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HISTORICAL CHANGES ON THE HAMPSHIRE COAST 1870–1965

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ABSTRACT

The changes which occurred on the Hampshire coastline in the period 1870–1965 are identified from a comparison of large-scale Ordnance Survey maps. The types of change are classified into six categories – erosion, accretion, lateral movement of spits, reclamation, loss of land, and narrowing or widening of the intertidal zone. In addition to cliff and beach erosion, narrowing of the intertidal area emerges as a major change which has taken place on many parts of the Hampshire coast. Changes in the most dynamic sections of coast are analysed for trends and patterns of variation and some rates of erosion are presented, derived from measurements on 1/2500 scale maps.

INTRODUCTION

The aim of this paper is to identify the major changes which have taken place on the coastline of Hampshire in the period 1870–1965. The types of change are classified and each section of coast is categorised according to these types. Both natural and human changes are included. Where changes are significant the amounts and rates of change are examined and the variations through the period 1870–1965 are distinguished. Trends and fluctuations are identified where possible, though no attempt is made to explain the causes of all the changes or to predict further changes. In documenting the changes shown by comparison of Ordnance Survey maps, this paper provides a reference for dating and assessing changes on the coast. The period selected for study is that covered by suitable Ordnance Survey maps.

The area covered is that of the present Hampshire coast (Fig 1), though in terms of coastal processes and changes, the coastal units should be seen as extending to Hengistbury Head in the west and Selsey Bill in the east. The coast of Hampshire varies considerably in character, form and process, ranging from rapidly eroding cliffs to sheltered harbours and extensive salt marshes. Much of the coast is within the relatively sheltered Solent and not subject to the most powerful waves and marine forces. In large part the coast is densely settled and has been subject to development for many centuries, especially around the harbours and river estuaries. Land reclamation from the sea has long been an important if piecemeal activity.

The broad categories of major change in the study period are identified in Fig 1. Onshore changes are those above the high tide level and include various types which will be discussed below, but erosion and reclamation are the most important. Offshore changes as indicated by movement of the Low Water Mark (LWM) are also investigated in this report and emerge as an extremely important type of change affecting a high proportion of the Hampshire coast.

Previous research has documented changes at specific sites, often as a background for coastal management and shoreline protection schemes. Important work has been undertaken by Harlow (1979 and 1982) on changes between Gilkicker Point and Selsey Bill. Historical evidence has been used by Barton (1973), Barton and Coles (1984), Nicholls (1984, 1985) and Lacey (1985) in studies of Christchurch Bay, Hurst Castle Spit and Calshot Spit. May (1966) has also assessed rates of erosion of cliffs. Other historical compilations are incorporated in unpublished reports from consultants and local authorities but a comprehensive and systematic study has not been carried out.

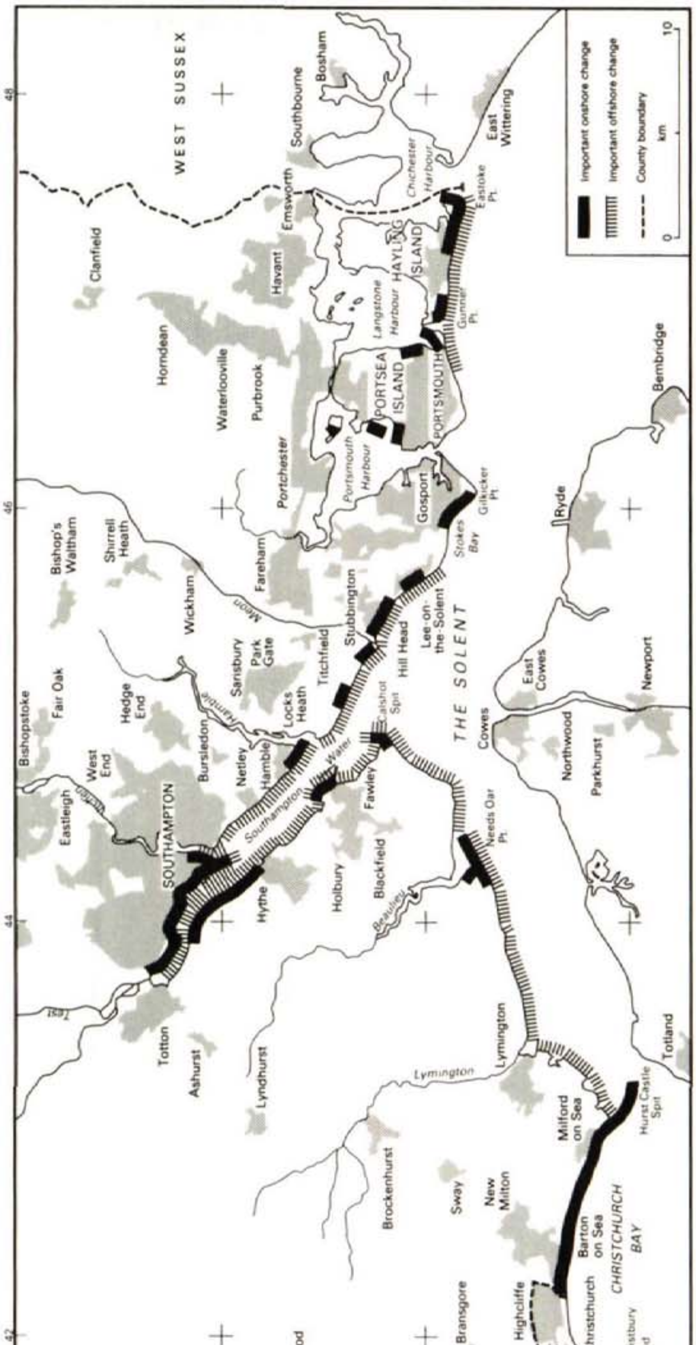

Fig 1. Zones of major change, 1870–1965.

METHODS OF INVESTIGATION

The basis of this investigation is the comparison of the coastline as shown on Ordnance Survey maps of different dates. The whole coastline was traced at 1/10560 (6 inches to 1 mile) scale using the OS Provisional Edition National Grid Series maps, mostly dating from the early 1960s. This base map was compared, by direct superimposition, with the 1/10560 OS First Edition County Series maps mostly dating from around 1870. These are the earliest large scale OS maps available and have therefore been taken as the starting point. Differences in both the High Water Marks (HWM) and Low Water Marks (LWM) were accurately marked on the base for the whole coast. Changes in structures such as sea walls, embankments, ponds and drains were also noted where appropriate. An example of information derived at this scale is given in Fig 5.

For the areas identified from this initial survey as having significantly changed, a more detailed mapping at 1/2500 (25 inches to 1 mile) scale has been carried out. For this the OS National Grid Series 1/2500 plan of most recent date available was used as base, the date varying from 1957 to 1975. This base was then compared with earlier editions of the OS 1/2500 County Series plans. Where full coverage is available this comprises four editions: 1st *c* 1870, 2nd *c* 1898, 3rd *c* 1910, and a revision of *c* 1932. Mapping was on the same basis as for the 1/10560 survey with HWM, LWM and cliff edges being marked; salt marsh was mapped when it appeared on the source maps. An example of the detail which can be derived from map compilations at this scale is presented in Fig 2. As a check on coastlines apparently exhibiting negligible change between 1870 and 1965, tithe maps drawn 1838–44 were consulted.

Such detailed mapping allows variation within the historical period to be identified. It also isolates discontinuous trends, and indeed those which reverse direction. For locations where the amount of change is significant, measurements of distances of movement have been made and rates of change have been calculated. The actual dates of maps quoted vary with location according to the date of survey or revision.

The definition of the coast itself is a problematic issue. In this analysis HWM is taken as the major criterion of the coastal edge, though beaches can extend above this line. LWM has also been mapped because this denotes the lower limit of the intertidal zone, or area which becomes exposed between high tides, which is important in coastal use and affects both coastal processes and the appearance of the coast itself.

There have been some changes in the notation and mapping of the tidal limits by the Ordnance Survey during the period of the maps. The major change was the alteration of the datum for tide heights from Liverpool to Newlyn which took place mostly between the 1910 and 1932 map editions. The difference in height for most of the Hampshire coast was 0.6 feet (0.18 m). However, this does not account for the changes found in position of High and Low Water Marks. On the present maps the tidal limits are indicated as HWM and LWM which is the medium or average tide, half-way between spring and neap tides. The HWM is surveyed and the LWM derived from aerial photographs taken at low tide. Before 1935 the lines so surveyed were called High and Low Water Marks of Ordinary Tides (H&LWMOT). In 1935 the term Medium replaced Ordinary and the abbreviation became H&LMMT. Since 1965 Mean has been adopted in place of Medium and the abbreviation has become Mean High or Low Water (MHW/MLW) (Harley, 1975).

Problems do arise in use of Ordnance Survey maps for analysis of change (Hooke and Kain, 1982), not only due to the definitions of tidal limits. The location of the edge of saltmarshes, beaches and cliffs may depend to some extent on the perception of the surveyor. In using maps which are revisions of previous surveys, it is not always certain that all changes were noticed and mapped. However, tidal limits were generally surveyed to a high accuracy because of their legal as well as structural significance. Errors due to map distortion have been minimised by matching up of common detail and fitting small areas of map at a time. Changes have been corroborated as far as possible by field checking though subsequent changes have obviously obliterated some features. Also, it should not be assumed that a trend or rate of change is continuous between two map dates; these can only show the net changes between those two points in time.

TYPES OF COASTAL CHANGE

Coastal change noted in the research may conveniently be categorised as follows: erosion, accretion, lateral movement of spits, reclamation, loss of land, and narrowing or widening of the intertidal zone. Parts of the coast not allocated to one of these categories were found to be stable in the study period. In a few cases the cause of change is difficult to distinguish, so for example some instances of mapped natural accretion may have been encouraged, enhanced or created by humans and could be classified as reclamation. However, here the category reclamation is reserved for accretion behind man-made embankments, walls and dykes.

Erosion

The coast is classified as eroding where there has been a net landward recession of the HWM shown on the maps. This results in a loss of land, and such areas are usually the focus of particular problems and subject to much investigation as well as expenditure on coastal defences. Erosion mostly affects cliffed zones of the coast and there are two major areas of erosion in Hampshire: Christchurch Bay in the west and parts of the eastern Solent between the Hamble estuary and Gilkicker Point (Fig 1).

Christchurch Bay. The most rapid erosion is in Christchurch Bay at Barton and Milford where a combination of erodible geological materials and the hydraulic situation of the coast, facing long fetch waves, results in subaerial erosion of the cliffs by landslips and mudflows and marine erosion of the base of the cliffs (Barton, 1973; Barton and Coles, 1984). Fig 2 is an extract of changes at Barton cliffs from the compilation of maps of different date at 1/2500 showing the scale of change and the amount of detail which can be derived from historical sources. In Fig 3 the amount of movement between each map date is given by the length of the bars, and the movement of the LWM, HWM and cliff top are shown separately for measurements taken at the position indicated. The maximum rates of movement averaged out per year are 1.24 m for LWM, 0.72 m for HWM, and 0.98 m for the cliff edge.

Along much of the western section the cliff has receded faster than HWM. The period of maximum recession in this section was in many cases 1898 to 1910. Farther east the period of dominant movement was 1932–1970 with, particularly at Milford, relatively little movement prior to that period. There is a zone of net accretion of LWMs and HWMs at Hordle Cliffs. At the western end of this section mudflows from the cliff may sometimes push the shore seaward, but farther east the accretion is due to coarse accumulation on the beach in front of the cliff. The erosion at the extreme eastern end is associated with the movement of Hurst Castle spit. Although rates of erosion per year can be calculated, it should be remembered that much of the movement is periodic and related to incidence of storms and wet periods. For example, Clark *et al* (1976) have described how severe landslips occurred in the winter of 1974–75 and affected buildings and structures on the cliff.

The Lee-on-Solent Area. This coast also faces the prevailing winds and waves but in this case the waves are less powerful because of the shelter of the Solent. Cliffs of height varying from 10 m at Solent Breezes (between Hamble and Hill Head, Fig 1) to around 5 m at Lee-on-Solent are present and composed of highly erodible sands and gravels. Maximum rates of erosion in this zone have been 0.4 m/yr in the period 1898–1964 (Fig 4).

Just to the west of Solent Breezes there was

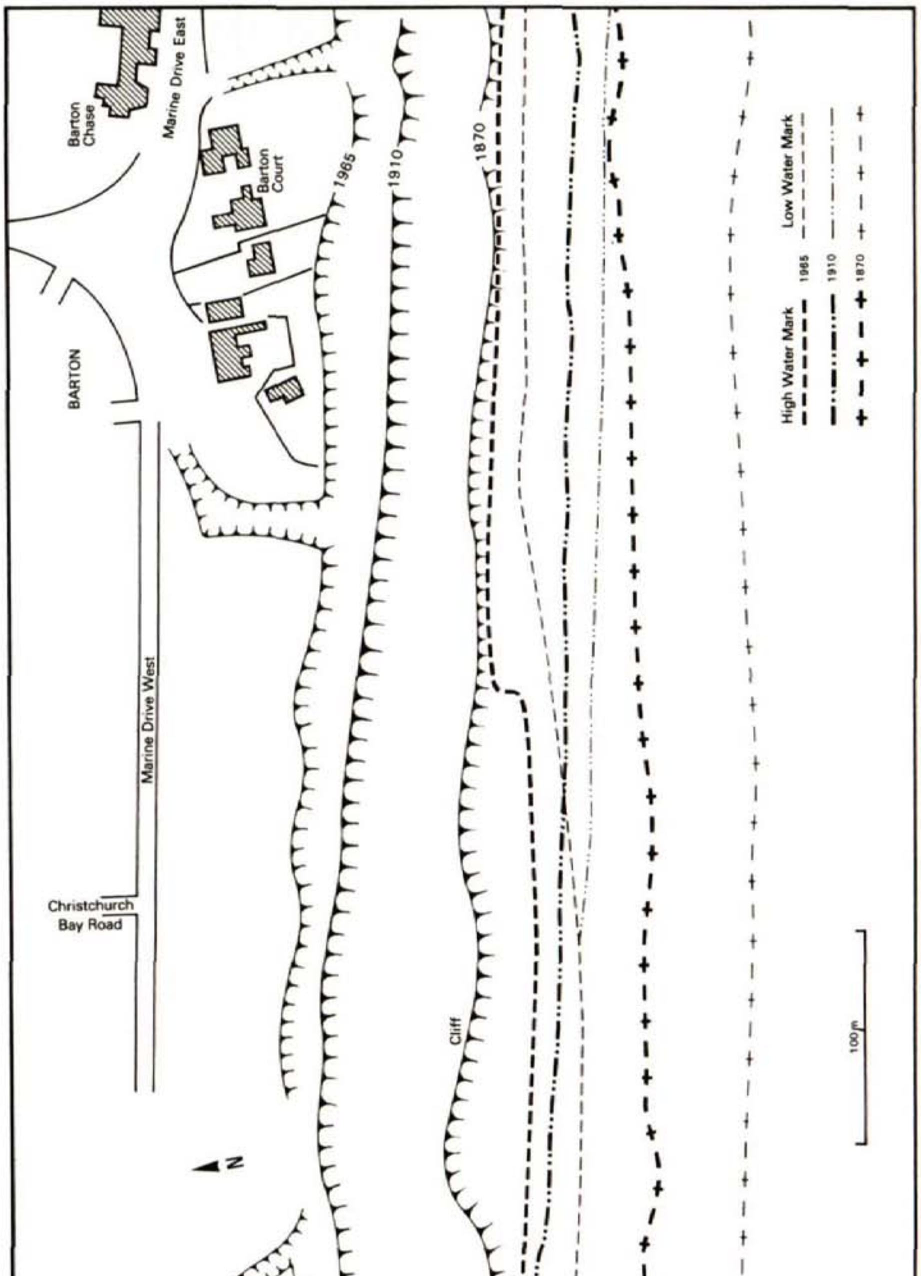

Fig 2. Changes at Barton Cliffs, 1870–1970, derived from 1/2500 Ordnance Survey maps.

erosion of *c* 15 m in the period 1910–1964. At Solent Breezes there has not been significant erosion, but further east are bare cliffs which still appear to be actively eroding. The historical rate of erosion has been 0.22 m per year. Erosion ceases again further east but further east still there has been erosion of about 17 m of cliff in 60 years. As Titchfield Haven, at the mouth of the River Meon, is approached the cliffs become more degraded and vegetated and the erosion recorded by the maps only amounts to a maximum of 10 m in the last century. The intertidal zone has narrowed by 50–100 m in this area.

At Hill Head there is a zone of recession of the HWM where there was marsh between the shore and the cliffs. The erosion amounted to 37 m between 1860 and 1964. A similar situation occurred at Crofton Cliffs, immediately to the west of Hill Head, although the erosion there was much greater. It was gradual and progressive, especially at the western end. In the period 1859 to 1964 there was a maximum of 70 m of erosion, but half of that occurred between 1932 and 1964 (or when the sea wall was built). Landward movement of LWM has also taken place but has resulted in little narrowing of the intertidal zone because of the erosion. The area below the cliffs at Crofton is called Salterns Park, and Brumhead (1963) suggests that the beach takes the form of a bar enclosing a small bay with an intervening swampy area which probably represents the infilling of a lagoon. He includes a photograph showing the swampy area. Thus there appears to be evidence for both erosion and deposition, and undoubtedly the cliffs must once have been erosional. Brumhead believes that the shallow offshore profile is an important factor influencing the processes.

Just to the east of Crofton Cliffs and at the northern edge of Lee-on-Solent the coast changes in character. Although the whole area is now protected by a sea wall and promenade, historically it was eroding quite rapidly with a net retreat of the HWM of about 20 m in the period 1860–1932. At the southern end of Lee-on-Solent the erosion amounts to 26 m, most of it post-1910.

Hayling Island. On the Hayling frontage a small area of erosion east of Gunner Point (Fig 8) is succeeded by a zone of net accretion at HWM. A cross-over point occurs 4 km east of the entrance to Langstone Harbour, and from there to Eastoke Point net erosion has occurred, 105 m at HWM since 1898, especially in the period 1910 to 1932, and 150 m at LWM since 1910.

The changes at Hayling Island have caused problems particularly at the eastern end where the erosion has increased the incidence of coastal flooding and even the danger of a breakthrough to the inlet behind at Eastoke. The coastal processes and sediment budget of the coast have been studied, particularly by Harlow (1979 and 1982), and a costly beach replenishment scheme has now been implemented.

Signs of continued active erosion on the coasts are unvegetated, steep cliffs and little or no beach in front. Some of the areas which were active historically are no longer eroding due to construction of sea walls and coastal defences. Most erosion is not actually continuous or regular from year to year, and takes place in major storms with powerful waves and/or wet periods encouraging slope instability. A full understanding of the periods of erosion would entail investigation of the incidence of such events, and is outside the scope of this paper.

Accretion

This is a natural process of addition to the land and is indicated by seaward movement of the HWM. This process mostly takes place in salt marsh areas and zones with shallow gradient beaches. The accreted land may remain only just above HWM as marsh or barren shingle, and therefore only in the very long term provides additional useable land. Siltation on the marshes is encouraged by growth of vegetation but requires a supply of fine material. Beach accretion takes place where there is a supply of material by currents and longshore drift and suitable conditions for deposition.

Net salt marsh accretion has not been especially widespread in Hampshire though there have been phases of accretion. In the late 19th century *Spartina townsendii/anglica* spread from Southampton along the coast, colonising salt marshes and encouraging their expansion and vertical accretion. Research indicates a recent die-back of *Spartina* in the harbours (Coughlan, 1982; Haynes and Coulson, 1982), and Domjan (1983) calculates that the marshes in Langstone Harbour reached their maximum extent between 1930 and 1960. The main zones of salt marsh accretion in Hampshire have been in the Keyhaven–Pennington area, north of Hurst Castle Spit (Fig 1) in the past, Calshot to Hythe on Southampton Water, and restricted areas at the upper ends of Southampton Water, Portsmouth Harbour and Hayling Island.

The main zones of accretion are in stretches of otherwise eroding coast. Perhaps surprisingly there is a zone of beach accretion in Christchurch Bay at Milford-on-Sea (Fig 3). Here the cliff is fronted by a broad shingle beach and although the cliff shows slight recession historically the HWMs and LWMs both show accretion. Similarly in Stokes Bay there is an accreting zone between the erosion at Lee-on-Solent and Gilkicker Point (Fig 4). On Hayling Island accretion has occurred on the main frontage between the eroding western and eastern ends. The maximum rates of accretion are 45 m in 72 years at the western end of Milford, 33 m in 105 years at Stokes Bay and 53 m in 60 years at Hayling Island.

Small areas of accretion have occurred at Netley (Fig 1) and at Hook Park on the eastern side of the Hamble estuary: both areas are now occupied by shingle ridges with some vegetation. The net seaward movement of HWM amounts to 11 m at Netley and 60 m at Hook Park.

Much of the accretion, though not deliberately caused by humans, may have been affected by works and sea defences and changes on other parts of the coast. As with erosion the process is not actually continuous and deposition may take place in particular phases or events, though it does tend to be a steadier process than erosion. The tendency for salt marshes to develop and for harbours to silt up earlier this century was noted by Perraton (1953) amongst others.

Lateral Movement of Spits

Spits have to be classified rather differently from the rest of the coastline because they are isolated from the main part of the land, have a coastline on both sides and generally shift in position rather than show a net loss or gain of land. In some cases the head of the spit may expand or contract and the neck may thin or thicken. Their very development indicates a focus for coastal processes, particularly depositional ones, but their maintenance requires a continued supply of sediment. Some of the problems of spits showing net erosion may be due to starvation of material because of sea defence works in the former supply zone.

There are several major spits which appear above the tidal zone on the coast of Hampshire, of which the most prominent are Hurst Castle Spit (Fig 5), Calshot Spit (Fig 7), Eastney Head (Fig 8), Gunner Point (Fig 8) and Black Point at the western end of Hayling Island (Fig 8). All are still mobile to some extent and composed of sand and shingle, but most have structures on them. By far the most mobile is Hurst Castle Spit.

Hurst Castle Spit. This is a well-known and much studied feature (Nicholls, 1985; Nicholls and Clarke, 1986). It extends south-eastwards into the Solent with a narrow neck about 1.6 km in length, composed of coarse shingle formed into a ridge 2–4 m high, and a northward pointing head with a smooth southern side and indented leeward side (Fig 5). It is a mobile feature; its long-term, geological history has been studied by many, including Lewis (1938) who discussed the role of different types and directions of waves.

In the period 1870–1970 the neck of the spit shifted progressively north-eastwards up the Solent. The rate and nature of the movement has, however, varied in different parts. At the upper end the movement was high 1867–97, then low, and appears to have accelerated in

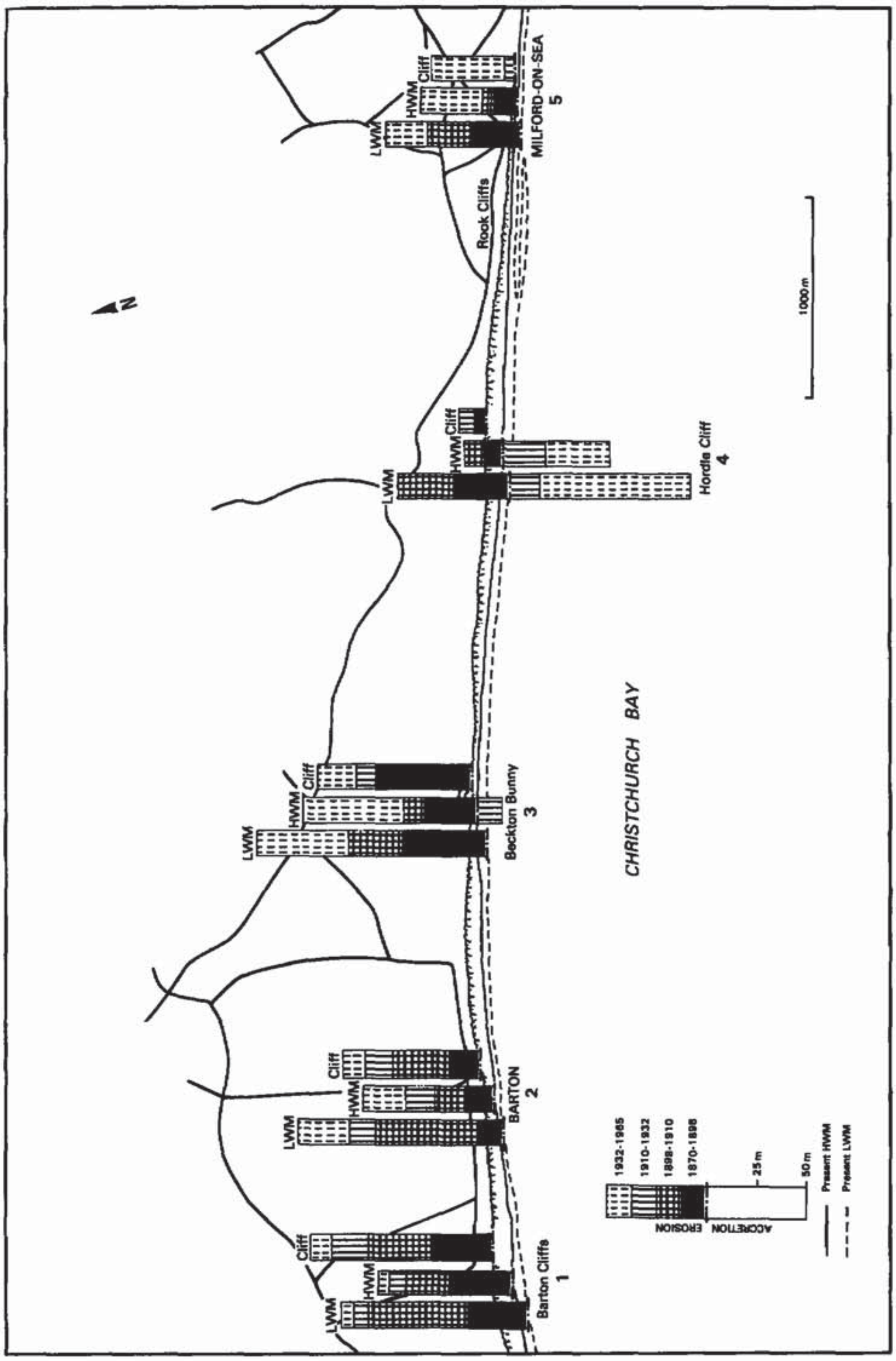

Fig 3. Variations in the amount and timing of coastal changes around Christchurch Bay, 1870–1970.

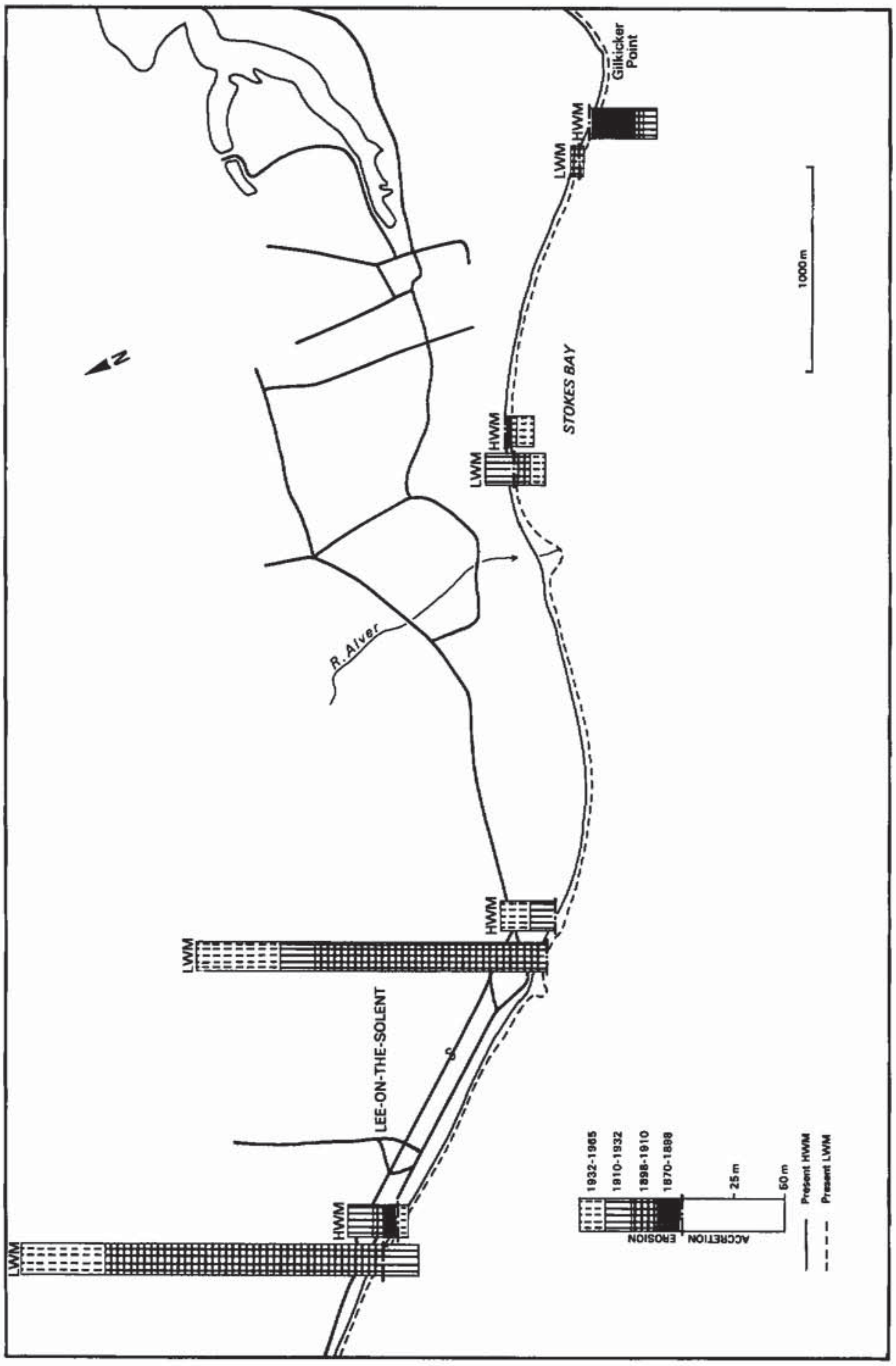

Fig 4. Variations in amount and date of changes, Lee-on-Solent and Gilkicker Point, 1870–1970.

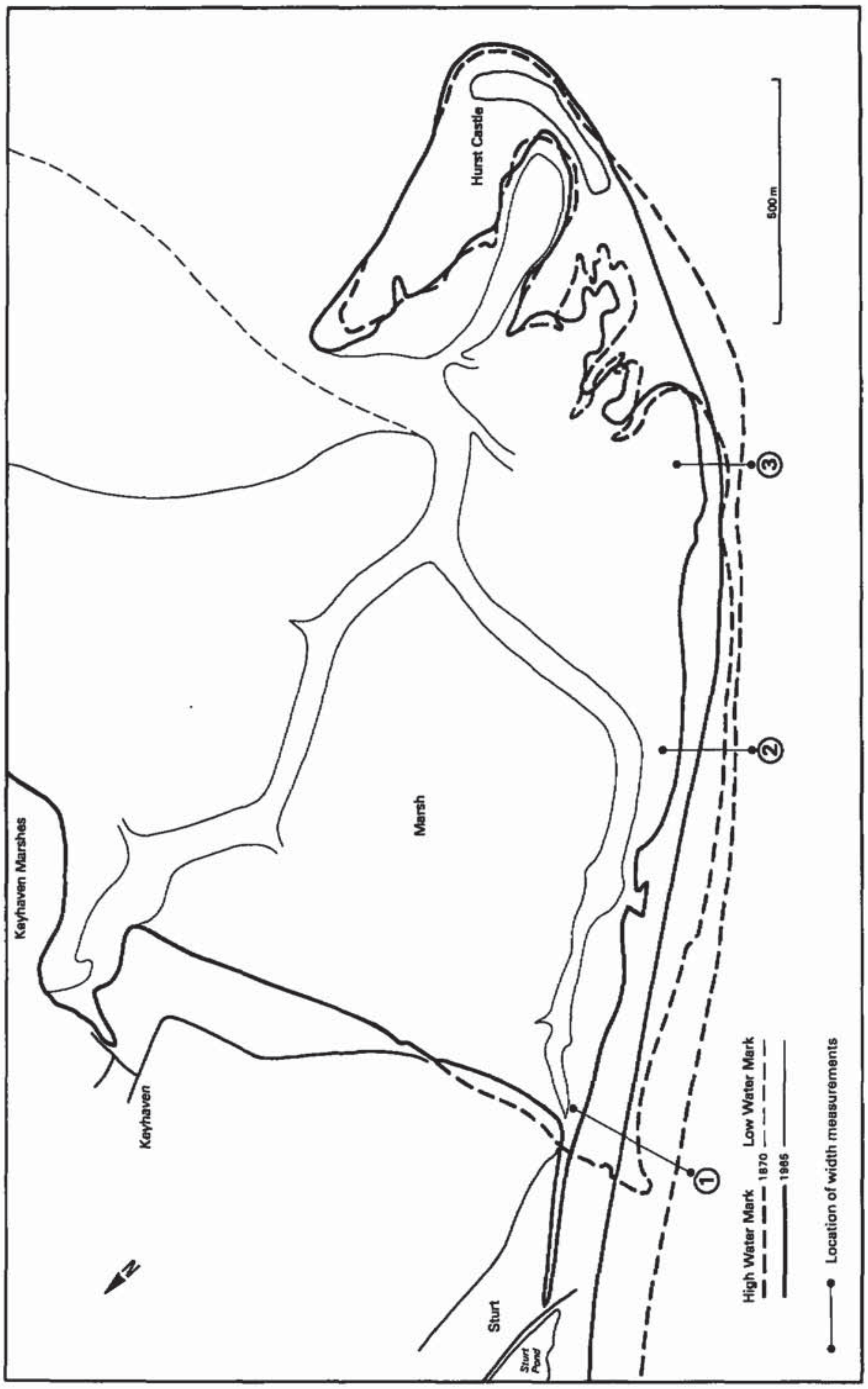

Fig 5. Changes in Hurst Castle Spit, 1867–1957.

Table 1
a. Amounts and rates of change at Hurst Castle Spit.

Location	*Dates*	*Distance of Movement, m.* LWM W Side	HWM N Side	HWM E Side
(1) N end of neck	a. 1867–1897	–45.0	–45.0	0.0
	b. 1897–1907	–19.0	0.0	– 2.5
	c. 1907–1931	–27.5	–27.5	–25.0
	d. 1931–1969	–55.0	–67.0	–90.0
(2) Middle of neck	a.	–37.5	–35.0	0.0
	b.	–14.0	+ 6.0	+ 4.0
	c.	–21.0	–26.0	–50.0
	d.	+ 2.5	– 7.5	+24.0
(3) S end of neck	a.	–52.5	–52.5	–10.0
	b.	– 7.5	0.0	0.0
	c.	–39.0	–62.5	–50.0
	d.			

b. Width of neck between W and E High Water Marks

	1867	*1897*	*1907*	*1931*	*1969*
Location (1)	95 m	52 m	49 m	45 m	42 m
Location (2)	23 m	37 m	42 m	65 m	35 m
Location (3)	70 m	28 m	30 m	30 m	18 m

the most recent period of map coverage. Between 1867 and 1897 movement of 45 m in the HWM on the westward facing edge was mapped, but between 1897–1910 there was negligible shift, then between 1910 and 1932 the HWM position shifted about 28 m; between 1932 and 1968 it shifted about 67 m. The leeside HWM showed an even greater shift in the latter period (Table 1). It can be seen from Fig 5 that the whole shingle ridge has moved more than the width of the neck in the past century, so that the present W-facing HWM is far beyond what was the lee or N-side of the neck in 1870. The LWM at the upper end has shown comparable movement, though with a greater amount in the earlier period.

In the middle part of the feature the movement is rather more variable with some fluctuation backwards and forwards, but there was a net movement of the order of 63 m in the period 1867–1968. The greatest movement was in the periods 1867–97 and 1910–32. Nearer the head the movement, especially of HWM, is again high, amounting to as much as 115 m in places. Just west of where the head broadens out is now also the narrowest part of the neck, and from 1867–97 was 70 m wide; between 1870 and 1932 it was approximately 30 m wide, but by 1968 had narrowed to about 17 m in width. At the upper end there has been a marked narrowing from 95 m in 1867 to an average of 50 m since 1897. Parts of the mid-section have widened so the position of the narrowest section has fluctuated, but there has been a net narrowing of the feature. Nicholls (1985) believes that recession increased to 3.5 m/yr in the period 1968–82, from 1.5 m/yr before that, due to direct starvation caused by the sea defences at Milford. May (1966) states that it is local opinion that beach levels have been lowered considerably since the extraction of shingle for ballast from west of the Needles: the impact of dredging on the coast is still a key question. The future status of Hurst Castle Spit is discussed by Nicholls and Webber (1987).

In contrast to the mobile neck of this feature, the head is much more stable, as witnessed by the survival of a *c* 1540 Henrician castle, while considerable Victorian extensions exhibit no sign of erosion. There has been some erosion on the SE side and some slight accretion to the NE of the castle with a lengthening and slight eastward rotation of the northern tip. The inner parts of the head show only relatively small, marginal movements.

The spit is bounded on the northern, inner side by extensive salt marshes. The outer LWM has shown a progressive movement landwards, but the low water channels have remained almost stable. The marsh itself is thought to have altered and no marsh edge at all was shown on the earliest maps. One other interesting feature present in this section is Sturt Pond (Fig 5) near the western end of the spit. This has an outlet eastwards behind the shingle ridge, but earlier the pond itself extended much farther southwards and has been progressively shortened by the northward movement of the shingle ridge. The pond margin was maintained otherwise it would have emptied through the shingle ridge.

Beaulieu River Mouth. The area at the exit of the Beaulieu River, south and east of Needs Oar Point, shows development rather than movement of a spit. The area extends from Gravelly Marsh through what is now known as Warren Farm Spit to Gull Island. Fig 6 shows some of the basic features of change, though unfortunately a 1932 map edition is not available.

On the 1868 map Needs Oar Point is present, though slightly shorter than now. The HWM between there and Gravelly Marsh (SW) is similar to that at present. There was a LW channel nearly parallel to the coast. The outer LWM was about 600 m off Needs Oar point and no salt marsh was shown at all. The situation was very similar in 1898 except there was some modification of the outlet of the LW channel near Gravelly Marsh.

By 1907 small spits were growing out from Gravelly Marsh, mapped as above the HWM. The maximum extension was 300 m and had pushed out the LW channel eastward at its western end. A narrow LW channel was still present parallel to the shore from Needs Oar Point westwards. Salt marsh was shown with its outer edge farther seaward than the present HWM and edge of saltings.

No further 1930s or 1940s OS maps are available, but by the date of the 1/10560 Provisional edition map, revised for major changes in 1957, the spit above LWM extended nearly to Needs Oar Point, a total length of almost 1400 m. By 1968 the outer LWM was about 175 m south of Needs Oar Point.

To the east of Needs Oar Point a straight narrow channel (The Swatchway) leads from the Beaulieu River southward to the Solent. In 1867 a bank above LWM but not above HWM was shown to the east. The LWM and river exit extended much farther eastwards than now. The situation was very similar in 1910 but with some edge of marsh shown. By the very latest edition of the 1/2500 map, 1970, a complete island above HWM, Gull Island, is shown. It has many channels in the salt marsh, some of them breaking through. The LW channel between Gull Island and Warren Farm Spit is very much wider – from 7.5 m in 1870 to 80 m in 1970.

The area near Needs Oar Point and the mouth of the Beaulieu River has been the subject of a number of research publications (Human, 1961; Coughlan, 1982; Dobson, 1964; Steers, 1964). It has been much investigated because it is owned by the Beaulieu estates and the changes have caused particular problems. Apparently the N–S channel from the Beaulieu River was cut in 1726. The bars grew either because of *Spartina* colonisation and/or because of groyning, according to Human (1961), but the Beaulieu estate consider that much of the extension of the shingle bars took place in winter storms of 1953/54 which coincides with the commencement of off-shore dredging. The bars became important wildlife reserves for birds. More recently the salt marsh has eroded and with the widening of the N–S channel, Gull Island in particular has been subject to erosion (Coughlan, 1982). In 1985 the Beaulieu estates presented a Bill to

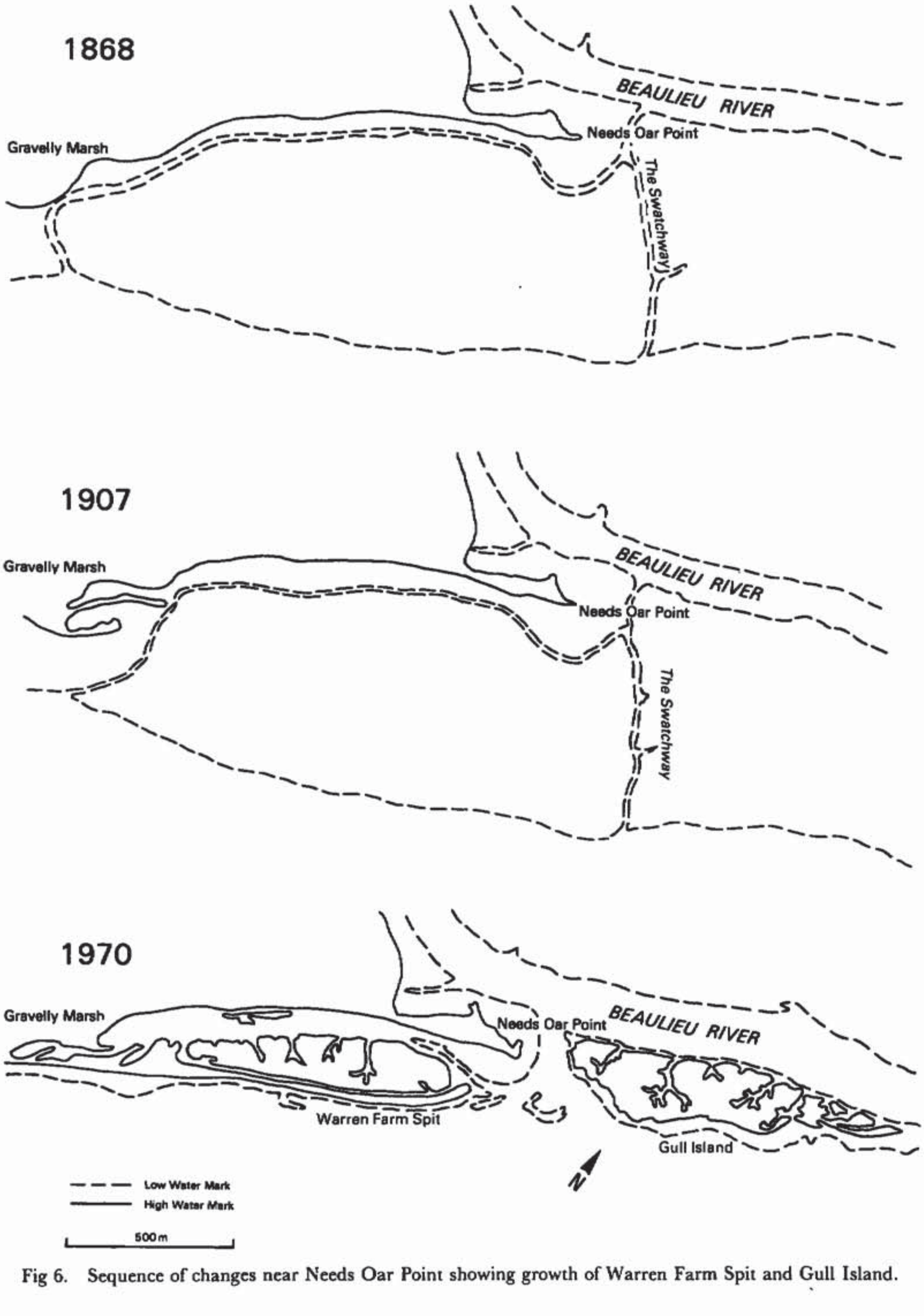

Fig 6. Sequence of changes near Needs Oar Point showing growth of Warren Farm Spit and Gull Island.

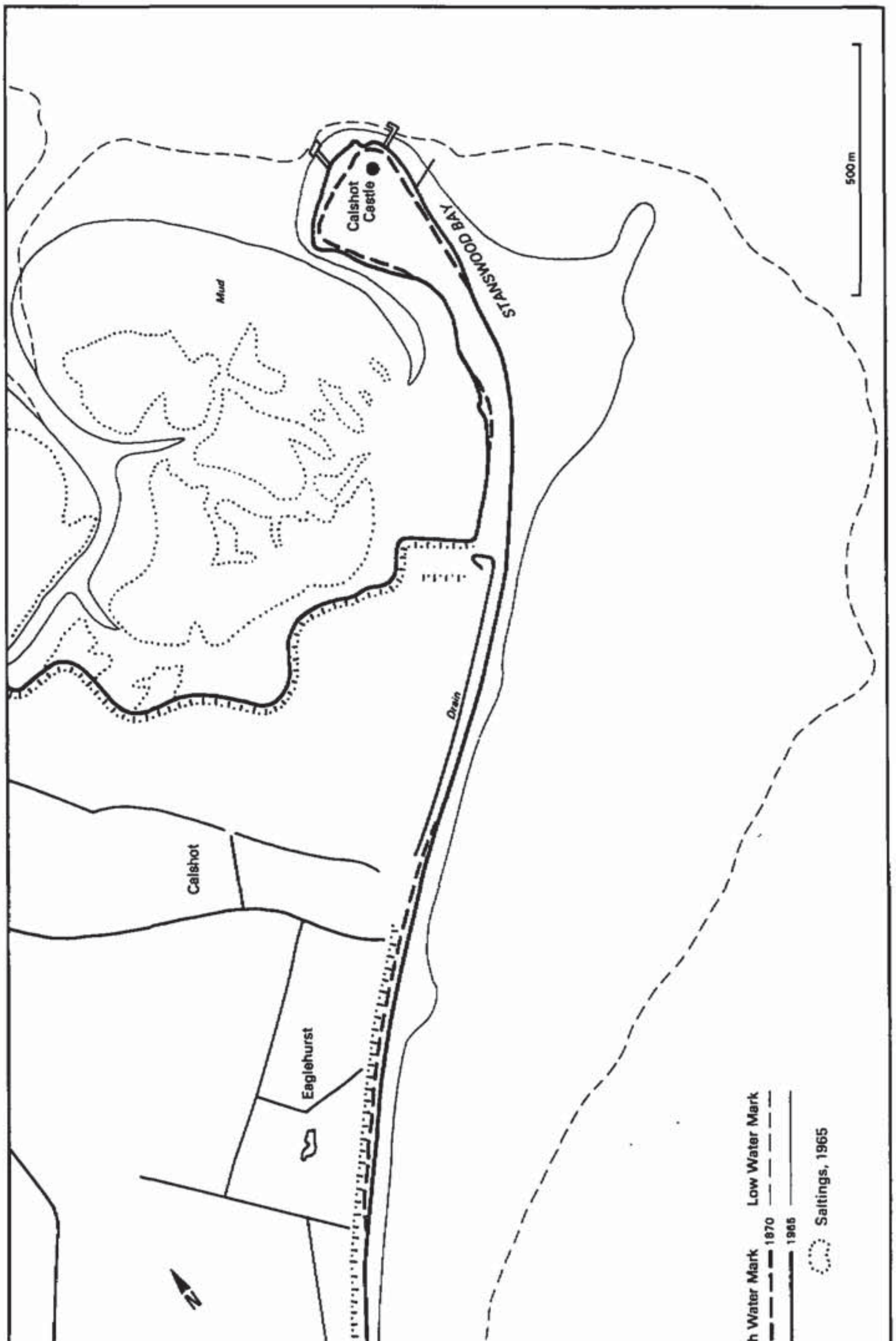

Fig 7. Changes of Calshot Spit and adjacent area, 1868–1971.

Parliament to have the gap between Warren Farm Spit and Gull Island closed and a shingle barrier has now been constructed. Dobson (1964) who monitored the change in these spits in the period 1953–63, reveals that the rate and manner of growth has been very irregular and he also suggests that the role played by *Spartina* is extremely important. He identifies three components of the spits: (i) an old shingle spit, lower than the main one and now deprived of shingle; (ii) the main spit with a complex of laterals; (iii) a narrow spit running out to the distal end along the seaward edge of marsh colonised by *Spartina townsendii*. Steers (1964) suggests a similar mode of formation.

Calshot Spit. This is another sand and shingle spit extending into the Solent, at the junction with Southampton Water (Fig 7). It is much more stable than Hurst Castle Spit and has shown only slight movements of its margins (Hodson and West, 1972). On the southern edge at the landward end of the neck, net accretion amounting to a maximum of 11 m has taken place, most of it in the period 1867–1907. There has been slight net erosion of 7.5 m at a little farther along and net accretion of 27 m at the eastern end before the broadening of the head, but this was preceded by erosion 1868–1907. On the north side of the neck mostly net accretion has occurred to a maximum of 15 m in the last hundred years. In terms of the LWM, on the south side a low water bar which on the provisional 1/10560 map (revised 1930–45) was rather pointed in shape was formerly much greater in extent and more rounded, but the variations have been complex, the intertidal zone at the western end of the spit being about 600 m wide in 1910, reducing to 75 m in 1932 and expanding to 500 m in width in 1970. On the head of the spit there has been net accretion on the north east edge of the castle in the period 1868–1910 (maximum 37 m) but the HWM has remained fairly stable since then. The continued existence of the Henrician fort demonstrates the stability of the spit. Some structures have been built on the north west side and the LW channel altered somewhat. The head of the spit may have been given added stability because of its use as a seaplane base in the interwar period.

There are also some other major intertidal features in Hampshire which have been subject to major change and do not necessarily have expression above High Water. These include Hamble Spit and the West and East Winners at the entrance to Langstone Harbour (Fig 8).

Reclamation

This is the deliberate enclosure of land or addition of material by man which has the effect of extending the HWM seawards. There are two types and phases of reclamation which have been dominant in Hampshire.

(i) Historically there has long been reclamation of intertidal marshy areas making them useable as grazing land. By construction of embankments, often incorporating drainage, the land is no longer subject to inundation and although not necessarily high-grade agricultural land it is suitable for cattle. Such areas usually exhibit a number of stages: mud, saltings, reclamation/drainage, rough pasture liable to floods, pasture, arable. The process would require two or more centuries to evolve, explaining the existence of embankments and enclosures pre-dating the period of this study. Local landowners were particularly active in establishing such simple reclamation works in the eighteenth century, as at Farlington, Keyhaven and Pennington Marshes.

(ii) This type of reclamation is where material (especially dredgings) is dumped either deliberately to create new land area or primarily for waste disposal. Much of this type of reclamation is more modern and is still taking place on a large scale in certain areas, such as Portsmouth Harbour. The areas associated with this type of reclamation are mainly the major built-up and dock areas of Southampton and Portsmouth, though even in these areas some of this type of reclamation dates from much earlier. Some of the sites of waste disposal are now becoming sites for marinas.

Portsmouth Harbour. The low water channels show remarkably little change from the cartographic evidence, doubtless because of the sheltered nature of the Harbour which in part gave rise to its selection as the site of a Royal Dockyard in 1496. Much of the harbour abutting the HWM is shown as arable in the tithe maps of 1838 indicating that the stability is of much longer duration than the time span of this study. Those changes that have occurred have almost entirely been as a result of reclamation work by the Royal Navy in particular and to a lesser extent by civil authorities.

The most substantial reclamation was undertaken between 1867 and 1876 when 200 acres were added to the Dockyard in what was known as the Great Extension (Riley, 1985). Much of the spoil from this operation was conveyed north to create a greatly enlarged Whale Island, the more southerly of the two islands in Portsmouth Harbour (Fig 1), as a naval gunnery school. A little later in the 1880s Great Horsea Island and Little Horsea Island were amalgamated by dumping (the island in the north of Portsmouth Harbour, see Fig 1) to fashion the torpedo testing range. Small areas on the Gosport side of the Harbour were reclaimed and tidal creeks cut off. Inevitably the new land gave rise to concomitant change in LWMs, particularly in the vicinity of the Dockyard and the major island, Whale Island, but subsequently stability has obtained.

Civil reclamation has consisted of the removal of the sea from a series of sheltered inlets by closing off the entrance. Examples are sites at North End, used as a recreation ground, at Stamshaw, both of which are on the north-western edge of Portsea Island (Fig 1) and at Alverstoke (retrieved from Haslar Lake, the large inlet to the south of Gosport (Fig 1). The entire length of Portcreek between Portsea Island and the mainland has been rationalised, generating a small area of land at Cosham, on the north side of the western land of the channel.

Langstone Harbour. Because of the absence of naval activity in Langstone Harbour, the level of intertidal stability has been even greater than in Portsmouth Harbour. Moreover, since there has also been far less population pressure, civil authorities have not had recourse to reclamation to anything like the extent experienced in Portsmouth Harbour. Inspection of tithe maps 1838–43 indicates that the land-use of plots adjacent to the sea wall was predominantly arable, indicative of several centuries of coastal stability within the Harbour, as might be expected.

On the southern side of Eastney Lake (Fig 8), large artificial changes have been effected. On the 1870 and 1898 maps a large area of mud to the east and also the area known as the Glory Hole, partially enclosed by barrages, are shown. By 1932 the Glory Hole was walled and the area to the east remained as tidal mud. Later the Glory Hole and adjacent area became a refuse dump and recently it has been excavated to form a marina. A large area to the west of the Glory Hole was reclaimed 1910 to 1932. Another reclamation, farther north on the eastern side of Portsea Island, at Milton Lake, lies outside the timescale of this report. Further north, the last remaining ponds of the former very extensive salterns have been removed, now forming the site of Portsmouth Sixth Form College, formerly Great Salterns School.

Much of the edge of Langstone Harbour has been walled since before the map study period, including the eastern side of Portsea Island, Farlington Marshes at the northern end of the Island and the western side of Hayling Island. There was possibly some accretion or reclamation in the north-east corner of the harbour even prior to the recent period of refuse dumping and reclamation.

Southampton Water. Extensive dock and quayage construction work has been associated with the port of Southampton (Bird, 1963). To the Inner and Outer Docks of 1851 and 1842 respectively were added the Empress

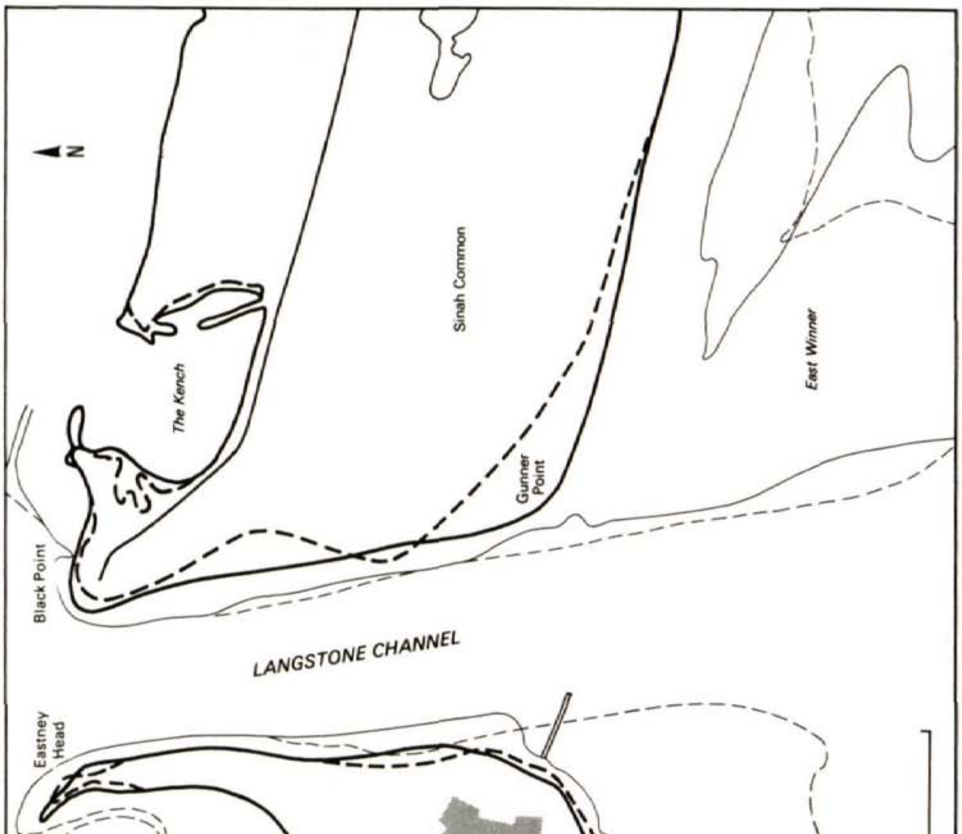

Fig 8. Changes at the entrance to Langstone Harbour, 1865–1965.

Dock in 1890, followed by the substantial southern extension on ground made from the mudlands at the confluence of the Itchen and the Test. Further docks were built in 1905 (Trafalgar Dry Dock) and 1911 (Ocean Dock). The River Itchen was the principal commercial waterway and on both sides up to Northam Bridge there has been reclamation of mudland for quayage and slipways, in addition to a substantial piece of reclamation north of the bridge largely used for railway marshalling yards. Between 1929 and 1934 more than 400 acres of land were reclaimed from the Test for the Western Docks and an industrial estate, much of the material being brought in by train from quarries in the Micheldever area (Biddle, 1955). Almost similar in scale is the container terminal, begun prior to, but completed after the time period under investigation. Inevitably these major dock schemes have altered the location of both HWM and LWM.

A substantial acreage of intertidal mudland and salt marsh has been reclaimed in several stages by Esso at Fawley from the 1920s to create space for their refinery and tank farm (Denton *et al*, 1964). The HWM was an irregular boundary of salt marsh in 1932, in spite of the presence of the refinery, but the edge of the saltings was farther out and shown in intricate detail even on the 1st edition maps, and there was net accretion of that edge in the period 1868–1932, of up to 100 m. The major seaward reclamation of a large block of land at the refinery is indicated on maps between 1957 and 1966. In this zone there was also a net landward movement of LWM in the century of map coverage, though it was less here than in other parts of Southampton Water, moving a distance of about 50 m.

North of Hythe lies an unusual reclamation site occasioned by its selection by the port authority as a location for material dredged from Southampton Water with the long-term objective of creating land for further container vessel quayage. Such was the volume of material that spoil was not only dumped between the existing sea wall and the new sea dyke, but also behind the existing sea wall (which appears on the 1841 tithe map), a fresh drain being constructed inland of the old sea wall. In addition, the height of the dredged material was allowed to rise *c* 3 m above the level of the existing terrain, creating a noticeable fall in height at the junction of the dredging and the new drain. The old sea wall has been entirely buried by the dredgings. The area of the dredgings was similar in scale to that of the Western Docks of Southampton, abutting into the Test by 0.8 km at one point. Its use as a container port is now unlikely, but it must represent valuable real estate nevertheless. The dumping operation has been continued farther south-east to Hythe where housing and a marina are under construction.

Further north from the reclaimed area, a military port was established by 1942, largely on land reclaimed in the 1920s, while a pier and quayage were constructed on ground reclaimed from the Test. The river was dredged at this point to allow vessels access to the quay, causing HWM and LWM to coincide. With the reclamation of mud flats adjacent to the military depot, the reclamation by CEGB for Marchwood power station and the changes on the Southampton side, all the work described has had the cumulative effect of very considerably narrowing the Test and as a consequence bringing the tidal limits closer and steepening the intervening gradient. Doubtless tidal scour improved and dredging costs were reduced while coastal stability is secured by virtue of the structures erected.

Loss of Land or Structures

This is a minor category encompassing situations where man-made structures or reclaimed land shown at an earlier date as above HWM have been lost to the sea resulting in a net recession of the HWM. This mainly occurs as a result of lack of maintenance of structures such as oyster beds and embankments. This type of change has only affected small, isolated areas such as on the north-west of Hayling Island, though of course, some of the erosion described earlier may be due, at least indirectly, to anthropogenic activities.

Narrowing and Widening of Intertidal Zone

All the changes discussed up to now have been onshore changes, that is, they involve loss or gain of land above HWM. The zone between High and Low Water Mark is the intertidal zone and is here categorised as offshore (though it can be considered part of the shore). It is not directly useable for permanent land activities but has a profound effect on coastal processes and the appearance of the coast as well as intertidal activities. Change is indicated by a shift in the position of the LWM on the maps and the historical map comparison has shown that this is an extremely important type of change in Hampshire.

There are two types of change: (i) where the LWM has shifted landwards resulting in a net narrowing of the intertidal zone; (ii) where the LWM has shifted seawards resulting in a net widening of the intertidal zone. The first of these has been by far the most important and the second is relatively rare on the coast of Hampshire. Landward movement of the LWM must be due to a loss of material or lack of replenishment and/or a rise in sea level. If the latter it would be expected that HWM would also show a change, but this is not always the case, though it is now known that sea level is rising in this area and is suspected as a cause of salt marsh erosion by researchers (Bird, 1985). The net result of a narrowing of the intertidal zone is the steepening of the beach and offshore profile and means that waves hit the beach with greater force. This intertidal narrowing may be due to a combination of natural and anthropogenic processes, but is thought to have been influenced by coastal defence works and dredging in certain places.

This type of change has affected a very great proportion of the Hampshire coast, but is most obvious, partly because of its horizontal extent, in the area of salt marshes such as at Keyhaven and Pennington. The intertidal zone has been reduced by 50% or more in some places. That the change is real and not an artefact of the changed sea level datum on the maps is confirmed, not only by the nature of its distribution, but also by field evidence of eroding edges of salt marshes. Some narrowing appears to have taken place since 1932 but in other areas it has been progressive throughout the period since 1870. Widening of the intertidal zone is much less common and is usually associated with accretion of spits and offshore bars and to some extent with accreting beaches.

On Keyhaven salt marshes or saltings (Fig 5) the major changes have taken place between HWM and LWM, and likewise, in much of the western Solent the major change has been a landward recession of the LWM. The width of the intertidal zone has been reduced by half along much of this section of coast. In the Keyhaven areas this has meant a reduction in width from about 1100 m in 1867 to 650 m in 1968. In the Pennington area the LWM moved onshore by about 225 m between 1898 and 1910 and 275 m between 1910 and 1968 (Fig 9). The maps also indicate a change in the nature of the salt marshes because the earliest edition marks no marsh at all, rather mud in the intertidal zone, whereas on the later maps a definite saltmarsh edge is shown. (This is not just a mapping convention because elsewhere marsh is shown on the early map.) It is thought this is related to the spread of *Spartina* from Southampton.

Remarkable changes have taken place in the position of the LWM on the coast near Lee-on-Solent. The intertidal zone is now very narrow with a very steep offshore profile, but it has narrowed by about 175 m since 1898. Brumhead (1963) discusses the changes in this area and states that between 1909 and 1959 55 ft (17 m) of cliff was lost to the sea, 38 ft (16 m) of that in the last 20 years. The local authority constructed the sea wall in 1959 to prevent further erosion. Brumhead considers that it is the change in the offshore profile which accounts for the greater erosion here than farther east.

CONCLUSIONS

Major changes of various types have taken place over the past hundred years or more on

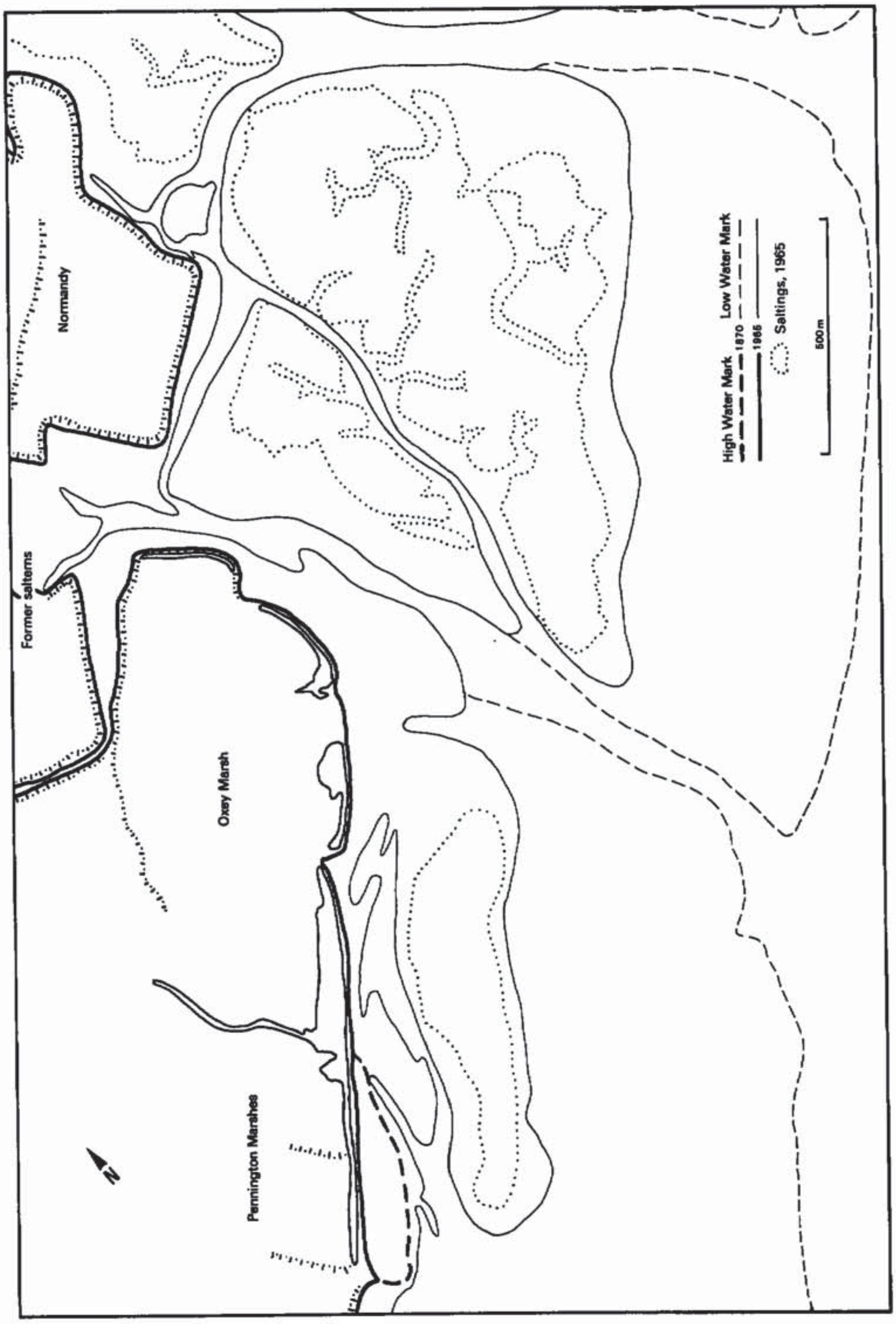

Fig 9. Changes near Pennington Marshes, 1867–1957.

the Hampshire coast. Some have now ceased or slowed in rate due to coast protection measures, but these have had effects on other parts of the coast and some rates of change have increased, probably due to these measures.

Erosion has been important and is still active on certain parts of the coast, notably in the cliffed areas of Christchurch Bay and to a lesser extent the eastern Solent and in the beach areas of eastern Hayling Island. It was formerly important at Lee-on-Solent. This long continued erosion is mainly due to natural causes, a combination of erodible cliff or shore materials and powerful marine forces. As the experience at Barton Cliffs has demonstrated, there are very great problems in trying to control such erosion.

Reclamation of land from the sea has been an important activity on various parts of the coast. Reclamation of marshes by construction of embankments and drains for agriculture and to prevent flooding dates from before the study period. Reclamation by dumping to create extra land and/or dispose of waste is mostly much more modern and is mainly associated with the docks and major urban areas of Southampton and Portsmouth.

A major type of change which has affected much of the Hampshire coast is the narrowing of the intertidal zone by the movement landwards of the Low Water Mark. This has occurred both on shallow-gradient, salt marsh coasts such as in the Keyhaven–Pennington area, and on steeper, beach-lined coasts such as Lee-on-Solent. The changes have occurred at different times in different places and are therefore difficult to ascribe to a single cause such as rise in sea level. It is thought that dredging, construction of sea defences, growth and decline of salt marsh plants and sea level rise could all have been contributory factors. The scale of change is enormous in places, the intertidal zone now being only a fifth of the width 100 years ago.

Fluctuations in the position and shape of the major spits have taken place throughout the period of map coverage, though in many cases the changes at LWM are much greater than those at HWM. By far the most mobile land spit is that of Hurst Castle which has shown progressive movement throughout the documented history. There is, however, evidence that the rate of erosion has increased in recent times and that the spit has become thinner. This is possibly due to decreased sediment supply to the zone as a result of coast protection works in Christchurch Bay.

The harbours of eastern Hampshire have mostly remained stable, apart from reclamation, but a phase of accretion followed more recently by erosion of the salt marshes has occurred. Minor variations in tidal channels may have taken place but these are mostly not mapped.

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REFERENCES

Barton, M E 1973 'The degradation of the Barton Clay Cliffs of Hampshire', *Quarterly Journal of Engineering Geology*, **6**, 423–40.

Barton, M E and Coles, B J 1984 'The characteristics of the various slope degradation processes in the Barton Clay Cliffs of Hampshire', *Quarterly Journal of Engineering Geology*, **17**, 117–36.

Biddle, R P 1955 'Southampton Docks', *Proceedings Institution Mechanical Engineers*, **169**, 919–23.

Bird, E C 1985 *Coastal Changes: A Global Review*, Wiley, Chichester.

Bird, J 1963 *The Major Seaports of the United Kingdom*, Hutchinson, London.

Brumhead, D D 1963 'The Coast Between Titchfield Haven and Lee-on-Solent', *Wessex Geographer*, **4**, 35–42.

Clark, M J, Ricketts, P J and Small, R J 1976 'Barton does not rule the Waves', *Geographical Magazine*, **48**, 580–8.

Coughlan, J 1982 'Solent Shores – The Scene Today', *In Solent Saltmarsh Symposium*, ed F Stranak and J Coughlan, Solent Protection Society, Winchester, 22–24.

Denton, G R *et al* 1964 'Economic Activity' in *A Survey of Southampton and its Region*, British Association for the Advancement of Science, 259–77.

Dobson, E B 1964 'The Growth of Warren Farm Spit, Hants', *Abstracts of Papers, 20th International Geographical Union Conference*, London, 111.

Domjan, K 1983 'The Distribution of Marshland Past and Present in Langstone Harbour', BSc Dissertation, Department of Biology, Portsmouth Polytechnic.

Harley, J B 1975 *Ordnance Survey Maps, A Descriptive Manual*, Ordnance Survey, Southampton.

Harlow, D A 1979 'The Littoral Sediment Budget Between Selsey Bill and Gilkicker Point, and its Relevance to Coast Protection Works on Hayling Island', *Quarterly Journal Engineering Geology*, **12**(4), 257– 65.

Harlow, D A 1982 'Sediment Processes: Selsey Bill to Portsmouth', PhD Thesis, University of Southampton.

Haynes, E N and Coulson, M G 1982 'The Decline of *Spartina* in Langstone Harbour, Hampshire', *Proc Hampshire Field Club Archaeol Soc*, **38**, 5–18.

Hodson, F and West, I M 1972 'Holocene deposits of Fawley, Hampshire and the development of Southampton Water', *Proc Geol Association*, **79**, 203–6.

Hooke, J M and Kain, R J P 1982 *Historical Change in the Physical Environment: A Guide to Sources and Techniques*, Butterworth, Sevenoaks.

Hooke, J M and Riley, R C 1987 'Historical Changes on the Hampshire Coast 1870–1965', Consultancy Report for Hampshire County Council, 59 pp.

Human, M 1961 'Preliminary Survey of Warren Farm Spit at the Mouth of the Beaulieu River, Hampshire' *Wessex Geographer*, **2**, 22–30.

Lacey, S 1985 'Coastal Sediment Processes in Poole and Christchurch Bays: and the Effects of Coast Protection Works', PhD Thesis, University of Southampton.

Lewis, W V 1938 'The Evolution of Shoreline Curves', *Proc Geol Association*, **49**, 110–15.

May, V J 1966 'A Preliminary Study of Recent Coastal Changes and Sea Defences in South-East England', *Southampton Res Series in Geography*, No 3, 3–24.

Nicholls, R 1984 'The formation and stability of shingle spits', *Quaternary Newsletter*, **44**, 14–21.

Nicholls, R 1985 'The Stability of the Shingle Beaches in the Eastern Half of Christchurch Bay', PhD Thesis, University of Southampton.

Nicholls, R J and Clarke, M J 1986 'Flandrian peat deposits at Hurst Castle Spit', *Proc Hampshire Field Club Archaeol Soc*, **42**, 15–21.

Nicholls, R J and Webber, N B 1987 'The past, present and future evolution of Hurst Castle Spit, Hampshire', *Progress Oceanography*, **18**, 119–37.

Perraton, C 1953 'Salt Marshes of the Hampshire–Sussex Border', *J Ecology*, **41**, 240–7.

Riley, R C 1985 *The Evolution of the Docks and Industrial Buildings in Portsmouth Royal Dockyard 1698–1914*, The Portsmouth Papers No 44, 31 pp.

Steers, J 1964 *The Coastline of England and Wales*, 2nd Edition, Cambridge University Press, Cambridge.

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