LLANELLI MARSH, LLANELLI, CARMARTHESHIRE

ARCHAEOLOGICAL AND PALAEOENVIRONMENTAL INVESTIGATION

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LLANELLI MARSH: ARCHAEOLOGICAL AND PALAEOENVIRONMENTAL INVESTIGATION

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LLANELLI MARSH
ARCHAEOLOGICAL INVESTIGATION

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This multi-disciplinary project investigated the palaeoenvironmental and lithostratigraphic development, as well as the history of enclosure, reclaimation and changing land use of an area of reclaimed coastal wetlands known as Llanelli Marsh at Machynys, Llanelli, Carmarthenshire. The report presents evidence of Holocene sea level rise with a major regressive episode which led to a phase of reedswamp, freshwater fen carr and raised bog development during the Neolithic and Bronze Age periods before a return to estuarine conditions. It also outlines the major phases of embankment and reclaimation that have resulted in the present Machynys landscape. The results have shown that the Burry Inlet and Loughor Estuary, whilst being subjected to localised events, was very much affected by wider processes and trends occurring throughout the Severn Estuary.

INTRODUCTION

The diversity, abundance and availability of natural resources found within estuarine wetlands has attracted people since the earliest of times. The unique biological conditions created by the mix of fresh and salt water and the continual supply and deposition of nutrients and sediment leads to a wide variety of habitats and ecozones, each supporting a diverse flora and fauna, making estuaries 'amongst the most fertile and productive ecosystems in the world' (Davidson 1991, 2). The key factor in defining the ecozones and the range of resources is salinity. As salinity decreases further from the sea the halophytic plants and marine animals give way to a more species rich flora which in turn attracts a more diversified fauna.

Early human exploitation of the wetlands would have been by hunter-gatherer-fisher groups making use of the seasonally available resources such as new plant growth, shellfish and returning fish and wildfowl stocks. Later as methods of subsistence changed and agriculture became established coastal and estuarine wetlands became increasing important for grazing. Without any form of intervention access for grazing would have only been possible between tides and periodic, so sea walls were constructed and the enclosed land drained to provide a stable landscape for permanent year round use. It also allowed settlement on the newly reclaimed land.

As well as its rich flora and fauna the Burry Inlet and Loughor Estuary, and this part of east Carmarthenshire, had one natural resource that has above all shaped the physical and social development of the Llanelli region: coal. From the medieval period onwards the coal industry and the metal processing industries that developed alongside it were the major factors in the economic and social development of the region as well as in the formation of the historic landscape. The presence of the coalfield and the ready access to the sea made Llanelli the ideal location for industry, and the town expanded dramatically in the 18^{th}- and 19^{th}-century as new investors and new businesses were attracted into the region. As industry expanded the flat land of the reclaimed marshes to the southeast of the town came under increasing pressure from developers, a situation that is echoed today as the area is again undergoing major redevelopment. A massive redevelopment scheme, the Millennium Coastal Park, which has dramatically remodelled the Llanelli coastline is currently nearing completion.

PROJECT BACKGROUND

This current project was initiated in response to recommendations outlined in an assessment report on the archaeological implications of the construction of Machynys Golf Course and its associated infrastructure (Page 1999), part of the Millennium Coastal Park currently being developed along the Llanelli coastline. One of that report's main recommendations was that a transect of boreholes should be sunk across the site to collect samples for palaeoenvironmental analysis to elucidate, where possible, the development processes of Llanelli Marsh. The recommendation was considered important in light of the fact that this area was to be transformed by the construction of the golf course and it was agreed that the sampling and analysis should be carried out. Following that agreement a programme of works was devised between Cambria Archaeology and the Centre for Wetland Archaeology, Hull University, and the boreholing took place in late December 1999 with the analysis of the samples being carried out in late winter and spring 2000.

Cambria Archaeology have carried out a number of archaeological projects in the Machynys region of Llanelli over the last decade. The projects have been a mix of threat related assessments and recording associated with development schemes and research-based survey. Together, they, along with a wealth of published literature on the Llanelli region, provide the framework for this examination of the development history of Machynys and the Llanelli Marsh area. This project and report were funded by the Millennium Coastal Park.

METHODOLOGY

The project involved two separate strands of investigation:

i) Analysis of the surface history regarding the enclosure and past landuse of the marshes. This part of the project used a variety of sources to investigate and establish, where possible, the chronology of the process of embankment on the marsh and the uses to which the newly reclaimed land was put. The sources included, primary cartographic and documentary material, geotechnical information, aerial photographs, published works, previous archaeological and historical surveys and palaeoenvironmental data.

ii) Palaeoenvironmental sampling and analysis of the sediments that make up the Llanelli wetlands. See below for details of the sampling methods.

THE SURVEY AREA

Machynys lies on the southeast edge of Llanelli, Carmarthenshire, and it forms the western extent of Llanelli Marsh, an area of low-lying reclaimed coastal marsh (centred on *c.*NGR-SS515982) that stretches from Machynys to the Penclacwydd Wildfowl and Wetland Centre on the north shore of the Burry Inlet and Loughor Estuary (fig 1). Llanelli Marsh is part of a larger system of reclaimed and unreclaimed marsh along the River Loughor that stretches as far inland as Llangennech Marsh, 4km upstream. It is backed to the north by a discontinuous crescent of high ground, which is traceable from Pembrey to Bynea and represents the remnants of former sea cliffs and raised beach deposits of the last interglacial period (Page 1997, 6). The former cliffs, which are composed of rocks of the Pennant Series of shales with coal and sandstones of the Upper Carboniferous Period, are dissected by numerous small north-south river valleys draining the high ground to the north into the Loughor river (James 1993, 8; Page 1997, 6). Aggradation of sediment from these rivers, in particular the Dafen, Lleidi, Lliw, and the Loughor itself has led to the formation of the extensive saltmarshes throughout the estuary and lower reaches of the Loughor. The Burry Inlet and Loughor Estuary has the second largest area of saltmarsh in Britain, and the most extensive estuarine saltmarsh in Wales (Burd 1989, 151; Smith and Yonow 1995, 38).

The present ground surface lies at between 3m and 5m above Ordnance Datum (OD), with a number of small islands of higher ground at *c.*8m OD, and a high point of *c.*15m OD on the site of Machynys House. These higher points are moraines of glacial till deposited by the retreating ice sheets of the last glaciation around 10,000 years ago. A shell midden, which included the skull of a roe deer, recorded on the gravel surface of one of these moraines at Morfa Baccas may be evidence of prehistoric use of these islands to exploit the estuary and the surrounding area. All of these islands have been the focus for agricultural settlement, some possibly since the medieval period. The Machynys moraine is the largest and it forms a gravel ridge (Plate 1) along the west side of the survey area; it formerly extended south across the estuary to Penclawdd on the north Gower coast. A navigation *Chart of Carmarthen Bay on the South Wales Coast* by Murdock Mackenzie, 1775, shows three small islands of gravel extending in a line south from Machynys which must be the remains of the Machynys moraine. On other early maps of the area, notably Saxton's map of 1578, Emmanuel Bowen's *Map of South Wales* (1740) and Mackenzie's *Chart*, Machynys is clearly shown as an island separated from the mainland by a small channel, which probably became the course of Penrhyngwyn Pill. It is likely that Machynys was a tidal island accessible at all times other than during high tide rather than a true island permanently surrounded by water.

The extents of Llanelli Marsh, also known as Morfa Mawr (*Great Marsh*), were described in an early 17th century survey (Rees 1953, 261) and many of the place-names mentioned (Llwyn wilog; Trostre; Maes-ar-dafen) were still traceable on the early Ordnance Survey (OS) maps, although most have since been lost to modern development. The 17th century survey, part of a survey of the Duchy of Lancaster Lordships in Wales, recorded that the tenants of the Borough of Llanelli 'tyme out of mynde have hadd and used to have of right Common for all manner of beasts...' (Rees 1953, 261), suggesting that grazing on the marshes dates

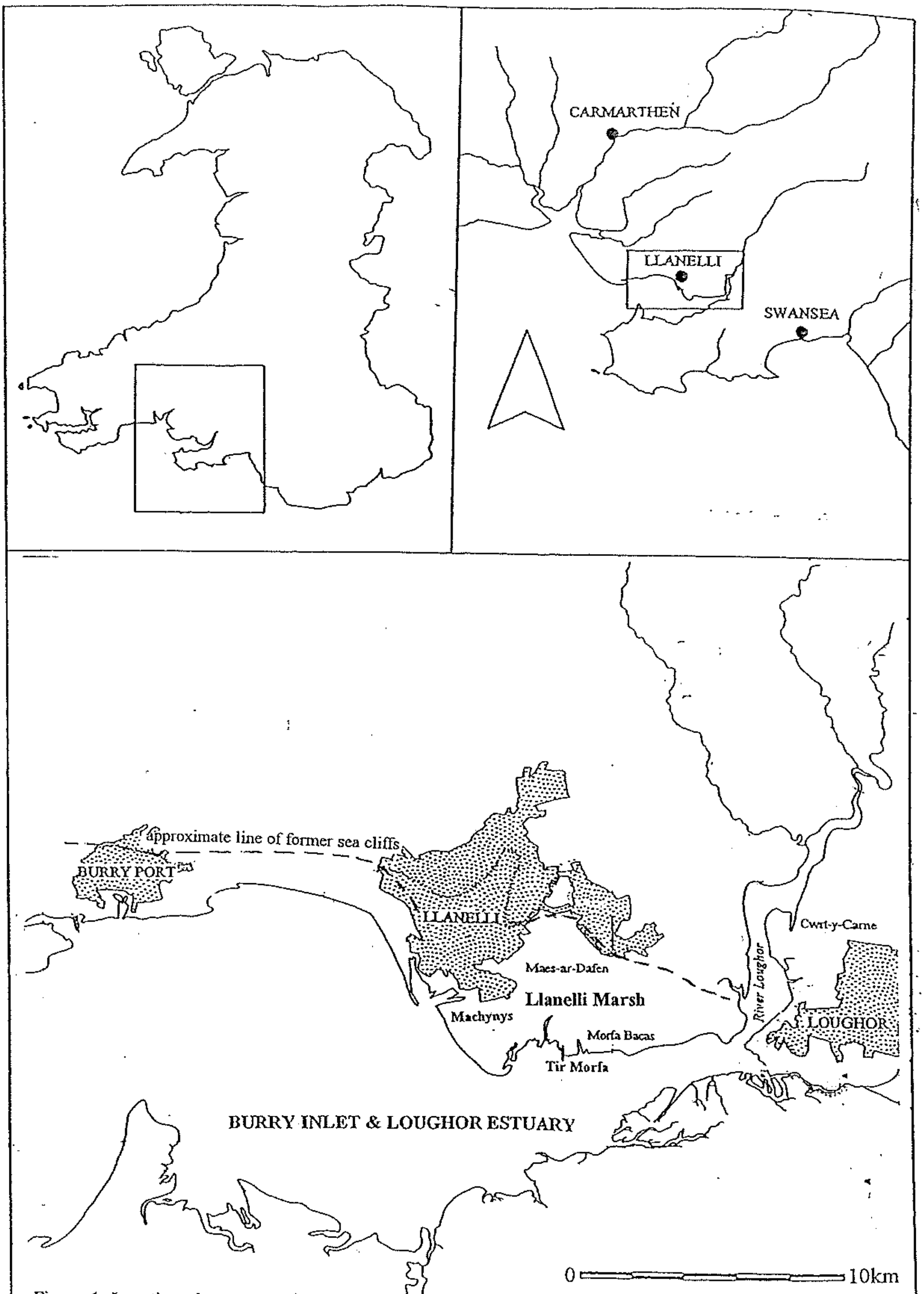


Figure 1: Location plan

back into the medieval period. Machynys is first mentioned with any certainty in an early 14th century rental in the Duchy of Lancaster accounts which records a tenant's payment of £7 10s in 1313 for 'the rent and farms of all the demesne lands, meadows and pastures of Maghenes' (James 1993, 14). This suggests that the area was settled and farmed by at least the end of 13th century, and an 8th century reference to *terra Machinis* in the Llandaff charters may also refer to land at Machynys (Davies 1979, 112).

Machynys: etymology

A definitive interpretation of the name Machynys is difficult, but the fact that as early as the 14th century the form *Meghinis* was used suggests a medieval root which has endured to the present day. Several attempts at translation have been made, including explaining the name as being derived from Manach + ynys (Manach being an early form of *mynach* = monk). There is an unsourced 18th century reference to an early 6th century monastery founded by St. Pizo on Machynys (Jones 1987, 24), and even though no evidence for it has ever been recovered the tradition of a monastery survives in local lore. However, a more mundane explanation may be closer to the truth. There are enough similarities between the elements and form of the names of Machynys and the town of Machynlleth, Powys, to suggest that they developed from similar roots and developed into their present forms in much the same way.

It is known that the name *Machynlleth* is derived from *Maes* + *cynllaeth* ("The Field of Cynllaeth"), Cynllaeth being itself a compound of *cyn* + *llaeth* (before or by the River Llaeth). The mutation of the initial "c" to "ch" in *cyn* after *maes* is a feature of medieval Welsh etymology. Machynys may similarly be interpreted as being derived from Maes + cyn + ynys (The field before or by the island). The step from Maescynynys to Machynys is a short one and appears consistent with the etymology of the Welsh language in medieval times (Paul Sambrook *pers comm*). On *Saxton's Map of Radnorshire, Brecknockshire, Cardiganshire and Carmarthenshire* (1578) Machynys appears as Bachhannis Insul, it was recorded as Machunnis on Emannuel Bowen's *Map of South Wales* (1740) and as Mahnnis I on Murdock Mackenzie's *Chart* (1775). The latter spelling may be an abbreviated form rather than a misspelling. By the time Denham produced a *Chart of the Burry or Llanelly Inlet* in 1830 the modern form, Machynys, was in use.

The changing Llanelli coastline

That the early Holocene Llanelli coastline was vastly different to that of today is evident, but just how different was it? D Q Bowen has suggested a possible shore-line (Fig 1) that ran from Pembrey along the foot of the steep coastal slopes to Sandy and on to a point close to the present town hall. From here the line turned south to Seaside before again turning east to Trostre and on to Bynea (Bowen 1980, 158-9). The line from Pembrey to Seaside has been fairly well established from the presence of marine alluvium recorded in boreholes, but the section from Seaside to Bynea is not so definite because here the sequences are complicated by thick layers of fluvial silts and clays, laid down by the Afon Dafen prior to it being canalised and rerouted in the early 19th century, which cover the marine deposits (Bowen 1980, 158-9). It is likely that the Dafen originally formed a tidal inlet, roughly delimited by the 8m contour, as far inland as Halfway. This has implications for the chronology and sequence of embankment and reclaimation within the region.

RECLAIMATION OF LLANELLI MARSH AND MACHYNYS

THE PROCESSES OF RECLAIMATION

The reclaimation of coastal wetlands relies on a three stage process to be successful. First a sea wall is constructed along the coastline and along the major rivers crossing the area. Once the wall is constructed it is necessary to modify the minor rivers and creeks that cross the area into an enhanced natural drainage system to ensure that they empty their waters through the sea wall and do not flood the newly embanked land. The final stage is to construct an artificial drainage system to carry water from the fields to the main drains and watercourses and out through the sea wall.

Active sea defences in the study area

The current sea defence is a wall constructed from sheet steel pile-driven into existing earth banks, and it runs along the southern edge of the study area from Machynys (NGR SS5059734) to Morfa Bacas (NGR SS54449798), a total length of 4.1km. Although the banks into which the steel has been driven are now linked to form a single continuous wall they actually represent several phases of embankment and range in date from the 16th century to the 19th century. The earliest phases are at Machynys at the west end and around Tir Morfa and Parc Einon at the east end, where two phases of embankments are shown in both locations on 18th century estate maps (Fig 3). At Machynys the two phases had occurred before 1760[1], which suggests that the primary embankment had taken place during the 17th- or early 18th-century, or earlier. There is also evidence to suggest that some embankment had taken place at Tir Morfa and Parc Einon by the mid 16th century[2] (Fig 4).

Historic sea defences

The history of embankment and enclosure within the area is complex. Prior to the Parliamentary Enclosure Acts of 1810, enclosure on Llanelli Marsh had been fairly small-scale and piecemeal with approximately 1200 acres (*c*.486ha) of the marsh having been embanked and reclaimed. A further 600 acres (243ha) were enclosed by The Great Embankment in 1810 which increased the area of reclaimed land by some 50%. The earliest known phase of embankment was carried out in the late1590s by one John Gwynne Jenkin, who enclosed approximately half an acre of the 'Commons called Kymmyn Bache' (Rees 1953, 261). Kymmyn Bache can be equated with the name Commons Bach which appears on the tithe map of 1841 (see Fig 4 for location of Commons Bach). Several other episodes of late 16th- early 17th- century enclosure were recorded in the marshes around Llanelli and Loughor to the east, although it has not been possible to identify the locations with any accuracy.

[1] Map of Machynys Farm, from William Chamber's Mapbook, 1760. CRO ref Stepney Clln SE72.
[2] Cawdor Vaughan Muniments 65/6695

There seems little doubt that enclosure had started on Llanelli Marsh during the medieval period, and even though there are no records of any medieval enclosure, there are some topographic clues to likely locations. One area of possible medieval enclosure is around the former sites of two farms, Maes-ar-Dafen Fach (Fig 2) and Maes-ar-Dafen Fawr, which are now occupied by the Trostre Steelworks. Maes-ar-Dafen Fawr was demolished when the steelworks was erected during the 1940s and 1950s, but Maes-ar-Dafen Fach survives in the steelworks grounds as a museum and functions hall (Page 1997, 15). Even though the landscape around Maes-ar-Dafen has been completely remodelled it is possible to at least partially reconstruct its earlier form from early maps and other historical sources (Fig 2).

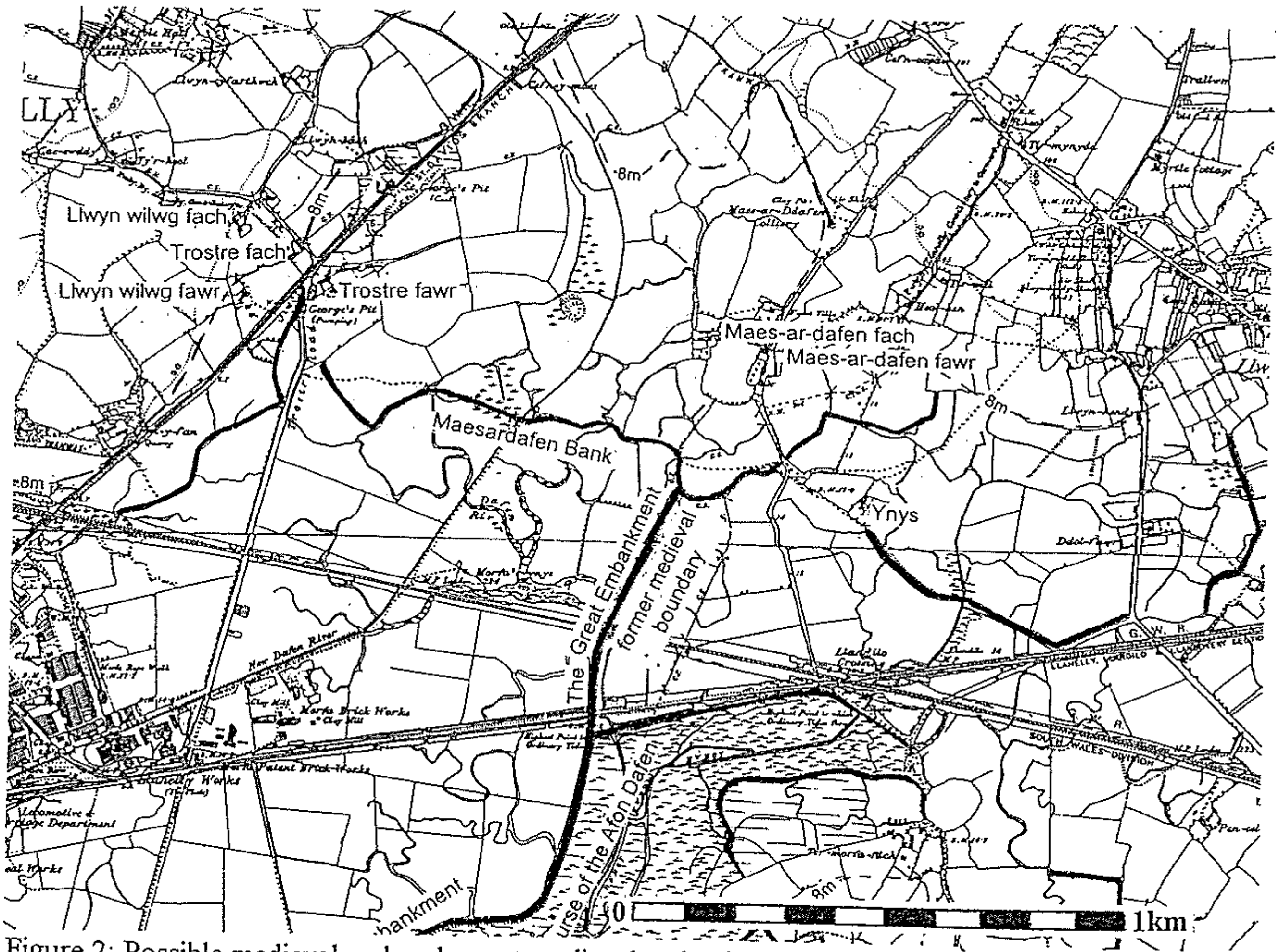


Figure 2: Possible medieval and early-post medieval embankment around Maes-ar-dafen and Trostre

It has been suggested (James 1993, 13) that the Maes-ar-Dafen area may have been settled and farmed before the 12th century. James records that the administrative boundary which now follows the line of the Great Embankment is an ancient one that formerly delimited the boundary between the medieval borough of Llanelli and its subsidiary manor of Berwick. The boundary is shown on a mid 18th century map of the Lands of Berwick[3] as 'the division between the hamlet of Westva and the Borough'. A 'gwestfa' was a Welsh food render, taken over by the Normans in the Welshries of their new lordships. The manor of Berwick, along with others in the region, were Welsh 'maenors' which, following Norman settlement of the area, were divided into Englishries and Welshries, with their boundaries perpetuating existing pre-Norman land and administrative divisions. Another possible indication of pre-Norman settlement is the former presence of two chapels in the area which may have been subordinate churches within the parochia of Llanelli. This, when considered alongside the early references to land at Machynys, does suggest that early settlement could well have taken place around Maes-ar-Dafen.

The earliest maps available are estate maps which show that the layout of fields depicted on the mid 19th century tithe map and early Ordnance Survey maps was already well established by the mid 18th century. Several fields along the south edge of Maes-ar-Dafen are called Bulwarke, or have Bulwark as part of their names in 1751, which when taken together with the irregular shapes of the fields suggests reclaimed land. To the north of the two farms were fields called Ca' Cefen which were in the mid 18th century still divided into the common strips or shares typical of a medieval open field. The area of possible medieval enclosure around Maes-ar-Dafen Fach has been lost during the construction of the steelworks, the Parc Trostre retail park and the new infrastructure developments.

The open field system is synonymous with medieval agriculture, although its origins may lay further back in time (Rowley 1988, 123). On Llanelli Marsh there are many references to 'landshares' and areas of strip fields recorded on 18th century estate maps and on the Llanelli parish tithe map. Most of these areas are concentrated around the islands of higher ground which means that they may pre-date embankment, and possibly date back to the medieval period. The evidence from estate maps and the tithe map clearly shows that the strip field system was extensive across the Llanelli Marsh area and that it survived in use well into the 19th century. Some traces of the now enclosed strip field system survive around the former site of Pen y Bryn Farm (Plate 2), which is today the site of a new sewerage treatment works.

Another block of fields that appear to have their origins in an open field system was shown on mid 18th century estate maps around Trawstre (modern Trostre), approximately 1km west of Maes-ar-Dafen on the opposite side of the Dafen Valley. The fields around Trostre were also irregular in shape and like the Maes-ar-Dafen fields appeared to have been bounded on their southern edge by an early embankment. Another embankment (hereafter the Dafen Bank to differentiate it from the others) constructed across the Dafen Valley to link the Maes-ar-Dafen and Trostre banks was first shown on Jones' 1751 map, but it probably dates from much earlier. Although the exact dates of these three banks (collectively known as Maesardafen Sea Bank) are unknown, both Maes-ar-Dafen and Trostre were mentioned in the early 17th century

[3] Lands Near or About Berwick Chapel, map by William Jones, 1751. Copy held in SMR. Llandeilo.

Duchy of Lancaster survey as marker points on the edges of Morfa Mawr (Llanelli Marsh). Therefore, it seems reasonable to assume that they date from at least the 16th century, and that the embankment of their southern boundaries had also taken place by that time. Furthermore, it is tempting to suggest that the Dafen Bank was also in place at the time and that it formed the northern boundary of the marsh.

The Maes-ar-Dafen and Trostre farms (Trostre Fawr and Trostre Fach), lie towards the edges of the Dafen floodplain, close to the 8m contour line which roughly marks the limit of the wetlands. They are situated at the point where the 8m contour defines the mouth of the Dafen Valley and where the river flowed into the marsh, the lowest point at which the Dafen could easily be embanked.

The area south of Maes-ar-Dafen, immediately outside the sea bank, around Ynys (formerly known as Ynys Ysty or Ynys Ystyn) was possibly embanked by the mid 16th century. Several parcels of land at Ynys Ysty were mentioned in rental release documents dating from 1576 (CRO refs Cawdor Vaughan Muniments 59/6428 & 65/6695), which suggests that at least some of the Ynys area was enclosed. An embankment shown on the 1st edition OS maps running southeast from Ynys towards Techon Fawr, may date from this period (Fig 2).

Machynys

Enclosure of the marsh at Machynys was carried out in two phases and had been completed by 1760. These two phases of embankment had taken place along the southeast and eastern edges of that area (Fig 3). The first phase bank which enclosed *c.*160acres acres (66ha), still forms the southernmost section of the present sea wall. Originally it extended north into the area later occupied by the Machynys Brick Works; it probably followed the original course of Penrhyngwyn Pill. Only a short length survives today, *c.*350m, 300m of which is incorporated into the present sea wall. The section inside the present sea wall is much eroded, standing to *c.*1.7-2m high, and has been truncated during construction of the new golf course on the site. Penrhyngwyn Pill, which is the main watercourse draining the southern half of Machynys, empties though the bank via a modern concrete and brick sluice at NGR SS51519735. There may be remains of an earlier sluice incorporated into the modern one.

The second phase bank originally extended from a point roughly 300m from the southern end of the phase 1 bank, from there it ran northeast before turning more northerly and terminating at *c.*NGR SS51509835. It enclosed 35acres (14ha). The northernmost 500m of the bank ran along the west bank of a large, former saltmarsh creek, which remains one of the main drains in the area. As with the phase 1 bank the southernmost 300m of this bank have been incorporated into the present sea wall. A further 100-150m of the bank survives inside the sea wall within the area of the golf course, although, here it is eroded and overgrown(Plate 3). A small, detached length of the bank survives as a low grass covered mound at approximately NGR SS51629812, and a better preserved section runs from NGR SS51649815, around the eastern edge of a small pond and ends at *c.*NGR SS51639821.

The enclosure of the marsh at Machynys was almost certainly carried out by the occupants of Machynys House Farm (Plate 4) which formerly stood on the summit of Machynys Bluff

(NGR SS50809822). There is documentary evidence to suggest that there has been a farm at Machynys since at least the medieval period. A 14th century lease details a payment of £7 10s for 'the rent and farms of all the demesne lands, meadows and pastures of Maghenes' (James 1993, 14), and in 1375 one John Wrenche is said to have lived there (*South Wales Evening Post* 29/06/91, p1). There is also a story that when Machynys House was demolished in the 1970s, some of the rafters had AD1450 carved into them (Jones 1987, 124). However, the use of Arabic numerals was not common in the medieval period, so the possibility of these timbers having such a date carved into them is considered unlikely.

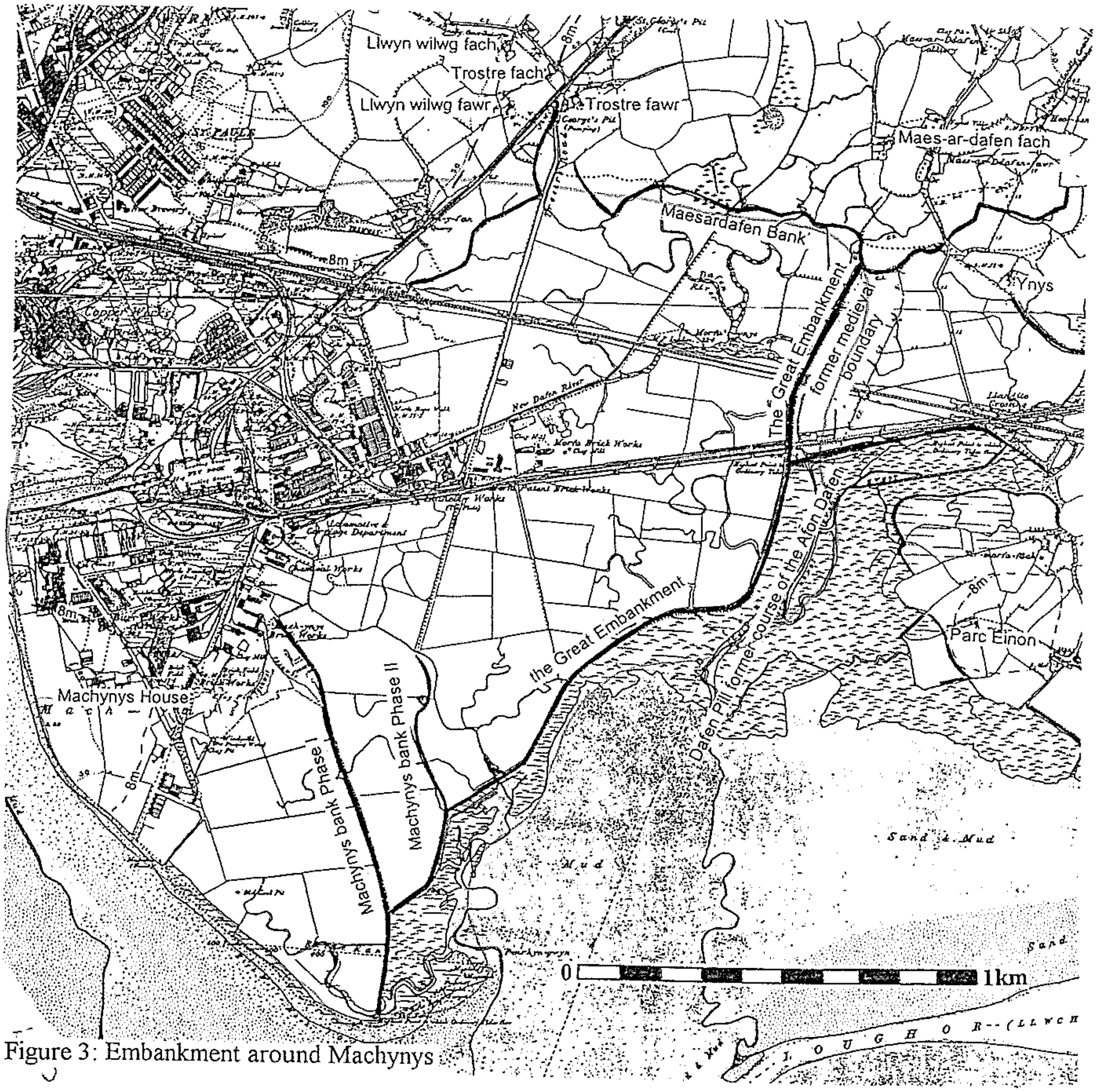


Figure 3: Embankment around Machynys

A series of 16th century Crown leases and rentals outline that David Vaughan shall have and hold '...the farm of all the lands and tenements meadows and other premises...' at Machynys for the sum of £7 16s 8d, which included 6s 8d for the tolls for the town of Llanelli[4]. By 1669 the rent for Machynys had increased to £8 3s 4d, and the toll for Llanelli was now assessed separately[5]. On the 1761 Stepney estate map one of the fields to the north of Machynys House Farm is called Llain-yr-Warren (*Warren Strip*) suggesting an artificial warren for breeding rabbits, a common practice from the medieval period onwards. When rabbits were first introduced by the Normans they were a luxury resource valued for their meat and pelts, but by the mid 18th century attitudes had changed and rabbits were regarded as food for the poor and a pest (Rackham 1994, 23). This change of attitude is significant because it suggests that the field name, Llain-yr-Warren, predates the 18th century and it may even date back to the medieval period. All this strongly suggests that Machynys was embanked by the mid 16th century, and probably even earlier.

As previously noted (see above) there is a strong local tradition that Machynys was the site of a monastery established by St. Pizo 'around the year 513' (Jones 1987, 124). The only known reference to the monastery is from an 18th century traveler, but no firm evidence for it has ever been recovered. Therefore the presence of an early monastic settlement is considered unlikely.

East of the Dafen (Fig 4)

The area to the east of the Dafen is outside the extents of Llanelli Marsh, but is briefly mentioned here as it was embanked, and drained as part of the overall process of reclaimation of the Llanelli wetlands. The sea defences to the east of the Dafen, the area between the Penclacwydd Wildfowl and Wetlands Centre and Yspytty were, in common with the rest of the area, erected piecemeal and of varying dates. There are references to enclosure dating from the 16th century on Commins Bach (Rees 1953, 261), an area identifiable as being around Bryn Carnarvon and Dyffryn (Fig 4). However, this may have been a reference to enclosure of previously embanked common land, rather than a new area of embankment.

Some embankment may have taken place at Park Eynon as early as 1615[6]. Park Eynon was a small parcel of land that in 1761 consisted of three fields, one of which was called 'outside the Bulwarke'[7]. The tithe map shows some strip fields in this area which again may pre-date embankment and the constructiuon of the 'Bulwarke'. A small farmstead had developed on the site by the late 19th century which was called Parc Einon on the OS 1st edition maps of 1891, but its name had changed by the mid 20th century to Penclacwydd-isaf. The holding was still recognisable until the Penclacwydd Wildfowl and Wetlands Centre was constructed on the site in the 1980s.

[4] CRO ref Cawdor Vaughan Muniments 21/598
[5] CRO ref Cawdor Vaughan Muniments 112/8399
[6] CRO ref: Cawdor Vaughan Muniments 2/26
[7] Map of Park Eynon, from William Chamber's Mapbook, 1760. CRO ref Stepney Clln SE72

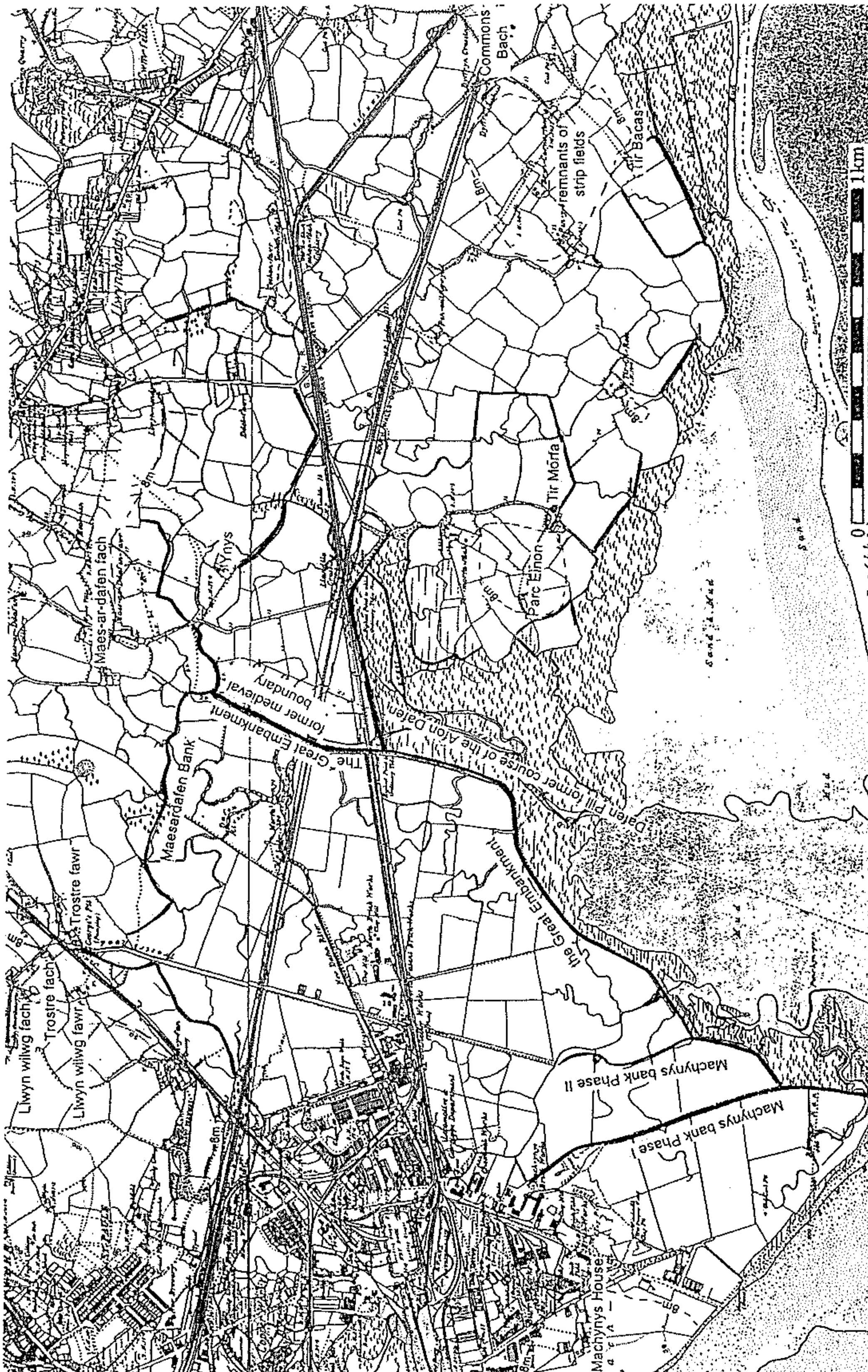


Figure 4: Embankment east of the Dafen, showing areas of early embankment around Parc Einon, Tir Morfa Tir Bacas and Commons Bach

Another possible area of 16th century embankment and enclosure bounds the east end of Park Eynon where a piece of land called Tyne y Morva, possibly modern Tir Morfa, is mentioned in a rental of 1576[8]. If Tyne y Morva is Tir Morfa (Plate 6) then it strongly suggests that some of the Tir Morfa area was embanked by the mid 16th century. The evidence is beginning to suggest that much of the landscape recognisable today, or at least the pre-redevelopment landscape, may have been in place as early as the 16th or 17th century, although the marsh farms such as Pen y Bryn (Ludlow 1995), Tir Morfa, Dyffryn and Bryn Caernarfon developed during the 18th century.

The final embankment of Llanelli Marsh (Fig 3)

The final major embankmet of Llanelli Marsh was the construction of the Great Embankment as part of a series of early 19th century Parliamentary Enclosure Acts (Fig 3; Plate 7). The embankment joined the second phase bank at Machynys with the Maesardafen Sea Bank to the northeast and enclosed 600 acres. One of the crucial factors that allowed the embankment of such a large area was the rerouting and canalisation of the Dafen river in 1808 from its original course to run in a new cutting to a scouring reservoir for New Dock. Several smaller episodes of embankment have occurred since to enclose the area between the Great Embankment and the Penclacwydd Wildfowl and Wetlands Centre.

Land loss

There has been a certain amount of land loss during the later 19th- and early 20th-century around Park Eynon and Morfa Baccas to the east. Areas of enclosure shown on the tithe map of 1841 were reverting to saltmarsh, or in some cases had been lost to the sea by the time of the 1st edition OS maps (1891). The loss is most notable round Morfa Baccas where a road, or track, and several allotments were lost to erosion in the 50 years between 1841 and 1891, but overall the land loss on the reclaimed Llanelli wetlands has not been significant.

Drainage of the reclaimed marshes

Once embanked the enclosed land had to be drained and in the study area that was achieved through a complex, hierarchical system of drains that combined the natural channels of the former saltmarsh creeks with the artificial drains (Fig 5). Previous study of the area (Page 1997, 12) has shown that there are three principal types of drainage present across Llanelli Marsh: a) natural drainage; b) enhanced natural drainage; and c) artificial drainage.

a) Natural drainage consists of former saltmarsh creeks and watercourses that drained the unenclosed marshes. The channels are typically serpentine and dendritic in character and give the landscape an irregular appearance.
b) Enhanced natural drainage channels are existing creeks and watercourses that have been modified in some way, i.e. recutting or minor rerouting, but still retain some natural characteristics. Enhancement of some the creeks would have allowed a certain amount of control over the movement of water and begun to stabilise the enclosed land.

[8] Cawdor Vaughan Muniments 65/6695

c) Artificial drainage is usually straight and uniform resulting in a regular, rectilinear pattern of fields and enclosures. It would have fully stabilised the enclosed land allowing year-round access and production. Artificial drainage includes both soft drainage (open drains) and hard drainage (buried ceramic or plastic drains). It also includes the main field boundary drains and the field drains.

All three types of drain are evident within the study area. Figure 5 clearly shows the pattern of old tidal creeks and watercourses that existed in the saltmarsh prior to embankment, some of the channels can be traced crossing the various phases of embankment at Machynys. In places, most notably in the second phase enclosure the channels were substantial enough to form field boundaries. Many of the creeks show evidence of enhancement, particularly the creek that feeds out of the sluice in the Great Embankment, which has clearly had its course smoothed to improve the flow of water towards the sluice. The artificial drainage is a combination of field drains, the field boundary ditches, main drains and the back drain which runs along the rear of the sea bank.

The whole drainage system is a complex feat of engineering, but its operation is relatively simple: field drains drain water into either the field boundary drains or the existing natural creeks which channel the water into the main drains and the back ditch and out through the sluices in the sea bank. The field drains in the area fall into three categories: i) ridge and vurrow; ii) a 'grip-like' chequer-board layout; and iii) modern buried ceramic and plastic drains (see information box below for discussion). Field boundary ditches have been generally 1m-2m wide and 1m-1.5 deep. Some of the boundary ditches were cleaned out relatively recently, but others had silted up and become blocked with vegetation and some have been deliberately blocked to divert the water flow.

In some places the ridge and vurrow and grip-like drains have apparently been replaced, presumably by modern underground field drains. There is little surface evidence of either form surviving, although the vegetation growth may be obscuring slight ridges and shallow gullies. The terms 'ridge and vurrow' and 'grips' are not necessarily local terms, but they were used in the earlier study of the area (Page 1999) in order to be consistent with other work in similar landscapes along the Severn Estuary (Rippon 1996b). The ridge and vurrow in the study area can be mostly identified with the early embankment at Machynys, although, there may have been some associated with Great Embankment as well. The ridges in the areas of early reclamation are generally wide spaced and not always straight or parallel, whilst the majority of those inside the Great Embankment are closer together and straighter, owing to the improved agricultural technology and methods of the 19th century. A gridded layout of grip-like drainage is more common across the eastern half of the area.

Descriptions of the major field drain types in the study area (taken from Page 1999)

'Ridge and vurrow'

Ridge and vurrow is a system of drainage that uses a series of parallel ridges to drain water from the field into the vurrows which channel it away to the field boundary ditches. The ridges are created by ploughing up and down a line always turning the sods to the centre of the ridge, thus raising the ridge and leaving the vurrow in between (Rippon 1996b, 50). This system is created specifically for drainage purposes unlike the similar 'ridge and furrow' which results from long-term ploughing for arable cultivation. The main difference between them is that ridge and vurrow is typically straight, whilst ridge and furrow has a characteristic reverse-S shape caused by the technical difficulties of medieval mouldboard ploughing which meant that the plough team had to start turning before reaching the end of the field (Rackham 1990, 79).

Grips

A grip is a channel cut into the surface of the field as opposed to a vurrow which is formed by raising the ground into ridges on either side. The grip system of drainage works on a grid formation where a series of parallel longitudinal grips drain water from the fields into cross grips which empty into the field boundary ditches. The drainage of the eastern end of the study area is 'grip-like' in its gridded layout, but there are some differences with the grip drainage recorded on the Severn Levels (Rippon 1996). The longitudinal drains of the study area are closer together than the grips in the Severn Levels, but it may be that the grip system replaced some earlier ridge and vurrow, or it was itself replaced by a later system of hard drainage, both eventualities would lead to the appearance of very close-packed longitudinal drains like that in the northern section of the area.

Figure 5: 1948 RAF aerial photograph of Machynys showing the main phases of embankment and the complex pattern of natural and artificial drainage

THE BOREHOLE RESULTS

by M C Lillie, J Kirby and H Griffiths

METHODOLOGY

A roughly north-south transect consisting of three 40mm diameter hand-augered Cores (Cores 1-3) and a 150mm diameter percussion core (Machynys 1) was excavated to a depth of 10m below present ground level. Cores 1 and 2 were positioned *c.*400m apart, with the distance between Cores 2 and 3 being *c.*300m (Fig 6). Core 3 was positioned at the furthest point inland, north of Core 1, that was possible in light of new road and housing development on this side of the floodplain. Core 1 was positioned 20m east of the percussion core. The recovered material was sub-sampled, processed and analysed for pollen, diatom, formanifera and ostracod evidence as well as particle size and moisture content analysis of the sediments.

Figure 6: Location of boreholes

Coring strategy and core locations

The coring strategy was to sample and examine the percussion core at a medium resolution and to complement this with lower resolution sampling and analysis of the hand auger cores to provide a background against which the main core could be assessed. The location of the percussion core was dictated by physical factors on site rather than archaeological considerations and this has had implications for the analysis results.

There were two main factors that dictated the final position of the percussion core; firstly, so much time had passed between the initial recommendation and receiving the go ahead that the bulk of the golf course had been constructed which meant that the optimum percussion coring sites were not available as they had already been landscaped; and secondly, it was the middle of a very wet winter and access to the site was badly restricted because of the waterlogged ground conditions, in fact the location of Machynys 1 was the only place on the entire site that the percussion core rig could reach.

Other problems included the way Machynys 1 was retrieved, it was taken in 500mm x 150mm diameter tubes with a 150mm long cutting head. The 150mm of sediment from the head was retained, but no stratigraphic continuity could be assumed in this context. As will be seen below, this had implications for identifying and dating the all important transition episodes between the formation of the main peat unit and the underlying and overlying alluvial sequences. Radiocarbon dates obtained from within the peat have provided a loose temporal framework for marsh development, but the transitions still lack absolute dates.

SOIL DESCRIPTIONS

Figure 7 shows the stratigraphy of the sampled section as recorded during field assessment. The results of the palynological analyses are given in Figure 8 and Table 1, and the results of the Diatom analyses in Figures 9 and 10. Pollen was present in countable frequencies in all samples, whilst diatoms were only present in five of the nine samples taken. Radiocarbon (AMS) dates are given in Table 2.

Borehole Machynys-1 was percussion cored by THYSSEN Construction Ltd, Llanelli. The sedimentological logs record modern overburden and dumping of brick-ash and cobbles to 1.1 m depth below the modern ground level onto a grey, soft-firm clay to 2.0m depth (3.117m to 2.217m OD). Two lengths of the core at 1.0m - 1.45m and 5.90m - 6.38m depths failed to preserve sediment in any significant quantities. This phenomenon appears to have compromised the integrity of the lowest part of the biogenic sediment sequence, which was used in the radiocarbon analyses. It has also resulted in the failure of the borehole to produce source material for the main stratigraphical contacts at the top and base of the peat (sections 4 and 5 below).

The remainder of the sequence below 2.217m OD (2.0m depth) comprised an oxidised brown firm-stiff clay onto a soft grey sandy silt at 2.50m depth (1.717m OD). The sandy silts overlie soft-firm brown peats (see Plate 7 for general shot of the upper sequence as revealed during excavation of one of the new golf course lakes) at between 4.50m to 6.50m depth (-0.283m to -2.283m OD). These peats are underlain by a grey peaty silt to 8.00m depth (-3.783m OD) onto soft sandy silts to 10.50m depth (-6.283m OD). This sequence is compared to the hand-augured evidence in sections 3.4-3.6 below.

Particle size analysis of the sediment distributions (Table 3) indicates that between 2.05m - 2.20m depth (2.167m - 2.017m OD) fine-coarse silts dominate the alluvial deposits at 42.72% with clays at 39.03% and fine sands at 18.25%. This distribution conforms to the field identification of layer 2 in the hand-augured core 1 described below in section 3.4. The organic content of this upper alluvial unit is low at 5.67% (Table 3). Moisture content increases down the core to the surface of the peats ranging from *c*.22% to 35%, a sample of peat at 5.75-5.90 m depth (-1.533m to -1.683m OD) which was analysed for moisture and organic content produced readings of 80.92% and 85.83% respectively.

In general, those sediments that were analysed from the percussion core that can be correlated with those obtained by hand auguring at SS51569780, confirm the field observations relating to the general silt-clay dominated nature of the alluvium, with sand inclusions reflecting tidal conditions along the coast. The increased medium-coarse sand contents occurring between -3.683m and -2.733m OD (6.95m - 7.90m depth) may well be a reflection of the prevailing regressive tendencies, occurring prior to the subsequent peat formation stage, and the development of more littoral, beach-like conditions at this location.

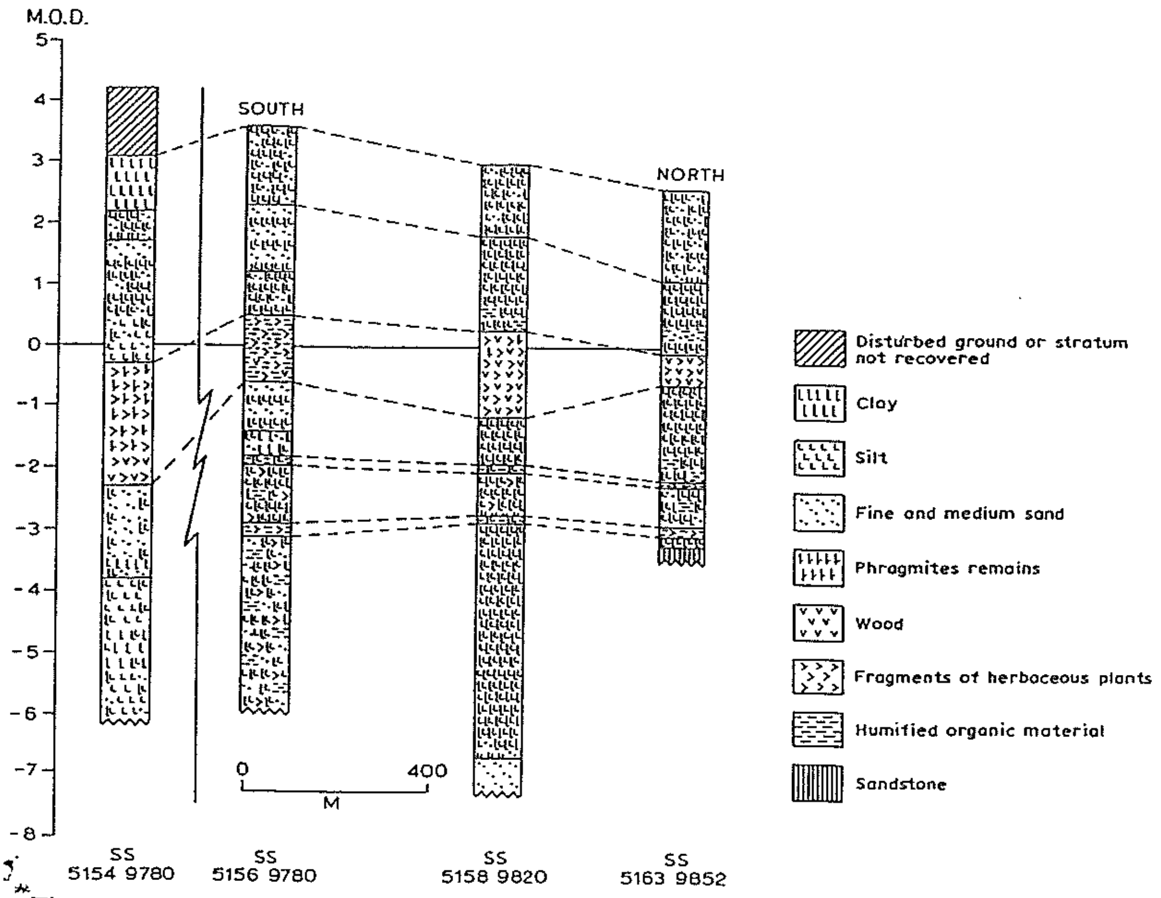


Figure 7: Sedimentological logs and borehole stratigraphy at Machynys

Core 1

Core 1 was excavated at a distance of approximately 20m east of the percussion core at a point where no overburden was in evidence. A partially oxidised blue-grey silt-clay with fine sands was identified between 0.00-1.29 m depth (3.612m - 2.322m OD). The sands are expressed in the form of fine *c.*1-2mm laminations below 1.0m depth (2.612m OD), reflecting tidal episodes. The water-table was encountered at 0.6m depth (3.012m OD). Below 1.29m the deposit grades into oxidised and laminated silt-clays and fine sands. The deposit is unoxidised below 1.8m depth (1.812m OD). The particle size analyses obtained from the percussion core at 20m west of this location at 2.167m - 2.017m OD fully accords with the field identification of these upper alluvial sequences.

Below 2.40m depth (1.212m OD) the upper alluvial sequence grades into an unoxidised clay-silt alluvium with occasional fine sands (<10%), and organic inclusions. The loss-on-ignition percentages obtained from the adjacent percussion core indicate that organic content in this unit is *c.* 6-10%. This would again accord well with the field observations. At 3.12m depth (0.492m OD) the alluvium exhibits a distinct (i.e. non-conformable) contact with the underlying peat. This non-conformity reflects the transgressive nature of the material associated with the upper alluvial deposits at this location. At Core 1 the top and base of peat are located at heights of 0.492m OD and -0.578m OD respectively.
Heights obtained for the top and base of the peats in the percussion core (20m west of Core 1) indicate a top of peat height of -0.283m OD and a base of peat height of -2.283m OD. The peat deposits in the hand augured cores do not exceed 1.37m thickness across the transect, with less than 0.5m of peat encountered at the floodplain margins at Core 3 (fig 7). The cause of this apparent discrepancy is ill-defined at present.

The peats in Core 1 were humified, red-brown and black in colour, being fibrous throughout and with frequent wood macrofossils to the base. This would conform to the evidence from palynological analysis which attests the on-site growth of alder and willow towards the base of this sequence. The contact with the underlying alluvial units is conformable but quite distinct, possibly reflecting some consolidation of the alluvium prior to colonisation. This observation would broadly accord with the ostracod and foraminifera data (from the percussion core) presented below. However, as with the palynological data, it is worth noting that a much higher resolution sampling strategy, which focuses on the contacts between the upper and lower alluvial units and the peat, is needed in order to produce valuable and meaningful results from this analysis.

The lower alluvial unit, between -0.578m and -5.588m OD (4.19m - 9.2m depth below the modern floodplain), comprises silt-clay with occasional laminations of fine sands and clay-dominated horizons below 5m depth (-1.388m OD). Peaty horizons and organic-rich alluvium occur throughout this lower sequence, with a peat horizon occurring at -2.988m to -3.088m OD (6.60m - 6.70m depth). This was sampled at its top and base.

Core 2

The hand-augured Core-2 was excavated to 10.2m depth between 2.981m OD and -7.219m OD at NGR SS51589820. At this location the peat is at 2.76m - 4.13m depth (0.221m to -1.149m OD), with peaty horizons within the underlying alluvium occurring at 4.94m - 5.06m depth (-1.959m to -2.079m OD) and 5.73m - 5.83m depth (-2.749m to -2.849m OD). A number of the contacts of these peat horizons have been sampled for palynological analysis, the results of which are presented below.

Core 3

The final borehole in the south-north hand-augured transect, Core 3, was excavated to a depth of 5.80m below the modern floodplain (2.601m to -3.199m OD) at SS51639852. The general sequence of alluvium over peat continues at this location, with the 0.47m thick wood peat occurring between -0.099m to -0.569m OD depth. As elsewhere, a number of peat horizons were shown to be intercalated with this alluvium, indicating a number of regressive episodes occurring prior to the development of the main peat unit at Machynys. At this location, which (as noted above) represents the innermost point at which coring was feasible in light of housing and road developments, the base of the core at -3.199m OD appears to have struck solid geology. Sandstones, as mapped on the Geology Survey Solid and Drift Sheets 247 (Swansea) outcrop to the immediate north of the Machynys alluvial deposits (above section 2.1) and the base of the sequence at this location may have encountered these deposits.

Radiocarbon Dating

As noted above, peat samples were submitted to Beta Analytic Inc, Florida, USA, for radiometric analyses (Appendix 1). These samples were obtained from three locations within the peat sequence at depths of 4.80m - 4.85m (-0.583m to -0.633m OD), 5.50m - 5.55m (-1.283m to -1.33m OD) and 6.10m - 6.14m (-1.883m to -1.923m OD) respectively (Table 2). However, as noted below in the discussion of the lithostratigraphy and palynology from this core, the lowermost sampling point has the appearance of non-conformity in terms of its contained pollen spectra, and as such this sample is not considered in the analysis.

The bulk organic carbon fraction of the samples was analysed after removal of any carbonates and rootlets. Calibrations are based on calibration data published by Talma and Vogel (1993), with reference to Stuiver and van der Plicht (1998) and Stuiver *et al.* (1998).

The calibrated ranges obtained from depths of 4.80m - 4.85m and 5.50m - 5.55m in the percussion core have produced radiocarbon determinations of 2870±70 BP and 3730±70 BP respectively, with absolute age ranges of 1270-845 cal BC and 2330-1935 cal BC (Beta-139982 and Beta-139983). These ranges would indicate a Neolithic-Bronze Age transitional date for the onset of pollen zone (PZ) Mach-3 (below fig 8), with the upper part of the peat sequence developing into the later Bronze Age period at -0.583m to -0.633m OD (4.80m - 4.85m depth). This date provides a *terminus post quem* for the uppermost 0.3m of peat development and the subsequent onset of alluvial sedimentation.

Obviously, the failure of the lower radiocarbon date to produce a realistic determination limits discussion of the onset of peat development at this location. However, the date of 2330-1935 cal BC (Beta-139983) from the central part of the peat sequence would indicate that a mid-earlier Neolithic age for the onset of peat formation would not be unrealistic in this context. This supposition could be, and needs to be, tested with the obtaining of a full, undamaged stratigraphic sequence from this location.

Palynological analyses

Sub-samples taken for pollen analysis have been processed using standard techniques according to Moore *et al.* (1991). At least 200 pollen and spore types have been identified in each sample and the percentage calculations are based on a sum consisting of all land pollen types (trees, shrubs and herbs) excluding aquatics and spores. The sum upon which the frequencies of aquatic and spore types are expressed is total land pollen (TLP) including the group aquatics or spores.

The main focus of the palynological investigations is the peat sequence sampled in the percussion borehole (Machynys 1). Three spot samples from the lower portions of the core have been taken from thin intercalated peat horizons (8.02m - 8.03m; 8.00m - 8.01m and 6.94m - 6.95m depth - see Table 1). The analysis of such spot samples provides some insights into the nature of the prevailing plant communities, and they also provide a means of approximate dating control for the deposits considered. The results of spot samples from adjacent cores are presented in Table 1.

Machynys 1 (8.00m - 8.01m [-3.783m to -3.793m OD] and 8.01m - 8.02m [-3.793m to -3.803m OD])

These samples are from a thin intercalated peat. Both samples are dominated by herbaceous pollen taxa (*c.*50% TLP), with Poaceae (Wild grasses) the main family represented. Frequencies of Chenopodiaceae (Goosefoot family) pollen are consistently present and probably originate from saltmarsh plants. Tree pollen is not well represented although this may simply be a reflection of the distance of the saltmarsh environment from the dryland woodland community. Nevertheless, it is apparent that *Quercus* (Oak) and *Corylus avellana* (Hazel) were important trees within the fringing woodland community, with *Alnus glutinosa* (Alder) and *Betula* (Birch) possibly occurring as a fringing wet woodland between the coastal marsh community and the adjacent dryland margins.

Indicative environment and Inferred Age

The abundance of herbaceous pollen taxa such as Poaceae and Chenopodiaceae suggests a saltmarsh/saline reedswamp environment. The formation of this peat unit within or just above the intertidal zone is supported by the occurrence of the organic test linings of foraminifera, which live in such littoral habitats. Assigning an age to this deposit is difficult due to the unknown distance between the local peat forming community and the surrounding dryland. However, *Ulmus* (Elm) percentages can often used as a diagnostic biostratigraphic marker due to the decline in pollen frequencies at *c.*3800 cal BC (5000 BP) (Smith & Pilcher 1973). Although the dating of this deposit using biostratigraphy in this context is somewhat insecure, percentage frequencies for *Ulmus* of 3% in sample 8.00-8.01 are probably high enough to suggest a pre-*Ulmus* decline age for this sample (i.e. older than *c.*5000 BP).

Machynys 1 (6.94m - 6.95m [-2.723m to -2.733m OD])
This pollen assemblage is dominated by herbaceous pollen types (70% TLP) with Poaceae (25%) and Chenopodiaceae (38%) being the main taxa represented. *Quercus, Alnus glutinosa* and *Corylus avellana*-type are the most important of the arboreal and shrub pollen types in evidence.

Indicative Environment and Inferred Age
The abundance of saltmarsh plant taxa such as Poaceae, Chenopodiaceae and Asteroideae (Daisy family), along with foram test linings suggests a saltmarsh origin for this pollen assemblage. Dryland pollen is not well represented with the majority of the *Quercus* and *Alnus glutinosa* pollen probably originating from a fringing oak/alder carr community. The low arboreal pollen percentage (28%) and low frequency of *Ulmus* pollen suggest a post *Ulmus*-decline age for this assemblage. However, it would be inappropriate to place any degree of certainty with this age as given that the depositional context may bias the observed frequency of arboreal pollen. At Goldcliff, towards the inner part of the estuary (*c.* 80 km linear distance), pre-*Ulmus* decline assemblages are characterised by a distinct lack of elm pollen due to the distance from the dryland edge (Smith and Morgan 1989).

Machynys 1 (main peat unit)
The results of the pollen analysis conducted on the main peat horizon (between 4.80m and 6.10m (-0.583m to -1.883m OD) is presented in Fig 8. Samples have been taken at 40mm intervals. Inconsistencies within the pollen stratigraphy are attributable to the loss of intact sediment between core runs. The pollen diagram presented has been drawn using TILIA spreadsheet and TILIA*graph software (Grimm 1993). The diagram has been divided into local pollen assemblage zones according to the stratigraphically constrained statistical cluster analysis (CONISS) method (Grimm 1987).

Pollen Zone MACH-1
The palaeoenvironmental setting indicated by the biostratigraphic results in this zone do not conform to the lithostratigraphy as identified above. The transition from clay sediment to organic deposits in this core represents a regressive contact related to a continued trend of negative sea level tendency. Such a shift in sedimentary environment is normally reflected by the occurrence of saltmarsh pollen taxa, followed by a succession through to freshwater reedswamp and fen carr, following a progressive series of vegetation changes leading to terrestrialisation.

The pollen results are ecologically incoherent in this respect as the basal sample indicates acidic conditions, with *Myrica gale* and *Sphagnum* as the prominent vegetation types. This represents a palaeoenvironment that is not associated with semi-terrestrial littoral vegetation communities typical of such regressive contacts. Further inspection of the sequence revealed a disturbed sedimentary sequence in this core. As a consequence, the pollen assemblage within this zone has to be considered to be unrepresentative, and cannot reliably be used to infer a palaeoenvironmental context for the deposits at this level.

Pollen Zone MACH-2
This zone is dominated by herbaceous pollen types, such as Cyperaceae (Sedge family) and Poaceae. The most characteristic feature of this zone is the decline in *Betula* pollen frequencies and a coincident rise in *Alnus glutinosa* percentages. *Salix* (Willow) is particularly well represented with percentage values *c.*15%. This can be considered to indicate on-site growth of willow, given the acknowledged underrepresented nature of this taxon in the pollen record (Bradshaw 1981).

Indicative environment
The pollen assemblage indicates the progressive invasion of eutrophic fen carr conditions (dominated by *Alnus* and *Salix*) with open areas of sedge and grass in close proximity. It is possible that the expansion of wetland tree species such as *Alnus glutinosa* is detrimental to *Betula*. The decline in *Betula* pollen can be considered to be due to a combination of actual exclusion from the local environment as it is out-competed by alder, and also because of the filtration effect associated with dense fen carr environments.

Pollen Zone MACH-3
This zone is characterised by a decline in *Alnus glutinosa* and *Salix* and a rise in herbaceous taxa such as *Lotus* (Birdsfoot-trefoil) and Poaceae. A range of other, wetland herb pollen types, are consistently recorded for the first time in this zone, with species such as Caryophyllaceae (Pink family), *Hydrocotyle vulgaris* (Pennywort, White-rot), Apiaceae (Carrot family) and Rubiaceae (Bedstraw family) in evidence. *Myrica gale* (Sweet Gale) and *Sphagnum* (Bogmoss) appear in the pollen record towards the close of the zone.

Indicative environment
This pollen assemblage represents an open fen grassland community (Wheeler 1980), which is dominated by eutrophic fen species such as Poaceae (probably *Phragmites* [Common reed]) and *Lotus*. The demise of fen carr conditions may be interpreted as increased wetness associated with a change in estuarine conditions (i.e. increasing marine proximity), as saltmarsh taxa (Chenopodiaceae and *Plantago maritima* [Sea plantain]) and foram test linings are recorded in this zone. This would raise the local groundwater level and flood the fen carr, resulting in fen meadow herbaceous communities which are tolerant of wet conditions (see Smith and Morgan 1989 for similar pathway of vegetation change, and also discussion below).

Pollen Zone MACH-4
This pollen zone is dominated by acidophilous vegetation such as *Sphagnum*, *Myrica gale* and *Calluna vulgaris* (Heather, Ling), which replace the grassland community evident in the previous zone. Frequencies of *Corylus avellana*-type pollen are better represented, but overall species diversity decreases in this zone.

Indicative environment
The pollen data in this zone indicate acidic conditions, with the development of ombrotrophic (rain-fed) bog. The development of this vegetation community indicates that the peat surface has become isolated from the influence of the groundwater table and the growth of the peat-forming environment is entirely dependent on precipitation. Pollen productivity under these

conditions is likely to be lower than in the preceding fen stages, which may be a likely explanation for the (proportional) increase in *Corylus avellana*-type pollen. However, the problems associated with separating grains of *Corylus* from *Myrica* may complicate this apparent trend (Edwards 1981).

Pollen Zone MACH-5
Percentages of *Sphagnum*, Ericaceae and *Myrica gale* decline in this zone coincident with a rise in Poaceae pollen.

Indicative environment
The most likely explanation for this change in pollen assemblage is that the transition represents a renewed rise in water level and flooding of the acid vegetation community with eutrophic water. Such a process may arise due to increasing site exposure to marine conditions associated with a rise in relative sea level. Saltmarsh taxa such as Chenopodiaceae, *Plantago maritima* and foram test linings are observed at the top of the zone which indicate the encroachment of saline marsh conditions onto the site prior to the transgressive overlap (this transgressive horizon was not recovered during coring).

In addition to the analysis of palynological samples from the percussion cored borehole, a number of spot pollen samples were obtained from hand-augured boreholes in an attempt to provide broad temporal correlations across the sampling transect. The hand-augured Core 1 overlaps with the percussion core (Machynys 1), and as such was not considered for pollen analysis. The remaining hand-augured boreholes were sampled at the top and base of the lowest identified peat horizon, and at similar sampling points in relation to the main peat unit identified. Discussion of these samples is presented below.

Core 2 Peat Base (5.82m - 5.83m depth [-2.839m to -2.849m OD])
This assemblage is dominated by herbaceous pollen types (66%), in particular Poaceae (44%) and Cyperaceae (21%). Coastal vegetation communities are indicated by the presence of Chenopodiaceae and foram test linings. Arboreal pollen is relatively poorly represented with *Quercus* being the main species in evidence.

Indicative environment
A saltmarsh/reedswamp environment is indicated by this pollen assemblage. Upland vegetation is likely to consist of *Quercus* and *Ulmus*. In this context, the lack of *Tilia* is likely to be a reflection of the poorly dispersed nature of its pollen.

Core 2 Peat Top (5.73m - 5.74m depth [-2.749m to -2.759m OD])
Arboreal pollen is well represented in this sample (55%) with *Alnus glutinosa* (31%) and *Quercus* (17%) the most frequent pollen types. *Salix* is an important shrub and herbs such as Poaceae and Cyperaceae are also prominent. Halophytic plants are also indicated by the occurrence of Chenopodiaceae.

Indicative environment
Fen carr is the palaeoenvironment suggested by this pollen sample, with *Alnus* and *Salix* the major constituents. Open areas of fen grassland are also suggested close to the site, with these

comprising Poaceae and Cyperaceae. Proximity to marine conditions is inferred by the occurrence of saltmarsh taxa (this may also be the source of some of the Poaceae and Cyperaceae pollen).

<u>*Core 2 Peat Base (4.10m - 4.11m depth [-1.119m to -1.129m OD])*</u>

Arboreal pollen is the most prominent group with <u>*Quercus*</u> frequencies of 38%. Shrub taxa such as *Corylus avellana*-type are also well represented. Herbaceous pollen is dominated by Poaceae (28%).

Indicative environment

Freshwater reedswamp is indicated in this assemblage. *Phragmites* is the probable source for much of the Poaceae pollen in this context. High values for <u>*Quercus*</u> and <u>*Corylus avellana*</u>-type pollen probably represent increased regional input of upland pollen due to the open nature of the local fen grassland community.

<u>*Core 2 Upper Peat (2.80m -2.81m depth [0.181m to 0.171m OD])*</u>

This assemblage is dominated by herbaceous pollen (67%) with Poaceae most abundant (58%). Arboreal pollen only contributes 11% to the total pollen spectra. Shrub pollen such as *Myrica gale* and *Corylus avellana*-type each occur with frequencies of 10%.

Indicative environment

A reedswamp is indicated, with close proximity to saltmarsh due to the occurrence of halophytic taxa such as *Plantago maritima*. Acidic poor fen communities are also suggested by the occurrence of *Myrica gale* pollen which indicates that bog conditions may have persisted at some locations in the vicinity at this time.

<u>*Core 3 Base Lower Peat (5.63m - 5.64m depth [-3.029m to -3.039m OD])*</u>

Herbaceous pollen dominates this assemblage with Poaceae attaining levels of 42%. Arboreal pollen is relatively well represented with *Alnus glutinosa* the most abundant taxa (15%). *Corylus avellana*-type is the most important of the shrub pollen taxa.

Indicative environment

This assemblage represents a freshwater reedswamp community consisting of Poaceae and Cyperaceae. Fen carr is indicated by the occurrence of significant frequencies of *Alnus glutinosa* and some *Salix*. This woodland community is likely to be colonising damp areas peripheral to the reedswamp vegetation.

<u>*Core 3 Lower Peat (5.50m - 5.51m depth)*</u>

This pollen assemblage is dominated by *Alnus glutinosa* pollen (47%) with other shrub wetland taxa such as *Salix* also present. Herb pollen is comprised mainly of Cyperaceae and Poaceae although Chenopodiaceae is also recorded.

Indicative environment

Fen carr conditions are inferred locally with evidence for saltmarsh conditions prevailing in the vicinity owing to the presence of saltmarsh pollen taxa.

Core 3 Base Upper Peat (3.17m - 3.18m)

Arboreal pollen is not well represented in this sample although *Alnus glutinosa* frequencies are significant (30%). Herb pollen is most important with Cyperaceae (48%) the most abundant type.

Indicative environment

Freshwater fen is suggested by the high frequencies of Cyperaceae. The occurrence of significant amounts of *Alnus glutinosa* and *Salix* suggest fen carr is also prevailing close to the site. Open fen and fen carr conditions are indicated.

Core 3 Peat Top (2.70m - 2.71m depth)

Shrub pollen dominates this assemblage with *Myrica gale* and *Corylus avellana* the main types but there are also significant percentages of *Calluna vulgaris* in evidence. Cyperaceae is the most abundant of the herb pollen, although some saltmarsh indicators also occur.

Indicative environment

Bog conditions are suggested by the pollen spectra, with *Sphagnum* moss probably forming the local community. The Cyperaceae pollen in this context is likely to be derived from *Eriophorum* - an acidophilous genus. Saltmarsh conditions are indicated close to the site by the presence of Chenopodiaceae and Potamogetonaceae pollen (which includes the halophyte *Triglochin*).

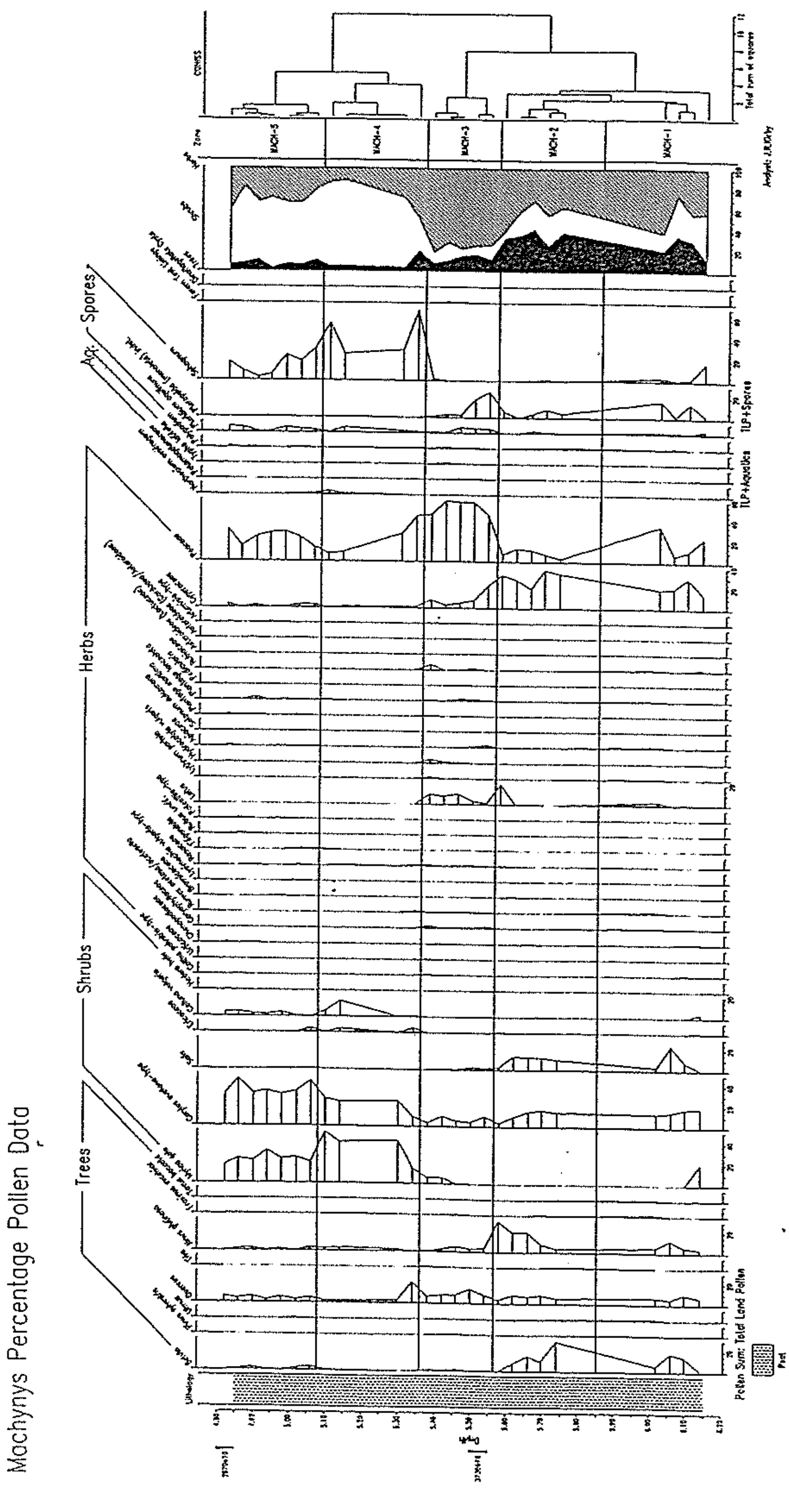


Figure 8: Pollen diagram from main peat unit at Machynys (Note: C14 date BETA-139984 not shown

Diatom analyses

Diatom analysis has been used to reconstruct palaeohydrological conditions associated with the phases of minerogenic sedimentation (i.e. past salinity regimes). The diatom samples were prepared according to Barber and Haworth (1981) and Palmer and Abbott (1986). Where possible, 200 diatom valves were counted on each slide and their frequencies are expressed as Total Diatom Valves (TDV). The diagrams have been drawn using TILIA (Grimm 1993). The diatoms have been classified according to their salinity tolerance and also by their habitat requirements (see Vos and de Wolf, 1988, 1993, Denys 1991).

Figures 9 and 10 show the results of the diatom analysis with data expressed according to salinity tolerance (Fig 9) and also according to the habitat preferences for the various taxa (Fig 10). No attempt has been made to divide this diagram into zones owing to the large gaps between individual samples, which precludes any assumptions of continuity. Nevertheless, some general observations can be made regarding the diatom communities recorded and the changes observed.

The basal three samples are dominated by polyhalobous (marine) and mesohalobous (brackish) taxa such as *Paralia sulcata* (planktonic [live in the water column]) and *Nitszchia navicularis* (epipelic [live attached to muddy sediments]). These diatoms are typical of assemblages found on intertidal mudflats.

At 8.00 m depth the sample was recovered from a thin intercalated peat (also analysed for pollen) (see above). The diatom results confirm the palaeoenvironment indicated by the pollen analysis, with this being a reedswamp/saltmarsh environment. Species such as *Navicula peregrina* are common in this sample. These live in muddy saltmarsh sediments, and the occurrence of freshwater species such as *Diploneis ovalis* point to a high marsh environment in this context. *Diploneis ovalis* is an aerophilous species, which means that it is capable of withstanding a high degree of subaerial exposure such as would be typical of the irregular flooding intervals characteristic of a high saltmarsh environment.

The samples obtained from 6.5m and 4.5m depth establish the estuarine nature of the sediments either side of the main peat bed. Unfortunately, the sedimentary contacts have not been sampled so the precise nature of the shift from marine to terrestrial conditions (and vice versa) cannot be established. It is likely however, that if further intact sediment cores could be obtained, a regressive and transgressive contact could be verified and used in the analysis of sea-level trends in the estuary.

The upper three diatom samples indicate an intertidal mudflat environment. However, any palaeoenvironmental interpretations are tentative, as the diatom preservation was increasingly poor towards the top of this unit, which resulted in low counts (<200). This is most likely related to drying and processes of oxidation, which result in the dissolution of siliceous diatom valves in late-Holocene sediments (Mayer *et al.* 1991). The study of foraminifera presented below is used in an attempt to overcome these problems and to establish more accurate palaeoenvironmental conclusions from these contexts.

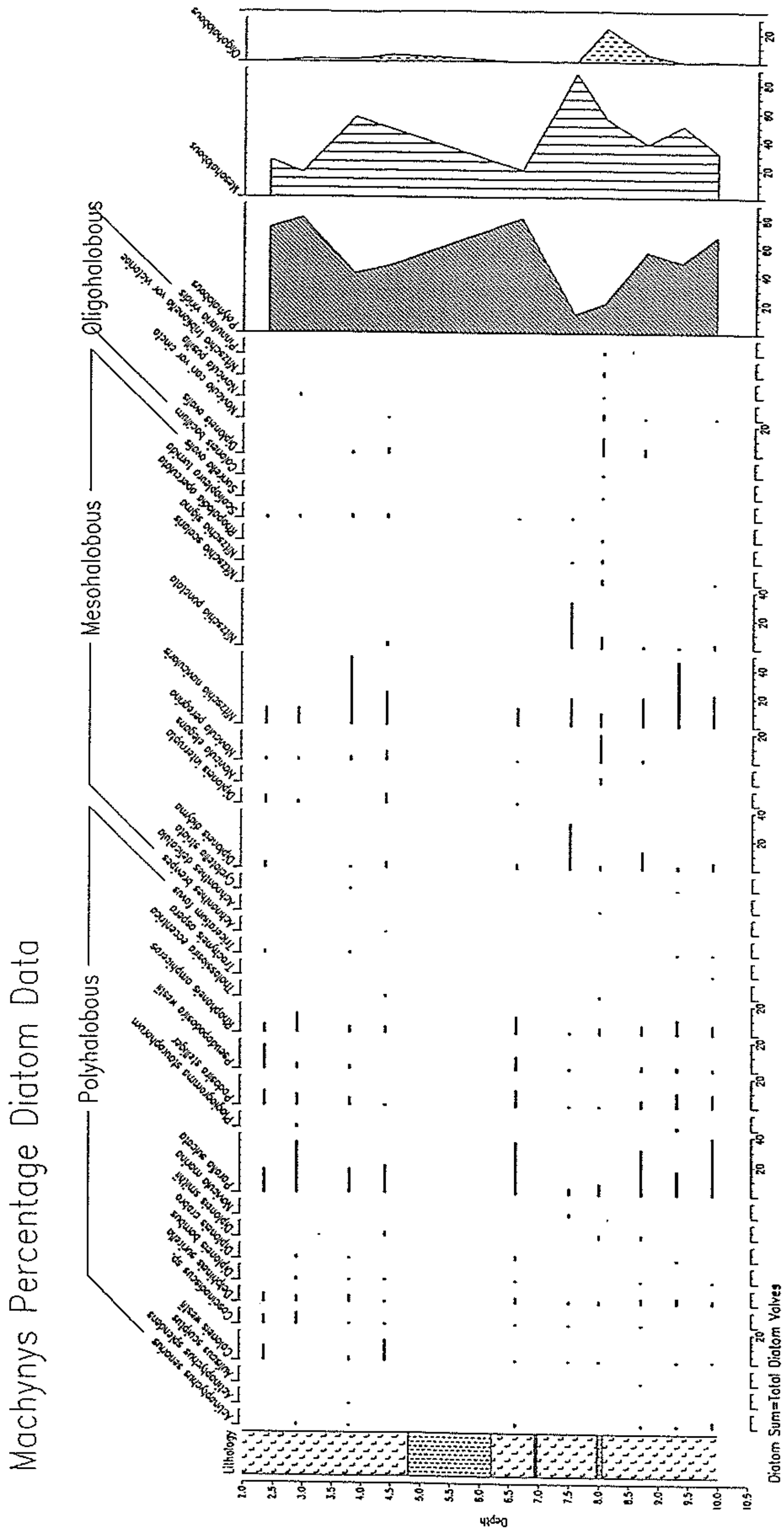


Figure 9: Diatom species abundance expressed by salinity class

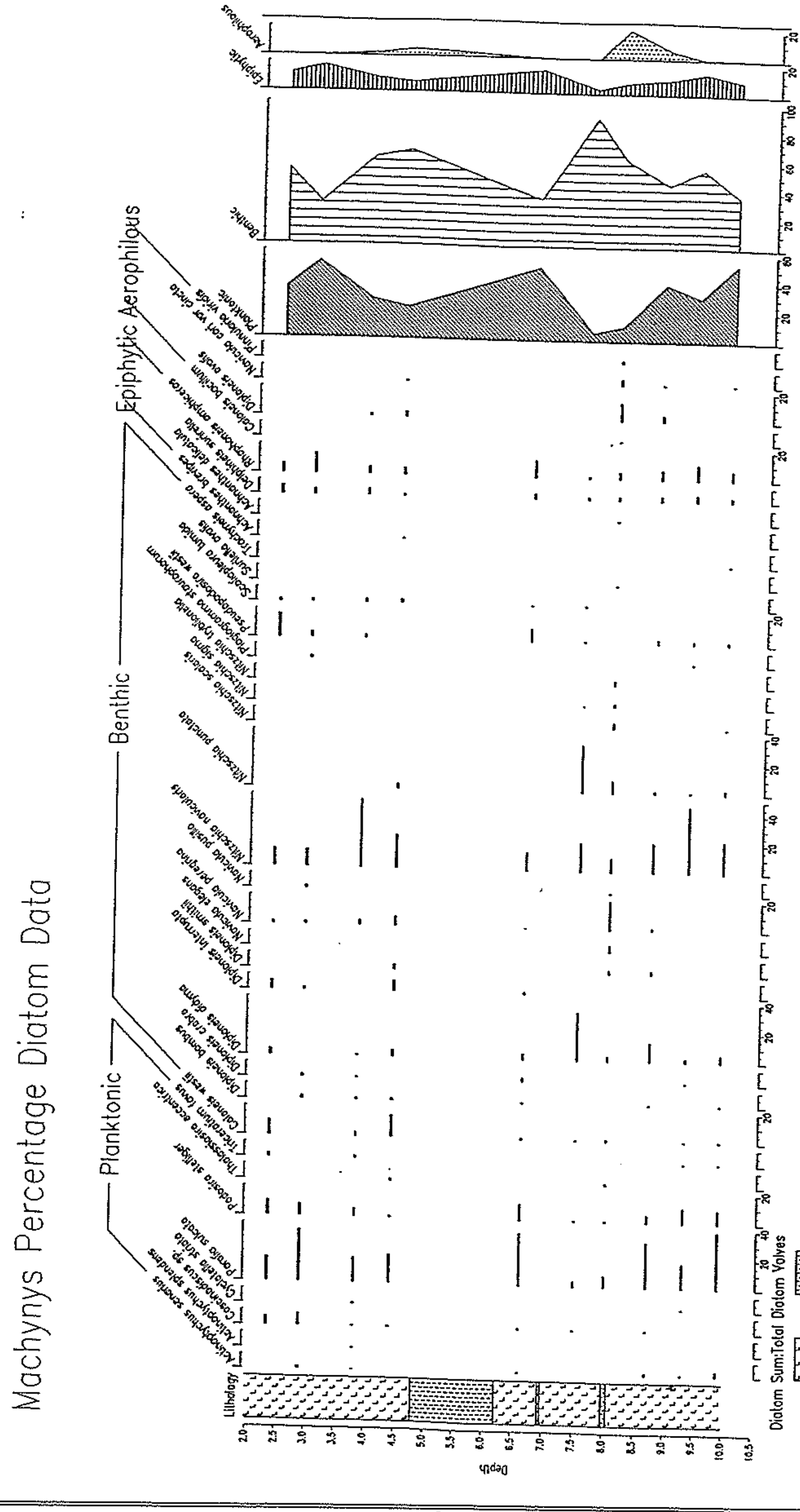


Figure 10: Diatom species abundance expressed according to habit preferences

Ostracoda and Foraminifera

Eighteen levels from the percussion core Machynys 1 were selected by lithostratigraphy for micropalaeontological analysis (see Table 4). Samples were disaggregated in dilute (5%) H_2O_2 and allowed to stand for several days prior to sieving to 250mm. Sieve residues were then hand-picked for ostracods and forams under a zoom dissecting microscope, individual microfossils being mounted on micropalaeontological slides in gum tragacanth (Griffiths *et al.* 1993). Specimens were identified from Athersuch *et al.* (1989) and Murray (1979).

Data were expressed as species numbers.sample^{-1}, species numbers.gram^{-1} and as total microfossils.sample^{-1} and were further analysed by UPGMA Cluster Analysis using binary (presence: absence data) with MVSP software (Kovack 1998).

Microfossil representation within the Machynys samples was unevenly distributed. Several samples (4.40m - 4.4.1m; 4.73m - 4.44m; 4.80m - 4.81m; 6.80m - 6.81m; 8.00m - 8.01m; 8.20m - 8.21m and 10.10m - 10.11m depth) failed to produce evidence for microfossils, while microfossil densities in other samples ranged from 0.025g^{-1} (3.80m - 3.81m) and 185g^{-1} (7.50m - 7.51m; see Table 4). This situation mirrors that found by Haslett *et al* (1997) wherein foraminifera abundance from saltmarsh samples at Northwick and Oldbury is typically <250 specimens per sample.

A total of five foram taxa were identified (Table 5):
Ammonia beccarii (agg.) (Linné)
Nonion germanicum (Ehrenberg)
Elphidium crispum (Linné)
Rosalina spp.
Bolivina spp.

In addition, a total of seven ostracod taxa were identified (Table 6):
Cyprideis torosa (Jones)
Hemicytherura cellulosa (Norman)
Leptocythere pellucida (Baird)
Leptocythere porcellanea (Brady)
Leptocythere psammophila (Guillaume)
Urocythereis britannica Athersuch
Palmoconcha sp.

All of the identified taxa are marine shallow shelf species, although the forams *N. germanicus* and *A. beccarii* are often found in estuarine contexts. In the Severn Estuary at sites such as Brean, Clevedon and New Passage *A. beccarii* has been shown to occupy mudflats, and this species also persists onto the saltmarsh zone, with additional species associations (Haslett *et al.* 1997: 32). In addition, Haslett *et al.* (1997: 34) note that the foraminifera Bolivina spp. and Rosalina spp. are uncommon, representing exotics arriving as post-mortem sediment transported material from the continental shelf. The fact that these forms occur mainly in mudflat and low marsh samples indicates that they rapidly settle out of suspension as the flood tide enters the saltmarsh zone (*ibid.* 1997: 34). Amongst the ostracods *Leptocythere* spp. and *C. torosa* are usually found in estuarine contexts, and *U. britannica* and *H. cellulosa* are littoral and (in the latter case) phytal. As its name suggests, *L. psammophila* is often found on sandy substrata, as is *U. britannica*. This suggests a strongly estuarine to outer estuarine signal for the fauna as a whole, with differences apparent between different core sediment horizons.

Cluster analysis (Fig 11) clearly separates the fauna, with the clearest division being between afaunal and other samples. Thereafter, sample groupings are less well defined. Within the fossiliferous horizons, samples 2.35m and 2.90m clearly cluster together, as (less closely) do samples 3.10m, 7.50m, 8.70m, 9.30m, 9.40m and 9.90m. Three further samples are relative outliers to these groupings. Thus species compositions suggest that ecological conditions in the uppermost part of the core (*i.e.* <3.10m depth) are more similar to those in its lowermost part (>7.50m - 9.90m), than to the intervening section (*c.*3.80m - 6.10m depth), although still faunally distinct.

The succession from Machynys comprises species known from shallow coastal environments in southern Britain today, and includes no species of biostratigraphic interest or of known value as a climatic indicator. This suggests that conditions throughout the core were analogous to modern UK coastal conditions. The Machynys palaeoecological signal is estuarine, and the known salinity tolerances of the species found emphasise this. The fauna indicates conditions of near normal marine salinity, but with some freshwater input, as emphasised by the presence of *E. crassus*, *A. beccarii* and *Leptocythere* spp. Moreover, the highly euryhaline ostracod *C. torosa* further indicates that conditions are not markedly freshened: *C. torosa* is a polymorphically noded species in which the degree of nodation has a loose correlation with reduced salinity. The Machynys material is entirely without noded valves. This is a condition, which is shown by Kilenyi (1972) to be associated with situations of near normal marine conditions at estuary mouths. Recent research by Haslett *et al* (1997) has shown that the foraminifera *Ammonia beccarii* is characteristic of assemblages located mid-way between MHWNT (Mean High Water Neap Tides) and MHWST (Mean High Water Spring Tides) (*cf.* low-middle marsh).

Much of the remaining signal apparent from the Machynys fauna relates to palaeodepth. The uppermost and lowermost parts of the core are suggested to derive from somewhat deeper water (albeit probably <50m) than the remainder. The middle part of the core is more shallow and littoral in character, with depths probably rather lower (perhaps a few metres or less at 7.50m). Samples 3.80m - 6.10m are suggested to derive from intermediate depths. This suggests that the lowermost and topmost samples in the core indicate approximately similar water depths, whilst those between are shallower, with lowest levels at *c.* 7.50m.

DISCUSSION OF BOREHOLE RESULTS

The analyses of both the percussion and hand-augured boreholes at Machynys has shown that a general sequence of fine grained silt-clay dominated alluvial deposits of marine and/or estuarine derivation underlies the inter-tidal deposits analysed. These deposits have been shown (diatom and foraminifera) to equate to deep-water positive (transgressive) sea-level tendencies and reflect the associated intertidal mudflats prevailing at this time. These deposits reflect a major phase of post-Devensian sea-level rise (Flandrian Chronozone I) (*after* Scaife and Long 1994). Periodic phases of more negative sea-level tendency, or a slowing in the rate of sea-level rise, have possibly been identified through analysis of intercalated peat horizons in these lower alluvial sequences.

Overlying the basal alluvial sequence throughout the surveyed area is a peat unit, the palynological analysis of which has shown a general sequence of development from fen-carr through open grassland communities. Some fluctuation in sea-level tendency is indicated by occasional evidence for saltmarsh taxa and increased wetness in the form of wet meadow species representation. The sequence subsequently progresses into acidic, ombrotrophic bog towards the top of the peat sequence. The reduced rate of sea-level rise that led to peat development has been dated to *c.*6500-5000 BP elsewhere in the Bristol Channel at the sites of Caldicot Pill, Uskmouth and Goldcliff (Scaife and Long 1994: 84, table 2). The absolute dating of the basal peats at Machynys would therefore enable comparisons to be drawn between this location and sites elsewhere in the region.

Chronologically, the middle and upper parts of the peat development at Machynys are bracketed by radiocarbon determinations of 3730±70 BP and 2870±70 BP (Beta-139983 and Beta-139982). These determinations calibrate to 2330-1935 and 1270-845 cal BC at the 2 sigma level (95% confidence), indicating a minimum range of development occurring in the Neolithic to Bronze Age periods.

The subsequent inundation episode at Machynys is associated with erosive sedimentary contacts indicative of an abrupt phase of sea-level transgression. Deep-water conditions are indicated by the overlying ostracod/foraminifera data and the estuarine nature of these deposits is confirmed both by the diatom analyses, which, on the weight of available evidence, attest intertidal mudflat environments, and the ostracod/foraminifera assemblages, which are indicative of estuarine-outer estuarine faunas.

Obviously, the fact that the main chrono-stratigraphic boundaries have not been investigated to any degree negates conclusions relating to the precise nature of the shifts from marine to terrestrial conditions (and vice versa). Further, higher resolution sampling for radiocarbon and pollen/diatom/ostracod/foraminifera is necessary to redress this imbalance in the data recovered. In this context it is interesting that the ostracod/foraminifera assemblages cluster in a way that suggests that the <3.10 m depth (uppermost alluvium) and >7.5 m depth (lower alluvium) are more similar than the material associated with the intervening regression, peat formation and subsequent inundation episodes at this location. The ostracod/foraminifera data relating to palaeo-depth also conform to this pattern with shallow littoral water bodies correlating to the stratigraphy immediately associated with the peat unit.

Vegetation and sea-level and climate change

In terms of the wider, regional context, of the results from Machynys the evidence presented above can be compared with similar sequences from the Goldcliff area, where marine regression is dated to *c.* 5900 BP. This event resulted in the development of peat and eventually fen carr (Walker *et al.* 1998). From around 5000 BP, raised mire development was widespread in the area. This development lasted for *c.*2000 years until its eventual demise due to marine inundation at *c.*3000 BP (Smith and Morgan 1989, Walker *et al.* 1998, Bell *et al.* 2000). Similar conditions are also recorded from the opposite side of the estuary in the Somerset Levels (Godwin 1975, Beckett and Hibbert 1979, Housely 1988) and from the Cardigan Bay area (Wilks 1989).

It is interesting to note that the precursor to acidification at Goldcliff is marked by an apparent increase in marine influence at *c.*5400 BP, which drowned the fen carr and led to development of fen grassland with a saline influence. The identification of a comparable wet horizon at Machynys (PZ MACH-3), which is dated to 3730±70 BP (Beta-139983), has important implications, as this may represent a regional, albeit time transgressive, expansion of estuarine conditions and not just a localised change in coastal configuration or sedimentary regime. More precise radiocarbon dating of such critical horizons may reveal any broad synchronicities, and as such highlight regionally significant estuarine events.

It is worth noting at this point that the mechanisms and pathways of vegetation change in coastal communities, which result in acidification and ombrotrophic bog conditions, has been a debated issue in palaeoecology since Walker's classic 1970 study of succession. More recent studies have shown that plant communities do not shift straight from fen carr into bog as Walker suggested but in fact pass through an intermediate stage before acidification takes place (e.g. Smith and Morgan 1989, Waller *et. al.* 1999). Fine resolution pollen analysis, radiocarbon dating and the analysis of plant macrofossils will enable further light to be shed on these processes at Machynys. At present, the palaeoenvironmental record obtained at Machynys lacks sufficient resolution to establish the indicative meaning of the clay-peat/peat-clay contacts, meanings which have been shown to be fundamental to our understanding of the precise nature of the sea-level episode being studied (e.g. Haslett *et al* 1997: 37).

CORE	PC-1		PC-1		PC-1		Core-2		Core-2		Core-2	
SAMPLE TYPE	Intercalated peat		Intercalated peat		Intercalated peat		Peat Base		Peat Top		Peat Base	
DEPTH	8.02-8.03		8.00-8.01		6.94-6.95		5.82-5.83		5.73-5.74		4.10-4.11	
		%		%		%		%		%		%
POLLEN CATEGORY												
TREES												
Betula	16	7.7%	10	4.7%	3	1.4%	3	1.5%	7	3.5%	2	1.0%
Pinus sylvestris	2	1.0%	3	1.4%			1	0.5%	2	1.0%	2	1.0%
Ulmus	2	1.0%	7	3.3%	2	0.9%	6	3.0%	3	1.5%	2	1.0%
Quercus	31	14.9%	43	20.0%	28	13.3%	29	14.4%	34	17.2%	79	37.6%
Tilia			1	0.5%								
Alnus glutinosa	9	4.3%	12	5.6%	15	7.1%	18	8.9%	62	31.3%	16	7.6%
Fraxinus excelsior					1	0.5%						
Taxus baccata	1	0.5%									2	1.0%
TOTAL	61	29.4%	76	35.5%	49	23%	57	28.3%	108	54.5%	103	49.2%
SHRUBS												
Myrica gale	1	0.5%	2	0.9%	3	1.4%					3	1.4%
Corylus avellana-type	23	11.1%	38	17.7%	11	5.2%	10	5.0%	11	5.6%	36	17.1%
Salix			1	0.5%			1	0.5%	13	6.6%	1	0.5%
Ericaceae												
Calluna vulgaris												
Hedera helix					14	6.6%					1	0.5%
TOTAL	24	11.6%	41	19.1%	28	13.2%	11	5.5%	24	12.2%	41	19.5%
HERBS												
Caltha palustris-type					1	0.5%						
Chenopodiaceae	5	2.4%	9	4.2%	81	38.4%	2	0.5%	2	1.0%		
Caryophyllaceae												
Lotus									5	2.5%		
Apiaceae									1	0.5%		
Plantago maritima												
Plantago lanceolata												
Rubiaceae*							1	0.5%	7	3.5%		
Asteroideae*					12	5.7%			1	0.5%		
Artemesia-type	1	0.5%					1	0.5%	1	0.5%		
Cyperaceae	6	2.9%	9	4.2%	2	0.9%	42	20.8%	26	13.1%	8	3.8%
Poaceae	111	53.4%	80	37.2%	52	24.6%	89	44.1%	23	11.6%	58	27.6%
TOTAL	123	59.2%	98	45.6%	148	70.1%	135	66.4%	66	33.2%	66	31.4%
AQUATICS												
Potamogetonaceae	2	1.0%									1	0.5%
Typha latifolia							1	0.5%	1	0.5%		
TOTAL	2	1.0%					1	0.5%	1	0.5%	1	0.5%
SPORES												
Polypodium	2	0.9%	1	0.4%	2	0.9%	4	1.9%	2	1.0%	2	0.9%
Pteridium aquilinum	4	1.9%	8	3.6%	7	3.1%	6	2.8%				
Pteropsida (monlete) indet.	1	0.5%	1	0.4%	3	1.3%	2	0.9%	9	4.3%		
Sphagnum					1	0.4%						
TOTAL	7	3.3%	10	4.4%	13	5.7%	12	5.6%	11	5.3%	2	0.9%
OTHER MICROFOSSILS												
Foram Test Linings	1	0.5%	1	0.4%	3	1.3%	5	2.5%				
TOTAL PALYNOMORPHS	217		225		238		216		210		213	

Table 1: Spot pollen assemblages from percussion core and hand-augured cores 2 and 3.

CORE	Core-2		Core-3		Core-3		Core-3		Core-3	
SAMPLE TYPE	Upper peat		Base Lower Peat		Lower Peat		Base Upper Peat		Peat Top	
DEPTH	2.8		5.63-5.64		5.5-5.51		3.17-3.18		2.70-2.71	
		%		%		%		%		%
POLLEN CATEGORY										
TREES										
Betula	3	1.4%	6	3.0%	15	8.3%	1	0.5%	5	3.8%
Pinus sylvestris					3	1.7%			1	0.8%
Ulmus	2	0.9%	2	1.0%	2	1.1%				
Quercus	13	6.2%	24	11.9%	16	8.8%	16	8.2%	21	15.9%
Tilia					1	0.6%	1	0.5%	2	1.5%
Alnus glutinosa	5	2.4%	30	14.9%	85	47.0%	58	29.7%	7	5.3%
Fraxinus excelsior					1	0.6%		.		
Taxus baccata	1	0.5%							1	0.8%
TOTAL	24	11.4%	62	30.8%	123	68.1%	76	38.9%	37	28.1%
SHRUBS										
Myrica gale	22	10.4%	3	1.5%					18	13.6%
Corylus avellana-type	22	10.4%	27	13.4%	19	10.5%	11	5.6%	22	16.7%
Salix			1	0.5%	5	2.8%	1	0.5%		
Ericaceae									6	4.5%
Calluna vulgaris	2	0.9%							12	9.1%
Hedera helix					2	1.1%				
TOTAL	46	21.7%	31	15.4%	26	14.4%	12	6.1%	58	43.9%
HERBS										
Caltha palustris-type									2	1.5%
Chenopodiaceae					4	2.2%			1	0.8%
Caryophyllaceae							1	0.5%		
Lotus										
Apiaceae	1	0.5%							1	0.8%
Plantago maritima	1	0.5%							2	1.5%
Plantago lanceolata	1	0.5%							3	2.3%
Rubiaceae										
Asteroideae	1	0.5%			1	0.6%				
Artemesia-type										
Cyperaceae	14	6.6%	24	11.9%	19	10.5%	94	48.2%	26	19.7%
Poaceae	123	58.3%	84	41.8%	8	4.4%	12	6.2%	25	1.5%
TOTAL	141	66.8%	108	53.7%	32	17.7%	107	54.9%	66	28.1%
AQUATICS										
Potamogetonaceae	6	2.8%			5	2.7%			1	0.8%
Typha latifolia										
TOTAL	6	2.8%			5	2.7%			1	0.8%
SPORES										
Polypodium	1	0.5%	1	0.5%	3	1.4%	2	1.0%	1	0.5%
Pteridium aquilinum	2	0.9%	2	0.9%	1	0.5%			6	3.2%
Pteropsida (monlete) indet.			7	3.3%	17	8.1%	12	5.7%	13	7.0%
Sphagnum			10	4.7%	7	3.3%			33	17.8%
TOTAL	3	1.4%	20	9.4%	28	13.3%	14	6.7%	53	28.5%
OTHER MICROFOSSILS										
Foram Test Linings	2	0.9%								
TOTAL PALYNOMORPHS	220		221		214		209		215	

Table 1 (cont.): Spot pollen assemblages from percussion core and hand-augured cores 2 and 3.

Machynys Percussion Core				
Lab Code	Uncalibrated Age BP	Calibrated Range BC (2σ)	Calibrated Range BP (2σ)	m OD
Beta-139982	2870±70	1270 to 845	3220 to 2795	-0.583 to -0.633
Beta-139983	3730±70	2330 to 1935	4280 to 3885	-1.283 to -1.330
Beta-139984	3790±70	2460 to 2020	4410 to 3790	-1.883 to -1.923

Table 2: Radiocarbon determinations and calibrated ranges from Machynys PC-1.

Depth	2.05-2.20	2.65-2.80	3.25-3.40	3.95-4.10		
% Moisture	22.32	26.2	30.26	35.30		
% Organic	5.67	11.57	8.14	6.67		
% Gravel	0.0	0.0	0.0	0.0		
% Coarse Sand	0.0	0.0	0.0	3.84		
% Medium Sand	0.0	0.0	0.0	3.27		
% Fine Sand	18.25	65.30	7.59	6.37		
% Coarse Silt	18.30	11.47	1.67	46.3		
% Medium Silt	15.05	5.5	23.64	21.88		
% Fine Silt	9.37	2.56	14.55	6.19		
% Clay	39.03	15.17	52.55	12.15		
Depth	6.95-7.10	7.75-7.90	8.35-8.50	9.05-9.20	9.65-9.80	10.25-10.40
% Moisture	46.96	36.90	25.10	29.15	26.70	24.62
% Organic	16.24	9.37	7.79	6.95	7.34	9.14
% Gravel	0.0	0.0	0.0	0.0	0.0	0.0
% Coarse Sand	7.26	0.17	0.0	0.0	0.0	0.0
% Medium Sand	19.47	3.33	0.0	0.0	0.0	0.0
% Fine Sand	15.77	8.52	4.88	2.50	12.10	26.87
% Coarse Silt	14.68	10.75	27.90	14.52	20.09	20.00
% Medium Silt	10.62	25.76	23.23	24.38	25.28	18.13
% Fine Silt	3.17	14.72	8.56	10.13	10.74	7.78
% Clay	29.03	36.75	35.43	48.47	31.79	27.22

Table 3: Particle size distributions, organic and moisture contents for the upper and lower alluvial units at Machynys.

HORIZON (m)	microfossils (per gram)
2.35-2.36	1.02
2.90-2.91	0.39
3.10-3.11	0.045
3.80-3.81	0.025
4.20-4.21	0.07
4.40-4.41	
4.73-4.74	
4.80-4.81	
6.10-6.11	7.5
6.80-6.81	
7.50-7.51	185
8.00-8.01	
8.20-8.21	
8.70-8.71	1.5
9.30-9.31	0.72
9.40-9.41	0.78
9.90-9.91	2.47
10.10-10.11	

No fauna = (shaded)

Table 4: Sample depth and microfossil densities from Machynys.

HORIZON (m)	*Ammonia beccarii* (agg.)	*Nonion germanicum*	*Elphidium crispum*	*Bolivina* sp.	*Rosalina* spp.	Foram. indet.
2.35-2.36	-	17 (0.7.g^{-1})	7 (0.28.g^{-1})	-	-	-
2.90-2.91	-	10 (0.18.g^{-1})	7 (0.13.g^{-1})	-	-	-
3.10-3.11	-	1 (0.02.g^{-1})	1 (0.02.g^{-1})	-	-	-
3.80-3.81	-	-	1 (0.02.g^{-1})	-	-	-
4.20-4.21	-	2 (0.05.g^{-1})	-	-	-	-
4.40-4.41						
4.73-4.74						
4.80-4.81						
6.10-6.11	2 (0.07.g^{-1})	117 (4.5.g^{-1})	24 (0.9.g^{-1})	1 (0.03g.$^{-1}$)	4 (0.15.g^{-1})	1 (0.03.g^{-1})
6.80-6.81						
7.50-7.51	34 (1.04.g^{-1})	208 (6.04.g^{-1})	448 (13.0.g^{-1})	-	-	24 (0.68.g^{-1})
8.00-8.01						
8.20-8.21						
8.70-8.71	9 (0.33.g^{-1})	16 (0.59.g^{-1})	2 (0.07.g^{-1})	-	-	13 (0.48.g^{-1})
9.30-9.31	4 (0.09.g^{-1})	14 (0.33.g^{-1})	8 (0.19.g^{-1})	-	1 (0.02.g^{-1})	4 (0.09.g^{-1})
9.40-9.41	4 (0.16.g^{-1})	14 (0.55.g^{-1})	-	-	-	2 (0.08.g^{-1})
9.90-9.91	4 (0.08.g^{-1})	68 (1.39.g^{-1})	28 (0.57.g^{-1})	-	-	20 (0.41.g^{-1})
10.10-10.11						

Table 5: Foraminifera species identified and abundance frequencies.

HORIZON (m)	*Cyprideis torosa*	*Leptocythere pellucida*	*Leptocythere cf. porcellanea*	*Leptocythere psammophila*	*Hemicytherura cellulosa*	*Urocythereis britannica*	*Palmoconcha* spp.	Ostracod indet.
2.35-2.36	-	-	-	-	-	1 (0.04g.$^{-1}$)	-	-
2.90-2.91	-	-	-	-	-	1 (0.02.g^{-1})	3 (0.06.g^{-1})	-
3.10-3.11	-	-	-	-	-	-	-	-
3.80-3.81	-	-	-	-	-	-	-	-
4.20-4.21	-	-	-	-	-	-	-	1 (0.07.g^{-1})
4.40-4.4.1								
4.73-4.74								
4.80-4.81								
6.10-6.11	-	20 (0.77.g^{-1})	3 (0.11.g^{-1})	2 (0.08.g^{-1})	2 (0.08.g^{-1})	-	-	12 (0.46.g^{-1})
6.80-6.81								
7.50-7.51	816 (23.3.g^{-1})	-	-	64 (1.86.g^{-1})	-	-	-	-
8.00-8.01								
8.20-8.21								
8.70-8.71	-	-	-	-	-	-	-	-
9.30-9.31	-	-	-	-	-	-	-	-
9.40-9.41	-	-	-	-	-	-	-	-
9.90-9.91	-	-	-	--	-	-	-	-
10.10-10.11								

Table 6: Ostracod species identified and abundance frequencies.

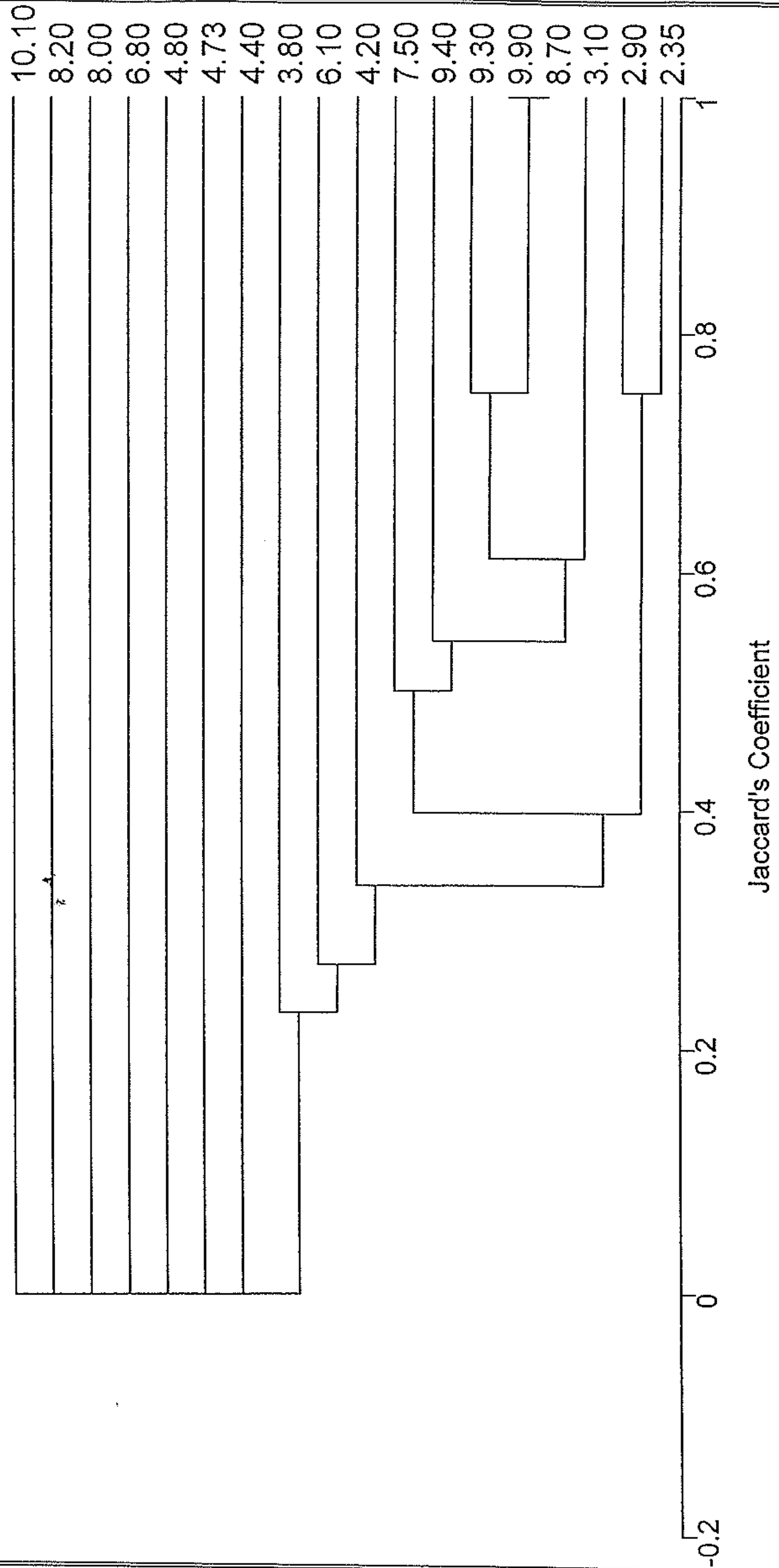


Figure 11: UPGMA cluster analysis for fossiliferous horizons at Machynys

CONCLUSIONS

This project is the first of its kind to be carried out on Llanelli Marsh, or any of the southeast Carmarthenshire coastal wetlands, and even though much more work remains to be carried out to fully understand the development of this complex landscape the results have been very encouraging. The integrated approach adopted for this study, which combined surface history and palaeoenvironmental sampling, has provided an outline history, albeit with some gaps, of the development of Llanelli Marsh from its early Holocene origins through to the present day.

It has been possible to identify a number of events in the alluvium and peat deposits which may eventually be seen to correlate with events and trends recorded at a number of comparable sites in the Severn Estuary. The later history of the site is dominated by episodes of embankment and enclosure which appear to have started in the medieval period and continued until the mid 19th century. Medieval occupation of the marsh was confined to the fringes, most notably at Machynys, Trostre and Maes-ar-dafen, with later settlement occurring at places like Tir Morfa and Pen y Bryn during the 18th century. During the later 18th and 19th centuries the area came under pressure from industrial development which eventually led to many acres of reclaimed land being lost during the construction of factories, roads and railways.

The collapse of the metal processing industries and the decline of the marsh farms during the early- to mid-20th century left much of the Llanelli Marsh area abandoned which led to various improvement schemes being implemented over the last thirty years. These have varied from the piecemeal removal of the old industrial buildings, houses and their associated infrastructure to the remodelling of the entire Llanelli coastline, including the Machynys/Llanelli Marsh area, by the Millennium Coastal Park which prompted this study.

APPENDIX ONE: RADIOCARBON DATES

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: est. C13/C12=-25:lab. mult=1)

Laboratory number: Beta-139984

Conventional radiocarbon age[1]: 3790±70 BP

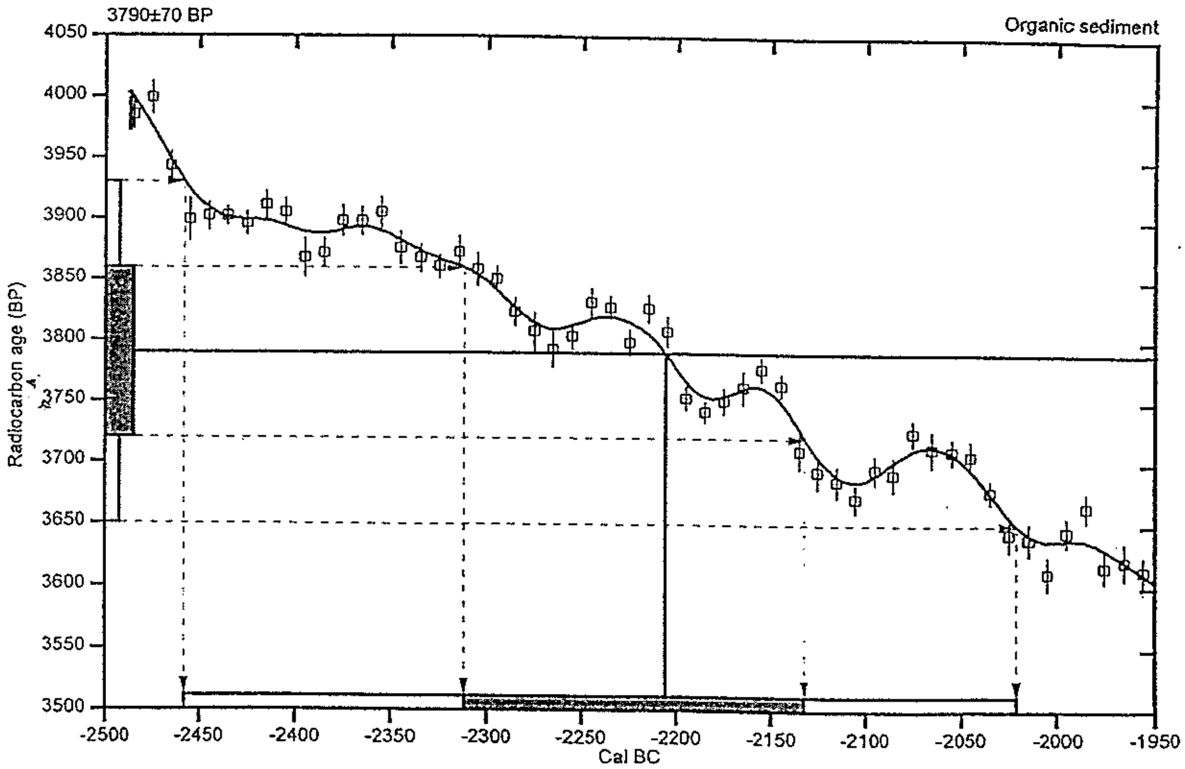
2 Sigma calibrated result: (95% probability) Cal BC 2460 to 2020 (Cal BP 4410 to 3970)

[1] C13/C12 ratio estimated

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 2205 (Cal BP 4155)

1 Sigma calibrated result: (68% probability) Cal BC 2310 to 2130 (Cal BP 4260 to 4080)



References:
Database used
INTCAL98
Calibration Database
Editorial Comment
Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xiii
INTCAL98 Radiocarbon Age Calibration
Stuiver, M., et. al., 1998, Radiocarbon 40(3), p1041-1083
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: est. C13/C12=-25:lab. mult=1)

Laboratory number: Beta-139983

Conventional radiocarbon age[1]: 3730±70 BP

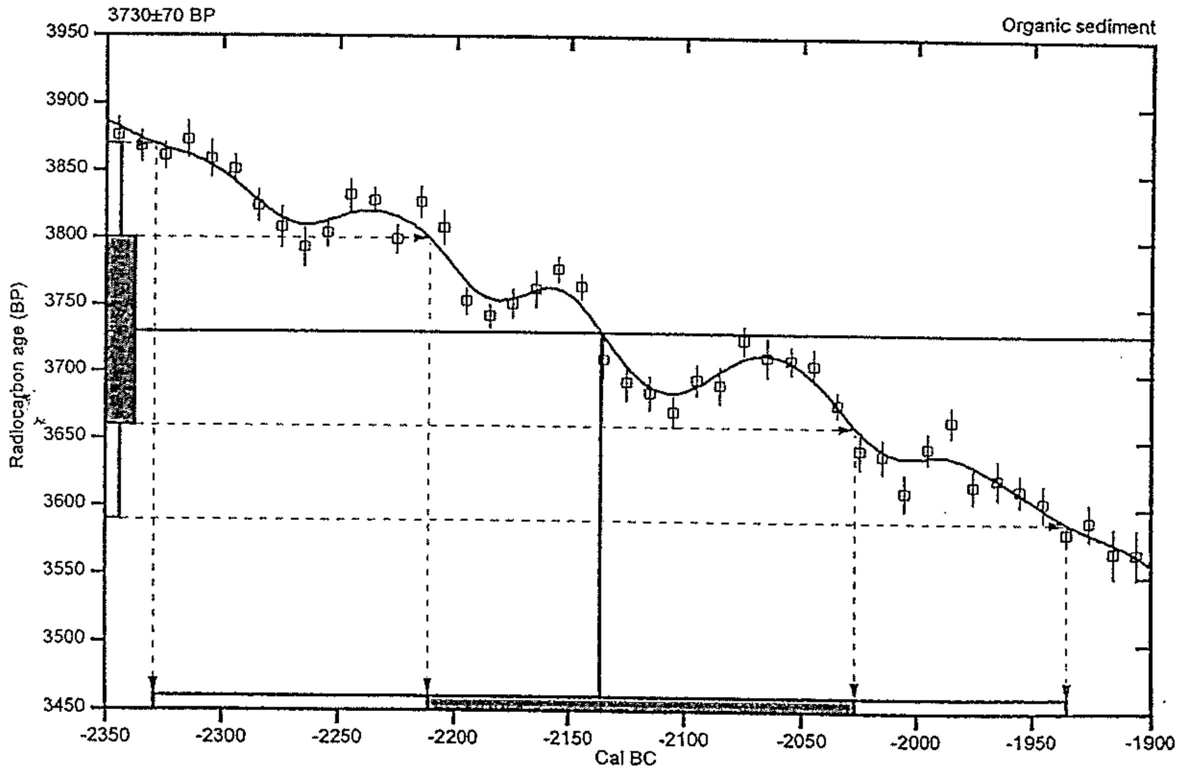
2 Sigma calibrated result: (95% probability) Cal BC 2330 to 1935 (Cal BP 4280 to 3885)

[1] C13/C12 ratio estimated

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 2135 (Cal BP 4085)

1 Sigma calibrated result: (68% probability) Cal BC 2210 to 2025 (Cal BP 4160 to 3975)



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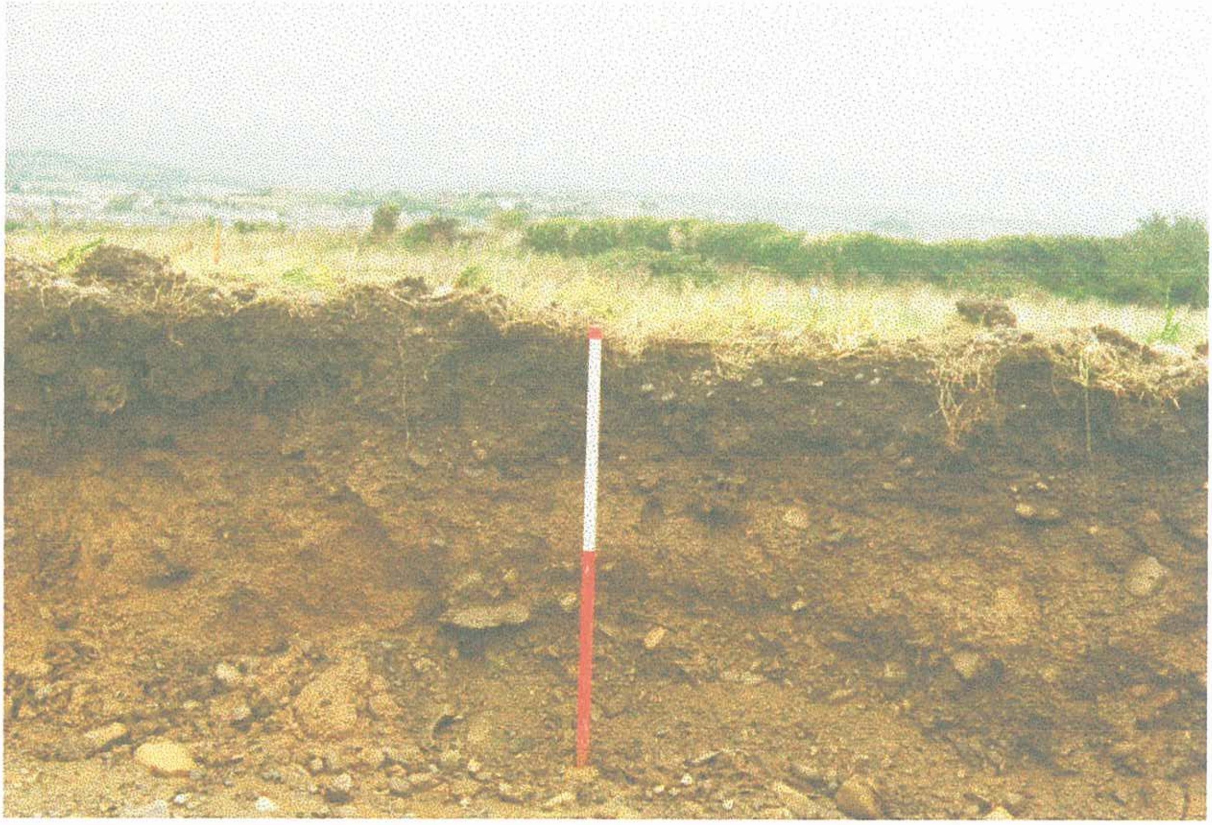

Plate 1: glacial gravels of the Machynys moraine exposed during construction of the new golf course.

Plate 2: remnants of medieval strip fields at Bryn Caernarfon

Plate 3: Surviving section of the Phase II (pre-1760) bank at Machynys

Plate 4: recording the remains of Machynys House

Plate 5: view of reclaimed marshland at Tir Morfa. Is this the Tyne y Morva mentioned in various 16th century rentals?

Plate 6: view southwest along the Great Embankment

Plate 7: Main peat unit exposed during construction of new lake for Machynys Golf Course

LLANELLI MARSH: ARCHAEOLOGICAL AND PALAEOENVIRONMENTAL INVESTIGATION

PROJECT RECORD NUMBER 41365

AUGUST 2000

This report has been prepared by Nigel Page

Position Project Manager

Signature .... Date 15 · 8 · 2000

This report has been checked and approved by Ken Murphy on behalf of Cambria Archaeology, Dyfed Archaeological Trust Ltd.

Position Field Operations Manager

Signature .... Date 16 · 08 · 2000

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