the harbour and the coastline matches very closely Daniell's observations.

A third work from this location was painted by William Turner of Oxford in 1854. Turner (designated as 'of Oxford' to distinguish him from J. M. W. Turner) usually painted coastal panoramas such as this from elevated locations. His style was detailed and topographically accurate. This view is from higher up the hill than the two previous works. Porchester Castle is clearly visible, as is the city of Portsmouth on the left.

Figure 3D.78: 'Portsmouth Harbour and Spithead'. A steel engraving by W. H. Bartlett (1848). The extent of the coastline near Porchester Castle is drawn in a precise manner. The present day view is shown above (Image courtesy of Wikipedia).

Figure 3D.79: A watercolour drawing from the top of Portsdown Hill looking south by William Turner of Oxford (1854). The present day view above shows the extensive development that has taken place. Image courtesy of Andrew Bryant.

How can the artworks inform coastal risk management?
Each of these three works emphasises the changes that have taken place in the coastal zone over the centuries and allow us to reflect on the development of this low-lying land, part of which is now densely populated and vulnerable to flooding and the impacts of sea level rise. Views such as these can be useful in understanding the evolution of Portsmouth Harbour over time including changes in the form of the coast as a result of both human and natural factors. Such historical images can also assist consultations with stakeholders over issues relating to flood risk as they highlight the vulnerability of the location even before much of the development took place.

Where can the original artwork be viewed?
Each of the three images can be viewed on the Internet at 'Portsdown Hill, Portsmouth Images'.

Ranking scores achieved:
William Daniell image: 55; William H. Bartlett 62; William Turner: 51.

D2. Yarmouth, Isle of Wight Study Site

Location
The study site comprises the mouth of the Western Yar river at Yarmouth on the north-west coast of the Isle of Wight.

Why was the site selected?
This site was chosen to illustrate how art can inform on flood risk and the impacts on intertidal environments in the face of sea level rise and climate change, as well as development impacts.

Geomorphological setting
The site lies in the flood plain of the River Yar, which flows from south to north across the western end of the Isle of Wight (Figure 3D.81a). The source of the River is on the south-west coast of the Island at Freshwater Bay where the river has cut through the west to east running chalk hills on its route northwards to flow into the Solent at the town of Yarmouth. North of the chalk downs the river flows gently through rocks of Tertiary age, which are covered by more recent deposits of alluvium.

Key coastal risk management issues for the frontage
It is the intention to continue to maintain and or improve defences that protect the town of Yarmouth because it is clear that existing defences will come under increased pressure as a result of climate change and sea level rise. The maintenance of the current defence levels without further improvements would not reduce the present and increasing risks from flooding (Isle of Wight Council, 2010). Over the next twenty years there will be a need to provide a higher standard of protection whilst rising sea levels and tidal inundation will continue to impact upon saltmarshes within the Western Yar estuary with coastal squeeze resulting in loss of habitat of nature conservation importance.

Observations on the artworks
Three artworks have been selected for this case study, which represent the three ranking time epochs (early 1770-1840; Mid 1840-1880 and Late 1880-1920). All three views are taken from the western side of the River Yar and look eastwards across the river towards the town of Yarmouth. The earliest view is a detailed copper plate engraving produced as one of a set of twelve views of the Isle of Wight by S. Barth and J. King in 1813. For such an early print it is

surprisingly detailed and gives a clear appreciation of the mouth of the Yar and the harbour at this time. The view predates the construction of the harbour breakwater and the bridge across the River Yar, which dates from the 1850s. In this view we can see the natural form of the coast prior to any human intervention. The second view is a steel plate engraving by the artist Robert Brandard (1848) and is viewed from Sandhard Beach, which is situated slightly forward and seaward of the print by Barth & King. The third image is a watercolour drawing looking across the River Yar in a north-easterly direction from rising ground just south of the two previous views. This watercolour is by Charles Robertson and was painted in 1891. Robertson was a follower of the Pre-Raphaelite Brotherhood of Artists who sought to capture nature in precise detail and this is reflected in this work.

Figure 3D.80: 'Yarmouth from the west', a copper plate engraving by S. Barth and J. King (1813). The detail of the extent of the harbour is carefully drawn in this view.

Figure 3D.81a Left: View of the mouth of the Western Yar after prolonged rainfall in 2007. Photograph: Andrew Butler. Figure 3D.81b Right: A view of the whole catchment of the Western Yar with the Solent beyond. Photograph courtesy of the Wight Light Gallery.

Figure3D.82: 'Yarmouth from the West' by Robert Brandard (1848)

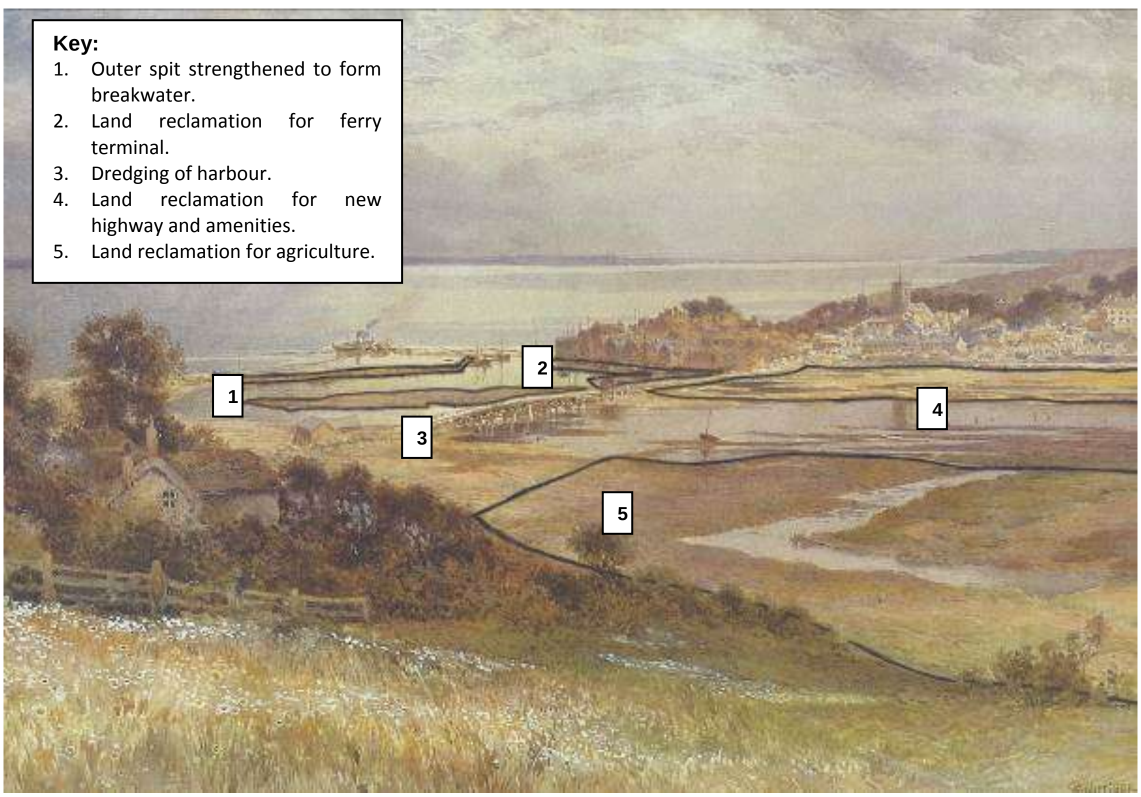


Figure 3D.83: 'Yarmouth' by Charles Robertson (1891) showing clearly the extent of the estuary and its relationship to the town. The painting has been annotated showing how harbour, highway and leisure development as well land reclamation, has reduced the width of the flood plain and the extent of the saltmarsh.

How can the artworks inform coastal risk management?

The three views of Yarmouth show a low-lying town of considerable historic and economic importance that is at risk from flooding and the impacts of climate change. They show the coastal geomorphology before it was altered by the construction of coastal defences and the harbour arm. Such views can be helpful when seeking to understand the implications of different coastal defence policy options under consideration through the shoreline management planning process.

Apart from the issue of coastal protection and flood defence such images can assist in understanding environmental loss and habitat changes. The Western Yar River, like most of the creeks and estuaries flowing into the Solent from both the Isle of Wight and Hampshire catchments, has been gradually silting up. Now, these coastlines are facing significant challenges from sea level rise with over 60% of the intertidal saltmarsh and mudflats expected to be lost by the year 2050.

In terms of understanding and quantifying this loss the watercolour by Robertson appears so accurate that it may be possible to over-lay the present day estuary limits and try and assess change over the last 130 years. The extent of riverside development in the Western Yar estuary for both commercial and agricultural purposes is indicated on the watercolour by Robertson. This has, to some extent, constrained the flows at Yarmouth. It also shows how works of art can be used to measure not just physical but also environmental and developmental changes over time.

Where can the original artworks be viewed?
The engraving by Barth and King is extremely rare and is contained in a number of art reference publications (McInnes, 2008b). The steel engraving by Bartlett is included in '*The History of Hampshire'* (Woodward *et al*., c.1848). The watercolour by Robertson is in a private collection.

Ranking scores achieved
The engraving by Barth & King scored 37 points; the view by R. Brandard scored 62. The very detailed watercolour by C. Robertson scored 77 points.

D3. Ventnor Undercliff, Isle of Wight study site

Location
The Ventnor study site comprises the section of developed coastline at Ventnor Bay on the south coast of the Isle of Wight.

Why was the case study site selected?
The Undercliff is a 12km long coastal cliff and landslide complex between Luccombe and Blackgang on the south coast of the Isle of Wight. The cliffs were formed as a result of deep-seated mass movements that occurred many thousands of years ago dating back to past glacial periods. The remnants of these ancient landslides extend a significant distance offshore and up to 700m inland of the shoreline where they comprise steep slopes and terraces up to 120m high. The Undercliff is regarded as one of the most unstable developed geological settings in the UK; the complex cliffs are formed in weak rocks that are sensitive to the effects of toe erosion and groundwater. The main area of interest for this case study concerns the section of Undercliff between Bonchurch and Ventnor.

The Undercliff study site was chosen to illustrate how art can inform us on physical change within a major coastal landslide complex.

Geomorphological setting
The coastal cliffs of the Isle of Wight Undercliff are formed within the Lower Cretaceous sequence of sedimentary rocks comprising Chalk, Upper Greensand, Carstone and Sandrock.

The sequence of strata is strongly bedded with a 2^0 dip seaward which pre-disposes the succession to large-scale landslides. The sea cliffs forming the present day 'toe' of the Undercliff are mostly cut into landslide debris, and erosion rates are typically 0.3m per year. In-situ soft sandstones (Sandrock) form the high sea cliffs at the east and west ends of the Undercliff at Luccombe and Blackgang where toe erosion rates are much higher, between 1-3m per year. The Undercliff has experienced a relative increase in sea level and winter rainfall over the historical period promoting toe erosion and excess groundwater levels both of which have an adverse impact on stability.

Figure 3D.84: View of Ventnor undercliff Landslide complex. Photo courtesy of the Wight Light Gallery.

Key coastal risk management issues for the frontage

Ground movement in the Undercliff generally takes the form of very slow and intermittent creep of the ground, the cumulative effects of which, over many years, has caused significant damage to property, businesses and other assets and services. Occasional rapid ground movements occur, for example at Blackgang in 1994, at Bonchurch in 2000, at Niton in 2001, and at Ventnor in 1960 when some residents had to be evacuated. Over the last 100 years, some 60 properties have had to be demolished in Ventnor due to impacts of ground movement, whilst others have sustained significant damage. The most notable impacts of ground movement can be observed in Upper Ventnor at a feature known as the 'Lowtherville Graben' which extends some 500m in length, 20m across, and has subsided vertically by up to 4m. The B3327 Newport Road and other services located across the graben are continually subject to damage due to ground movement. The A3055 Undercliff Drive was routed through Niton, St Lawrence, Upper Bonchurch and Ventnor and provided a strategic road network linking the coastal towns, communities and businesses across the southern and south west coast of the Isle of Wight. A landslide in February 2014 severed the route east of Niton. The present value annual risk of damage caused by ground movement in the Ventnor Undercliff has been estimated to be £4.64m (Lee & Moore, 2007).

The Undercliff is sensitive to toe erosion and deep-seated ground movement due to the inherent geology and exposure of weak rocks to weathering, excess groundwater and coastal erosion. There is concern that increases in relative sea level and winter rainfall will result in accelerated ground movement rates and more frequent landslide events over the next 100 years. The impact of these events is expected to be limited to the current extent of the Undercliff and is likely to involve significant recession of the headscarp; the Shoreline Management Plan estimates a total of 2,485 properties (worth £511m) are at risk from landslip in Ventnor and Bonchurch, and combined with estimated of replacement value of other assets including highways, footpaths and services, the total value of assets at risk is estimated to exceed £600m.

The local authority implemented a *Landslide Management Strategy* in the Undercliff in 1992. The main purpose of the strategy has been to engage key stakeholders and the community to raise awareness of the issues and promote best practice for managing ground instability through a range of practical measures and improved planning and building control. However, a quantitative risk assessment of coastal instability and erosion at Ventnor completed in 2006 demonstrated that, whilst these measures were beneficial, active civil engineering intervention would be necessary to avert the increasing risks of major ground instability due to the effects of climate change and rising sea level; further, the study identified a positive benefit to cost ratio for stabilisation in the form of deep drainage and improved coastal protection measures.

Climate change poses a significant challenge to the future stability and management of the Undercliff and other similarly marginally stable coastal landslides in southern Britain. The value of site investigation, continuous monitoring of weather, groundwater levels and ground movement rates is clearly demonstrated in this case study. The relationships and understanding derived from analysis of these data provide the basis for design of robust early warning and response strategies and engineering stabilisation works; reducing the potential adverse impacts and consequences of such events. Reliable assessment of the hazards and risk of large pre-existing coastal landslide complexes can only be achieved through detailed site investigations which are needed to inform effective planning, management and stabilisation.

Observations on the artworks

Three artworks have been selected to illustrate their value in the case of the Ventnor site. They are, first, an aquatint engraving of Ventnor Cove by Charles Raye (1825); second, a steel engraving by William Westall of the same view dated 1842. Finally a steel engraving showing Ventnor Beach by Rock & Co. dated 1863.

The views by Raye and Westall both look across Ventnor Bay from east to west. They show the coastal slopes of the seaward face of the landslide complex very clearly and bare of tree cover and later housing and tourism developments. Both views are carefully engraved with the early scene by Raye focusing more on Ventnor Cove itself whilst Westall's view includes the downland behind. The third image by Rock & Co. is of Ventnor beach looking in the opposite direction from west to east. The point of interest is the rock formation shown on the beach seaward of the sea cliff behind. The importance of the information provided in this engraving is explained below.

How can the artworks inform coastal risk management?

In recent years research has sought to understand more about the formation and development of the Undercliff landslide complex in order to support effective planning and risk management. A fundamental need was to understand how the landside complex was formed and its extent seawards. These issues were investigated through both field geomorphological mapping as well as interpretation of historical evidence including old maps, artworks and photographs.

The views by Charles Raye and by William Westall were particularly useful because they showed the town of Ventnor before the coastal frontage was extensively developed from the 1830s onwards. The planting of the Holm Oak during the early 1900s led to a rapid spread of the species; this also masks the coastal geomorphology today. In the two nineteenth century engravings it is possible to identify some of the main components of the landslide complex including back-tilted blocks of the Upper Greensand strata that have slid from the rear escarpment behind and above Ventnor Cove, peri-glacial deposits of landslide debris that were washed down from the hills behind and areas along the toe of the landslide at beach level that are affected by heave.

The small steel engraving by Rock & Co. (1863) shown in Figure 3D.87 is particularly significant. It shows the relic of a former cliffline lying seaward of the existing sea cliff. When the Undercliff geomorphology was being interpreted there was uncertainty as to whether the existing sea cliff represented the seaward extent of the Undercliff landslide complex as a whole. However, this image provided clear evidence of another cliff further seaward. Following further studies off-shore a landslide model for the Ventnor Undercliff was developed successfully (See Figure 3D.88).

Where can the original artworks be viewed?
The engraving by Charles Raye is published in his '*Picturesque Views of the Isle of Wight'* (Raye, 1825). The William Westall engraving is contained within '*Views of Carisbrooke Castle and Environs'* (Westall, 1842). The engraving by Rock & Co. of Ventnor Beach is from *'Views of Ventnor and neighbourhood'* (Rock & Co., c.1865).

Ranking scores achieved
Charles Raye *' Ventnor Cove'* – 55; William Westall *'Ventnor'* – 62; Rock & Co. *'Ventnor Beach'* - 55

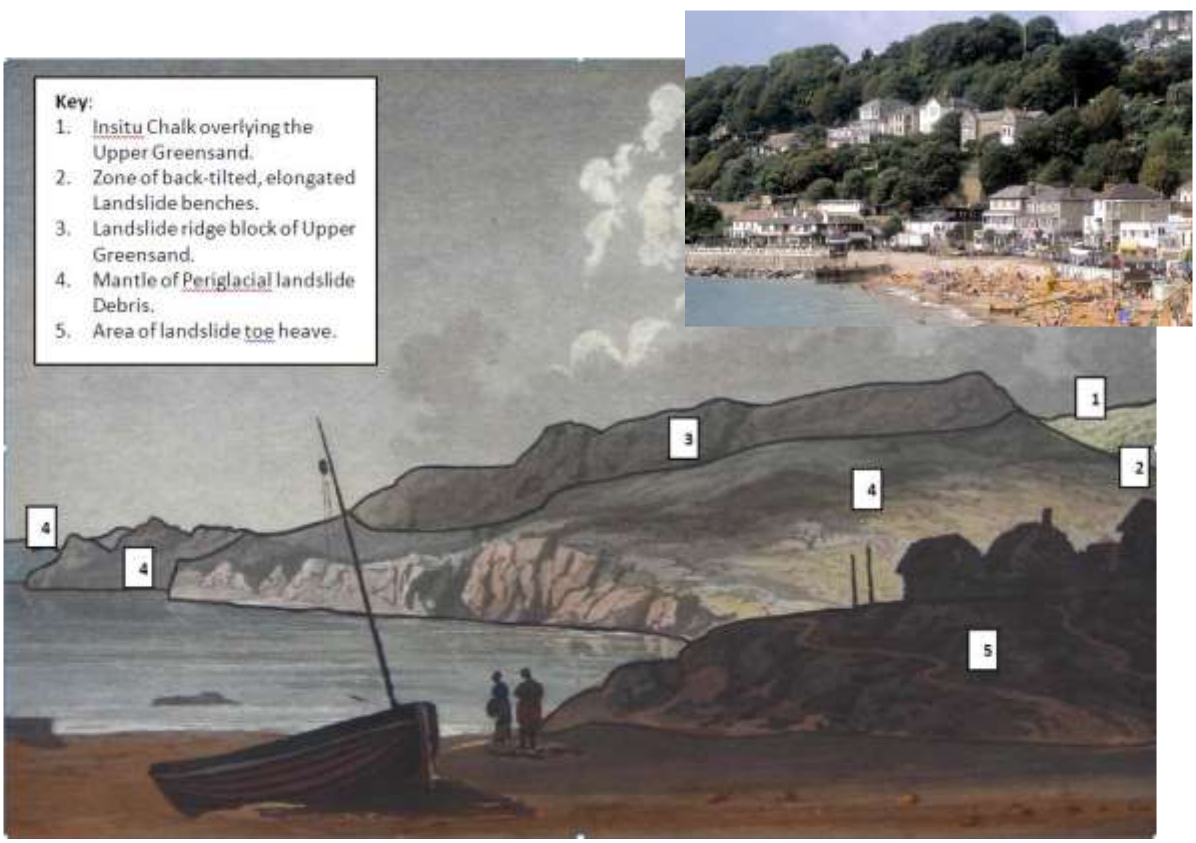


Figure 3D.85: 'Ventnor Cove' by Charles Raye. 1825. The geomorphology of the seaward face of the Undercliff landslide complex is clearly visible compared with the present day view

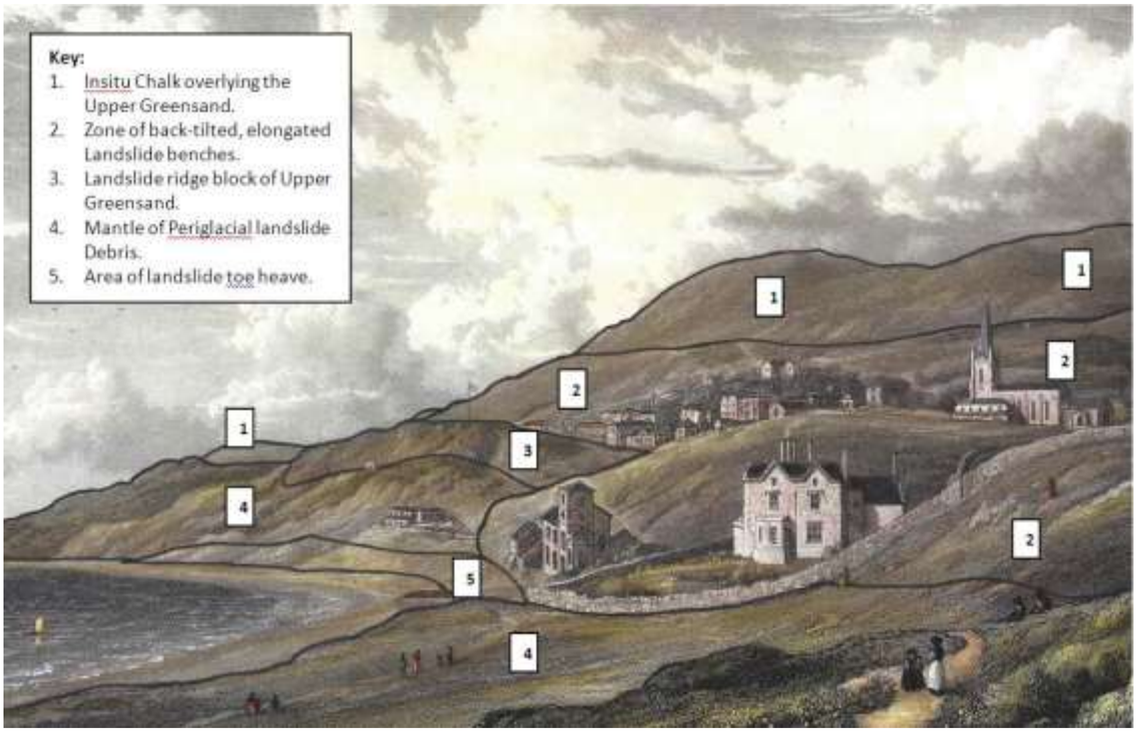


Figure 3D.86: A view of the same location by William Westall is rather more extensive and even more detailed. Victorian and Edwardian development over the coastal slopes and planting and spread of the Holm Oak in the early 20th century now masks the geomorphology.

Figure 3D.87: 'Ventnor Beach' by Rock & Co. 1863. The view shows a rock formation seaward of the existing sea cliff.

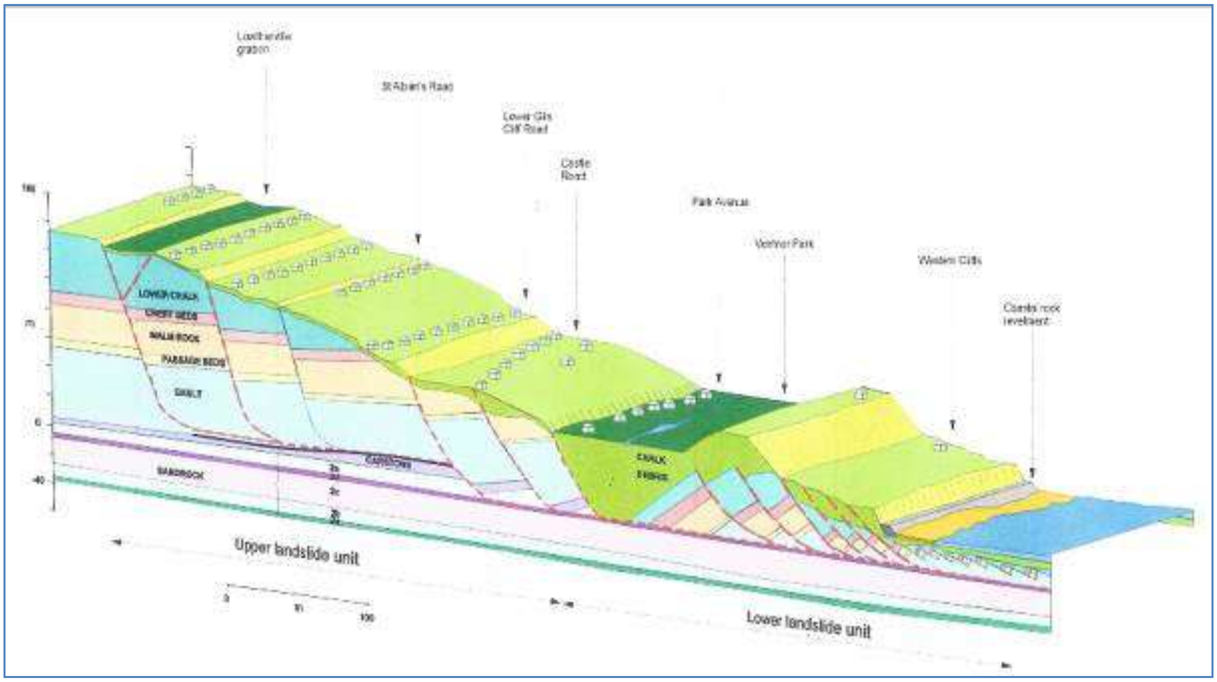


Figure 3D.88: The rocks depicted in the engraving by Rock & Co have long since been lost through erosion, they identified a former cliffline further seaward and helped to develop this landslide model for the Undercliff.

3D.7 ANALYSIS

The Solent and Isle of Wight study has combined the use of archaeological and palaeoenvironmental data, paintings, historic photographs, maps and charts in order to demonstrate how these tools can be used to improve our understanding of coastal change in the long and short term. The coastlines of the study area are constantly evolving, analysis of the past enables us to assess progressive changes and alterations to the coast and by understanding past coastal change it is possible to predict future changes and potential impacts more accurately. This section reviews the most informative and reliable data gathered from this study area for contributing to understanding of the scale and pace of coastal change.

3D.7.1 Archaeological and Heritage Features

Archaeological assessment focussed on the western Solent and Langstone Harbour, an analysis of the results is presented in this section.

Bouldnor Cliff and the wider landscape of the western Solent was chosen as a case study as it contains a long sequence of stratified prehistoric landscapes including Mesolithic occupation evidence (Figure 3D.89). The site scored maximum points for each criteria using the ranking methodology outlined above as it contains a long sequence of deposits demonstrating changing sea levels over 10,000 years, it contains dated and analysed evidence of the changing environment including associated human occupation evidence, and finally the long sequence of prehistoric landscapes and associated inundations are directly related to each other. Because of this it was also chosen for further archaeological fieldwork.

The well preserved sediment archives in the western Solent, particularly at the site of Bouldnor Cliff have improved our understanding of the formation of the Solent. Analysis of the bathymetry, sediments, diatoms and foraminifera at Bouldnor Cliff has revealed a sequence of events that saw final inundation by the sea around 6,000 BC. This was followed by the deposition of brackish estuarine sediments, which served to protect the palaeolandscape. Evidence suggests that the sea entered the system via the River Yar and by 4,000 BC rising sea levels eroded the barrier to the east of the basin with the western barrier being breached about 2000 years later. This formed the Solent which changed from a sedimentary sink in the estuary to the new Solent channel cutting across the infill deposits and removing most of them. Some of these deposits remain in sheltered areas to the north and south, including Bouldnor Cliff, although they are still subject to ongoing erosion (Momber et al, 2011).

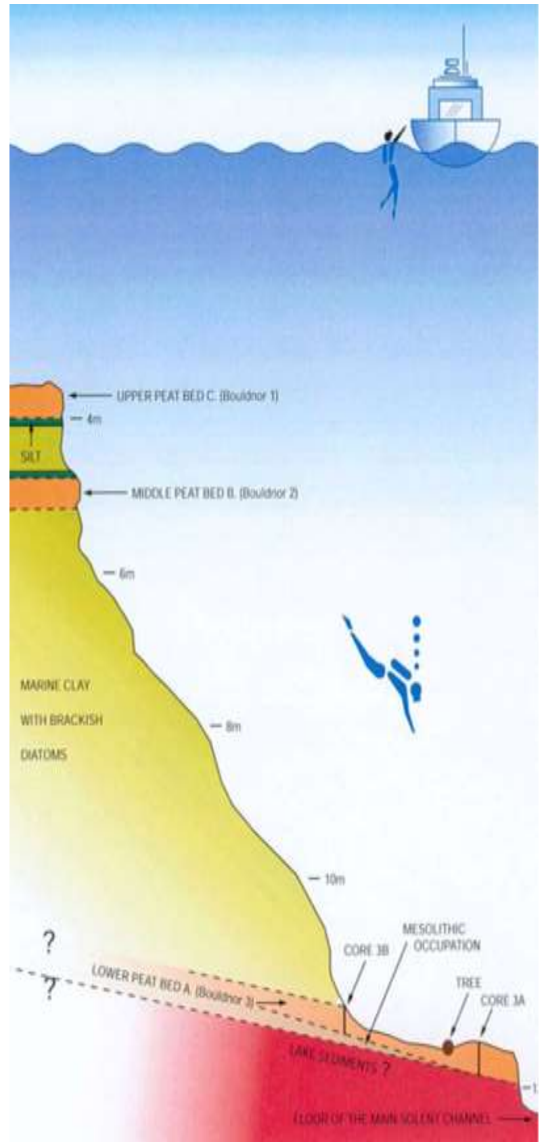


Figure 3D.89. Cross section through the submerged prehistoric landscape at Bouldnor Cliff (SCOPAC)

The formation of the Solent dramatically remodelled the seabed by reshaping and transforming the submerged palaeolandscape (Figure 3D.90). First, estuarine deposits covered protected earlier surfaces and secondly, sea level rise overtopped hills to the east and west allowing a new channel to be formed perpendicular to the original drainage pattern. This masked the previous north-south flowing river. Modern technology and analytical procedures have proven that the palaeolandscape was something other than it first appeared and shows that the seabed morphology did not reflect the earlier land surface.

It has been through detailed archaeological and palaeoenvironmental research that an understanding of how the Solent formed has been possible. These unique deposits have been preserved within an oxygen-free environment afforded by the fine fluvial and marine silt, allowing information on the past environment and how it changed to be obtained. This sequence of deposits provides vital evidence on how the Solent formed and continues to provide information on the ongoing rate and scale of coastal change which is further eroding the palaeolandscape.

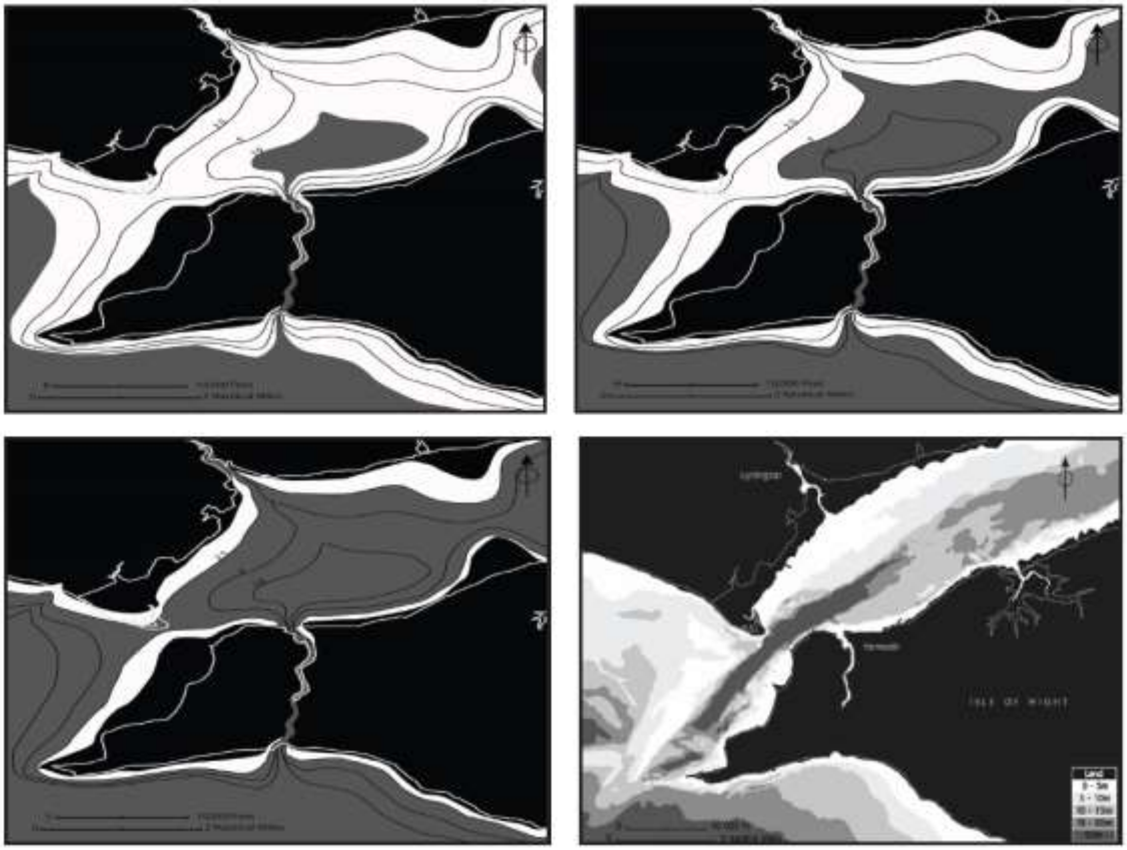


Figure 3D.90: Images showing the development of the western Solent. About 3,500 years ago, the breaching of the final land link to the island transformed a salt marsh into a channel that would eventually extend over 10km long and up to 60m deep. The strong tidal currents introduced when the channel was formed continue to erode the Solent shoreline today.

Langstone harbour was selected as a case study area due to its rich and diverse archaeological record and its history of archaeological investigation. The large project carried out in the 1990's (Allen & Gardiner, 2000) was followed by further work in 2002-2003 and again in 2012-2013 by the MAT, providing a gap of close to a decade which demonstrates how the harbour has changed over time with modern erosion exposing more material.

By combining the recent work with previous surveys and excavation it was possible to build a more accurate picture of how this landscape has changed over time, resulting in a 4D evolution model of the harbour from the Mesolithic to present day. Study of this data allows a better understanding and modelling of past incidents of, and reactions to, coastal change. This in turn can aid our planning for future changes and inform on sustainable policies for adapting to coastal change.

The combination of recent fieldwork with the previous projects in the area revealed intermittent human activity commencing in the Middle Stone Age and adapting, at various times, to a rising sea level. These changes were accompanied by a retreat of the shore from mudflats and saltmarsh. Significant stages in the evolution of Langstone Harbour began with a transition from a down-cut ravine to a silted river valley. This occurred during the Late Middle Stone Age. Dominant marine influences did not enter the channels within the harbour until after 800BC. There then followed periods of stasis and episodes of both accelerated erosion and deposition. These dynamic episodes show a relationship with concurrent changes in relative sea-level and shifts in local currents and the tidal system (Allen and Gardiner, 2000: 186-198).

Mesolithic – In the Mesolithic Langstone Harbour was an inland site, the landscape was dominated by a valley with steep sides leading down to fresh water streams.

Neolithic – The Neolithic landscape saw woodland on high and dry land while the valley had been in filled by organic material giving it a more shallow gentle profile.

Bronze Age – During the Bronze Age the area developed towards a stronger marine environment made up of salt marsh and tidal rivers.

Iron Age – The small rise in sea level during the Iron Age made the area much wetter and the now, almost non-existent valley was flooded.

Current - Langstone harbour is now a large shallow, marine inlet off the English Channel

Figure 3D.91. The evolution of Langstone Harbour, screen shots from the 4D model showing how the landscape has changed over time (the full interactive model is available on the portal).

3D.7.2 Artistic Depictions

The Solent and Isle of Wight case study sites have provided examples of how artwork can support understanding of long-term evolution of coasts, harbours and estuaries as well as environmental and habitat changes. The case studies also explain how art, maps, charts and photographs can improve our understanding of coastal geomorphology, erosion and ground instability problems.

Artworks

Where highly ranked artworks are available for study such as the view of Yarmouth by Charles Robertson or the very detailed engraving by William Westall of Ventnor it is possible to study coastal features in much more detail. Whilst the Yarmouth view shows very clearly how the river morphology and environment has been altered as a result of human intervention, the Ventnor engraving supplies geomorphological information that is now far less obvious through visual inspection; the whole of the coastal zone being masked by tree cover or development.

The small engraving by Rock & Co, which shows the vestiges of a former sea cliff on Ventnor beach illustrates how historical artworks may have recorded useful information, which has since been lost as a result of coastal erosion.

Historic Photographs

Historic photos provide detailed and accurate information on coastal change. Two areas in particular can demonstrate this; Lymington and Hurst Spit.

Hurst Spit is a cuspate shingle foreland dominating and protecting the entrance to the western Solent. This feature is best known to most for the presence of Hurst Castle. The castle is a national historic monument and tourism asset situated at the tip of the spit. Its survival depends on the future stability of the spit yet, by its very nature, the spit is an evolving coastal beach-form capable of dispersal or migration.

For observers of shoreline behaviour, the spit is of particular importance because of the natural protection it has long provided for the sheltered coasts and habitats of the western Solent seaway. The spit is an ephemeral coastal feature that is capable of changing its form and shifting its position. It is now known that its entire development must lie within the past 8,000 years. Some perceptible shifts in the configuration of the spit are evident in recent history and can be seen through historic photographs. Below is an aerial photograph from 1953 obtained through the Britain from Above Project. This is presented next to a current view of the area (Figure 3D.92).

Comparison of these images shows the extent of the sediment erosion on the spit, the sea now reaches the walls of Hurst Castle. However, further north at the old jetty by the lighthouse the accretion of shingle around the jetty made this no longer usable by boats.

Figure 3D.92: Hurst Spit in 1953 (left) and 2013 (right).

Loss of intertidal mudflats and saltmarsh at the entrance of Lymington Harbour can also be seen through historic photos. Below is an aerial view from 1952 compared to a view from 2013.

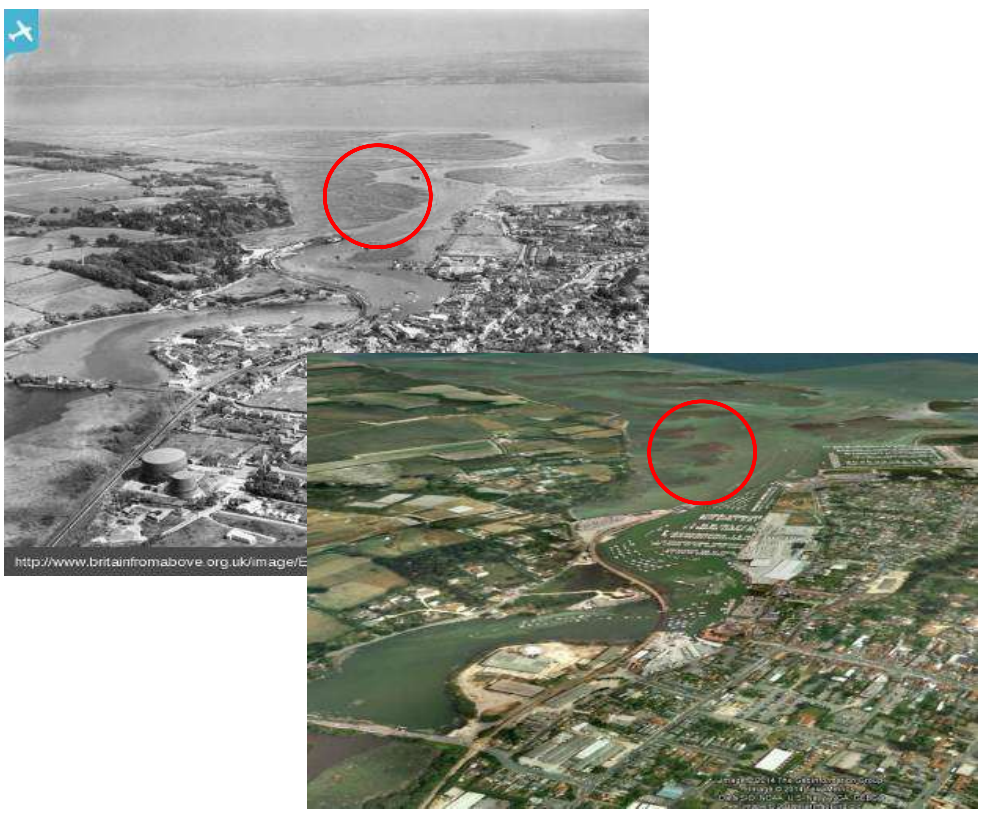


Figure 3D.93: Lymington Harbour in 1952 (left) and 2013 (right). The red circle marks the most notable changes in the saltmarsh.

The specific cause of saltmarsh loss is little understood. A combination of factors including wave action, lack of sediment supply, dieback of vegetation, tidal currents and sea level rise are all thought to influence the erosion of the saltmarsh (NFDC, 2014). The use of historic resources such as these images may not provide the answer as to the specific causes of erosion, but can provide high resolution data on the rate and scale of erosion since at least the 1950's. Combining this with historical maps, charts and archaeological/palaeoenvironmental data will provide a long term perspective on the rate and scale of change to help with management in the future.

Maps and Charts

The loss of saltmarsh around Lymington discussed above can be further understood through the analysis of historic maps. The highest scoring maps from the western Solent area were georeferenced and the limit of the saltmarsh digitised. This allowed us to see the rate of change from 1781 to the present day (Figure 3D.94).

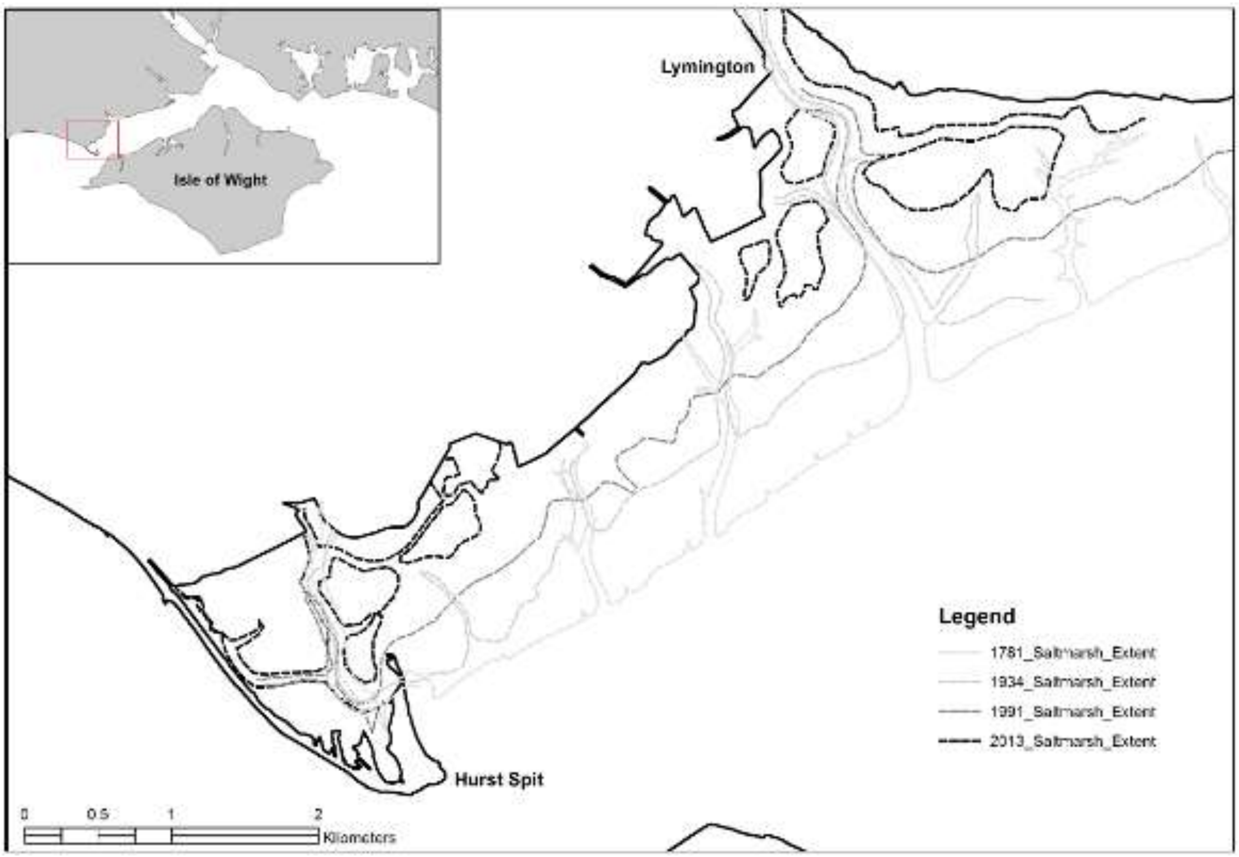


Figure 3D.94 : Saltmarsh and mudflat regression from 1781, 1934, 1991 and 2013 based on the analysis of historic maps.

This analysis has helped us to understand the rate of change in this area. Over a period of 153 years from the date of the first map (1781) to the second map (1934), the area witnesses around 500m regression of the saltmarsh. Over the next 57 years this is between 200-400m, then dramatically in just 22 years the saltmarsh erodes by up to 500m in places. The rate of erosion has dramatically increased in the last 100 years. As mentioned above the specific cause of saltmarsh regression is little understood and these maps cannot provide an answer, but they can provide high resolution detail on the rate and scale of change from the 18th century.

3D.7.3 Combined Resources

The issues of saltmarsh and mudflat regression in the north west Solent are detailed above. Data from archaeological diver survey, seabed monitoring points, maps, charts, art and marine geophysical survey have been utilised to map changes in this area. Understanding the underlying formation processes in the Solent can help resolve the patterns of change. In turn, this could help anticipate the cumulative effects of future coastal intervention.

By its very nature and position, Hurst Spit holds a key position in the natural protection of the coast of the western Solent. The shoreline habitats to its east are clearly dependent upon its survival and on the nature of its configuration. Despite these dependencies, far too little is known of the evolution of the spit and its eastward migration. Little is also known of the sediment history of the coastal wetlands that the spit may, or may not, continue to protect. A principal historic building on the spit offers some prospect of observing recent changes in sea level or water-level in later historic times and the analysis of historic photographs, maps and charts outlined above demonstrates these more recent changes.

It is in the sediment archives that the highest potential may be found at this location. Some of these lie in the cusp of the spit where there is an opportunity to gain firm knowledge of the long-term agenda of spit-formation and coastal behaviour that is shaping this vulnerable coastline. Through the project it was possible to recover some samples from the spit for environmental analysis. The results of this analysis and dating, outlined in Section 3D.4.1.5 above demonstrate how new data is constantly transforming understanding of the movement of the spit and its relationship to long-term geomorphological processes from the formation of the Solent.

The 3D model of Langstone Harbour was primarily created using archaeological and palaeoenvironmental data as detailed above, this covered the Mesolithic to the Saxon period. However, in order to reconstruct the post-medieval landscape several high ranking historic maps and charts were used. This has allowed us to create a model covering a period of over 8,000 years, demonstrating how the harbour has changed (Figure 3D.95). Similarly in Belgium, the Scheldt polders have been mapped using a combination of archaeological and palaeoenvironmental data for prehistoric periods and historic maps and charts for the post-medieval period (see case study report 3M).

Figure 3D.95 Left: reconstruction of the post-medieval landscape prior to the reclamation of Farlington marshes in 1771. This has been based on high ranking historic maps such as the one presented above right by Milne and can be compared with the present day (bottom right), aerial image courtesy of the CCO.

3D.8 Conclusions and Recommendations

The western Solent archaeological study area provides evidence of how the Solent formed, these processes which formed the Solent continue to affect the area with continuing erosion deepening and widening the seaway. Evidence from the archaeological and palaeoenvironmental studies of the submerged landscapes can reveal past environmental changes and human responses to this, which in turn can be compared with the events being witnessed today and improve our understanding of how this coastline evolved. Through a better understanding of how the Solent became what it is today coastal managers will be better placed in planning for the future.

The huge dataset available from the western Solent, particularly the sequence of deposits analysed at Bouldnor Cliff should now be used to create a 4D evolution model of the area. This will provide a visual tool for coastal managers to see the rate and scale of change in this region and to emphasise that the area is continuing to change and we will need to adapt. Combining the archaeological and palaeoenvironmental data with artistic resources, including historic maps, charts, photographs and artworks will allow us to understand change from prehistory up to the present day. Artistic resources have been valuable tools in understanding the rate of saltmarsh loss in the north west Solent, the recent changes to Hurst Spit and erosion affecting the soft cliffs around the west coast of the Isle of Wight.

It has been possible to use all of these resources to create an evolution model of Langstone Harbour, this should now be used in future shoreline management plans and provides a clearer understanding of how the harbour became what it is today which can in turn help better understand how it may change in the future. These resources can support the development of sustainable policies for adapting to future coastal climate change.

The art case studies demonstrate the value of examining a sequence of artworks over time by different artists in terms of providing a record of long-term coastal change. They allow detail and accuracy to be compared across artists and artworks to improve confidence in the reliability of the depictions in addition to the value of the information they impart.

The Solent and Isle of Wight coastlines were one of the most painted regions of the British Isles. The opportunity exists, therefore, to apply the Arch-Manche approach along most of this extensive coastal frontage.

In many locations around the Southern North Sea - Channel coastline monitoring has taken place for less than twenty years. The case studies help explain the rate of change over past centuries as a result of erosion or sea level rise. This can supplement existing and future monitoring of trends and can support predictions for the future.

The Ventnor case study provides an example of a geomorphological feature depicted in an artwork that does not exist today and which provided an important clue to the interpretation of the history of landsliding at that location.

Recommendations

The results of the case study and density of the archaeological, historical and artistic resources for this region make it a key area for demonstrating the Arch-Manche approach. Following the project the following recommendations are put forward:

- All studies relating to coastal and shoreline management should take full account of the archaeological, palaeoenvironmental, art and other historical resources available to improve understanding of coastal evolution and trends.
- Where ranking has indicated archaeological and palaeoenvironmental sites have the potential to reveal important data on coastal change then field studies should be undertaken.
- Potential impacts on important archaeological and palaeoenvironmental sites through either natural or humanly induced risks should take into account the potential loss of data on coastal change.
- Where artworks are sufficiently detailed and have been ranked highly it may be possible to make qualitative comparisons of change against present day views.
- Early artworks of sufficient accuracy can improve understand of coastal geomorphology by showing the landscape prior to extensive seaside development taking place.

Figure 3D.96. The Old Battery on the Needles, Isle of Wight. This heritage feature is now being destroyed by erosion, resources including archaeology, art, historic photographs and maps can all help improve our understanding of the rate and scale of past change to help plan for the future.

3D.9 Case Study References

Allen, L C, & Gibbard, P L, 1993 Pleistocene evolution of the Solent River of Southern England, Quaternary Science Reviews, 12, 503-528

Allen, M J & Gardiner, J (eds), 2000 Our changing coast:a survey of Langstone Harbour, Hampshire, CBA Res Rep 124. York: Council for British Archaeology

Alley, R B, Meese, D A, Shuman, C A, Gow, A J, Taylor, K C, Grootes, P M, White, J W C, Ram, M, Waddington, E D, Mayewski, P A, and Zieginski, G A, 1993 Abrupt increase in Greenland snow accumulation at the end of the Younger Dryas event. Nature 362, 527-529

Alley R B, 2000 The Younger Dryas cold interval as viewed from central Greenland, Quaternary Science Reviews, 19, 212-26

Anderson, F W, 1933 The new dock excavations, Southampton, Papers and Proceedings of the Hampshire Field Club 12,169-176

Andersen, S T, 1970 The relative pollen productivity and pollen representation of north European trees and correction factors for tree pollen spectra. Danmarks Geologiske Undersogelse R.II. 96, 1-99

Andersen, S T, 1973 The differential pollen productivity of trees and its significance for the interpretation of a pollen diagram from a forested region, 109-115, in Birks, H.J.B West, R.G. Quaternary Plant Ecology. Blackwell, Oxford.

Archibald, E. H. H., 1980. 'Dictionary of Sea Painters'. Antique Collectors Club. Woodbridge, Suffolk.

Baily, B and Pearson, A. (2007) Change detection mapping and analysis of saltmarsh areas of Central Southern England from Hurst Castle Spit to Pagham Harbour.

Bates, MR, 2001 The meeting of the waters: raised beaches and river gravels of the Sussex Coastal Plain/Hampshire Basin, in Wenben-Smith, F F, & Hosfield, R T (eds), Paleolithic Archaeology of the Solent River, Lithic Studies Occasional paper No 7, 27-45

Bradbury, A.P., Colenutt, A.J., Cross, J., Eastick, C. and Hume, D. (2003). Evaluation of coastal process impacts arising from nearshore aggregate dredging for beach recharge - Shingles Bank, Christchurch Bay. In International Conference on Coastal Management 2003, R. G. McInnes (ed.), pp. 98-112. London.

Brampton, A. H., Evans, C. D. R and Velegrakis, A. F., 1998. Seabed Sediment Mobility Study - West of the Isle of Wight. Project Report No 65. London: CIRIA.

Brannon, A., c.1860. 'A Voyage Around the Isle of Wight – Being an Indispensable Handbook to every Stranger'. Wootton, IW.

Brannon, G., 1841. 'Graphic Delineations of the most Prominent Objects in the Isle of Wight'. Wootton, IW.

Brannon, G., 1850a. 'A Picture of the Isle of Wight'. Wootton, IW.

Brannon, G., 1850b. 'The Pleasure Visitors' Companion in making a Tour of the Isle of Wight'. Wootton, IW.

Brannon, G. & A., 1821-1876. 'Vectis Scenery'. Private Press. Wootton, IW.

Bridgland, D R,& D'Olier, B, 2001 The Pleistocene evoloution and Paaeolithic occupation of the Solent River, in Wenben-Smith, F F, & Hosfield, R T (eds), Paleolithic Archaeology of the Solent River, Lithic Studies Occasional paper No 7, 15-25

Brown, R.C., Gilbertson, D.D., Green, C.P. and Keen, D.H. 1975. Stratigraphy and environmental significance of Pleistocene deposits at Stone, Hamphire.*Proceedings of the Geologists' Association, London,* 86, (3) 349-363

Bruce, P., 2008. Solent and Island Tidal Streams. Lymington: Boldre Marine.

Bullar, J., 1819. 'A Companion in a Tour of Southampton'.

Calvert, F., 1846. 'The Isle of Wight Illustrated'. London.

Case, C., 2009a. Isle of Wight. Annual Report 2007. Southeast Strategic Regional Coastal Monitoring Programme. Channel Coastal Observatory.

Case, C., 2009b. Isle of Wight. Annual Report 2009. Southeast Strategic Regional Coastal Monitoring Programme. Channel Coastal Observatory.

Cooke, W. B., 1808. 'A New Picture of the Isle of Wight'. Private Press. London.

Cope, S N, Bradbury, A P, and Gorczynzka, M, 2008 Solent Dynamic Coast Project: Summary report, Available: http://www.channelcoast.org/reports/ Accessed:12 August 2008

Crocombe, A., 2008. Isle of Wight. Annual Report 2004. Southeast Strategic Regional Coastal Monitoring Programme. Channel Coastal Observatory.

Daniell, R. & Ayton, R., 1814. 'A Voyage Round Great Britain'. Longman & Co. London.

Dean, J M, 1995 Holocene paleo-environmental reconstruction for the nearshore Newton area, Isle of Wight, Unpubl BSc Thesis, University of Southampton.

Devoy, R J, 1982 Analysis of the geological evidence for Holocene sea-level movements in southeast England, Proceeding of the Geologist Association 93, 65-90.

Dix, J, 2000 A geological and geophysical investigation of the submerged cliff at Bouldnor, in McInnes, R & Jakeways, J, (eds), Coastal change, climate and instability, final technical report, LIFE 97 ENV/UK/000510, European Commission, L'instrument foncier pour l'environnement. 2, 5-13

Dix, J K, 2001 The geology of the Solent river system in F. F. Wenban-Smith & R T Hosfield (eds) Palaeolithic archaeology of the Solent River, Lithic Studies Society, Occ. paper. No 7, British Museum. Quaternary Section, London, 7-14

Draper, J C, 1968, Mesolithic distributions in SE Hampshire. Proc. Hampshire Field Club & Archaeological Society 23, 110-119

Drummond, M, and McInnes, R. 2001. The Book of the Solent. Chale, Isle of Wight: Cross Publishing.

Dyer, K R,1969 Some aspects of coastal and estuarine sedimentation. PhD thesis, Department of Oceanography, Southampton University.

Dyer K R, 1975 The buried channels of the 'Solent River' Southern England, Proceedings of Geological Association of London, 86(23), 9-246.

East Solent Coastal Partnership., 2013. 'Southsea and North Portsea Island Coastal Flood and Erosion Risk Management Schemes – Scoping Report'. Portsmouth City Council.

Ellis, A (Ed.). 2004. 'Catalogues of Oil Paintings in Public Collections in Southampton, Hampshire and the Isle of Wight'. 2 Vols. The Public Catalogues Foundation.

Englefield, Sir H., 1816. 'The Isle of Wight – A Description of its Scenery, Antiquities and Geological Phenomena'. Private Press. London.

Environment Agency, 2010. 'Fact Sheet – An Environmental Summary of Portsmouth'.

Everard, C. E. 1954 The Solent River: a Geomorphological Study, Transactions of the Institute of British Geographers 20: 41-58.

Fox, W E, 1862 How and when was the Isle of Wight separated from the mainland? Geologist 5, 452

Fulford, M, Champion, T, & Long, A, 1997 Englands's coastal heritage; a survey for English Heritage and the RCHME. EH/RCHME, London.

Galloway, J. 2009, Storm flooding, coastal defence and land-use around the Thames Estuary and tidal river c.1250-1450'. Journal of Medieval History Volume 35, Issue 2, June 2009, Pages 171-188

Gilpin, W., 1804. 'Observations on the Coasts of Hampshire'. London.

Graves, A., 1901. 'A Dictionary of Artists who have Exhibited Works in the Principal London Exhibitions from 1760-1893'. Kingsmead Press. Bath.

Grove, R. A., 1832. 'Views of the Principal Seats and Marine and Landscape Scenery in the Vicinity of Lymington'. Private Press.

Hack, B, 1999 More stone tools from Rainbow Bar, Hillhead, Proc. Hants Field Club & Archaeological Society 54, 163-171

Hampshire County Council. 2014. Lymington-Keyhaven Nature Reserve. Available from: http://www3.hants.gov.uk/countryside/lymington-keyhaven.htm [Accessed April 2014].

Harlow, D. A., 1980. Sediment Processes, Selsey Bill to Portsmouth. Unpublished PhD thesis, Department of Civil Engineering, University of Southampton.

Hodson F, & West I M, 1972 Holocene Deposits of Fawley, Hampshire, and the Development of Southampton Water Proceedings of Geological Association, 83, 421-442

HWTMA, 2002/2003 A Year in Depth. The Annual Report of Hampshire and Wight Trust for Maritime Archaeology.

Isle of Wight Council, 2010. 'Isle of Wight Shoreline Management Plan Round Two. Centre for the Coastal Environment. Ventnor, IW.

Ke, X, & Collins, M, 2002 Saltmarshes in the West Solent (southern England): their morphodynamics and evolution, in T Healy, Y Wang & JA Healy (eds), Muddy Coasts of the World: Processes, Deposits and Function, Elsevier Science BV, 411-440

King, R., 1845. 'A Handbook of Lymington and the New Forest'.

King, A. & Soffe, G. 1994 'The Iron Age and Roman temple on Hayling Island' In A P Fitzpatrick & E L Morris (eds) The Iron Age in Wessex: Recent Work. Salisbury: Wessex Archaeology, 114 -16.

Lambourne, L. & Hamilton, J., 1980. 'British Watercolours in the Victoria and Albert Museum'. Crown Copyright. London.

Langstone Harbour Board, 2009. Langstone Harbour Management Plan Environmental Revisions.

Lee, E. M. & Moore, R., 2007. 'Ventnor Undercliff Development of Landslide Scenarios and Quantitative Risk Assessment'. Proceedings of the International Conference on Landslides and Climate Change, Ventnor, Isle of Wight, p.323-333.

Loader, R, 2007 *Isle of Wight: Upper Palaeolithic and Mesolithic Resource Assessment*. Contributory section for the Solent – Thames Regional Research Framework. http://www.buckscc.gov.uk/bcc/content/index.jsp?contentid=-1701835648

Long, A J, & Scaife, R G, 1996 Pleistocene and Holocene Evolution of Southampton Water and its tributarie,. Report of Environmental Research Centre, Department of Geography, University of Durham.

Long, A J, & Tooley, M J, 1995 Holocene sea-level and crustal movements in Hampshire and Southeast England, United Kingdom, Journal of Coastal Research Special Issue No.17, 299-310.

Lugar, R., 1828. 'Villa Architecture'. London.

MacKenzie, I., 1987. 'British Prints'. Antique Collectors Club. Woodbridge, Suffolk.

Mallalieu, H. L., 1984. 'The Dictionary of British Watercolour Artists up to 1920'. Antique Collectors Club. Woodbridge, Suffolk.

McInnes, R. G., 1989. 'The Isle of Wight Illustrated'. Cross Publishing. Chale, IW.

McInnes, R. G., 1993. 'A Picturesque Tour of the Isle of Wight'. Cross Publishing. Chale, IW.

McInnes, R. G., 1999. 'The Garden Isle – Landscape Paintings of the IW'. Cross Publishing. Chale, IW.

McInnes, R. G., 2004. 'Fifty years along the Undercliff'. Cross Publishing. Chale, IW.

McInnes, R. G., 2008a. 'Art as a Tool in Support of the Understanding of Coastal Change in Hampshire and the Isle of Wight'. The Crown Estate-Caird Fellowship 2008. Crown Copyright.

McInnes, R. G. 2008b., 'A Romantic and Picturesque Tour of the Isle of Wight'. Cross Publishing.

Melville, R.V. and Freshney, E.C. ,1982, British Regional Geology: The Hampshire Basin and adjoining areas, 4th ed., Institute of Geological Services, HMSO.

Momber, G., 2000. Drowned and Deserted: A submerged prehistoric landscape in the Solent, England. The International Journal of Nautical Archaeology, 29.1: 86-99

Momber, G, 2004 The inundated landscapes of the western Solen in N. Flemming (ed). Submarine Prehistoric Archaeology of the North Sea. The inundated landscapes of the Western Solent. CBA Research Report 141. 37-42

Momber, G & Geen, M, 2000 The application of the Submetrix ESIS 100 Swath Bathymetry system to the management of underwater sites, Int J Naut Archaeol, 29(1), 154-62

Momber, G., Tomalin, D., Scaife, R., Satchell, J. and Gillespie 2011 Bouldnor Cliff and the Submerged Mesolithic Landscape of the Solent. York: CBA Monograph Series 164.

Momber, G. 2011a. Changing landscapes fit for human occupation. In Momber, G., Tomalin, D., Scaife, R. Satchell, J. & Gillespie, J. (eds), 2011. Mesolithic occupation at Bouldnor Cliff and the submerged prehistoric landscapes of the Solent. Council for British Archaeology (York): pp123-125.

Momber, G., 2011b Submerged landscape excavations in the Solent, southern Britain: climate change and cultural development. In: Benjamin, J., Bonsall, C., Pickard, C & Fischer, A. (eds): Submerged Prehistory. Oxbow Books (Oxford): 85-98.

Moore, PD & Webb, JA, 1978. An Illustrated Guide to Pollen Analysis. London: Hodder & Stoughton

Moore PD, Webb, JA & Collinson, ME, 1991 Pollen Analysis, 2nd edn. Oxford: Blackwell Scientific

Moore, R., Carey, J. M. & McInnes, R. G., 2010. 'Landslide Behaviour and Climate Change: Predictable Consequences for the Ventnor Undercliff, Isle of Wight'. Quarterly Journal of Engineering Geology and Hydrogeology; Vol. 43, pp. 447-460.

Mottershed, D., 1976 The Quaternary history of the Portsmouth region. In Portsmouth Geographical Essays, Vol 2, 1-21

Mudie, R., 1840. 'Observations on the Coasts of Hampshire'. London.

Munt, M. & Burke, A. 1987. The Pleistocene geology and faunas at Newtown, Isle of Wight.*Proceedings of the Isle of Wight Natural History and Archaeological Society*, **8**: 7-14

New Forest District Coastal Group. 2007. Summary Notes of NFDC Coastal Group's research relating to Lymington saltmarshes. Available from:
http://www.rlymyc.org.uk/Harbour/documents/saltmarsh%20loss%20summary%20for%20RLYC.pdf
[Accessed April 2014].

NFDC, 2014. Saltmarsh Erosion. New Forest District Council http://www.newforest.gov.uk/index.cfm?articleid=7182

Nichols, R J, & Clarke, M J, 1986 Flandrian peat deposits at Hurst Castle Spit'. Proc. Hants. Field Club and Arch. Soc. 83, 421-441.

Nowell, D A G, 1995 Faults in the Purbeck-Isle of Wight Monocline, Proceedings of the Geologists Association, 106, 145-150

Pastscape 2007: Fort James:
http://www.pastscape.org.uk/hob.aspx?hob_id=238752&search=all&criteria=fort

Pennant, T., 1801. 'Journey from London to the Isle of Wight'. London.

Raye, C., 1825. 'A Picturesque Tour of the Isle of Wight'. London.

Rock & Co. c.1865. 'Views of Ventnor and Neighbourhood'.

Rowe, G., 1826. 'Views of the Isle of Wight'.

Russell, R., 1979. 'Guide to British Topographical Prints'. David and Charles. Newton Abbot.

Scaife, R G, 1980 Late-Devensian and Flandrian palaeoecological studies in the Isle of Wight. Unpubl. PhD thesis. University of London, King's College.

Scaife, R G, 2000a Palaeo-environmental investigations of the submerged sediment archives in the West Solent at Bouldnor and Yarmouth, Chapter 4, 13-26 in Coastal Change, Climate and Instability. European Commission LIFE project. LIFE-97 ENV/UL/000510 (1997-2000). Isle of Wight Council.

Scaife, R., 2003 The Langstone Saxon Log Boat: A preliminary Pollen Analysis of the associated sediments. Unpublished Archive Report.

Scaife, R. G. 2011 Pollen Evidence for Vegetation Changes, in G. Momber et al. (eds.) Bouldnor Cliff and the Submerged Mesolithic Landscape of the Solent. . York: CBA Monograph Series 164.

SCOPAC. Standing Conference on Problems Associated with the Coast. www.scopac.org.uk

Taylor, K C, Mayewski P A, Alley, R B, Brook, E J, Gow, A J, Grootes, P M, Meese, D A, Saltzman, E S, Severinghaus, J P, Twickler, M S, White, J W C, Whitlow, S, Zielinski, G A, 1997 The Holocene-Younger Dryas Transition Recorded at Summit, Greenland, Science, 278, 5339, 825 – 827

Tomalin, D J, 2000a Palaeo-environmental investigations of submerged sediment archives in the West Solent study area at Bouldnor and Yarmouth, in R McInnes, D J Tomalin & J Jakeways (eds) Coastal change, climate and instability: final technical report vol 2, European Commission Life Project 97 ENV/UK000510. Ventor: Isle of Wight Centre for the Coastal Environment, 13-45

Tomalin, D, J, 2000b Geomorphological evolution of the Solent seaway and the severance of Wight: a review, in M. B. Collins & K. Ansell (eds) Solent Science: a review, Elsevier, Amsterdam, 9-19.

Tomalin, D, J, 2006, Coastal Villas, maritime villas; a perspective from Southern Britain. In Journal for Maritime Archaeology, vol 1, no 1, 29 – 84.

Tomalin, D, J, 2011 The assemblage of lithic artefacts from the Mesolithic occupation features on the sea floor at Bouldnor Cliff. in G. Momber et al. (eds.) Bouldnor Cliff and the Submerged Mesolithic Landscape of the Solent. . York: CBA Monograph Series 164.

Tomalin, D J, Loader, R D and Scaife, R G 2012 Coastal Archaeology in a Dynamic Environment: a Solent case study. Oxford BAR British Series 568, 292-294

Tomkins, C., 1796. 'Tour of the Isle of Wight'. London.

Trott, K. & Tomalin, D. J., 2003. The maritime role of the island of Vectis in the British pre-Roman Iron Age. In, International Journal of Nautical Archaeology 32.2: 158– 181.

Turley, R., 1975. 'Hampshire and Isle of Wight Bibliographies'. Barry Shurlock & Co (Publishers Limited). Winchester.

Turley, R., 1977. 'Hampshire and Isle of Wight Art'. University of Southampton Library. Southampton.

Velegrakis, A F, Dix,, J K & Collins, M B, 1999 Late Quaternary evolution of the upper reaches of the Solent river, Southern England, based upon marine geophysical evidence, J Geol Soc London 156, 73-87

Velegrakis, A, 2000 Geology, geomorphology and sediments of the Solent system in M B, Collins & K, Ansell, (eds), Solent Science: a review. Elsevier. Amsterdam, 21-34.

Wenban-Smith, F F, & Hosfield, R, (eds), 2001. Palaeolithic Archaeology of the Solent River, London, Lithic Studies Society, Occasional Papers, 7:112

Wessex Archaeology. 2010a. New Forest Rapid Coastal Zone Assessment, Phase 1: Desk Based Assessment. Ref: 72200.02.

Wessex Archaeology. 2010b. New Forest Rapid Coastal Zone Assessment Survey, Phase 3: Final Report. Ref: 72201.02.

West I M, 1980 Geology of the Solent Estuarine System In: The Solent Estuarine System: An assessment of the present Knowledge. NERC Publications, Series C, No 22, 6-19.

West, I M, 2008 Hurst spit Barrier Beach of the West Solent Hampshire: Geology of the Wessex Coast. Available: http://www.soton.ac.uk//~imw/Hurst-Castle-Spit.html

Westall, W., 1842. 'Carisbrooke Castle and its Environs'. Private Press.

Whitcombe, L. J., 1995. Sediment Transport Processes, with Particular Reference to Hayling Island. Unpublished PhD thesis, Department of Oceanography, University of Southampton.

Whitewright, J., 2011. Monitoring the Flower of Ugie. In The Archaeology and History of the Flower of Ugie, wrecked 1852 in the Eastern Solent, J. Whitewright and J. Satchell (eds), pp. 79-84. Hampshire and Wight Trust for Maritime Archaeology Monograph Series 1, Oxford: British Archaeological Reports, British Series 551.

Wood, C., 1978. 'The Dictionary of Victorian Painters (2nd Edition)'. Antique Collectors Club, Woodbridge, Suffolk.

Woodward, B. B., Wilks, T. C. & Lockhart, C., Not dated. 'The History of Hampshire'. London.

Woollard, D., c.1915. 'Pencil Sketches of the Isle of Wight'. A. & C. Black, London.

Worsley, Sir R., 1781. 'History of the Isle of Wight'. London.

Wymer, J, 1991 Mesolithic Britain, Princes Risborough: Shire Publications

Wyndham, H. P., 1793. 'A Picture of the Isle of Wight'. London.