Changing Tides:
The Archaeological Context of Sea Level Change in Prehistoric South Wales

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Summary

Evidence for the effects of past sea level change can be found in the submerged landscapes within the intertidal zone of Britain. Such evidence is particularly prevalent in Wales, but understanding the rate at which these changes occurred during prehistory is limited, due to a dearth of palaeoenvironmental, archaeological and temporal data. Wide-scale sea level models cannot provide a high enough chronological resolution to understand sea level change at a human focussed level, causing difficulties when it comes to placing archaeological evidence within its contemporary environmental context.

This thesis focuses on the human experience of sea level change and the environmental changes that occur alongside to provide new archaeological, palaeoenvironmental and chronological data from two previously unstudied sites on the Gower Peninsula in South Wales: Broughton Bay and Port Eynon. Focussing on the remains of submerged forests and landscapes in the intertidal zone, this thesis aims to identify localised effects of sea level change on the landscape and the people who inhabited it during prehistory. In doing so it links palaeoenvironmental pollen data from localised environmental sequences with archaeological data from both the immediate vicinity and wider landscape, aided by new radiocarbon dates from the intertidal deposits. The archaeological evidence used includes the human and animal footprints at Port Eynon and securely dated archaeological deposits from the Mesolithic and Neolithic funerary depositions in the wider Gower area. The research also reviews the approach taken to interdisciplinary research within the intertidal zone and proposes solutions to common issues faced in investigating these environments.

By combining multiple evidence sources at a localised level, in depth narratives can be drawn about human experience of sea level change in the past, that have the potential to be applied to human experience of current and future sea level driven changes in our own landscapes.

Keywords: Mesolithic; Neolithic; footprints; submerged forest; Broughton Bay; Port Eynon; Gower; archaeology, palaeoenvironment; sea level change; pollen.

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In memory of Dr. Peter Volans, first PhD holder in the family.

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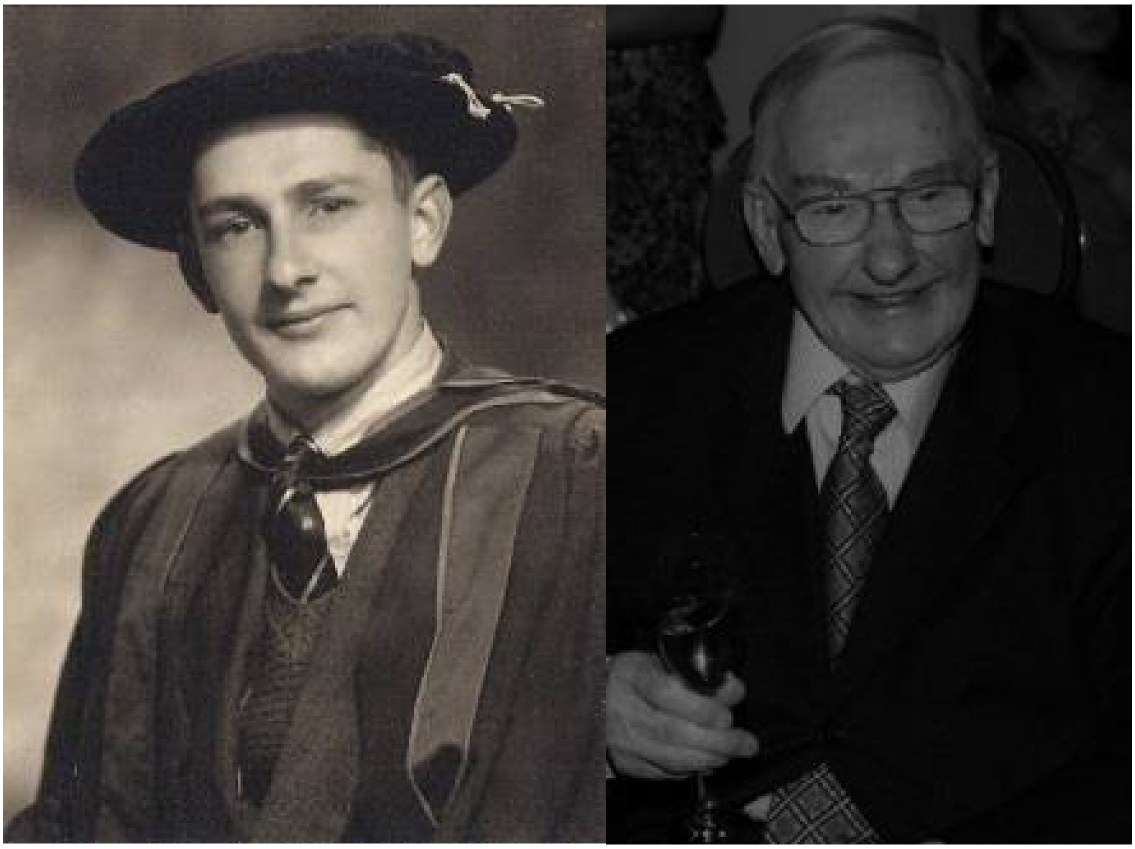

1 Introduction

1.1 Project Overview:

This thesis explores the archaeological and palaeoenvironmental evidence for the effects of sea level change on the prehistoric human populations of Britain, with particular focus on the inhabitants of South Wales. 10,000 years ago, sea levels around Britain began to rise dramatically following the end of the last ice age. Models suggest that by around 6000 years ago, changes in sea levels stabilised within close range of modern day levels (Lambeck 1995; Shennan and Horton 2002), but troubling predictions for future rises have led to sea level change becoming a very current concern. Globally, millions of people live in coastal areas at direct risk of being affected by rising sea levels (Shennan et al. 2015, 1). Sea level rise projections for the 21st century range from 25cm to 2.5m, having already risen 20cm in the last century (Edwards 2017b, 6). As a result, coastal flooding was cited as one the top four priority risks for the UK Government in 2017.

Sea level change in the present day is focussed on rise. This is because it presents the greatest risk to modern day society. Potential effects of sea level change are measured in loss or damage, whether that be to properties, services, agricultural land, infrastructure or economy (Edwards 2017b). In popular culture sea level rise is often portrayed as a catastrophic event. Films, such as *"The Day After Tomorrow"* (Emmerich 2004) and *"Flood"* (Mitchell 2007) depict mass flooding events occurring over short timeframes with disastrous long lasting consequences.

The obsession with an impending catastrophic flood is understandable for a society with permanent settlement in direct line of the advancing tide. However, by concentrating on rise exclusively, the human experience of the full effect of sea level change is not realised. It fails to recognise that changes can be both big and small, sea levels can fall as well as rise, and the impact on local resources can be beneficial as well as detrimental (Leary 2009, 235).

This is an issue when investigating the effects of sea level change in the past. In the modern day we are conditioned to understand sea level change within wide scale narratives and with negative consequences, but not necessarily to see the day-to-day or even year-to-year effects of such changes. In effect we miss the human scale; encouraged to see the collective endpoint rather than an individual perspective. The tools available to investigate past sea level change also present a problem. Past sea level models have been constructed to understand overall trends in sea level change over time. They are not designed with short time frames in mind, often because the data is not available to create that depth of resolution. In the past sea level models have been used by archaeologists to provide background environmental context for archaeological periods, however, the resolution of modelled past sea level change is not suited to an archaeological viewpoint.

According to nationally applied models, sea levels rose by around 55m between 10,000 and 6000 years ago (Lambeck 1995; Shennan and Horton 2002). After this period, the models suggest that sea levels stabilised around modern day levels (Bell 2007e,10). Archaeologically this gives the impression that sea level change affected Mesolithic communities more than those in the later prehistoric periods and that coastal ranges were similar to the modern day by the Neolithic period. However, when archaeological evidence is brought into the mix, it is clear that prehistoric experience of sea level change is not so clear cut. Archaeological and palaeoenvironmental evidence from intertidal zones around Britain, including the Severn Estuary (Bell et al. 2000b; Bell 2007b; Bell 2013c), Langstone Harbour (Allen and Gardiner 2000a), Hullbridge (Wilkinson and Murphy 1995) and the Isles of Scilly (Charman et al. 2016c), has shown that despite the apparent reduction in sea level rise, the effects of fluctuating sea levels (both transgressions and regressions) were felt throughout the prehistoric periods, from the Mesolithic through to the Iron Age and beyond within humanly perceivable timeframes (Bell 2000c, 19). This is unlikely to have been in the form of catastrophic events. Rather, despite early Holocene movements appearing significant, archaeological evidence suggests prehistoric coastal populations would have experienced very gradual and fluctuating change with an average of 1cm rise per year (Shennan et al. 2009).

This thesis argues that, in order to properly interpret the impact of sea level change on specific human communities, sea level change must be considered alongside archaeological evidence at a local scale both geographically and chronologically, as local fluctuations outweigh overall trends from the perspective of the individuals impacted. In doing so, the nuances of sea level become clearer and move the focus from rising sea levels to fluctuating environments.

This thesis specifically targets previously unstudied intertidal sites in South Wales, providing an original contribution to knowledge through the collection, combination and interpretation of new palaeoenvironmental (specifically pollen, non-pollen palynomorphs, microcharcoal and diatoms), temporal (radiocarbon) and archaeological data. It uses these sources of evidence to suggest specific effects of sea level change as experienced in specific locations at specific times.

In doing so it also addresses the current state of intertidal archaeological evidence (archaeology found within the intertidal zone) and research in South Wales and evaluates current approaches to intertidal investigation with the view to proposing approaches for future investigation of intertidal evidence. Findings are further contextualised through the use of pre-existing archaeological and palaeoenvironmental data, within the wider British context.

Human experience cannot be adequately interpreted through the wide scale narratives provided by sea level modelling. By approaching the subject of sea level change in relation to archaeological evidence, a more detailed and tangible understanding of the potential impact of these significant natural processes on human communities can be obtained.

1.2 Specific Research Aims

This thesis argues that sea level change in the past should be addressed on a site by site basis, combining archaeological and palaeoenvironmental data, if archaeological value is to be gained. It disputes the effectiveness of relying on wide-scale sea level models when inferring the effect on human populations and advocates developing and using localised data to build up an evidence base from which models can be drawn. Within the confines of this project, it also addresses the following specific research aims:

- Addresses the state of intertidal archaeological evidence and research on the southern Welsh Coast and compares to that of Britain as a whole.
- Provides new environmental datasets from selected study sites in order to increase the available collated evidence for environmental change in South Wales, heeding the call for increased palaeoanalysis in Wales, in particular within the marine environment (Caseldine et al. 1990, 123-125; Caseldine 2017).
- Acquires new temporal data for previously undated intertidal sites in South Wales. The dates collated will also help to increase the chronological data held in Wales, an ongoing concern as emphasised by (Caseldine et al. 1990, 18) and more recently in the Archaeological Research Framework for Wales (Caseldine 2017, 30).
- Assesses the effect of sea level rise on the sites investigated and how this fits in to the regional and national narratives.
- Records new and updates previously known archaeological data from selected study sites.
- Builds on pre-existing environmental and archaeological data from South Wales to move towards a more complete understanding of environmental change and human interaction on the southern Welsh coast.
- Evaluates current investigative strategies in the intertidal zone.
- Proposes approaches for future investigation of intertidal evidence.

1.3 Introduction to the study area

1.3.1 South Wales

South Wales has been chosen as the focus of research within this thesis. Wales and South Wales in particular, hosts a high concentration of intertidal archaeological and palaeoenvironmental evidence. However, despite highly detailed investigations in the Severn Estuary (Bell et al. 2000b; Bell 2007d) and well publicised discoveries of intertidal deposits at sites such as Swansea Bay (Nayling 1998b; Sherman 2009b,2010,2011) and Borth (BBC 2012), many sites remain unstudied, with limited interpretation often reliant on assumptions of similarity rather than specific tailored research.

South Wales is subject to the brunt of prevailing winds from the Atlantic and some of the strongest and highest tidal ranges in the world courtesy of the Bristol Channel (Horsburgh and Horritt 2006, 272). This leads to high levels of exposure and erosion, which leaves intertidal archaeological and palaeoenvironmental remains at high risk of destruction.

The southern Welsh coastline is also subject to a number of proposed developments including tidal lagoons at Swansea Bay, Cardiff and Newport (Tidal Lagoon Power Plc 2018). However, archaeological interest has so far been limited to desk based assessment and minimal walkover and geophysical surveys (Evans 2014).

1.3.2 Evidence Base

The evidence used in this thesis to explore the effects of sea level change on the prehistoric landscapes and people of South Wales includes both archaeological and palaeoenvironmental evidence.

The archaeological evidence includes any archaeology found within the intertidal zone (between low and high tide). This includes artefacts, structures and remnants of human interaction with the environment, including footprints and charcoal. The potential types of archaeological evidence are described in further detail in chapter 2.3. On top of the intertidal evidence, terrestrial archaeology from the immediate surrounding areas of the study sites will also be identified to investigate temporal links between the intertidal and terrestrial evidence. This will allow the now submerged landscape to be contextualised alongside the terrestrial, as they will have co-existed as one continuous landscape at points within their past. This reflects the "seamless" approach to archaeological investigation termed coined by Allen and Gardiner (2000, 17) in their investigations at Langstone Harbour in Hampshire as outlined in chapter 4.

The palaeoenvironmental evidence is sourced from environmental deposits within the intertidal zone representing the past landscape, now submerged by tide on a daily basis. The sequence of sedimentary layers beneath the surface can provide information about how the environment has changed through time, as well as organic material that can be used for radiocarbon dating. Bell suggests that these sediment sequences can be particularly useful in furthering our understanding of the Mesolithic, a period that remains understudied in Welsh contexts (Bell 2007e, 3), though evidence also suggests that these deposits provide information spanning the prehistoric periods from Mesolithic to Iron Age, as will be addressed in chapter 2.3. By investigating deposits such as these, the effect of sea level change, at the site under focus can be understood along with other affecting factors, such as human impact, climate, disease and animal grazing. These factors will be explored in full in chapter 2.4.

Within this thesis, site selection has been driven initially by the presence of unexplored palaeoenvironmental deposits. The process by which specific study sites were selected is outlined in chapter 4.1, but the rationale behind the choice in overall study area is explained below:

1.3.3 Known Deposits

A documentary peat survey was conducted by Bell in 2007, which recorded 75 separate intertidal peats and submerged forests along the entire Welsh coastline and also within the Bristol Channel area on the SW English coast, the results of which can be seen in Figure 1. These sites were sourced from Antiquarian reports, Geological survey memoirs and field surveys (Bell 2007d, 3).

The survey highlighted all the sites where peat had been noted in the past, but does not necessarily represent the situation as it is today. Bell (2007d, 3) acknowledged that some of the sites listed in earlier sources may no longer survive.

Bell’s survey underlined the great potential for further intertidal research in Wales, particularly in the South where many of the sites listed lacked radiocarbon dates and recent investigation. It offered the most comprehensive overview to date and was therefore used as a starting point to work from and to assist in choosing the most suitable sites for further analysis.

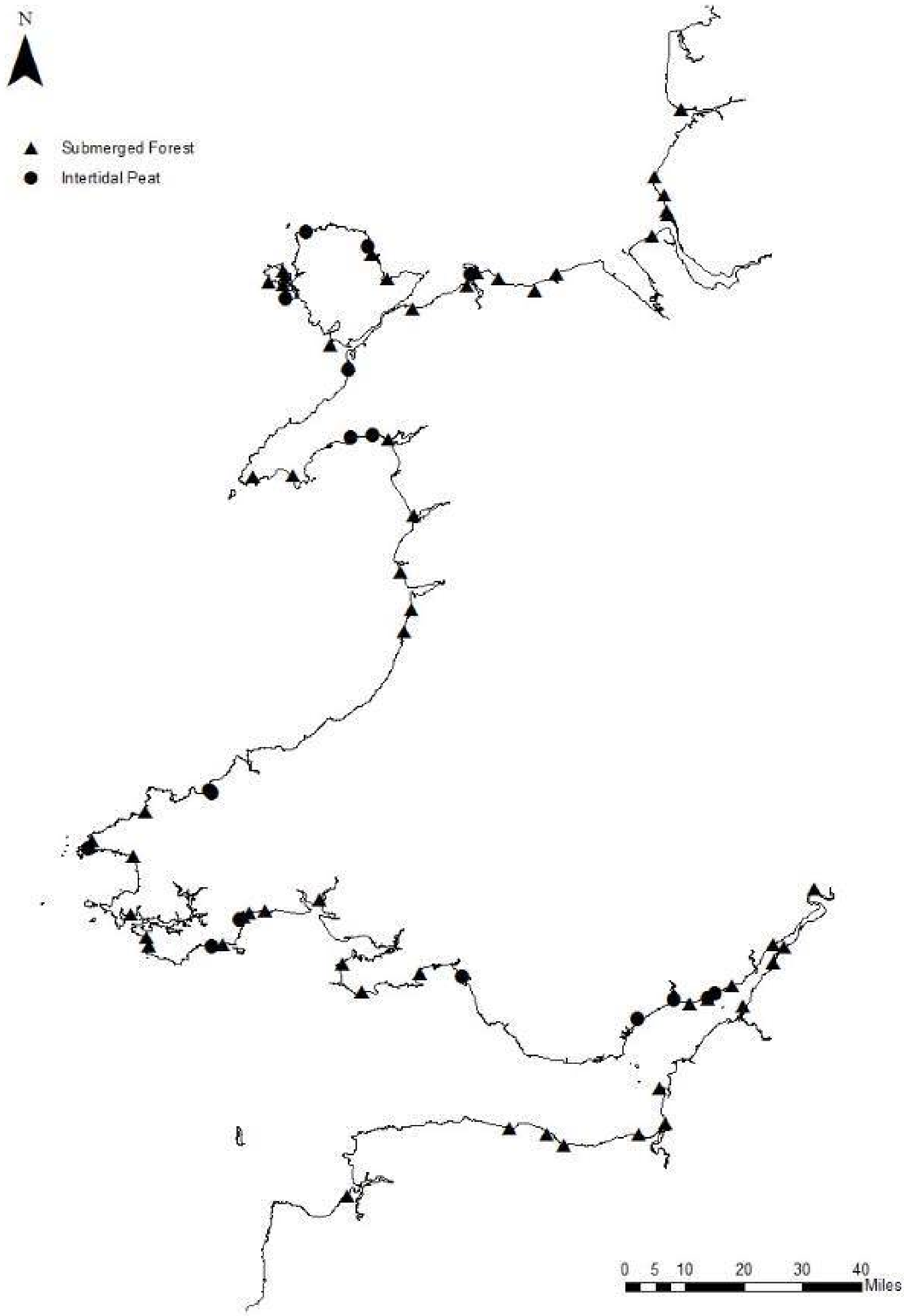

Figure 1: Map detailing all Submerged Forests and Intertidal Peats recorded by Bell in the 2007 survey. Data sourced and adapted from (Bell 2007, CD 1.2) and displayed using ArcGIS software.

1.3.4 Study Area

For the purposes of this investigation, the study area has been limited to a specific stretch of the southern Welsh coastline to allow for an in depth investigation of the chosen sites (Figure 2).

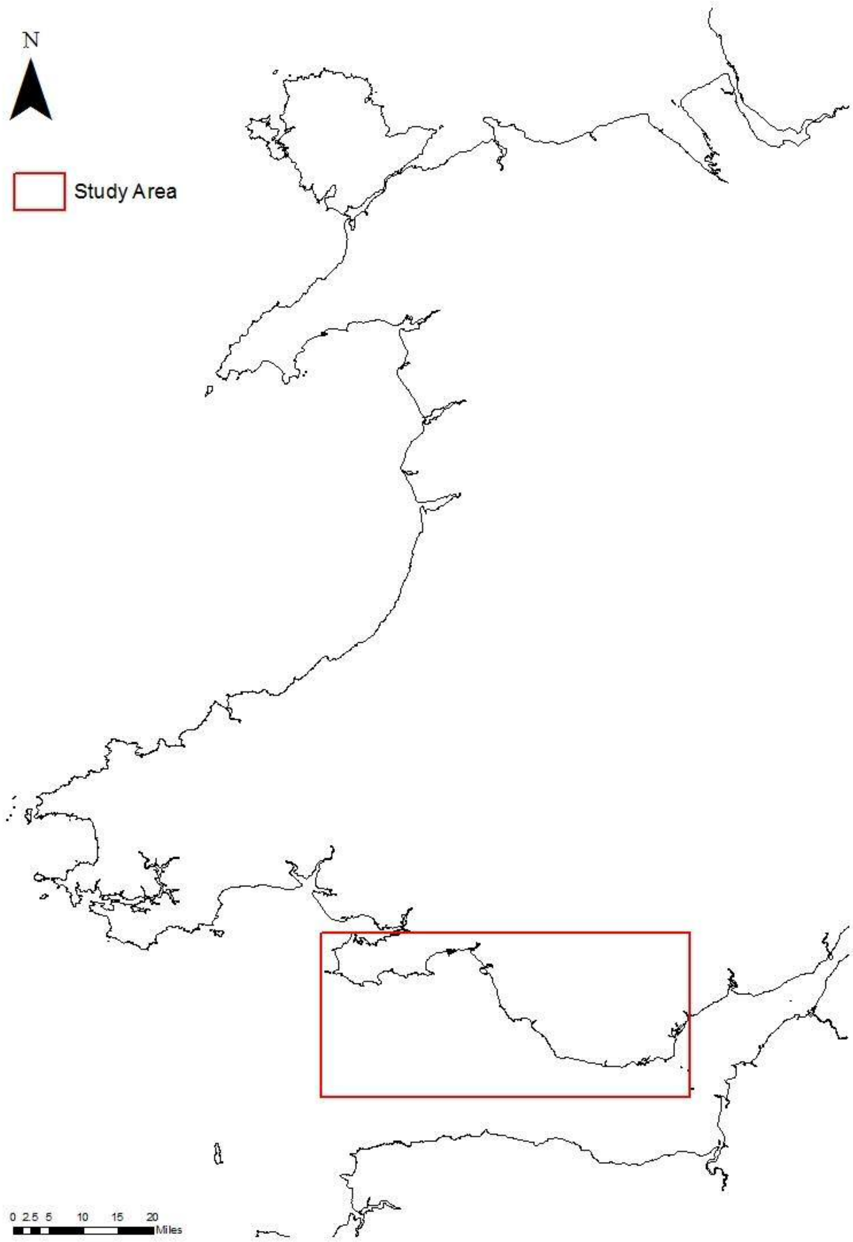

Figure 2: Chosen study area

Due to the large body of work that already exists for the Severn Estuary (Bell and Neumann 1997; Bell 2000b; Bell et al. 2000b; Bell 2007d,2013d), this thesis focuses on coastal rather than estuarine sites in order to avoid repetition and to build on the research already undertaken. The initial area chosen runs from Cardiff in the East, to Whiteford Sands on the North West coast of the Gower Peninsula (Figure 3).

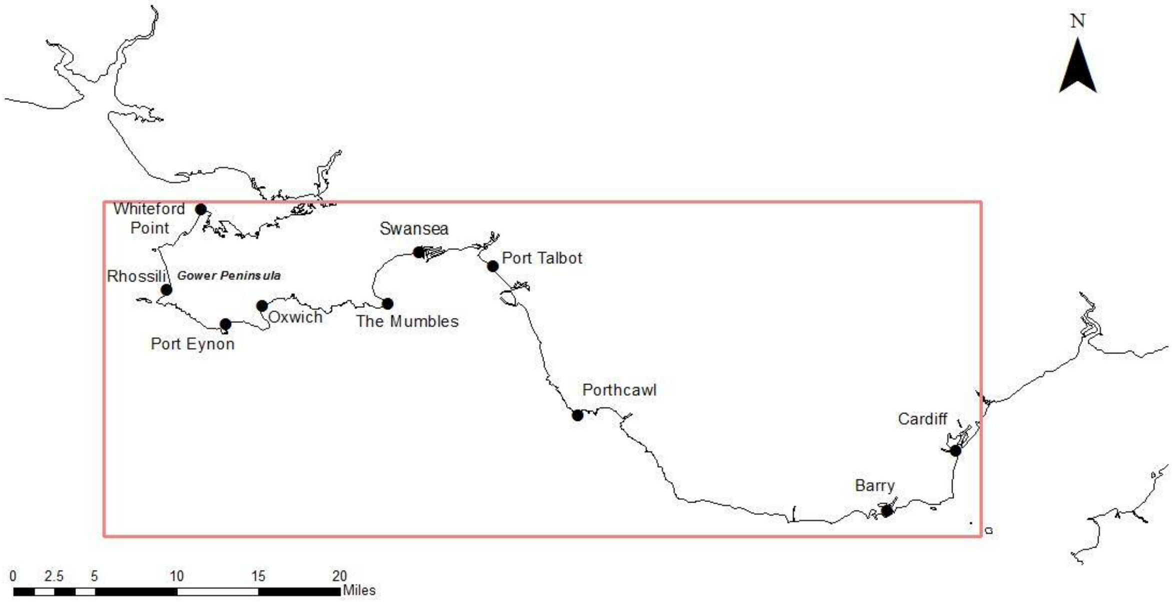

Figure 3: Map displaying extent of the study area for preliminary peat survey in South Wales

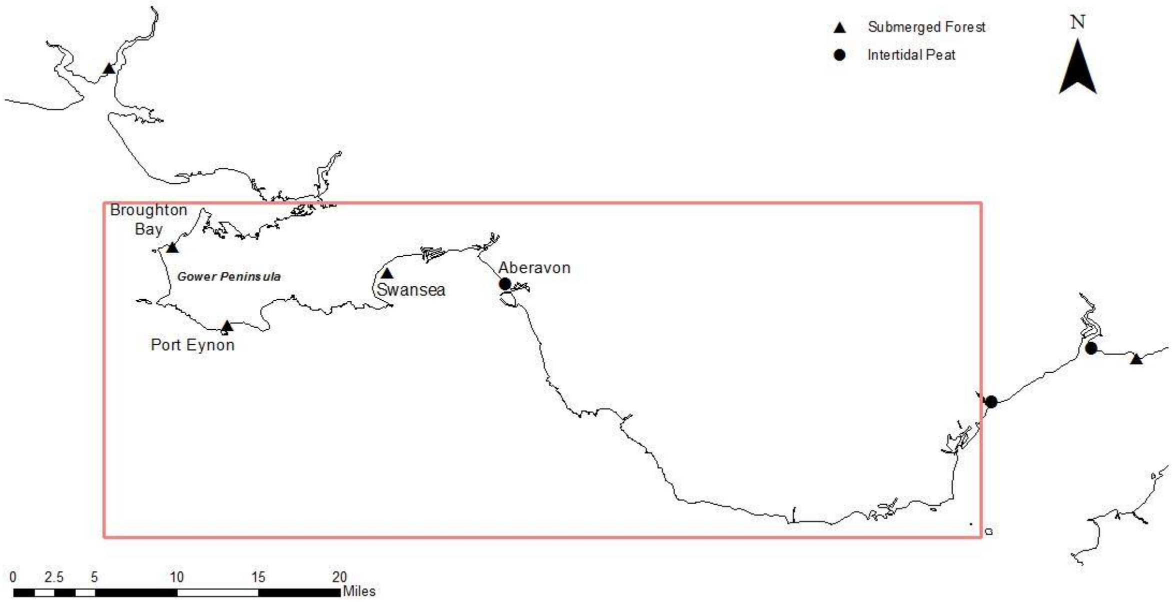

Figure 4: Map showing submerged forests and intertidal peats recorded by Bell (2007, CD 1.2) within the study area of this investigation.

In terms of intertidal remains, Bell identified three submerged forests and two intertidal peat deposits within the area selected for this study (Figure 4). None of the sites listed are recorded as having been radiocarbon dated (Bell 2007d, CD1.2).

However, the potential for the existence of intertidal remains extending further to the east towards Cardiff is exhibited in the existence of peat in dock sections at Barry (Strahan 1896; Beaudette and Beaudette 1985; Bell 2007d). The deposits to the east of Cardiff have been disregarded for this particular study, as they are included in the Severn Estuary Research (Bell and Neumann 1997; Bell 2000b; Bell et al. 2000b; Bell 2013d).

Bell's 2007 survey provides a substantial launch pad for intertidal research in Wales. Since the release of this publication, South Wales has been hit by the erosive effects of increasingly stormy conditions, particularly in the winter of 2014, which has led to the exposure of further intertidal palaeoenvironmental and archaeological evidence. Chapter 4.1 further explores the evidence for intertidal deposits within the area selected for study, before identifying specific sites for more in depth analysis.

1.4 Chapter Synopsis

1.4.1 Chapter 2: Sea Level Change

Chapter 2 introduces the drivers behind sea level change and the ways in which these changes can affect the landscape and the people who inhabit it. This includes the immediate effect of inundation and the loss of land associated, but also long-term effects, such as changing vegetation and land use. The chapter also introduces the sources of evidence, both archaeological and palaeoenvironmental, for past effects of sea level change.

1.4.2 Chapter 3: A History of Intertidal Archaeology

This chapter contextualises the research undertaken for this thesis. It features a review of the history of intertidal research in Britain. As Wales has been prominent in the development of intertidal study, and is the centre of this study, it will form the major focus for the review, but examples will also be drawn from other locations in Britain. A second evaluation will specifically investigate the current state of sea level change research, and the way in which intertidal evidence is used to contribute towards regional and national modelling of past sea levels. It will critique the effectiveness of this data on an archaeological level and suggest changes in approach to improve resolution within human timeframes.

1.4.3 Chapter 4: Initial Surveys

Two initial desk-based surveys were undertaken to select sites for further study, and to create a background archaeological context within which to place the data obtained during this research. The first follows Bell's 2007 intertidal survey as outlined in section 1.3 of this chapter, enhancing the resolution and separating out sites that have been combined previously. It also adds newly discovered sites and suggests potential locations for future discoveries based on local factors. From this initial survey, the study area is narrowed down and specific sites for further analysis selected.

The second survey collates all known archaeological evidence within the narrowed down study area to contextualise any new archaeological and palaeoenvironmental evidence collected within this study. This chapter describes the approaches and methodologies of both surveys and presents their results, enabling further contextualisation of the identified sites in terms of their surrounding landscape and archaeological evidence within the local area.

1.4.4 Chapter 5: Methodologies

This chapter outlines the methodologies used to investigate the palaeoenvironmental and intertidal evidence during the primary phase of this research. The methodologies are presented beginning with the topographic survey of the chosen study sites, followed by descriptions of the archaeological, sampling, radiocarbon dating and palaeoenvironmental methodologies respectively. The chapter concludes by outlining the approach used to investigate past sea level change at the chosen study sites.

1.4.5 Chapter 6: Results

Results from each of the primary investigations are presented in chapter 6. The chapter is split into five sections detailing the results from each of the different investigative methodologies.

1.4.6 Chapter 7: Discussions

Chapter 7 discusses the changes in the environmental and archaeological record during the time period indicated by the programme of radiocarbon dating undertaken during this study, and compares them to other known intertidal sites in South Wales and further afield. The approach to intertidal study is also discussed and compared with other intertidal investigations to critique the methodology and work towards improved procedures for intertidal study.

1.4.7 Chapter 8: Conclusion

This chapter concludes the research undertaken in this thesis and discusses how the outcomes will contribute to the development of archaeologically focussed sea level studies (or perhaps sea level focussed archaeological studies), and further our knowledge of intertidal archaeology both at a localised site level and also within a wider British context. The conclusion also highlights the limitations of the thesis and proposes recommendations of approach for future research.

2 Sea Level Change

This chapter introduces the impact and investigation of prehistoric sea level change in the area of interest for this project; the South Wales coast. Section 2.1 identifies the factors which drive sea level change, while Section 2.2 describes the effects sea level change can have on the environment and its inhabitants. Section 2.3 and Section 2.4 discuss the archaeological and palaeoenvironmental evidence for sea level change respectively. Section 2.5 outlines the various approaches to modelling sea level change and explores their utility for archaeological purposes. Section 2.6 provides a summary of the concepts introduced in this chapter.

2.1 Drivers of Sea Level Change

Sea levels change due to a combination of localised Isostatic (crustal) movements and global eustatic (movement of water) changes. Isostasy refers to the vertical tectonic displacement of continental plates in relation to the weight of ice sheets above. Continental plates act as rafts floating on the magma below. The ice sheet causes the depression at one end of the plate, which in turn causes the crust to rise at the opposite end, much like a see-saw, in order to compensate (Bell and Walker 2005, 116). Eustasy refers to an overall uniform change in sea level due to an influx or thermal expansion of water (Douglas 2001, 8), which is caused by changes in climate; the main driver of sea level change.

Warming climates lead to the interglacial periods, which cause ice sheets to melt and recede. During these periods, the weight of the ice is reduced, which can have the opposite effect on the crustal movements, causing uplift in once glacial locations. The apparent position of the land relative to the sea changes depending on the crustal movement. Meltwaters from these interglacial periods feed back into the oceans causing eustatic rise (Bell and Walker 2005, 116). During glacial periods this water can be reabsorbed in to ice masses, causing a eustatic fall alongside the subsequent localised isostatic movement causing either uplift away from sea level, or depression towards it. These methods either result in sea level transgression (rise) or regression (fall).

The idea that permanent catastrophic sea level rise can be instigated by a single event, such as a Tsunami or storm surge is relatively unfounded, with effects of such events being more short term. However, the erosive nature of such catastrophic events can cause natural sea defences, such as sand banks or back barrier systems (see section 2.2.3) to be breached. If the previously protected landscape was below sea level, this could lead to effective inundation (see section 2.2.1) but would not necessarily be classified as a rise in sea level. An increase in storm surge activity can be linked to the same climatic drivers of sea level change, with the increase in global temperatures leading to more frequent stormy conditions.

2.1.1 British Holocene Sea Level Change

The Holocene refers to the period starting at the end of the ice age (around 11,000 years ago) through to the present day (Bell and Walker 2005, 2), within which the sea level change investigated in this thesis occurred. During the last ice age, large ice sheets existed over much of northern England, Scotland, Wales, Ireland and the Irish Sea Basin (Bell and Walker 2005, 110). The weight of the ice sheet to the north caused the southern parts of Britain to rise in compensation. This tectonic movement outweighed eustatic rise, effectively leading to a drop in sea levels in areas of uplift. Water caught up in the ice sheet also contributed to reduced sea levels (Bell and Walker 2005, 118). As the climate warmed towards the end of the ice age, the ice sheets began to melt, releasing water back into the sea, but also reducing the pressure on the landmass, causing the tectonic plate to rebound. Those areas that were raised began to fall in order to maintain equilibrium. This readjustment combined with eustatic gain led to substantial sea level rise which continued into the Holocene period.

This is, however, a relatively simplistic version of events. Glacial isostatic uplift/subsidence varied across Britain, dependent on ice thickness and position and crustal responses to decaying ice sheets (McCabe 1997, 601), meaning the effect on sea levels also varied at a local level. In order to account for this, Glacial Isostatic Adjustment (GIA) models based on regional sea level observations have been implemented to estimate the effect of isostatic movements, but a lack of suitable data from a number of regions, including the Bristol Channel, means the models are constrained in their effectiveness (Shennan 1989). Modelling of sea level changes using GIAs and other methods will be addressed fully later in this chapter (section 2.5).

2.2 Direct Effects of Sea Level Change

When investigating sea level change from an archaeological point of view, it is relative sea level change in relation to land that is the major point of focus (Bell and Walker 2005, 116). Rising sea levels can have a variety of physical effects on the coastal landscape. Land is lost by submergence through inundation or by erosion of beaches or cliff faces. Water tables can rise, and aquifers and surface water can be affected by salt intrusion, potentially leaving the landscape impassable and removing freshwater sources. Fluctuating water tables can also affect local vegetation, with changes affecting habitats for local wildlife, soil acidity, food sources and mobility through the landscape. Vulnerability to severe storms can be increased, with flooding events becoming more likely (Douglas 2001, 1).

2.2.1 Land Loss

Inundation

Direct inundation is the primary mechanism for land loss on sheltered, low-lying coastlines (Nicholls et al. 1995, 28). While the effects of inundation over wide timeframes appear substantial, in general, it is a slow process when viewed within short, human-scale timespans (Shennan et al. 2009). Catastrophic inundation can occur as a result of events such as a Tsunami or storm surge, however in terms of physical land loss, the effects are generally short-lived and do not lead to permanent inundation. These events can however have longer term effects on the surrounding environment and ground water as is discussed below.

Erosion

Rising sea levels can lead to loss of land via erosion. As sea levels rise and the coastline regresses, the higher impact tidal zones move inland and erode softer terrestrial deposits. Topography can also play a part, as wave energy can be condensed into shortened distances if the break of slope becomes steeper, increasing the eventual erosive force (Nicholls et al. 2014). High energy events such as a Tsunami or storm surge can cause immediate erosive effects, breaking through natural sea defences and allowing inundation of once protected areas (Coles 1998, 69).

2.2.2 Land Gain

As has already been alluded to, sea level can go down as well as up. This means that at certain points within prehistory, land will have been created rather than lost. Depending on the temporal and spatial extent of the regression, land can remain under marine influence, or if protracted enough, can develop into freshwater and eventually dryland habitats as is outlined in the Vegetation Change section below. Land gain may have had both positive and negative consequences: it could potentially increase the landscape and resources available to inhabitants of the area, but it might also make resources and route ways more difficult to access, particularly if the development of wetland habitats made land impassable.

2.2.3 Groundwater Levels

Sea level rise can cause gradual changes in the local groundwater levels, leading to a damper environment and encouraging the decline of woodland and dryer landscapes in favour of freshwater wetlands (Timpany 2005, 365-6; Edwards 2006, 582; Murphy et al. 2014, 31). Inland vegetation communities without direct tidal influence, (though still within proximity of a coastline), can therefore still be affected by sea level change, as rising sea levels force local groundwater levels to rise, causing waterlogging through freshwater seepage or flooding (Pratolongo et al. 2009, 96). This environment is sometimes referred to as the “perimarine zone” (Hageman 1969). If water levels in these areas rise too quickly or too high and begin to pool, vegetation can drown, leading to complete loss of habitat and potential loss of resources (Douglas 2001, 2). In areas closer to the marine source, saltwater ingress into freshwater aquifers can leave water sources contaminated and areas potentially uninhabitable.

2.2.4 Vegetation Change

Fluctuating groundwater levels lead to successional changes in the local vegetation via hydroseral and haloseral succession.

Hydroseral succession is the process by which vegetation in a freshwater environment transforms from aquatic species through to dryland species, from reed swamp, to fenland, to carr woodland, to forest (Walker 1970, 118). Though described here in conventional order, within this study, hydroseral succession is addressed primarily in reverse, since the deposits under investigation were once dry land and have become submerged. However, this is not to say that hydroseral succession will be observed in a linear form, as sea levels changes do not often occur in this way. More often periods of regression follow transgression, which in some cases can allow plant communities to recolonise and revert to earlier habitats. Reverse succession can also be influenced by other disturbance factors such as climate, disease and human influence. These will be discussed along with other possible factors in section 2.4.

In a perfect succession, the sequence will begin at the edge of water bodies and slow flowing streams, where aquatic and algal species form. As the water shallows, either by a drop in the water table or through the deposition of dead plant material, reeds and other shallow water plants begin to emerge. By a process of further accumulation of dead plant matter continuously building on the soil layer, the once submerged land becomes exposed, encouraging fenland to take hold, followed by wetland tolerating trees and shrubs and eventually dry woodland (Tansley 1939b; Godwin 1981, 3-4). In practice, the succession will not reach the dryer stages and is more likely to culminate in raised bogs or mires (Walker 1970, 118), particularly in "more oceanic regions" (Wheeler 1980, 780).

In estuarine or coastal contexts, hydroseres are initiated when salt marsh becomes freshwater (Walker 1970, 124), which becomes more likely as sea levels fall. Haloseral succession relates to the changes within the salt marsh itself and the transformation between the upper, middle and lower intertidal zones, which are described in full in section 2.4.1. As sea levels rise, vegetation moves from freshwater, to brackish and then marine favouring species as the environment becomes more affected by salt water (Packham and Willis 1997, 22).

High energy inundation, through events such as Tsunamis and storm surges can cause breaches in sand bars or barriers protecting freshwater environments from marine influence and speed up the process of vegetation succession. An example of a current, un-breached back-barrier system can be seen in Figure 5. Salt water ingress can immediately affect the freshwater vegetation present and has been credited with the demise of some of the now submerged forests in Britain (Timpany 2005, 1). If sea level rise is maintained, this can lead to a transition through brackish to fully marine conditions and the development of salt marsh.

Figure 5: Clear example of a back-barrier system on Jura, Western Isles, Scotland (freshwater to the left, salt water to the right) (Philp 2016)

2.2.5 Effects of sea level change in Britain

During the Holocene, over 186,000 square kilometres of British land was lost to rising sea levels, the majority of which occurred between 11,000 and 7,000 years ago, at an average of around 1cm rise per year (Shennan et al. 2009). Land loss was most prevalent on coastlines bordering the North Sea and English Channel followed by the Western Seaways coastline (Sturt et al. 2013, 3972-3973). This is unsurprising, given that these areas are predominantly low lying. Land loss on the Atlantic coastline was much lower, likely due to the predominance of steep rocky coastlines (Nicholls et al. 1995, 28).

In the North Sea and English Channel, a Tsunami caused by the Storegga slide, an underwater landslide off the Norwegian coast, occurred in c.8200 BP (c.6250 BC), and has been argued to have had a catastrophic effect on the contemporary Mesolithic coastlines (Weninger et al. 2008, 17). This event coincides with the final submergence of the area of land known as Doggerland (Coles 1998) and is often cited, particularly in the media, as the underlying cause, conjuring dramatic images of rapid inundation and population displacement (Rincon 2014; Andrei 2017; Hill et al. 2017; Heritage Daily 2018).

In reality, the effects of the Tsunami are less clear. Leading up to the Tsunami, the landscape changed gradually in “fits and starts”, as a result of post glacial sea level rise within a generational rather than individual timeframe (Coles 1998, 67-69). Sturt et al. (2013, 3973) argue that, though the Tsunami may have played a part in the final inundation of what remained of Doggerland, the effect would not have been uniform along the contemporary coastlines. Furthermore, Coles (2000) and Leary (2009) maintain that it was the long term changes in sea level, rather than specific inundation events that had the greatest effect on the local Mesolithic populations. The Tsunami is likely to have caused the final breach in the sand banks separating the North Sea and the Channel, but this was an isolated incident within a much longer campaign of sea level change that continued for at least another 2000 years (Coles 2000, 399).

Land loss in relation to sea level change continued across Britain after 7000BP, but at much reduced rates. It is likely that effective land loss was less by a movement of the coastline and more due to the changing nature of the landscape, induced by sea level change, leading to potential loss of resources and accessibility issues.

2.2.6 Broad Effects of Sea Level Change in Wales

Sea levels are recorded to have risen c.55m around Wales since the end of the ice age, leading to the coast receding by over 50km. The Bristol Channel and Severn Estuary are not recorded to have existed until between 9000 and 7500 cal BC (Bell 2007e, 8-9), with dryland extending to the present day South West of England. This early Holocene change is shown in Figure 6.

For South Wales in particular, understanding of the later effects of sea level change is limited due to a lack of data suitable for localised sea level modelling (Heyworth and Kidson 1982, 95). This is an issue that will be explored later in this chapter (2.5).

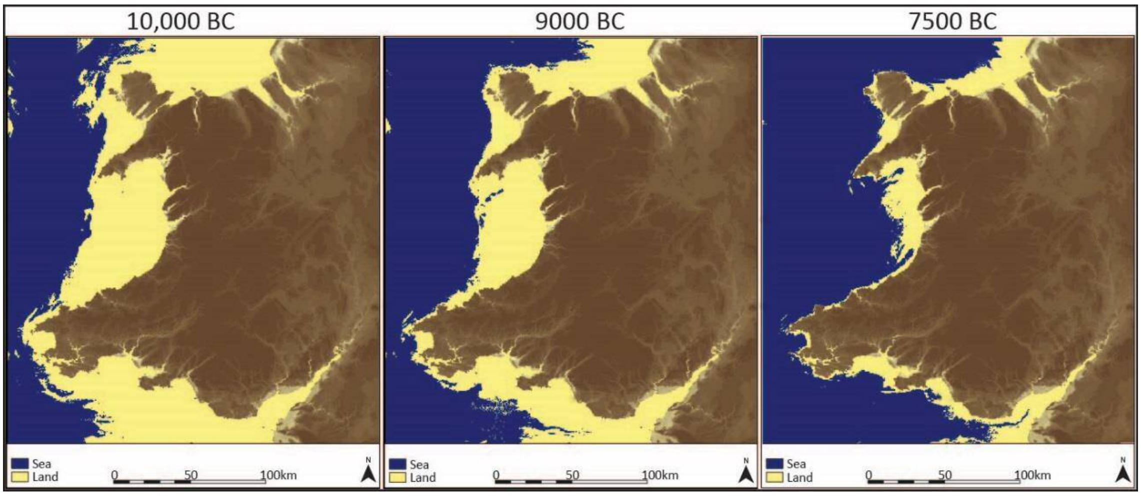

Figure 6: Holocene sea level change in Wales derived from Bell (Bell 2007e, 8-9).

2.2.7 Human Response to Sea Level Change in Prehistory

Evidence for Response

Archaeologically, response to sea level change has been suggested in physical evidence for the movement of populations (including evidence for migration away from and towards the coastal zone), changes in landscape management and resource use (seen in palaeoenvironmental evidence) and changes in the types of activities occurring within the landscape (as suggested by the surviving archaeological evidence) (Leary 2009, 232-3). Trying to recognise these responses within the archaeological record and identify that they are related directly to sea level change is difficult.

Suggestions have also been made that ceremonial or ritual activities would have intensified during periods of sea level rise (Leary 2015, 71). In particular, Leary cites evidence of special deposits in the Netherlands containing worked flint and animal skulls within now intertidal contexts and the location of Mesolithic funerary deposits and cemeteries close to the sea edge on islands off of Brittany. In Britain, however, physical Mesolithic archaeological evidence is still extremely rare and an increase in ritualistic activity due to sea level change cannot be inferred.

Research into the perceptions and responses of prehistoric communities to sea level change in Britain has been limited, but where it has been undertaken, it often focusses on human response to disaster and perceived negative impacts of sea level change (Leary 2009). However, it is not necessarily true that humans will react and respond to environmental change in this way. The idea that sea level change (rise in particular) is a natural hazard with potential disastrous consequences is a modern day assumption, based on modern social context. (Hewitt 1983, 4) suggests that hazards are a social construct of the time in which they arise. We must therefore be careful in applying such interpretations when attempting to understand the effects of sea level change in the past. It cannot be assumed that prehistoric inhabitants of coastal regions affected by sea level change understood such changes (either transgressive or regressive) in a negative way. Their perception of events and response to them depends on their understanding as driven by their own social context (Bell and Walker 2005, 14).

Human resilience is another important factor to consider when thinking about response to sea level change in prehistory. Human populations are pragmatic and adaptive and are likely to take advantage of new situations if they work in their favour (Redman 2005, 72). In the case of sea level change, this might be seen in evidence for interaction with or even management of the newly formed landscape or the uptake of newly available resources. After a rise in sea level, this may be seen in the utilisation of marine resources further inland, or the exploitation of wetland resources. After a fall in sea level this could be seen in the expansion of territories or the resumed utilisation of wetland resources. Bell(2007b, 321) suggests that it was the dynamism of a fluctuating environment and the diversity of resources that were created as a result that provided the draw for human inhabitants during the Mesolithic and into the Neolithic, at sites such as Goldcliff in the Severn Estuary.

Goldcliff also provides clear evidence for human manipulation of the environment in the form of episodic reed burning. This was suggested to have been undertaken in order to encourage the growth of more economically valuable vegetation such as hazel, which is demonstrated to have been a significant resource at the time, evidenced by the large quantities of charred hazelnuts found within the archaeological record (Bell 2007b, 325). Leary (2009, 233) states that this was a clear indication of the resilience of the local prehistoric population.

Coles (1998, 76) supports the view that positive outcomes were likely gained from rising sea levels for the Mesolithic inhabitants of Doggerland, suggesting that the expansion of the estuarine environment and the diversity of resources that would have resulted from such an expansion would have compensated any loss of land or negative impact from sea level rise.

Research into the effect of sea level change on prehistoric populations rests heavily on the Mesolithic period, however changes in sea level continued to happen into later prehistoric periods. While sedentism and domestication began to take hold in the Neolithic period, intertidal evidence from sites such as Formby in the North East of England suggest that mobile existence was maintained in coastal and surrounding areas, taking advantage of the still fluctuating environment. Archaeological evidence such as sustained flint assemblages indicate repeated but temporary (potentially seasonal) visits to the then freshwater wetland areas, now represented in the intertidal zone (Gonzalez and Cowell 2007, 24). Bell (2007b, 337) also advocates this view, citing evidence from the Severn Estuary and also Prestatyn in North Wales, where seasonal activities in the still fluctuating coastal zones and wetland edges continued into the Neolithic period for some time after a transition to sedentism had occurred elsewhere, albeit at a lower intensity to activity during the later Mesolithic period (Bell 2007c, 248).

Moving into the Bronze Age, the extent of trackways, fish traps and jetties suggests populations fully engaged in utilising the wetlands and coastal backwaters. While small scale transgressive and regressive sea level changes were ongoing, the saltmarsh and pastoral grazing provided by the growing intertidal zone proved an important resource for Bronze Age inhabitants and their livestock in places such as Redwick in the Severn Estuary (Bell 2013c, 317).

It is likely that human inhabitants of the coastal zones and wetland edges would have lived a fluid existence (Leary 2015, 87), adapting to changes in the environment as they occurred. However, while the effects of sea level change would have been a major driver in the fluctuations encountered, other environmental factors would also have played a role, as will be explained in section 2.4.2.

2.3 Archaeological Evidence of Sea Level Change

As a result of sea level rise in Britain, a substantial amount of archaeological evidence is now located in submarine, intertidal and coastal contexts. The extent of sea level change during the Holocene means that early prehistoric archaeology (Mesolithic through to Bronze Age) found within the present-day intertidal zone is unlikely to be contemporary with the prehistoric shoreline. However, from the Iron Age onwards, archaeological evidence is much more likely to be associated with the coastal conditions and may indicate interaction with a shoreline, rather than inland activities (Allen et al. 1997, 104).

2.3.1 Types of Evidence

Archaeological evidence within the intertidal zone benefits from the anaerobic conditions provided within waterlogged sediments, often consisting of thick peats, which allow for the preservation of remains that are much less likely to survive in a terrestrial context. This leads to the survival of waterlogged remains such as wooden structures and environmental remains (Bell 2000d, 1).

Categorisation of intertidal archaeology is influenced by the time period and environmental context in which it was deposited. Within the earlier prehistoric periods of the Mesolithic and Neolithic, the evidence has the potential to represent inland sites used for everyday activities. These can include flint scatters, evidence for burning in the form of charcoal or burnt stones/flint, the presence of pottery or stone tools and even shallow features (Wilkinson and Murphy 1995, 7). Evidence in this form can be problematic, as artefacts are relatively mobile and can be easily eroded from deposits and moved, which can make interpretation difficult.

In most cases, this kind of evidence indicates short lived activities, however evidence from Goldcliff in the Severn Estuary indicated much more prolonged activity on a seasonal basis throughout the Mesolithic and into the Neolithic periods. Here potential structures have been identified in the form of grouped clusters of artefacts and potentially related post holes (Bell 2007c, 233). Evidence for a wide range of activities was also present, including hunting, butchery, processing of skins and plants, cooking (potentially with heated stones) and woodworking (Bell 2007c, 230).

A rare, but significant source of early prehistoric archaeological evidence within the intertidal zone is the presence of footprints, which survive in peat and minerogenic deposits at a small number of sites across Britain. Worldwide, it has been reported that there are just 40 sites recorded with Holocene era human footprints (Lockley et al. 2008, 122). A quarter of those can be found on the British mainland, where there are currently 11 recorded intertidal footprint sites of Holocene origin (Aldhouse-Green et al. 1992; Huddart et al. 1999; Bell 2007d; Brayshay et al. 2007; Bennett et al. 2010; Eadie and Waddington 2013; Murphy et al. 2014; RCAHMW 2014, Sherman 2016 pers. comm.) (Figure 7). The presence of footprints generally denotes a shallow and low energy wetland context (Allen 1997). Footprints can also provide unprecedented information about the demographics of the people who left them, including age, sex and height, as well as their gait, footwear (or lack of) and the direction in which they are travelling (Scales 2007). Animal footprints can inform on potential sources of prey, predators and, into the Neolithic period, animal domestication and husbandry techniques.

Wooden Structures, such as trackways, bridges, landing jetties and fishing structures are all present within intertidal zones around Britain. They are often associated with the exploitation of saltmarsh and coastal areas (Bell 2013b) and are therefore more commonly dated to the Bronze and Iron Ages, when sea levels were settling at a level closer to that of today (Wilkinson and Murphy 1995, 8). The remains survive due to the excellent preservation conditions provided by the waterlogged sediments in which they are encased. Nineteen trackways were identified within the later deposits at Goldcliff dating to the late Bronze Age Period (Bell 2000e, 157). Further trackways also dated to the Bronze Age and Iron Age have been identified in Swansea Bay (Sherman 2011), on the Essex Coast (Wilkinson and Murphy 1995, 164) and the Humber Estuary (van de Noort and Ellis 2000, 421).

At Langstone harbour in Hampshire, a site that did not become tidal until the Iron Age, Bronze Age features such as ditches, cremation burials and evidence for salt and metal working are all present within the intertidal zone, much as they would have been within a terrestrial based excavation. Their preservation is likely due to the low energy environment of the harbour, though it is stated that they are currently at risk from erosion (Allen and Gardiner 2000b, 219).

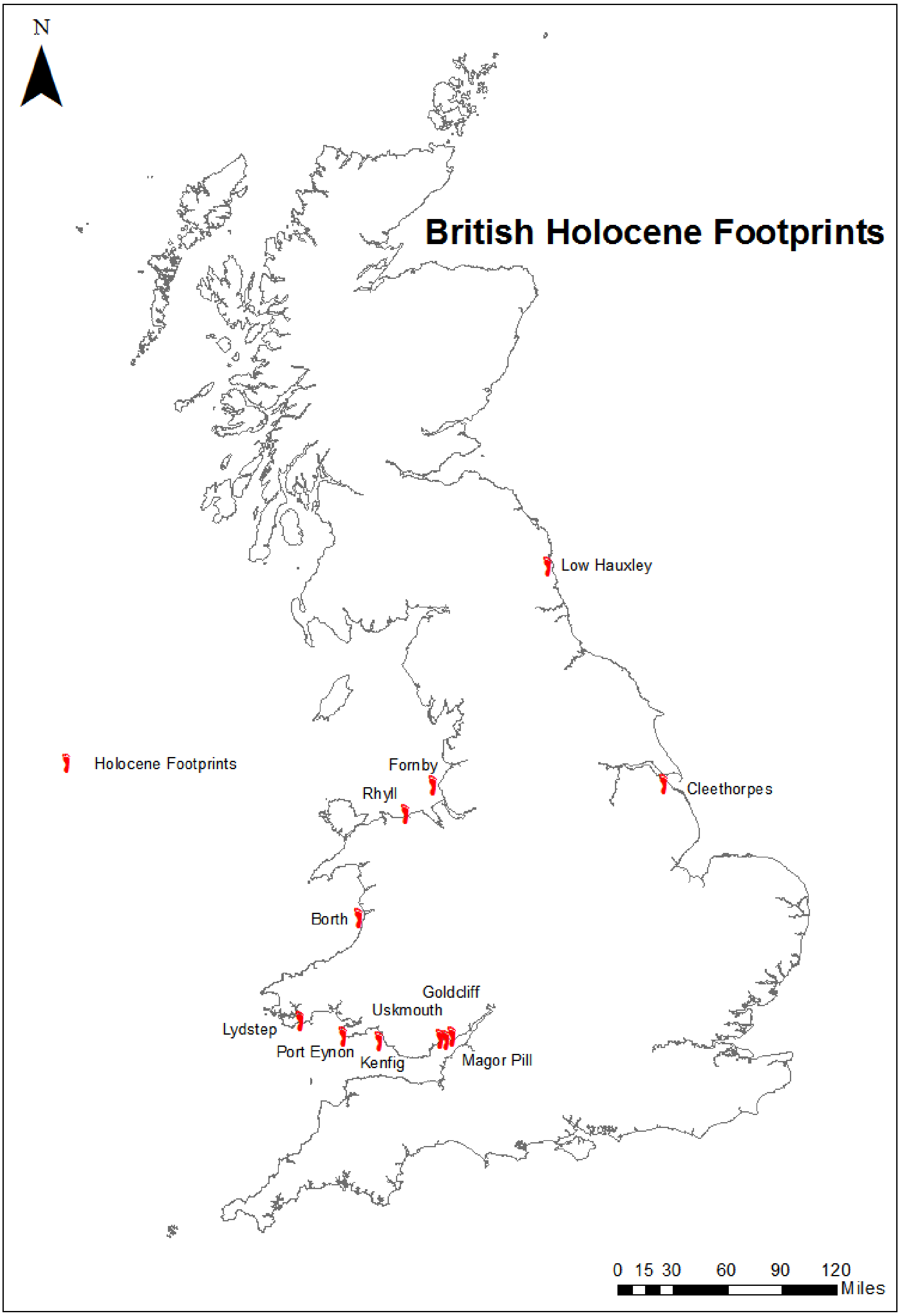

Figure 7: Map showing location of all recorded human footprint sites within the intertidal zones in Britain

2.3.2 Threats to Intertidal Archaeology

Archaeological evidence within the intertidal zone is highly prone to erosion, due to high energy wave action and the twice daily exposure and flooding caused by the rising and falling tides. While erosive processes aid in the discovery of sites, they can also very quickly lead to their destruction. There is very little that can be done to protect sites within these environments. Although sea defences may help to protect the terrestrial edge of sites, construction of such defences is expensive and must be justified by overall economic and social benefit (Sidell and Haughey 2007, vii). This kind of defence cannot aid in the protection of archaeology already within the intertidal zone, which is virtually impossible to protect.

A more modern threat to intertidal archaeology is the development of the intertidal zone. Driven predominantly by the energy sector, more intrusive development within this area is becoming more common. In Wales specifically, prospective infrastructure projects such as the (admittedly now contested) Tidal Lagoons in Swansea and Cardiff (Tidal Lagoon Power Plc 2018) have been proposed, and across the Bristol Channel, the nuclear power station at Hinkley point is in the process of being built (EDF Energy 2010). These developments present a direct threat to intertidal archaeology and palaeoenvironmental deposits, but can also provide an outlet for investigation, as is highlighted in Chapter 3.

Awareness of the fragility of archaeology within intertidal contexts has grown in recent years with projects set up in Wales, Scotland and England to record evidence as it becomes exposed and monitor known sites for the effects of erosion. These projects have all been successful in utilising people power, by training volunteers to survey and record archaeological evidence within the coastal and intertidal zones. However they are reliant on unreliable funding streams, and while projects such as CiTIZAN in England (MOLA 2014) and SCAPE in Scotland (SCAPE 2018a) have managed to maintain funding and extend past initial fixed term timelines, Arfordir in Wales was restricted to its 5 year schedule, ending in 2015 (GGAT 2015a).

2.4 Palaeoenvironmental Evidence of Sea Level Change

As well as providing ideal preservation conditions, the palaeoenvironmental deposits, within which intertidal archaeological evidence is found, themselves provide a further dimension to our understanding of the direct effects of sea level change on the local environment; as a driver of environmental change, and on its inhabitants, along with insight into human utilisation and impact on the past landscape. In particular, changes in vegetation can reflect fluctuating environmental conditions.

This section introduces the sources of palaeoenvironmental evidence used to investigate environmental change in this study. It then introduces the likely vegetation communities encountered within intertidal palaeoenvironmental deposits, which will be used as evidence to infer past environmental change in this thesis.

2.4.1 Palaeoenvironmental Proxies

The layers within a sediment sequence itself can provide clues as to the environment that existed during material accruement. Changes in the sediment character can indicate different sources of sediment supply. For example, the presence of dark, fibrous peat is likely to be indicative of a damp freshwater environment, which facilitates the growth of the plants from which the organic material forms. The accretion of minerogenic (inorganic) sediments, however, is generally associated with water movement, such as tidal changes or fluvial depositions. A salt marsh would therefore be minerogenic in character, and in sites where sea level rise is expected to have occurred, presence of minerogenic sediments are likely to indicate an introduction of marine influence (Pratolongo et al. 2009, 92). However, to obtain an accurate understanding of the past environment, physical characteristics of that environment (proxies) preserved within the sediment deposits require analysis.

The following four environmental proxies, found within intertidal sediments, have been used in the research undertaken for this thesis:

Pollen

Pollen grains are produced by seed plants to aid germination and fertilisation, by providing a receptacle in which to transport male gametes or sperm cells to the female reproductive structure of a plant of the same species (Moore et al. 1991, 1). They are particularly resistant to decay due to the chemical structure of their outer walls, known as the exine. There are also clear variations in the form of the protective exine, which allows for direct identification to species (Moore et al. 1991, 2). Pollen can survive in any environment where microbial activity is suppressed, including waterlogged, saline, anaerobic or desiccated conditions (Moore et al. 1991, 2). These attributes make pollen a very useful tool in the reconstruction of past environments stretching back many thousands of years.

Pollen can be dispersed via a variety of different mechanisms. These include wind, rain, gravity and in-washing via drainage water, rivers, streams and tidal waterbodies. These dispersal mechanisms can in some cases, carry pollen grains away from their original source area. The density of vegetation can affect the movement of pollen. For example, in thick woodland pollen may not move large distances due to lesser air currents, whereas in open landscapes pollen can be blown further afield (Moore et al. 1991, 12-13). River systems can carry pollen away and even out to sea, to be deposited in a completely unrelated location. Conversely, still water bodies such as wetlands and lakes can provide a mechanism for pollen capture that prevents further movement of pollen grains. For example, pollen produced by aquatic species in these situations is expected to remain within the immediate surroundings of its source and is likely to represent a larger percentage of the overall pollen count than species from sources on the periphery of the pollen source area dispersed by wind (Moore et al. 1991, 13). All these factors must be accounted for when interpreting pollen data.

Pollen is sampled sequentially from column samples extracted from sediment sequences. By analysing the species of pollen represented within sedimentary deposits, it is possible to construct a picture of the environment, and how it changed through time. Changes in pollen levels for specific species can inform on both local and wider spread changes in vegetation, which can include transitions between open and enclosed, wet and dry, and freshwater and saline environments. The relationship between specific species and environments is covered in section 2.4.2 of this chapter. In some cases, the pollen record can also indicate human interaction with the environment, through the introduction of domesticated plant species such as cereals, or the growth/decline of certain species in archaeological record in conjunction with other factors such as charcoal or evidence of domesticated grazing (see below).

Indirectly, pollen can also be used to infer turbulence within the environment, as its absence or the inclusion of non-local species can suggest movement and mixing of sediments at a point in the history of the sequence (Caseldine 2000, 210).

Limitations

There are a number of limitations with the use of pollen for environmental reconstruction. These include differing preservation rates and issues regarding overrepresentation of certain species.

Preservation is an important consideration in analysing pollen. Some pollen grains are hardier than others, which can lead to underrepresentation of more delicate species. If the context from which samples have been taken has not maintained stable preservation conditions, this may affect the state of the pollen within. Also, during pollen processing, the chemical treatments used to separate pollen from its sediment matrix can affect the grains themselves, causing damage to pollen grains and difficulty in identification. For example, while the acetolysis method is useful in removing cellulose from the sample, it has also been observed to cause degradation of pollen grains, which can affect identification (Hesse and Waha 1989). Another side effect can be changes in the size of pollen, which is a problem in cases where size is the only discerning factor between species (*Poaceae* vs *Cerealia*). The use of glycerin as a mounting medium can also have this effect, whilst the use of Hydrofluoric Acid is known to cause shrinkage (Moore et al. 1991, 46).

Overrepresentation can also occur. Some species have a higher pollen output that others, meaning they can mask the influence of low pollen producers. Species such as alder and hazel are often overrepresented in the pollen record for this reason. This needs to be kept in mind when analysing the pollen present, in order that environmental indicators are not missed (Moore et al. 1991, 181). For example, at Pett Level on the East Sussex coast, the alder pollen levels would have led to the suggestion of an alder dominated environment, however the vast amount of physical tree remains present on site indicated the presence of species highly underrepresented in the pollen record, such as ash. Thus, the alder pollen was masking species with lower pollen yields (S. Timpany 2017, pers. comm.).

Resolution can also be an issue. If pollen preservation is bad, or time constraints are in place, it can be difficult to count enough pollen grains to create a statistically viable assemblage, which may result in unrepresentative results.

Diatoms

Diatoms are microscopic aquatic algal organisms with very specific environmental preferences depending on their species. They are found in sediments laid down in waterborne conditions. As with pollen, diatoms are highly resistant to decay. They are siliceous in structure and have clear species (or subspecies) specific characteristics, which allow for confident identification

(Zong and Sawai 2015, 233). Like pollen, diatoms are also sampled sequentially through sediment layers.

On a broad scale, they can be used to indicate fluctuations between freshwater and marine environments (Hill et al. 2007, 639) with concentrations of salinity dictating the potential species present (Zong and Sawai 2015, 234), but they can also be used to identify environments on a more specific level due to the fact different species can inhabit anything from wet soils or peats to mudflats, or open water (Zong and Sawai 2015, 233). Within open water settings, diatom species distribution is similarly diverse, with clear vertical zonation (Hill et al. 2007, 639) allowing for specific tidal zones to be identified in coastal deposits.

Limitations

Despite being a robust proxy, preservation within deposits, particularly those within the intertidal zone, is not guaranteed and can be affected by the mixing or washing of sediments caused by external factors such as storm surges or more long-term erosion. This was found to be the case within the Isles of Scilly, where diatoms do not survive on a universal basis (Ratcliffe and Straker 1996; Charman et al. 2016b).

Non-Pollen Palynomorphs

Non-pollen palynomorphs (NPPs) are fossilised fungal remains that can provide further information about the immediate environment in addition to and sometimes enhancing the pollen record. They are usually preserved in peat deposits formed in relatively dry conditions and are rarely found in sediments related to open water contexts (van Geel and Aptroot 2006, 325). NPPs are analysed alongside pollen and go through the same preparation processes.

Some NPPs are associated with specific types of plant, for example the occurrence of *Meliolia ellisii*, a parasitic fungi, on heather (van Geel and Aptroot 2006, 322) or *Ustulina deusta*, a parasite causing soft rot in a number of tree species which, unlike the pollen, cannot be spread further than the immediate area, indicating on site presence (van Geel 2002, 106). *Chaetomium* species can indicate decaying vegetation and are common in peat deposits (van Geel 2002, 107). Coprophilous, or dung fungi are associated with the presence of herbivorous animals (Cugny et al. 2010) and can most commonly include species such as *Cercophora-type*, *Podospora-type, Sporomiella* and *Sordaria* (van Geel 2002, 106; van Geel and Aptroot 2006, 324). Some species can indicate specific environmental conditions, for example *Valsaria* requires wet eutrophic conditions to thrive (van Geel and Aptroot 2006, 325). Fungi such as *Nerurospora crassa* are known to occur on burnt plant remains (van Geel and Aptroot 2006, 326). Non-pollen palynomorphs can also include algal spores where aquatic environments are present, and eggs belonging to parasitic organisms which are often associated with human or animal waste (van Geel 2002).

Limitations

As with pollen, there are limitations regarding the preservation of NPPs. Spores can be affected by the chemical processing of the samples, along with natural decay processes if the integrity of deposits is compromised. Most commonly, only spores with thick walls remain preserved (van Geel and Aptroot 2006, 326), meaning complete diagnostic evidence is unlikely to survive. Coprophilous fungi are often used as an indicator of potential human influence, however as will be explained in section 2.4.3, it is very difficult to tell between wild and domestic sources. Further factors, such as concentration of spores and contemporary human indicators must be taken into account in order to understand the role of humans in the landscape. Finally, the study of NPPs is in its infancy, meaning the full significance of this proxy is yet to be fully explored (van Geel and Aptroot 2006, 326).

Charcoal

Evidence for fire in the palaeoenvironmental record can be found in both the macroscopic and microscopic record. Larger macroscopic charcoal fragments, can suggest in situ burning (Simmons 1996, 118) and can also often offer information regarding affected species if identifiable remains such as seeds, leaves or larger wood particles displaying cell structure are present (Hather 2000, 18). In some cases charred trunks and branches may also survive, once again suggesting in situ burning (Bell 2007b, 322). Within the microscopic record, charcoal horizons can denote major burning episodes, while lower background signals might indicate an atmospheric signal denoting smaller scale burning within the wider vicinity. Species identification is possible at the microscopic level for some herbaceous species such as *Poaceae* and *Cyperaceae* (grasses and sedges) where cell structure is still visible (Dark 2007, 170).

Limitations

Micro charcoal suffers from similar issues to pollen, in that it is easily carried by the wind and so can be blown in from a wide range of sources (Dark 2007, 174). This makes interpretation difficult, and it is assumed that unless macro charcoal is present within a sample, burning has not occurred in the immediate vicinity. If no macro charcoal is present, the micro charcoal record is limited in its use, but fluctuations in levels can indicate potential changes in fire activity within the wider area. As with the other proxies utilised in this investigation, though human influence can be inferred, other factors must be accounted for if it is to be proven.

2.5 Potential Vegetation Communities

The vegetation communities described below are drawn from evidence collated from intertidal sites investigated in Britain, and specifically South Wales, as these provide the most likely comparison to the evidence obtained within this research. They include saltmarsh, reed swamp, tall herb fenland, ombrotrophic bog, carr woodland and deciduous woodland.

Saltmarsh:

Salt marshes develop in low energy coastal conditions (Packham and Willis 1997, 6). There are five categories of saltmarsh related to the physical landform in which they exist: open coast, back barrier, estuarine-fringing, embayment and loch or fjord-head (Packham and Willis 1997, 89). Open coast salt marshes require large areas of low-lying land and low energy tidal conditions. They are prevalent in the east of England, but less so in the rest of Britain, particularly on the western and Welsh coasts due to the higher energy tidal environment (Packham and Willis 1997, 89). Loch or fjord-head form within the sheltered heads of lochs or fjords. Within the British Isles, these are mainly confined to Scotland (Packham and Willis 1997, 87). Embayment marshes form in sheltered bays, which act as sediment traps. A number of embayment marshes exist on the southern coast of England including some of the large harbour bays, such as Portsmouth, Langstone and Chichester (Packham and Willis 1997, 89). On the southern Welsh coast, the submerged deposits at Kenfig indicate the presence of prehistoric salt marsh (Bennett et al. 2010, 73), which could potentially be the result of an embayment situation, with sediment sourced from Swansea Bay (Pye and Blott 2009, 40). The potential for further embayment deposits in South Wales is high, as sheltered bays are common along the coastline.

In Wales today most salt marshes are found within estuarine environments (Chapman 2008). Previously investigated prehistoric sites in South Wales have identified salt marsh environments related to estuarine conditions in the Severn Estuary (Aldhouse-Green et al. 1992; Caseldine 2000, 215; Allen and Yendell 2007, 210; Dark 2007, 192) and the Loughor Estuary (Edwards 2006). Much further west in Pembrokeshire, the possibility for the presence of back barrier systems has been raised (Murphy et al. 2014, 24). In Swansea Bay the Holocene sequence is described as consisting of a number of barrier beaches, often topped by sand dunes, protecting marsh and tidal flat deposits behind (Pye and Blott 2009, 39).

British salt marshes are predominantly minerogenic in nature (Packham and Willis 1997, 88). Accretion relies on the build-up of sediment suspended in the water and so areas with large amounts of sand or mud are likely to see saltmarsh formation if topographic factors allow.

Coarser sediments such as sand are likely to be deposited first in the lower margins, whereas finer silt and clay particles will stay in solution for longer, allowing them to reach the upper marshes. Most sedimentation occurs in areas with the least vegetation (Packham and Willis 1997, 99).

Salt marsh vegetation is unable to colonise until sediment reaches the correct height in relation to tide. Therefore in order to form, accretion of sediment will have already occurred prior to the onset of vegetation (Packham and Willis 1997, 89). Salt marshes are relatively species poor (Rodwell et al. 2000b, 17; Timpany 2005, 42). They consist of a mixture of halophyte species (those that exist specifically in salt water conditions) and other species (glycophytes) that are just as likely to exist further inland and in freshwater conditions. The concentration of halophytes to glycophytes depends on whether they are found in the lower, middle or upper salt marsh, with the lower containing more halophytes and upper more glycophytes (Rodwell et al. 2000b, 17).

There are three distinct zones within any saltmarsh: lower, middle and upper (Packham and Willis 1997, 107; Rodwell et al. 2000b). Tidal flooding occurs on a twice daily basis in the lower saltmarsh which is inhabited by the most saline hardy halophytic plants, which in prehistoric Britain included *Salicornia spp., Suaeda maritima* and/or *Puccinellia maritima* (Timpany 2005, 43) along with *Aster spp.* (Timpany 2005, 44). Vegetation diversity is lowest in this zone (Timpany 2005, 43). Through the middle zone, common species include *Juncus, Artemesia spp., Festuca* and *Plantago* (Timpany 2005, 44). The upper limits of the saltmarsh are defined by the highest possible astronomical tide height and flooding in this zone may only occur occasionally during the highest spring tides (Packham and Willis 1997, 87). Here species are tolerant to brackish conditions due to the mixing of the saline seawater with the freshwater from emergent groundwater (Packham and Willis 1997, 90). This zone is dominated by grasses (Timpany 2005, 44).

Within the prehistoric pollen record, salt marshes can be indicated through an increase in open herbaceous species such as grasses and halophytic species (Dark 2007, 174). On intertidal exposure sites in South Wales, the presence of *Chenopodiaceae* in particular has been highlighted as the main indicator of the presence or onset of tidal conditions in the vicinity (Caseldine 2000; Dark 2007; Timpany 2007). Chenopodiaceae are the largest family of halophytic plants (Alghamdi 2012, 9), including many of the halophytic species mentioned above, but at pollen level are difficult to distinguish from each other. Plants within this family are well adapted to a great variety of conditions including erratic variation in temperature, water supply and salinity. In order to cope in often inhospitable environments, the plants produce heteromorphic seeds; multiple seeds of often differing size, colour and shape, which can also have different rates of dispersal, dormancy and germination. This allows the best possible chance for reproduction. Other species groups with similar abilities include *Asteraceae* and *Poaceae*, both also common species within salt marsh environments (Wang et al. 2008, 757).

Reed swamp

Reed swamps are either permanently or intermittently waterlogged, often found on the fringes of larger waterbodies such as lakes, rivers, streams and estuaries as well as at the transitional edges of salt marshes, though they are not restricted to these environments (Rodwell et al. 2000a, 109). They are another example of a species poor habitat, however species within them are often hardy and tolerant to saline, brackish and freshwater conditions, so can be first to colonise areas as sea levels fall (Timpany 2005, 46).

Reed swamp acts as a catalyst for sediment accumulation, due to the close-knit vegetation which allows sediment to become trapped and settle in one place. This encourages the transition from aquatic to more terrestrial environments (Timpany 2005, 47). Evidence for this can be seen in the initiation of peat development, particularly following a minerogenic phase, as plant material begins to accrue. Species families such as *Phragmites*, *Cyperaceae*, *Poaceae* and *Typha* are all commonplace in reed swamp environments, along with the presence of aquatics such as algae and pond weed on water margins (Rodwell et al. 2000a, 117). The presence of water lilies (*Nymphaea alba*) and bulrushes (*Typha latifolia*) can indicate very nutrient rich sediments (Tansley 1939a, 34).

Reed swamp can be identified at a macroscopic level through the inclusion of *Phragmites* macrofossils within the sedimentary record, and this has been used to identify such environments at a number of sites on the southern Welsh coast (Aldhouse-Green et al. 1992, 26; Timpany 2007, 192; Sherman 2009a, 3; Murphy et al. 2014, 34).

In the prehistoric pollen record many of the reed and grass species will only be identifiable as *Poaceae* (Dark 2007, 192), but significant increases in this pollen along with the occurrence of species such as *Typha latifolia* along with freshwater aquatic species like *Potamogeton* and *Nymphaea alba* strongly indicate the onset of reed swamp conditions.

Tall herb fen

Tall herb fen vegetation forms as sediment accumulates within reed swamp, raising the surface further above the ground water level and allowing for species preferring a dryer environment to take hold. There are a number of different types of tall herb fen community identified in Britain, but all maintain a similar structure with a restricted number of core plants, including reeds and grasses coupled with a richer mosaic of understorey herbaceous species (Rodwell et al. 2000a, 117).

Phragmites and other grass species dominate, along with many different varieties of the sedge family (*Cyperaceae spp.*), including both the *Cladium* and *Carex* genera (Rodwell et al. 2000a, 118). Herbaceous species such as *Urtica, Galium*, *Filipendulum* and *Epilobium* amongst others can occupy the understorey along with shrubs such as *Salix* and *Alnus* saplings (Timpany 2005, 47).

In the macroscopic record, *Phragmites* rhizomes may again be identifiable along with seeds from the vegetation present if the correct preservation conditions have been maintained. This is more likely in wetter settings. In the pollen record, increases in *Cyperaceae* along with the presence of open environment species such as *Poaceae* and a greater increase in herbaceous plants in general will point towards a fenland environment.

In South Wales, tall herb fen has been recognised as a key phase in the hydroseral succession identified at a number of sites in the Severn Estuary, both in the macroscopic and microscopic record. *Salix* (willow) (Caseldine 2000, 216) and *Urtica* (nettles), along with flowering species such as, *Lychnis-type* and *Lotus-type* (Timpany 2007, 192) and *Hydrocotyle (Aldhouse-Green et al. 1992, 27)* have all been noted as indicators of tall herb fen, along with the occurrence of sedges and grasses. Further round the coast at Lydstep (Murphy et al. 2014, 36) the predominance of *Cladium* mariscus (great fen sedge) is also noted as an indicator.

Ombrotrophic Bog

Ombrotrophic, or raised bogs form when peat accumulations are no longer fed by groundwater, relying instead on precipitation to maintain bog conditions (Godwin 1981, 6). This type of environment is therefore almost exclusively climate driven and indicates that sea levels are not rising in the local vicinity as ground water is not an affecting factor.

Within the pollen record, an increase in *Calluna* (heather), often associated with the presence of *Meliolia Ellisii,* a parasitic fungus which thrives on heather, has been used to indicate that ombrotrophic bog has taken hold. Evidence for an increase in these species has been noted at Goldcliff, as well as in the Somerset Levels (Smith and Morgan 1989; Caseldine 2000; Timpany 2007). However, ombrotrophic bog does not appear to be present at Lydstep (Murphy et al.

2014), Kenfig (Bennett et al. 2010) or Uskmouth (Aldhouse-Green et al. 1992), suggesting that it is a more localised phenomenon, likely to be linked to topography.

Carr-woodland

Carr woodlands are a primary woodland, requiring wet to waterlogged soils and are often associated with fen peats or on the edges of flood plains (Rodwell et al. 1991, 83). The woodlands take hold once saplings established in the tall herb fen stage begin to spread and colonise (Timpany 2005, 48). In some cases this transition can be extremely fast, taking around 100 years (Timpany 2005, 50), which may put such a substantial environmental change within human living memory.

There are a number of different types of carr-woodland as defined by their species composition, the most common in South Wales having an *Alnus* (alder) or *Betula* (birch) dominance, though *Salix* (willow) can also be significant. The cause of one carr woodland species' dominance over the others is considered to be down to chance, however the floristic variation in the understorey will be based on the nutrients within the soil and climatic conditions, rather than the predominant species of tree (Rodwell et al. 1991, 30).

Carr woodland will form a thick dark peat within the sedimentary record, and often contain woody inclusions, sometimes in the form of felled trees and stumps within the peat itself. Tree remains have been identified in the upper submerged forest at Goldcliff where dominant taxa within the tree remains are listed as alder, birch and oak (Timpany 2007, 189-90).

In Prehistoric South Wales, alder appears to have been the dominant carr coloniser, with examples of alder carr being noted at nearly all investigated intertidal sites at some point in their history (Caseldine 2000; Dark 2007; Timpany 2007; Bennett et al. 2010; Murphy et al. 2014). It has been suggested that *Alnus* woodland (along with *Tilia* woodland) was the most dominant woodland within the Severn Estuary and Bristol channel area during the mid-Holocene, however this is not necessarily reflected in the pollen record (Timpany 2005, 35). At Uskmouth, in contrast, birch is seen to have a greater significance (Aldhouse-Green et al. 1992, 28) and this appears to be reflected to the west of the Goldcliff study area (Caseldine 2000, 217). Additionally, at points in the environmental sequence at Goldcliff and Uskmouth, willow is seen to become more dominant. Once willow carr was established at Uskmouth, alder was unable to recolonise until more drastic changes in groundwater levels occurred (Aldhouse-Green et al. 1992, 28).

Within the pollen record, the presence of high levels of any of the above colonisers along with aquatic species associated with a waterlogged environment would indicate the onset of a carr-woodland setting (Rodwell et al. 1991, 33). Due to the likely position of carr-woodland on the edge of swamp or fenland, species from these environments are also likely to be present.

Deciduous woodland

The now extinct ancient deciduous woodlands of Britain have been termed the "Wildwood"(Rackham 1990, 26). They thrived during the Mesolithic and Neolithic periods due to a climatic warm period, but became extinct after a series of subsequent cold periods during and after the Bronze Age (Rackham 1980, 97). Oak and hazel woodlands dominate the dryland wooded landscapes of South Wales from the Severn Estuary in the east (Smith and Morgan 1989; Timpany 2005, 35) through to Pembrokeshire in the west (Bennett 1989, 142),

Direct evidence for this dryland wildwood environment in South Wales are suggested to be seen in the lower submerged forest deposits within the Severn Estuary, where oak trunks and stumps dated to the early Mesolithic period (c. 6000 cal BC) have been identified within the peat at sites including Goldcliff East, Redwick and Gravel Banks, and at other locations in between (Bell 2007a, 36). Similar deposits have been identified around the British coast, with oak being the most dominant in the surviving remains, though this is suggested to be due to preservation rather than a true reflection of the environment (Timpany 2005, 41).

Dark (2007, 178) proposes that the presence of oak tree remains in the early Mesolithic deposits at Goldcliff indicate the presence of a dryland woodland, which was then inundated by sea water during a marine transgression, killing the trees. Oak remains are also reported in the upper peat deposits at Goldcliff. Timpany (2007, 192) states that the oaks here would have been part of the carr-woodland, colonising the wetland rather than being relics of a dry woodland landscape. Interestingly, it is also apparent that after inundation, these oaks took longer to die out than the alder trees, allowing them to remain growing within the landscape for some time post submergence (Timpany 2007, 198).

Further direct evidence for deciduous woodland, in the form of felled trees or stumps, is not readily available from the intertidal contexts so far studied on the southern Welsh coastline. Though other submerged forests remains do exist, for example at Broughton Bay and Whiteford Sands, initial analysis of species present has identified a community more closely resembling that of a carr environment, including alder and birch, though oak and hazel are also present (George 2015). This indicates that deciduous dryland woodland during the later prehistoric periods was located further in land, and not directly associated with the study sites.

The arboreal species identified within the pollen record provide evidence for the main character of the woodland. High levels of certain species will identify the most common within the woodland habitat. Density of woodland can be interpreted by the presence or absence of certain understorey species. Occurrence of *Ilex* (holly) or *Hedera helix* (ivy) pollen can suggest a more enclosed environment, whereas the presence of shrubby tree species such as hazel or an increase in herbaceous species will indicate a more open woodland or at least the presence of clearings within.

2.5.1 Drivers of Vegetation Change

While sea level change is the major focus of this thesis, other drivers of vegetation change must also be taken into account when interpreting palaeoenvironmental data. These include naturally occurring factors such as climate, fire, disease, the effect of grazing wild animals and events such as besandment; as well as human driven factors such as burning episodes, vegetation clearance and the introduction of domestic plant and animal species.

Natural Disturbance Factors

Climate

Changes in local climatic conditions can be inferred from the palaeoenvironmental record through changes in vegetation, particularly those denoting an increase in wetness. For example, evidence for the onset of ombrotrophic bog can indicate a period of increased precipitation (Godwin 1981, 6). An increase in windy conditions would have also had a significant effect on local vegetation. In extreme gales large areas of forest can be felled, creating gaps in the woodland canopy, which encourage light seeking species and younger saplings to thrive (Timpany 2005, 60).

A climatic deterioration in Britain has been identified in the late Mesolithic to early Neolithic periods through the reconstruction of surface wetness changes in peat mires, indicating a period of increased wetness (Bell and Walker 2005, 91). From the Neolithic period it becomes more difficult to disentangle natural climate change from that related to anthropogenic factors. However a further wet period is detectable around 4000BP, during the Bronze Age (Bell and Walker 2005, 89-92).

Fire

Natural wildfires in Prehistoric Britain would have most likely been caused by lightning strike (Simmons 1996, 127; Bell and Walker 2005, 31). However, it has previously been suggested that it would have been more difficult to burn Britain's deciduous woodlands than "almost any of the world's forests" (Rackham 1980, 103). This is due to the moist nature of the foliage and leaf litter within the understorey (Simmons 1996, 125; Timpany 2005, 65). Observations suggest deciduous woodland is still unlikely to ignite naturally, although there appear to be seasonal opportunities for fire to take hold; namely in the spring prior to leaf growth and then in the autumn once leaves have fallen, provided recent weather has been dry. If conditions are perfect, it is possible a lightning strike will cause a tree and its surrounding dry vegetation to ignite. However any resulting fire is likely to be confined to the immediate vicinity, the area affected measuring merely tens of metres (Simmons 1996, 121).

Resin rich coniferous species such as *Pinus* and *Abies* are particularly prone to ignition, and woodlands with high concentrations of such species can be subject to substantial fires (Simmons 1996, 124; Bell and Walker 2005, 185). However, these were not prevalent in early Prehistoric Wales (Bennett 1989, 143).

Disease

Diseases can cause catastrophic damage to the population numbers of any affected species, and lead to changes in the environment. For example, a disease that attacks a large and prevalent species of tree might lead to the opening up of woodland, which in turn could encourage the growth of different species of plant and tree more suited to open environments. This may attract animals to the area, potentially altering the vegetation record further (see section on wild animal grazing and browsing below).

Elm decline in the Neolithic is noted as a potential outcome of disease. It is of particular interest due to its potential bearing on the interpretation of the Mesolithic-Neolithic transition in Britain and its likely contemporaneity with the sequences investigated in this project.

Elm disease is caused by a fungus carried by host beetles which blocks the vessels that distribute nutrients through the tree, causing it to wilt and die (Parker et al. 2002, 22-23). More recent occurrences of the disease, affecting elm numbers in Europe (Dutch Elm disease), have led to suggestions of similar events in the prehistoric period (Perry and Moore 1987, 72). Studies found proportional reductions in modern day elm numbers due to disease were very similar to those noted in fossil studies (Perry and Moore 1987, 73). This is currently regarded as the main cause for this particular elm decline (Parker et al. 2002, 21). However, other possible explanations have cited climate change, human impact, soil deterioration and local competition as contributing factors (Peglar and Birks 1993, 61; Parker et al. 2002, 2).

There have been a number of reported elm declines through history, most recently in the 1970-80s (Perry and Moore 1987, 72) and also in the Anglo Saxon period (Rackham 1980, 266). The

Neolithic elm decline is a well-documented fall in elm levels in Britain and across Europe during the Neolithic period. Recent Bayesian analysis of related radiocarbon dates from 139 sites across Britain has placed this Elm decline event between 6347–5281 cal BP (4397-3331 cal BC) (Parker et al. 2002).

Evidence of a decline in elm has been noted at key coastal sites in South Wales, but the reasons for decline are not universal. At Lydstep in Pembrokeshire, although elm appeared underrepresented throughout the sampled sequence (thought to be due to filtering effects of the prevalent local alder population (Murphy et al. 2014, 31)), a slight decline was detected around 4200-3400 cal BC. It was concluded that this was more likely to be due to disease rather than human influence, as the decline in elm was accompanied by a rise in other arboreal species (Murphy et al. 2014, 36) indicating that wide scale deforestation was not occurring.

At Goldcliff, the decline has been dated to c.4900BP, in line with the general trend across Britain (Caseldine 2000, 219). It had been argued that this perceived elm decline preceded a period of human led clearance, meaning disease could explain the decline (Smith and Morgan 1989, 160). Caseldine suggests however that human activity may have been present in this landscape up to 200 years earlier than the decline, and could have had an impact on the elm populations (Caseldine 2000, 219). More recently Dark has suggested that changes in vegetation linked to the elm decline at Goldcliff are more likely to be resultant of hydrological changes, which could provide a link between localised elm decline and sea level change (Dark 2007, 185).

Interpretation of the elm decline is not as clear as its frequent casual usage in archaeological research might suggest. The extent and impact varies widely across Britain depending on the original extent of elm friendly habitat, and also the speed at which levels recovered, making comparisons between sites difficult (Parker et al. 2002, 3). The evidence cited above proves that it is very difficult to assign vegetation decline to disease and that all other potential corresponding factors should be considered.

Wild Animal Grazing and Browsing

Intensive wild animal grazing has been shown to prevent the regeneration of vegetation, which can lead to a block in vegetation succession and a reduction in certain species. Studies have shown that fluctuations between grazing and browsing species during the Holocene has had a direct effect on the composition of certain environments, particularly the understorey within forests and woodland (Bradshaw and Mitchell 1999; Timpany 2005, 66). For example, deer have been known to deplete localised holly and ivy populations (Rackham 1980, 20). Grazing from wild herbivores has been linked to the maintenance of open landscapes and woodland clearings as well as woodland edge plant communities (Bell 2007b, 321)

Wild animals can also facilitate the spread of certain types of vegetation. For example, at Goldcliff, caches of hazelnuts discovered in the deposits are cited as evidence for collection and burial by a number of different animal species, including squirrels, mice, voles and birds. It is proposed that these aided the spread of hazel stands from the source on Goldcliff island to wetlands as sea levels fell, initiating vegetation succession (Timpany 2007, 199).

Besandment

Movement of sand, whether by wind or tidal influence, can lead to significant changes in landscape, making it uninhabitable for many species. In time, however, it may become a habitat in its own right, in particular for herbaceous species: for example the Machair in the Outer Hebrides (Clarke and Rendell 2009, 35) and the substantial dune systems located around the coast of Wales (Williams and Davies 2001).

Human Disturbance Factors

Humans were environmentally destructive throughout prehistory, though it is suggested more so after the onset of agriculture (Nicholson and O'Connor 2000, v). Markers which reflect the impact of humans at different stages in prehistory can be identified in the palaeoenvironmental record from around 7000BP onwards (Behre 1986, VII).

Fire

Fire can be used as a clearance tool to clear areas of dense woodland in order to attract animals such as deer and wild boar, which could then be hunted. During the Mesolithic period, drops in arboreal pollen combined with a high charcoal signal are often used to identify a period of intense burning, possibly associated with human action (Mellars 1976; Simmons 1996; Caseldine 2000).

The burning of reed swamps has also been identified for the same period, at sites such as Star Carr in Yorkshire (Mellars and Dark 1998, 201) as well as at a number of sites in the Severn Estuary (Caseldine 2000, 183; Brown 2007b, 255-256). Direct physical evidence at Goldcliff was found in large quantities of microscopic charred grass remains within environmental samples from reed swamp deposits (Timpany 2005, 132). Reed swamp burning was undertaken in order to prevent succession and keep the landscape open, again in order to encourage animals and potentially improve sight lines for hunting or defence (Caseldine 2000, 183). Reed burning episodes at Llandevenny, Woolaston and Hills Flats in the Severn Estuary has been linked with seasonal activity, having been undertaken in the winter to early spring period (Brown 2007b, 262).

An increase in hazel has also been identified as correlating with burning episodes and Mesolithic remains at key British Mesolithic sites including Star Carr and Flixton (Smith 1970, 82). Smith relates this alignment with the Mesolithic population's use of fire to clear unwanted species, specifically to encourage hazel growth and increase the stock of hazelnuts. Simmons (1996, 126) suggests this theory is radical however, and others have highlighted that while fire is likely to have played a major role, this was not necessarily deliberate, and unique climatic conditions may have also played an important role (see above) (Huntley 1993, 215). There is burning of hazel woodland at Goldcliff alongside the apparent burning of reed beds. While this could be a deliberate move to encourage the regeneration of the plants to produce more hazelnuts, it is difficult to prove this in the pollen record. Other options, such as the accidental burning at the woodland edge in conjunction with the reed bed burning have also been suggested (Caseldine 2000, 183). As explained previously, fires could have natural causes. However, to make an impact in the wider environmental record, burning would need to be intense, extensive or frequent.

Evidence for human use of fire is maintained into and throughout the Neolithic and is likely to represent similar behaviour to that in the Mesolithic in encouraging useful species such as hazel or herbaceous landscapes to thrive. Wetland edge management through fire may also still be a resounding factor. However, it has been suggested that fire was used on a slightly smaller scale at this time (Brown 2007b, 262). In the later prehistoric phases, charcoal in the environmental record is generally seen as sourced from domestic fires, and large-scale burning episodes are less common (Buckland and Edwards 1984, 138).

Clearance Vegetation

Along with open area indicators such as *Poaceae* in the pollen record, an increase in species such as *Plantago lanceolata* and *Urtica* (nettles) can be indicators of human related disturbance (Moore et al. 1991, 189). *Chenopodiaceae* may be used as a disturbance indicator (Simmons 1996, 121), however local context must be taken into account. Within a predominantly arboreal environment a rise in *Chenopodiaceae* suggests disturbance, but in an open environment with the presence of minerogenic sediment within the sequence indicating marine inundation, *Chenopodiaceae* is used to identify the onset of salt marsh (Caseldine 2000, 60).

Introduction of Domestic Plant Species

The first appearance of cereals in the pollen record is generally seen as the indicator for the onset of farming in the Neolithic, with evidence from charred cereal grains suggesting first cultivation from c.3950 cal BC (Brown 2007a, 1048). Some have argued that earlier examples exist (Edwards and Hirons 1984; Innes et al. 2003), but the difficulty in distinguishing between some wild grasses and *Cerealia* means that many of these hypotheses are difficult to prove without further contextual information (Parker et al. 2002, 21; Bell 2007b, 339) or multivariate analysis (Tweddle et al. 2005). This is particularly true in coastal areas where wild grasses such as *Glyceria* can be prevalent. In these cases pollen grains are very difficult to distinguish from *Cerealia* (Dickson 1988).

Introduction of Domestic Animal Species

The effect of domestic animal species can be very similar to that of wild herbivores, leading to the maintenance of woodland clearances and open landscapes, and the potential decimation of certain species (Buckland and Edwards 1984). Domestic species may have been used to manage vegetation in the landscape in order to maintain certain environments to encourage certain resources or maintain ease of access.

The presence of herbivorous animals is indicated by an increase in coprophilous fungi within the microscopic environmental record. Though it is difficult to distinguish between wild and domestic from the presence of coprophilous fungi alone, high concentrations for an extended period of time suggest a relatively long term presence of herbivorous animals (van Geel 2002, 107) and therefore may suggest management by humans.

2.6 Modelling Sea Levels

In the previous sections of this chapter, the main drivers, effects and evidence for sea level change have been summarised, along with a selection of other factors that must be taken into consideration when investigating past environmental change. This section outlines how prehistoric sea level change is modelled and the limitations presented when used within an archaeological context.

There are two major approaches to modelling sea levels described below. The first utilises evidence from specific locations to indicate the relative level of the sea to land at specific points in time, and builds a model based on the combination of multiple measurements known as Sea Level Index Points. The second uses Glacial Isostatic Adjustment models based on the estimated size of prehistoric ice sheets to try to understand the effect of related isostatic and eustatic movements on sea levels.

Examples outlined in this section focus on how national and regional sea level models relate to the Bristol Channel, as the body of water associated with the South Wales coastline and the area under study in this thesis.

2.6.1 Sea Level Index Points (SLIPs):

Sea Level Index Points are obtained by taking samples from within sediment sequences that reflect environmental changes caused by or indicative of sea level change. Interfaces are identified between salt and fresh water environments using sediment characterisation and microfossil data, from sources such as pollen, diatoms and foraminifera. A SLIP can be created to represent the sea level at a specific time and place as long as the following four factors are known:

- **Location** in the form of geographic co-ordinates
- **Age** via a secure and calibrated radiocarbon date
- **Elevation** in relation to past and present Ordnance Datum
- **Tendency** - whether it is related to the increase or decrease in marine influence

(Shennan 2015, 8-14).

When all factors are known, SLIPs can be used to reconstruct a localised past relative sea level, and in combination with isostatic and eustatic models (see below) can contribute towards regional and national models (Bell and Walker 2005, 116). However, the following factors must be considered to ensure that the measurements taken are accurate:

Compaction

To estimate sea level change, the elevation of the deposit in relation to sea level at the time of formation is required. However, submarine deposits are liable to compaction due to overburden of later deposits, and in some cases the weight of the sea itself. It is therefore important to locate a basal deposit directly overlying the bedrock, where the elevation will not be affected by overburden. Later deposits indicating sea level change above can then be corrected for compaction relative to this fixed point.

Vertical displacement within a sequence is related to the deposit's height above the substrate. Though there is no universal methodology for compaction correction (Massey et al. 2008, 416), estimates in previous studies have suggested that with an overburden of 7-19m, a maximum of 0.2m vertical displacement would be applied to sediments within 1m of the basal substrate. However where overburden was less than 7m, displacement would be significantly less than 0.2m and may prove negligible (Gehrels et al. 2011, 122).

When developing the recent sea level curve for the Isles of Scilly, (Charman et al. 2016b, 182) disregarded the effect of compaction on the deposits analysed due to their shallow depths and therefore lack of deep overburden. A similar reasoning was given for sea level curves produced in the Severn Estuary (Bell 2007c, 218) and the Loughor Estuary (Edwards 2006, 578), suggesting that investigation of deposits within the upper intertidal zone do not necessarily require compaction to be taken into account, unless overburden is particularly substantial.

Secure Dating

Radiocarbon dates obtained for SLIPs must be taken from secure deposits free from mixing and contamination. This means that eroded contacts (where layers have been exposed for a period prior to being overlain), along with sequences displaying a prolonged hiatus in accumulation, should be avoided (Shennan 2015, 9). To obtain accurate chronologies, multiple dates are required from within the sequence to confirm the validity and integrity of the sample.

Indicative Meaning

Diatoms, along with other proxies such as Foraminifera, can be used to accurately establish the indicative meaning of a SLIP. This is the difference in height between a dated sediment and its contemporary mean sea level (Zong and Sawai 2015, 240). Indicative meaning is drawn from the modern vertical range of the specified proxy in relation to sea level (Horton et al. 1999, 117). Data is collected by conducting modern studies of similar environments to that inferred by the palaeoenvironmental data, often within the local vicinity, though this can be extended to include data from similar contexts across a wider area (Horton et al. 1999, 120).

2.6.2 Glacial Isostatic Adjustment (GIA)

GIAs provide simulations of past sea level change during the Holocene by combining models that simulate ice thickness and distribution, deformation of the Earth's crust due to ice load and subsequent redistribution of ocean mass. There are limits to the accuracy of such models when used on a site-by-site basis, due to incomplete field evidence drawn from seismic, geological and glaciological sources, meaning they are often used in conjunction with further evidence such as observational records and data provided by SLIPs in order to refine the results (Brooks et al. 2011, 575-576). GIAs are particularly relevant in the areas closest to former ice shelves, of which Britain is a prime example (Edwards 2006, 575; Massey et al. 2008, 415). Progress has recently been made in improving the accuracy of GIAs, enabling greater chronological definition in archaeologically significant 500 year time slices (Sturt et al. 2013). However, despite the increase in chronological resolution, the utility of such a model at a localised or even regional scale is still questionable given the lack of data points for any given location.

2.6.3 National Sea Level models

National sea level models for Britain have been created by Lambeck (1995), Shennan et al. (2000), Shennan and Horton (2002), Shennan et al. (2006) and most recently Sturt et al. (2013). They are formed using large scale Glacial Isostatic Adjustment models alongside data from regional investigations across Britain. Bell (2007e, 8) highlights the fact that the earlier versions were more focussed on the early Holocene. It is only the more recent attempts that have sought to take a more archaeologically focussed approach and extend models into the later Holocene (Sturt et al. 2013).

Figure 8 shows key stages in Holocene sea level change as extracted by Bell (2007e, 8) from national models created by Lambeck (1995) and Shennan *et al* (2000) and how they might have affected the Bristol Channel area. The model suggests modern day sea levels by 6000 cal BC, a claim that is refuted by more regional and localised data. However, more recent national models have excluded data from the Bristol Channel area due to questions of reliability, which will be addressed below. Shennan and Horton (2002, 521) state that records from South Wales in particular are *"too sparse to make reliable estimates."* This means that on top of the lack of relevance to individual sites already stated, these new models may not be representative of South Wales at all.

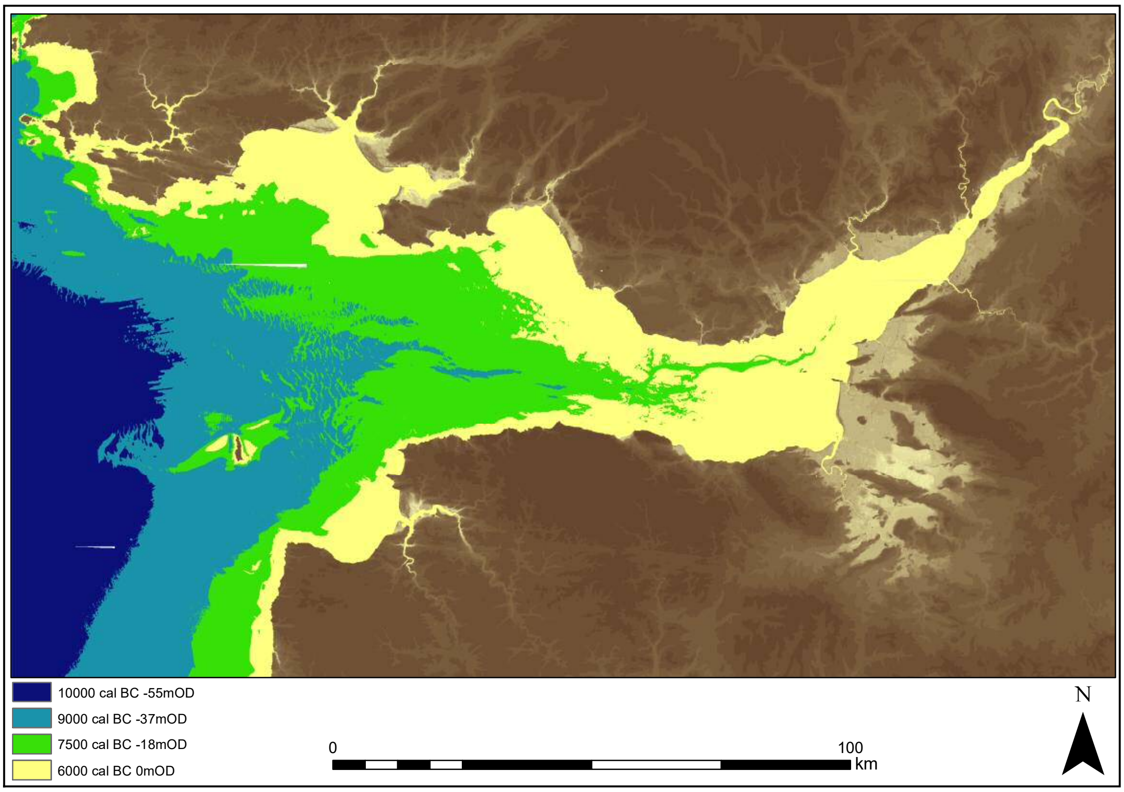

Figure 8: Holocene sea level change in the Bristol Channel derived from Bell (2007a, 8) from British sea level reconstructions by Lambeck 1995 and Shennan et al 2000 displaying very little definition from the Mesolithic period onwards. SeaZone Gridded Bathymetry [ESRI Shapefile geospatial data], Scale 1:50000, Tile(s): NW55150045, Updated: June 2017, SeaZone Solutions Ltd., Using: EDINA Marine Digimap Service, <http://digimap.edina.ac.uk/>, downloaded: September 2017. Bathymetric values have been corrected to display Ordnance Datum rather than Chart Datum using Mumbles tidal gauge correction. OS Terrain 50 DTM [Shape geospatial data], Scale 1:50000, Tile(s): SR89, SR99, SS38, SS09, SS19, SS39, SS48, SS49, SS58, SS59, SS, Updated: July 2015, Ordnance Survey, Using: EDINA Digimap Ordnance Survey Service, <http://digimap.edina.ac.uk/>, Downloaded: September 2017.

National models serve a purpose in identifying overriding trends, but without additional independent data points, they cannot provide an accurate representation of past sea level change and its effects at specific times and in specific places, and they can be misleading in their portrayal of such events. In an archaeological framework, the information provided by such models is limited, and those limitations described above suggest that a more localised approach would be better suited.

2.6.4 Regional Sea Level Curves

Sea level curves created on a regional scale are formed using field data in the form of sea level index points from several locations within a research area. This information is then combined to form an approximate profile of sea level change, as a generalised best-fit of the historic sea levels observed at each of the sites. They can help to build a picture of sea level change over a wider area, but at the cost of site-specific detail.

Sea level curves for the Bristol Channel have been produced by Hawkins (1971,1973), Kidson and Heyworth (1973,1978), Heyworth and Kidson (1982), (Scaife and Long 1995) and (Jennings et al. 1998). The most recent curve is based on 49 index points distributed across the Bristol Channel, a plot of which is shown in Figure 9 . Haslett et al. (1998, 197) identify South Wales as severely lacking in available data within the Bristol Channel curve. Of the 49 index points obtained in the Jennings curve, 11 were from the Welsh coast and are all from one site (Goldcliff) (Jennings et al. 1998, 166). Previous curves have also lacked Welsh data; Heyworth and Kidson's 1982 approach utilised six SLIPs from the southern Welsh coast, but again, three are from one location (Margam) (Heyworth and Kidson 1982, 104). The lack of Welsh data and geographical spread within that data is an issue most recently highlighted by the 2017 archaeological research framework for Wales, which states that Wales as a whole "lacks a coherent model for its coastline at a 'regional' scale" (IFA Wales/Cymru 2017b).

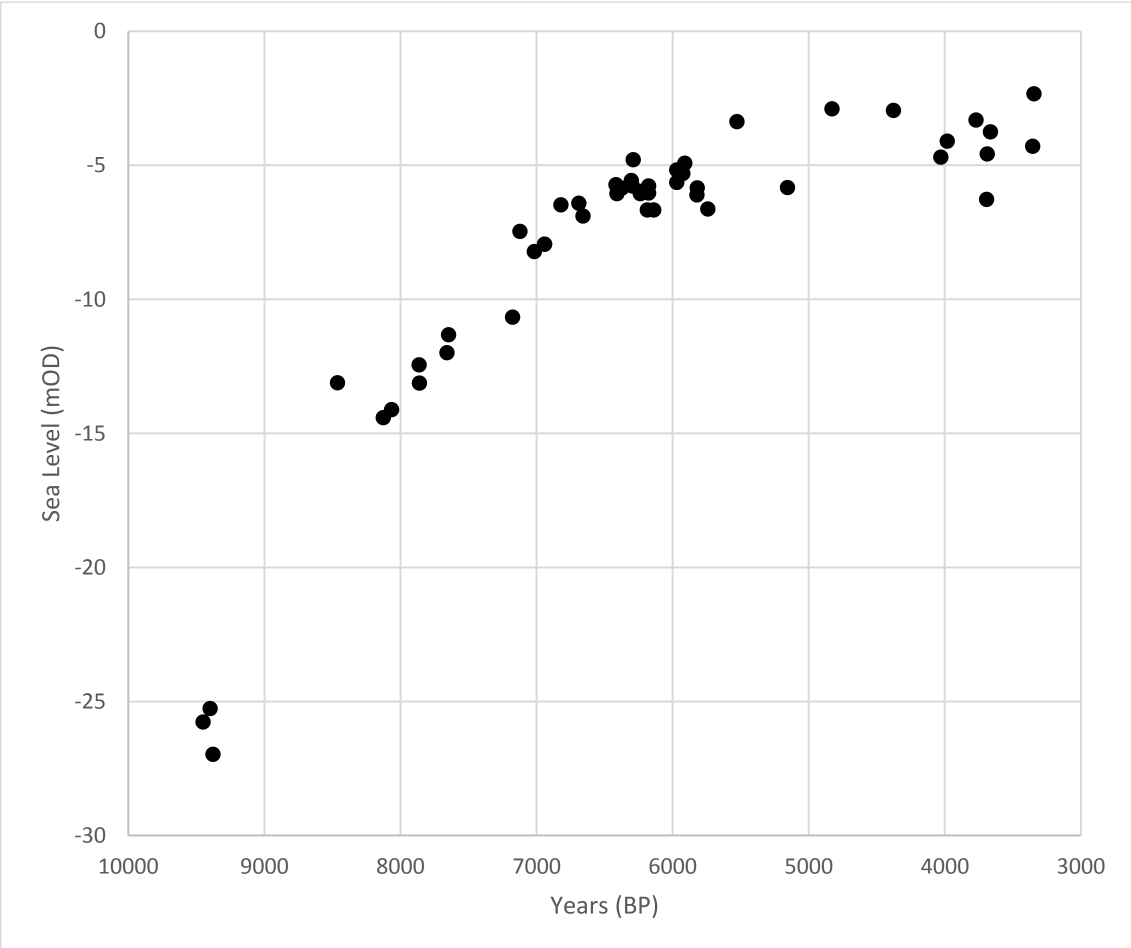

Figure 9: Graph to show distribution of SLIPs from the most recent Bristol Channel sea level curve. Data extracted from (Jennings et al. 1998).

The SLIPs used within the Jennings model demonstrate a key issue in such wide-scale data assemblages, in that different sites appear to have different sea levels at the same time. For example, at Goldcliff and Clevedon (Figure 10) there is over a metre difference in mean sea level at around 4227 BC. These two sites are almost opposite each other across the channel. (Jennings et al. 1998, 172) suggest this to be a legitimate finding due to the significant tidal range within the channel. Allen (2005) has also identified slight variations in sea level fluctuation based on geographic location. If this is the case, then it supports the concerns about the lack of localised data for the South Wales coast, as the sea level curves are based on data exhibiting a known, but unaccounted for variance. By reducing the data to a single representative curve, there is a risk that evidence of localised regressive sea level phases and other significant local phenomena can be lost.

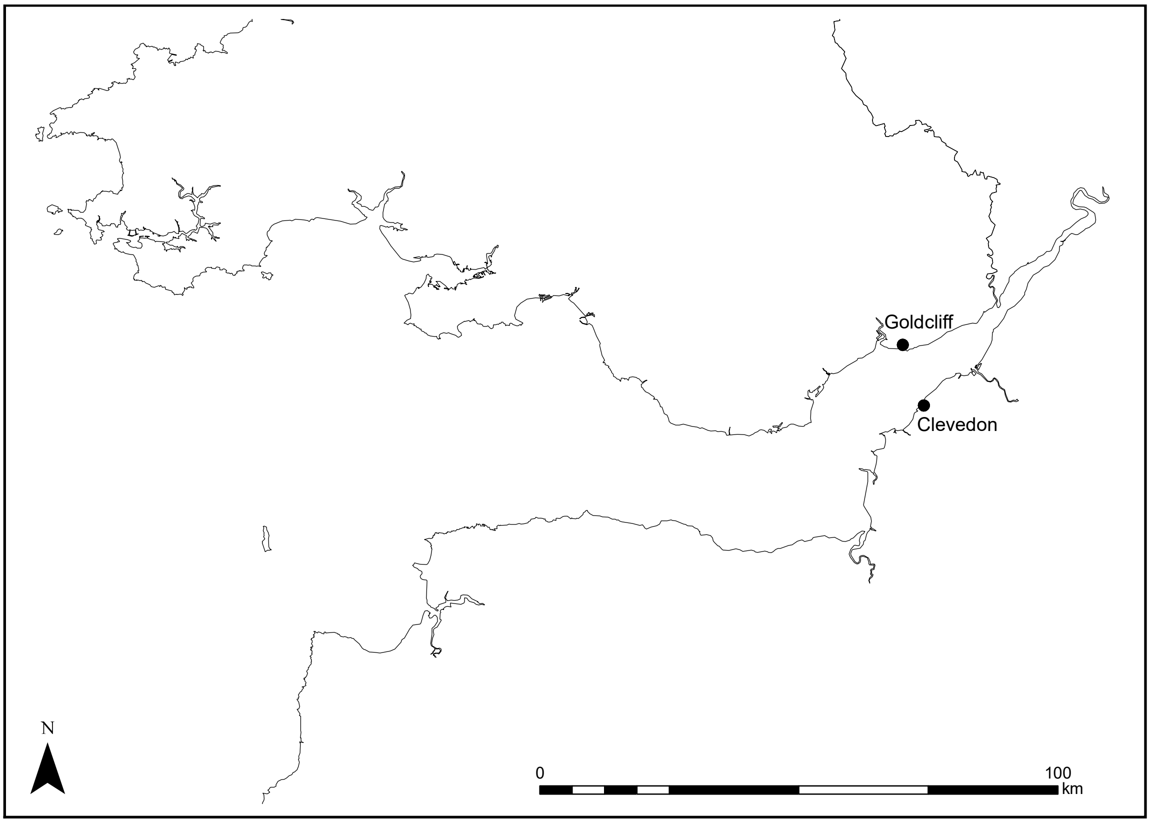

Figure 10: Location of Clevedon in relation to Goldcliff within the Bristol Channel area.

Additional to the lack of data, Haslett et al. (1998, 197) call further into question the reliability of the SLIPs used within the current regional curves, as a proportion have not been taken from basal sediments and do not take compaction into account. While studies such as Bell (2007c) have begun correcting for this effect on a local scale, as discussed in the next section, many of the existing SLIPs neither take compaction into account nor include the information required to do so.

Taken together, there is still a clear need for further, and better quality, investigation in the Bristol Channel, particularly in South Wales.

2.6.5 A localised approach

Recently a more localised approach has been taken to sea level research within the Bristol Channel area. Smaller scale investigations have been undertaken in the Loughor and Severn estuaries (Edwards 2006; Bell 2007c), which have combined new SLIPs from smaller research areas with those from pre-existing models. This has allowed a much greater temporal resolution to be obtained and it has been argued in both cases that the new SLIPs are more accurate because they are either unaffected by compaction due to the lack of soft Holocene sediments beneath the peat deposits sampled (Bell 2007c, 218), or take compaction into account (Edwards 2006). However, in both investigations the new data is still combined with the wider ranging and more generalised pre-existing sea level curves, such that the impact of any local tidal influence is effectively smoothed out. This may be necessary due to the lack of local data points but comes at the cost of local specificity, which is key to understanding the effect of sea level change on specific prehistoric communities.

2.6.6 Towards an archaeological context

By focussing on smaller areas, greater definition can be obtained when researching the effect of fluctuating sea levels on prehistoric coast lines. This is of particular importance when trying to understand these kinds of environmental change on a human level. Bell (2000c, 19) suggests that it is likely that inundations occurred in humanly perceivable phases and that it may be possible to interpret specific human responses from the archaeology. Localised data allows changes in sea level to be placed within generational time frames, which can then help to inform on behaviours and choices made by the human inhabitants, as indicated by the archaeological evidence left behind.

A clear theme on the interrelatedness of different scale models has also emerged, with the wider scale models relying on the smaller scale models to improve their accuracy. Therefore, by improving data definition at the smallest scale, this can positively influence future developments of the larger models.

This project proposes that only by approaching intertidal and sea level research on a site by site basis can we begin to understand these environmental changes within a human time frame, and within the specific context of the place affected. In focussing on individual sites, the opportunity to create new SLIPs is increased, which can then be integrated into far more accurate sea level curves and models at a local, regional and even national scale.

2.6.7 A note on deeper chronologies

While the lack of archaeologically useful sea level data for the later Holocene is a concern, there is also a lack of evidence pertaining to earlier sequences. This is highlighted in the approach taken by (Charman et al. 2016a, 193) in the Isles of Scilly, where mapping of modelled sea levels relied on the broader scale GIA based data early in the Holocene, from 9000 cal BC, and detailed data from the new localised sea level curve from 5000 cal BC onwards. This data distribution is representative of the availability of evidence, with later sources of dating material more easily accessible in the intertidal zone. It is an issue also observed in the Bristol Channel and around the Welsh coastline as a whole, with a lack of investigations into deposits within the subtidal zone (below 20m depth) (IFA Wales/Cymru 2017b, 13). Though sub-bottom profiling and boreholes have been utilised around the Welsh coastline, this has been restricted to areas of aggregate or gas and oil interest (Fitch et al. 2011; IFA Wales/Cymru 2017b, 14) and have not yielded sufficient environmental data from which to proceed. Such gaps in data have led to a limited understanding of offshore submerged landscapes in Britain (Brooks et al. 2011). This is a notable issue within the context of wider sea level research, even if not necessarily a problem for archaeological study within the later Holocene.

2.7 Summary

This chapter has outlined the causes and effects of sea level change, how these effects can be seen in the archaeological and palaeoenvironmental record, and how models are used to provide a picture of how sea levels have changed over time. It has specifically introduced the various potential outcomes from land loss and gain, in particular the changes in local vegetation that may occur and the positive and negative effects they can have on local human populations. It has also identified issues in using the inherently low-resolution sea level models for archaeological purposes.

The next chapter addresses the history of intertidal research, outlining the development of understanding in the intertidal zone from mythology to scientific investigation and how this has led to the development of integrated sea level and archaeological studies.

3 A History of Intertidal Curiosity

In Britain, intertidal prehistoric remains in the form of peat beds and submerged forests representing previous land surfaces have invoked interest throughout history, and Wales has often been at the forefront in terms of developments in research approach. This chapter gives an account of the evolution of intertidal curiosity in Wales, from the earliest recorded acknowledgement in 3.1, through myth and legend in 3.2 and into the introduction of scientific study in 3.3. The development of an interdisciplinary attitude to intertidal research is outlined in 3.4 and an overview of the new approaches being developed in modern studies is provided in 3.5. The chapter is summarised in section 3.6.

3.1 Earliest acknowledgements:

The earliest written reference to intertidal deposits in Wales and potentially in Britain comes from the early 12th century chronicler Giraldus Cambrensis, who described a storm in St. Bride's Bay, west Wales that:

> *"…laid bare…the surface of the earth which had been covered for many ages and discovered the trunks of trees cut off, standing in the very sea itself" (1189; 2001 edition, 37).*

In his account Cambrensis recognised the fact that the land has become submerged and, noting axe tool markings on the tree trunks, suggested that it had happened within a human timescale. He cited Noah's flood as one possible reason for submergence, but interestingly, also appeared to have been open to more scientific interpretations, suggesting the land could instead have been submerged:

> *"…in ancient times, by the violence of the sea always overflowing its bounds and encroaching on the land" (Cambrensis 1189; 2001 edition, 38).*

This early acknowledgement of the effects of sea level change was remarkably close to the truth, however further scientific explanation remained elusive for many centuries, with most accounts based on myth and legend.

3.2 Myth and Legend:

As this thesis will demonstrate, in Britain, archaeological evidence shows that rising sea levels have indeed caused the inundation of areas of land, leaving glimpses of those past landscapes within the intertidal zone as peat deposits and submerged forests. Attempts to explain the effects of sea level change can be found within legends and mythology. Such stories are often presented as truth (Nicolaisen 2013, 993), based on long held oral traditions and apparent generational memories. They often include loss of land, cities and palaces.

However, the available evidence points to these inundations happening many thousands of years ago, and not necessarily being caused by the catastrophic flooding events so often cited in the stories (see following examples). Though it is possible that changes occurred within humanly perceivable time frames (Bell 2000c, 19), recent high resolution sea level studies have shown that sea levels have not risen dramatically within the past 4000 years (though it is clear smaller scale localised rises do occur, likely as a result of storm surges) (Sturt et al. 2013, 3975). This leads to questions about the validity of such stories and whether other factors may be involved.

3.2.1 The Atlantis effect

By far the most famous submergence legend is that of Atlantis, an island lost beneath the Atlantic Ocean along with the highly advanced civilisation that supposedly inhabited it. Though popularly believed to have been sourced from communal knowledge of a catastrophic inundation event (Naddaf 1994, 189), the story is the invention of the Greek philosopher Plato (Gill 2017, 1). It is believed (by both ancient and modern scholars) that Plato used it as a device to explore philosophical ideas (Gill 2017, 1). Despite this, the myth has persisted in popular culture and is often revisited by the modern media when submerged archaeological remains are discovered. A cursory Google search returned three separate "Atlantis proving" archaeological discoveries in 2017 alone (Griffiths 2017; Martin 2017; Nevett 2017).

"Britain's Atlantis"

In the modern day, the Atlantis story is often used, again particularly in the media, to describe discoveries closer to home. For example, the phrase "Britain's Atlantis" has been used to recently describe the lost port of Dunwich on the East Coast of England, submerged due to coastal erosion (BBC 2013; Smith 2016; Briggs and Connor 2018), and Doggerland, the submerged North Sea landmass that once connected Britain to Europe, inundated due to rising sea levels following the last ice age (Waugh 2012; Keys 2015; Freeman 2017). Despite the attempt to sensationalise these events, both are well documented and understood.

The loss of lands to a mysterious and sudden inundation has been integrated into much longer-lived British myths and legends. A famous example is the late 16th century legend of Lyonesse, a submerged land lying between Cornwall and the Isles of Scilly. Here it is said that multiple towns and 140 churches were suddenly engulfed. To substantiate the claim, testimony from fisherman is used describing masonry and window fragments brought up with their nets (Charman et al. 2016c, 23).

3.2.2 Welsh examples

There are a number of famous British legends surrounding inundation attributed to Wales. These include the stories of Llys Helig and Cantre'r Gwaelod, both of which describe kingdoms lost to submergence in the 6th century (Edwards 1849; Bromwich 1950; Senior 2002). Llys Helig is supposedly situated 2 miles off shore on the north coast of Wales between Penmen Mawer and Gogarth (North 1940) and Cantre'r Gwaelod within Cardigan Bay on the west coast of Wales (Edwards 1849) (Figure 11).

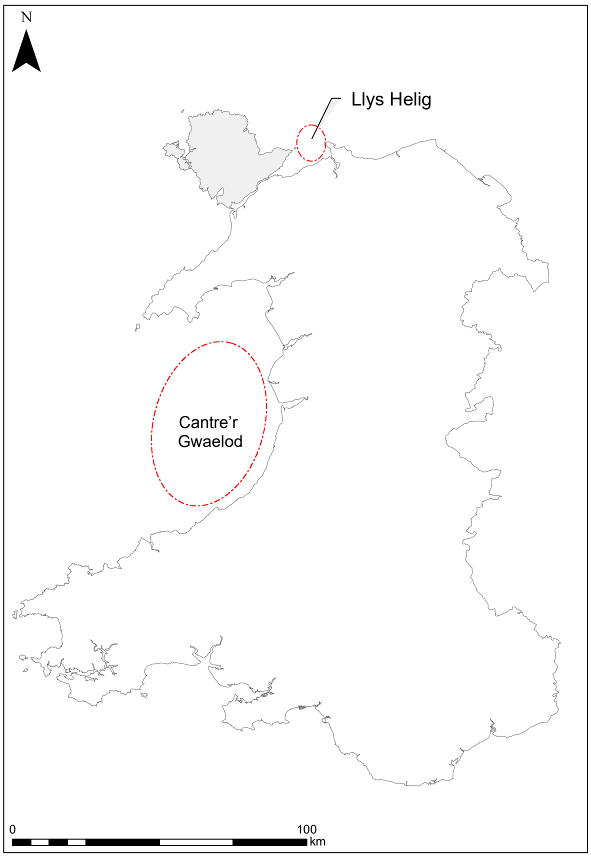

Figure 11: Approximate locations of the two submerged kingdoms mentioned in the legends of Cantre'r Gwaelod and Llys Helig (Edwards 1849; North 1940).

Though mention of the individual, Helig, and an inundation is noted in the 13th Century *Bonedd y Saint* within the Peniarth Manuscript No. 16 (Senior 2002), the written form of the Llys Helig story is first found in a 17th Century manuscript known both as: *An Ancient Survey of Penmaenmauer*, a title attributed by its 19th century publisher, and its original title: *Notes to bee observed before you let your Survay passe your hands* (North 1957, 19). The manuscript was originally attributed to Sir John Wynn of Gwydir, (North 1957; Senior 2002, 17), but is now believed to have been written within Wynn's lifetime by a different, unknown author (Senior 2002, 24). This early version is simplistic, referring to part of the territory of Helig ap Glannawg being lost to an inundation. Helig and his people retreat to higher ground to save themselves and look over the scene, mourning the loss of:

"…soe ffayre, soe ffruitful, and soe ffeartill a countrey beyinge beaten backe with unpleasant, over- whelmynge waves…" (Unknown, communicated by Wright 1861, 141).

Helig is believed to have lived between AD 634 and 664, placing the inundation within the 7th century (Rees 1836, 301; North 1957, 21), though an inundation is also claimed to have occurred in the 6th century (mistakenly cited as 5th century in text (North 1957, 22)), which engulfed the entirety of the North Wales coast (Edwards 1914). This account has been widely acknowledged as lacking in substance, and is seen as an indication that the legend had become cemented within an accepted local history (North 1957, 22; Kingshill and Westwood 2012).

The Cantre'r Gwaelod legend also appears to originate in the 13th century from a poem in the Black Book of Carmarthen (Bromwich 1950, 217), produced around AD 1250, though the exact date is unknown (Pennar 1989, 9). The poem describes the submergence of lands belonging to Seithennin, caused by the misdemeanour of Mererdid, the "fountain cup-bearer" (Bromwich 1950, 222). In the 17th century "Cantred Gwaylod" is mentioned within the same *Notes to bee observed…* manuscript as the Llys Helig story. The area is mentioned as part of the lands ruled by Helig that are affected by the inundation. This suggests the supposed inundation affects large swathes of the North and West coast of Wales and provides a potential link between the two stories, placing both legends in the same time frame and potentially same event (Unknown, communicated by Wright 1861, 141). Once again, the early version of the legend does not offer in depth description or explanation and despite the apparent 7th century placement of the event, no earlier references to either story are apparent.

During the 19th and 20th centuries, both legends are embellished and become much more elaborate. In the case of Llys Helig, further characters are introduced along with a prediction generations earlier that a catastrophic flood would occur in vengeance of the crimes of Helig's ancestors (North 1957, 16). Themes of gluttony and alcoholism also become prominent. In these later versions, rather than Helig and his people surviving, most perish due to becoming intoxicated at a feast, with only the harpist (often portrayed as pure and good in Welsh mythology) surviving (North 1957, 96-97).

This is a theme that also carries in a later version of Cantre'r Gwaelod, where Seithennin is depicted as a drunkard who fails to close the sluices of the dykes that drained the land, causing it to flood and all but a select few to perish (North 1957, 148). None of these details are found within the previous versions of the stories and are likely to have been added by their reporters in order to make them more interesting to the mainstream, rather than the previous confined audience of scholars and "the curious reader" (North 1957, 243). In the case of Cantre'r Gwaelod in particular, it is found in manuscripts related to the 18th century inventor of the Bardic tradition and well-known literary counterfeiter, Iolo Morgannwg (Löffler 2007, 1), which has led scholars to cast doubt on the provenance of later interpretations (North 1957, 152; Senior 2002, 34).

These embellishments may have served further purpose than merely clarifying details within the stories. Bromwich (1950, 240) highlights "ecclesiastical influences" in the drowning of sinful acts and saving of the good and pure, and temperance principles can be seen in the negative portrayal of alcohol in some versions. The legends appear to become more politicised, perhaps playing on a public appetite for heroic mythology and links to a forgotten past.

Similarities

(Doan 1981, 80) suggests that the Llys Helig and Cantre'r Gwaelod stories are so similar that they may well have originated from the same source and later been adopted by the separate communities of Cardigan and Conwy Bays as their own. The inclusion of Cantre'r Gwaelod within the 17th century version of Llys Helig, as part of Helig's affected land, may also add credence to this theory. More recent speculation has suggested, however, that the two stories are separate, but explore the same inundation event in different locations (Senior 2002, 27).

Similarities have also been drawn further afield, with Bromwich (1950) and Doan (1981) highlighting the distinct resemblance between Cantre'r Gwaelod and the Breton Legend 'Ker Is.' The associated poems are remarkably similar, provoking the suggestion that the author of the Ker Is poem borrowed heavily from the Cantre'r Gwaelod, however further research has suggested that individual submergence folktales may well have existed at both locations prior to their immortalisation in popular fiction (Doan 1981, 82) and that similarities in format may come down to a shared approach to traditional Welsh and Breton storytelling (Bromwich 1950, 16).

Proof?

Despite blatant elaboration and exaggeration during the later periods, many people sought to prove the legends to be true, particularly that of Llys Helig. There were a number of expeditions to the site of the supposed submerged palace in Conwy Bay. In 1816, Edward Pugh claimed to have seen the remains of a stone causeway and suggested that this credited the legend as being true (Pugh 1816, 41). In 1864 an expedition was made by Charlton R. Hall and the Rev. R. Parry. They claimed to have seen seaweed on the surface of the water that appeared to run in regular lines and that stone could be felt beneath, suggesting a manmade structure with a courtyard or interior space. Once again this was deemed sufficient evidence to indicate that the legend was based on truth (North 1957, 72).

The legend was still capturing the imagination of visitors into the 20th century. In 1908 William Ashton visited the area on an extremely low spring tide. He too noticed the lines of "stones" topped with seaweed and suggests that they were so straight in form, that there could be no explanation other than human construction (Ashton 1920, 199). However, he suggested that rather than buildings, the walls might actually represent boundaries (Ashton 1920, 200). This was supported by the Llandudno, Colwyn Bay and District Field Club who visited a year later, (North 1957) and claimed a lack of mortar indicated the remains were collapsed walls, rather than structures (North 1957, 201). As late as 1913, Ashton's interpretation was still being supported, after a plan matching his description was produced by Horace Lees on visiting the site.

Throughout this period, despite some differences in the interpretation of the perceived layout, all but Lees, who entertained the possibility that the supposed remains might be Roman in origin (Ashton 1920, 202), remained wedded to the idea that this was the palace belonging to Helig. North suggests that the differences in interpretation of the layout of said remains comes down to the differing states of tide, combined with the acute angle from which they are viewed (the site can only be viewed from a boat, but covers a large area and so right angles and straight lines may be seen that would not be apparent if viewed from above (North 1957, 75). He also draws attention to the fact that most of the observations are based on the seaweed and not the physical stones, meaning it would be very difficult to draw full conclusions as to the layout of the supposed remains.

Having visited the site himself in 1939, North stated that there was actually “no regularity” in the layout of said stones and that they were categorically not walls (North 1957, 76). He acknowledged that some of the stone could be said to appear faced, but that this was likely to be due to natural processes. The presence of non-native stone, another factor which has been presented as “proof” that the supposed structures were manmade, was suggested by North to be related to glacial drift (North 1957, 78). A similar formation can be seen at Degannwy on the coast to the east of the supposed submerged remains, which North surmised would present a similar scene to that of Llys Helig if partly submerged (North 1957, 81).

January 1607

The fact that both Cantre’r Gwaelod and Llys Helig begin to become popularised in the 17th century may not be a coincidence. In January 1607, the Bristol Channel and Severn Estuary were subjected to extensive flooding, which affected the Welsh coastline from Carmarthenshire to the head of the Severn Estuary (Bryant and Haslett 2002, 163). Eyewitness accounts described the destruction of houses four miles inland (Bryant and Haslett 2002, 164) and flood waters 2-3m deep (Horsburgh and Horritt 2006, 272). The waters are reported to have caused damage to property and land in 26 parishes, with many local inhabitants drowned, along with livestock and crops (North 1957, 88). It is likely that these events, though not local to the sites of the famous legends, may have influenced the contemporary development of the stories, inspired by widely distributed pamphlets detailing the event (North 1957; Bryant and Haslett 2002; Horsburgh and Horritt 2006). North suggests that prior to the writing of manuscripts such as “*Notes to bee observed…,”*stories such as Cantre’r Gwaelod and Llys Helig were not widely known, despite the 13th century reference, and that aspects may well have been a creation of the author (1957, 84). Interestingly, despite the 1607 flood, there are few inundation legends on the same scale as those from the North West on the southern coast of Wales. This is not to say that they do not exist at all (a selection are discussed below), but they certainly do not hold the notoriety of those from the north.

Further to the 1607 Bristol Channel flood, during the late 16th century, climatic conditions had worsened in Europe leading to a number of fatal flooding episodes, particularly on the continental coast of the North Sea (Lamb 1977, 199). The spread of news from such events may well have influenced the popularisation of submergence legends in Britain.

Inundation Legends in South Wales

Though the famous legends surrounding inundation are centred on the north and west coasts of Wales, there are also tales of inundation that occur on the south coast. Rhys (1901, 402) refers to stories told by "the old people" of Swansea Bay, which describe Coed Arian or Silver Wood, a forest that stretched from the Mumbles foreshore, all the way to Kenfig Burrows, effectively filling what is now Swansea Bay. Rhys also mentions the "sunken meadows of Grove Island," where trawlers had reported seeing the foundations of "ancient homesteads overwhelmed by a terrific storm which raged some three centuries ago" (1901, 402). Grove Island was supposedly part of land belonging to the Angel family, which extended out from Oystermouth, at the western end of Swansea Bay and is said to be where their house was situated (Morris 1964, 70). The reference to an event 3 centuries ago might again suggest a link with the 1607 storm surge, though it is unlikely that the supposed lost land was actually within the bay and may instead represent the destruction of a homestead further inland. Interestingly both stories are still cited within the local community today, despite archaeological evidence proving that peat deposits within Swansea Bay date, at the very latest, between the late Iron Age and early Roman period (Sherman 2011, 1).

Explaining the unexplained

Though the 1607 flood is likely to have inspired many of the adaptations to the original legends, the fact remains that submergence events were referred to from the 13th century onwards. There is no direct evidence, physical or historical, to suggest that any kind of flooding events occurred affecting the north and west coasts of Wales during the 6th or 7th centuries AD, when Cantre'r Gwaelod and Llys Helig are supposed to have occurred. This is despite other notable events, such as a solar eclipse, earthquake and very hot summer all being recorded (North 1957, 54). It is unlikely that an event such as this would have been ignored by contemporary commentators.

Instead, perhaps a more straightforward explanation can be gleaned in the origin of such tales. The 12th century record of a beach stripped bare to reveal a long-lost landscape, shows that evidence for prehistoric submergence was, at least periodically, accessible prior to the earliest known versions of the Welsh submergence legends. Without scientific knowledge, the remains of trees and soils submerged by the tide may have been difficult to understand. Bromwich suggests that the stories are likely to have derived and then mutated from a desire to explain these natural phenomena without the scientific knowledge to do so (Bromwich 1950, 241). As the scientific advances detailed below began to emerge, these stories became further mythologised, but are often still quoted as potential truths.

3.3 Scientific developments

The advancement of scientific knowledge and techniques led to the development of more in-depth investigations within the intertidal zone and clearer understanding of the effects of past environmental changes and their climatic drivers. Many of these advancements originated in research undertaken in the intertidal zones of South Wales itself. This section describes the chronological development of intertidal research, focussing on the main instigators.

3.3.1 Environmental Pioneers

Hamon

Initial investigations of submerged deposits relied on macroscopic plant remains and wood identification. Swansea Bay in South Wales became the focus of one of the earliest studies in Britain, with the first recorded reference to intertidal deposits noted by Isaac Hamon in 1657 (Emery 1965, 98). He described seeing submerged tree and roots at Oystermouth and recognised that sea levels had risen.

Moggridge

These deposits were not investigated until the construction of Swansea Docks in the 19th century, when a number of peat layers were identified in the section during the docks' excavation (Moggridge 1856). Tree species were identified from plant macrofossils found within the peat indicating the presence of oak, beech, birch, alder, hazel and crab-tree (Moggridge 1856, 170). Moggridge noted a lack of Coniferous trees and the presence of reeds and grasses, suggesting a mixed environment of open land and wooded areas. This appears to represent some of the first environmental assessment done, certainly in Swansea bay and potentially in Britain. In a nod to the submergence legends described above, Moggridge mentions the local legend of Silverwood, a forest that supposedly stretched from Oystermouth across the Bay. However, though he suggests the remains are part of an ancient forest, he falls short of linking them explicitly with the legend (Moggridge 1856, 170).

Reid

Reid is often perceived as a pioneer of intertidal research (Grant and Sturt 2017). In publishing "Submerged Forests" in 1913, Reid introduced a scientific approach to intertidal remains. His study described the broad range of evidence present around the British Isles, encompassing much of the east coast and its estuaries, the southern Atlantic coast, and most importantly for this study, he included the Bristol Channel and Irish sea, highlighting in particular deposits discovered in the construction of Barry Docks (Reid 1913, 52). Reid drew attention to the links with past climate and sea level change (Reid 1913, 108) as well as acknowledging the role of human influence on the vegetation record (Reid 1913, 111) and noted the archaeological potential offered by such deposits (Reid 1913, 113). Reid recognised that previous work had been undertaken on submerged forest deposits (1913, 10), but highlighted that it had often been done "unsystematically" or from only one academic viewpoint – generally geological. In doing so he was an early advocate for approaching intertidal evidence in a multi and interdisciplinary manner:

"…it is well to bear in mind the probability that here geology, archaeology, and history meet and overlap." (Reid 1913, 120)

Reid acknowledged that full understanding had not at this time been achieved. Rather he sought to draw attention to an area of research, which he saw to have been neglected (Reid 1913, 107). His approach paved the way for more recent integrated research, including this project.

Cundall, Landman and George

Investigations into intertidal peats remained focussed on the identification of macroscopic remains into the 1920s and 1930s. In 1925, peat exposures including tree stumps were identified in Swansea Bay at Blackpill and West Cross (Cundall and Landman 1925, 20). These deposits were identified again five years later by George (1930). He described peat deposit stretched between "Vivian's Stream and Oystermouth Station" visible around the high water mark and passing under the sand and inland (George 1930, 101). This would suggest exposed peat extended all the way from the Mumbles to Brynmill, around half of Swansea Bay. George also noted the discovery inland of peat to the east of this area, acknowledging occurrences at Victoria Station, the aforementioned docks and in the Sandfields District (between Brynmill and the docks). Deposits were once again mentioned specifically at Blackpill and West Cross (George 1930, 101). George also identified the species of tree from within the peat, although it is unclear whether this relates to a specific peat shelf, or the overall environs of Swansea bay (George 1930, 102).

Von Post et al

By 1930, the approach to intertidal study had begun to change. Von Post is recognised as having pioneered palynology as an approach to past environment interpretation in 1916 (Edwards 2017a). Some of the earliest intertidal pollen studies were conducted in Swansea Bay at Blackpill in 1930 by Von Post (1933), where he identified a transient marsh environment. Elsewhere in

Wales, others soon followed suit, with early coastal and submerged pollen work being conducted at Ynslas (Godwin and Newton 1938), Abergele and Rhyl (Bibby 1940).

Godwin

It was Godwin who carried forward and further developed the new palynological techniques to investigate coastal peat deposits specifically. In doing so he became known as the pioneer in pollen analysis within intertidal research (Bell 2007e, 5). He initially undertook research in Wales at Borth and Ynslas (Godwin and Newton 1938) and then moved south to further Von Post's research in Swansea Bay (Godwin 1940). This led to research in the Somerset levels (Godwin 1941) and eventually to a national synthesis of coastal peats throughout the British Isles (Godwin 1943), forming the basis for later investigations into Britain's prehistoric vegetation and establishing palynology as a major contributor to intertidal research, which continues to this day.

3.3.2 Sea Level Studies

Between the 1960s-1980s investigation of tidal peats using the methods developed by these environmental research pioneers became synonymous with the study of past sea level change, in particular dating of inundation phases within the environmental record (Bell 2007e, 5). These studies developed to encompass greater areas and approach bigger climatic research questions, leading to the precursors of the regional and national sea level models discussed in Chapter 2. While these models were not archaeologically focussed, they provided a foundation on which more archaeologically relevant projects could be built, as is explained in the next section.

3.4 Interdisciplinarity

In the last 20 years, the focus of intertidal research has been on interdisciplinary approaches. Multiple studies have been undertaken in the intertidal zone around Britain to understand environmental and archaeological changes and activities that took place in and around the now submerged landscapes. Major research projects such as the Somerset Levels project (Coles and Orme 1980), the Hullbridge Survey (Wilkinson and Murphy 1995), Langstone Harbour (Allen and Gardiner 2000a), the Humber Wetlands survey (Van de Noort 2004), investigations in the Severn Estuary (Bell et al. 2000b; Bell 2007d), the Lyonesse Project in the Isles of Scilly (Charman et al. 2016c), and investigations at Pett Level (Timpany 2018), have all undertaken an interdisciplinary approach. They all incorporate environmental and sea level analysis with archaeological investigation in order to fully understand the sites in question and how humans reacted to changes in climate and landscape. These projects have contributed valuable data, allowing the construction or reworking of local and national sea level curves, which in turn has helped to highlight areas of archaeological potential. Some of the most recent research is outlined in the following case studies:

Severn Estuary

Since the formation of the Severn Estuary Levels Research Committee (SELRC) in 1985 (Whittle and Green 1988, 12), a highly co-ordinated approach to research in the Estuary has been undertaken, which has led to regular publication of research through the SELRC series: *Archaeology in the Severn Estuary* (SELRC 1990-Present). The quantity of literature available demonstrates the sheer volume of research that has been (and is still being) undertaken in the area. Much of the research undertaken has utilised and in some cases helped to develop integrated methodologies that have led to a wealth of knowledge regarding the development of the historic (and prehistoric) environment within the estuary.

The investigation and description of the Wentlooge Formation, which represents the sedimentary deposits laid down during the Holocene (Allen and Rae 1987) has led to further studies in the Severn Estuary embracing an integrated approach, and in particular considering the effect of sea level change in relation to the archaeological evidence. The formation, split into Lower, Middle and Upper phases (Table 1), represents trends in environmental change that occurred over long periods of time from an archaeological perspective providing an overall environmental framework within which local archaeological evidence can be contextualised.

Lower Wentlooge	Mesolithic - Neolithic	Deposition of estuarine clays followed by a deceleration in sea level rise. Open environment consisting of mudflats and saltmarsh, with some regressive periods leading to more freshwater and/or dryer land conditions. Archaeological evidence related to both regressive and transgressive periods.
Middle Wentlooge	Neolithic – Iron Age	Episodes of freshwater peat formation interspersed with estuarine silts and clays suggesting short lived marine transgressions. Lower peat beds dominated by reed beds, but as deposits thicken there is evidence for a transformation from reed swamp to carr woodland dominated by alder and then willow. Towards the end of the phase raised bog begins to form in places.
Lower Wentlooge	Iron Age – Roman	Marine silts and clays begin to form as a result of estuarine sedimentation and indicating that sea levels have risen once again.

Table 1: Descriptions of each phase of the Wentlooge Formation derived from Bell et al. (2000, 329-330)

By far the largest interdisciplinary contribution to research in the Severn estuary has been led by Martin Bell. Along with a large team of collaborative specialists, Bell has investigated intertidal sites on both sides of the Severn Estuary in order to provide a narrative of archaeological and environmental change from the early Mesolithic communities, through to the Iron Age (Bell and Neumann 1997; Bell et al. 2000b; Bell 2007d,2013d). Evidence from the key sites of Goldcliff (Bell et al. 2000b; Bell 2007d) and Redwick (Bell 2013d) has been combined with previous studies at Uskmouth, Magor Pill and Cold Harbour (Whittle et al. 1989; Aldhouse-Green et al. 1992) and wider scale intertidal surveys both within the estuary itself and extending to the rest of Wales' coastline (Bell 2007e, 3) to create a comprehensive understanding of environmental change in relation to archaeological evidence.

In specific archaeological terms, the research has highlighted the high potential for the existence of Mesolithic and early Neolithic archaeology within the intertidal zone (Bell 2007b, 342). The research has shown human interaction within a wetland setting throughout a period of continuous environmental change caused by fluctuating sea levels. It is suggested that rather than disrupting human activities in the area, changing environments encouraged the exploitation of the diverse resources on offer and made the coastal margins and freshwater wetlands highly attractive to local inhabitants (Bell 2007b, 321). This continues to be a theme into the Bronze and Iron Ages where once again, transgressive periods appear to attract human activity in these areas (Bell 2000a, 349).

The combined research has also produced extensive palaeoenvironmental data, which represents a significant proportion of the available data within Wales as a whole, particularly from lowland and coastal contexts, which were lacking prior to these investigations (Caseldine et al. 1990, 17; Bell 2000d, 6). The evidence collected has produced a localised interpretation of sea level change, which begins to question the validity of regional and national sea level models within an archaeological context, as discussed in Chapter 2. The research has also developed intertidal fieldwork methodologies, which have been consulted in the development of this project.

Lyonesse Project

The Lyonesse project aimed to reconstruct the Holocene environment and the progression of sea level change in the Isles of Scilly, while assessing the impact of marine transgression on the islands' inhabitants through time (Charman et al. 2016c, 26). It addressed concerns about the reliability of previous sea level change models and created new sea level index points to plot alongside pre-existing points (Charman et al. 2016b, 169). This was combined with palaeoenvironmental analysis, topographic survey and investigation of the archaeological record (Charman et al. 2016c, 17). Crucially, the project developed a methodology for intertidal survey and analysis which has been adapted and utilised in this investigation (see chapter 5).

The project identified and recorded both known and unknown intertidal and subtidal peat deposits on eight of the islands within the archipelago (Mills 2016, 29). An updated sea level curve was created for the islands after generating new Sea Level Index Points (SLIPs see section 2.2), which showed that the rate of change fluctuated, with lower sea levels present during the Mesolithic period than had been previously suggested and opening up the possibility of further archaeological potential within the intertidal zone. Periods of substantial land loss were identified during the Mesolithic and again in the late Neolithic to early Bronze Age period (Charman et al. 2016a, 185). These later changes are suggested to have evoked possible reactions from the local populations, with the construction date of Bronze Age entrance graves coinciding with a period of substantial land loss (Johns et al. 2016, 206). The project also drew attention to the abandonment and rebuilding further inland of an Iron Age settlement at Halangy as a potential reaction to later marine transgression (Johns and Mulville 2012, 186), indicating that later transgressions were still substantial enough to be humanly perceived.

Pett Level

Some of the most recent integrated intertidal investigations have been undertaken on the intertidal peat and submerged forest at Pett Level in East Sussex (Timpany 2018). An assessment of the intertidal remains was undertaken to improve understanding of the submerged palaeoenvironments in the area. The project was also used as a way of further developing methodologies in working in the intertidal zone, both to engage the public and improve strategies within the commercial sector. Their approach included the use of drones to accurately record deposits from the air (Zoe Hazel, Historic England, pers. comm.). This and the involvement of the general public on the ground was deemed particularly important in terms of ongoing monitoring of the effects of coastal erosion on the deposits at the site (Timpany 2018, 3).

Prehistoric human-environmental interactions once again formed a major focal point for the research (Timpany 2018, 5). The palaeoenvironmental deposits spanned from the Mesolithic period through to the Bronze Age and once again identified non-linear trends in the environmental changes related to both transgressive and regressive periods of sea level change. New relative Sea Level Index Points were obtained and will be used to contribute to local sea level studies in the future (Timpany 2018, 59). As this project is still at initial assessment phase, no further sea level interpretation was gleaned from the data at this stage, but the act of creating index points demonstrates the fact that integration of archaeological, palaeoenvironmental and sea level studies has become the norm in intertidal research.

3.5 New Approaches

Large scale research projects such as many of those listed above are reliant on the availability of funding, which is becoming more difficult to obtain in the current economic climate. As such, the days of large area research appear to be waning, with the focus turning to individual sites and finds rather than larger intertidal landscapes. The Pett Level project bucks the trend slightly, but while it had academic objectives, the project was conducted as both a community and commercial venture, a trend that is being seen throughout intertidal research.

Community

A "Citizen Science" approach has been used to bring previously unknown exposures and archaeological features to light, whilst also monitoring known features. Successful projects have included the Arfordir Project in Wales (GGAT 2015a), the Shorewatch Project in Scotland (SCAPE 2018b) and the CiTIZAN project in England (MOLA 2014). These projects have created standardised approaches to intertidal recording and provided training for the public in order to encourage them to record discoveries in the intertidal zone, often through online systems. The intent is to build up a picture of the extent of archaeological and palaeoenvironmental remains within the intertidal zone that might otherwise go unrecorded.

Commercial

A potential answer to the lack of further investigation may be found in a commercialised approach. As mentioned in Chapter 2, development in the intertidal zone has become increasingly common in recent years. Prospective infrastructure projects such as the proposed Tidal Lagoons in Swansea and Cardiff (Tidal Lagoon Power Plc 2018) and the nuclear power station at Hinkley point (EDF Energy 2010) have led to archaeological evaluation taking place within the intertidal zone. This kind of development provides opportunities for developer-funded research, but does require understanding and support from local authorities.

In the subtidal zone, an example can be seen in the West Coast Palaeolandscapes Survey (Fitch et al. 2011). The project was funded by the Marine Aggregates Levy Sustainability Fund and Aggregate Levy Fund for Wales, which were set up to offset the environmental impact of aggregate production (BMAPA 2011) and utilised data obtained by commercial bodies predominantly from the petroleum industry (Fitch et al. 2011, 19). It used pre-existing 2D seismic survey data to attempt to characterise the submerged prehistoric landscape within the Bristol Channel. The project highlighted areas with high archaeological potential within the subtidal areas of the Bristol Channel (Fitch et al. 2011, 52), but also demonstrated the potential for developer sponsored research.

3.6 Summary

Though the approach to the study of the intertidal zone has changed through time, interest in submerged and intertidal archaeology has continued to grow, as can be seen in the increasing involvement of the public in related research. It is interesting to note that Wales has often been at the forefront of the development of intertidal research, from the first records to the creation of specific mythologies, and from the development of new scientific techniques, to the utilisation of public and commercial resources. However, there is still much that can be gleaned from the many submerged and intertidal and archaeological deposits that remain unstudied along the Welsh coastline.

This research follows the lead of its interdisciplinary forerunners and will utilise the techniques, methodologies and approaches that have been developed previously, while also critiquing and adapting aspects to the specifics of this particular project. It will combine archaeological, palaeoenvironmental and sea level change evidence to produce as comprehensive a study as possible within the research constraints. Specifically, it will look to develop methodologies that fit limited budgets, partially out of necessity, but also to explore and develop strategies for the commercial sector, where time and budget may be limited. It is here that the future of intertidal research lies.

The following chapter begins this task by identifying the sites within the study area outlined in Chapter 1 that have the most potential to provide new data and fresh context to established archaeological frameworks

4 Initial Surveys

This chapter outlines the initial surveys undertaken in order to identify unstudied intertidal sites within the stretch of the South Wales coastline chosen (as outlined in Chapter 1) for further investigation in the form of palaeoenvironmental and archaeological analysis.

Section 4.1 documents the desk-based assessment, followed by walkover surveys undertaken in order to identify accessible sites with exposed peat and submerged peat deposits that had not been fully investigated. The target area was restricted to the coastline running between Cardiff and the Loughor Estuary, as an area comparatively underrepresented in the field of intertidal research in South Wales. A more targeted topographic survey was then undertaken after the specific study sites were selected.

Section 4.2 outlines the subsequent archaeological survey that has been undertaken in order to identify all known archaeological sites within the wider local vicinity of the sites chosen for further study. The purpose of this survey was to provide a broader archaeological context for the archaeological and palaeoenvironmental outcomes of the project. Archaeological data was sourced from publicly accessible historic environment records and mapped according to period and site type. The temporal constraints of the archaeological survey were determined by dating evidence cited in sources obtained during the desk based intertidal survey.

4.1 Intertidal Deposits

4.1.1 Desk-based Preliminary Peat Survey

A desk-based assessment was undertaken to identify all known and potential intertidal peat and submerged forest deposits within the South Wales study area outlined in Chapter 1 in order to identify potential sites to become the basis of the palaeoenvironmental and archaeological investigations within this study.

The assessment was initiated using the most recent survey of coastal peat (Bell 2007d) to provide baseline data of known intertidal peat exposures and submerged forest remains. These records were then augmented by the addition of all known peat exposures identified in the local Historic Environment Record (accessed via the online Archwillio application (GGAT 2015d)), the Glamorgan Gwent Archaeological Trust's Historic Landscape Character Area (HLCA) reports (GGAT 2006a), along with past research papers and publications. This methodology was based on a similar survey conducted by English Heritage for the English coastline in 2008 (Hazell 2008). General internet searches were also conducted to obtain public sightings and personal accounts of exposures within the study area. By combining evidence from public sightings with official records it was possible to ascertain that significant exposures existed along the southern Welsh coastline and that a number remained unexplored in an official capacity.

Most potential study sites were identified via documented accounts of intertidal peats or submerged forests and a number were included because of the presence of peat discovered through the construction of docks or through boreholes. In these cases, it was proposed that the intertidal zone should be investigated for any traces of related deposits, though it was also accepted that construction of docks and localised dredging activity were likely to have caused disruption to localised deposits.

Three sites were included that did not have any recorded relationship with peat, however their surrounding topography is similar to sites with known outcrops and so they were deemed worthy of further investigation. Pre-recorded archaeological evidence directly related to the deposits was also noted.

Once sites had been initially identified, further internet-based research was then undertaken using Google Maps to assess the potential to undertake fieldwork safely investigate issues such as land ownership and ease of access with cumbersome equipment.

4.1.2 Desk-based Survey Results

Twenty-two sites of potential interest were identified during the desk-based survey of the study area (Figure 12). Source data and descriptions of each site including related archaeological evidence can be found in Appendix 1.

4.1.3 Preliminary site visits

Where possible preliminary site visits were undertaken at potential sites to gauge the feasibility of further study. At 10 of the sites, walkover surveys were conducted to assess whether exposed deposits were present. Descriptions from these visits are in Appendix 2 and a summary of findings is presented in Table 2.

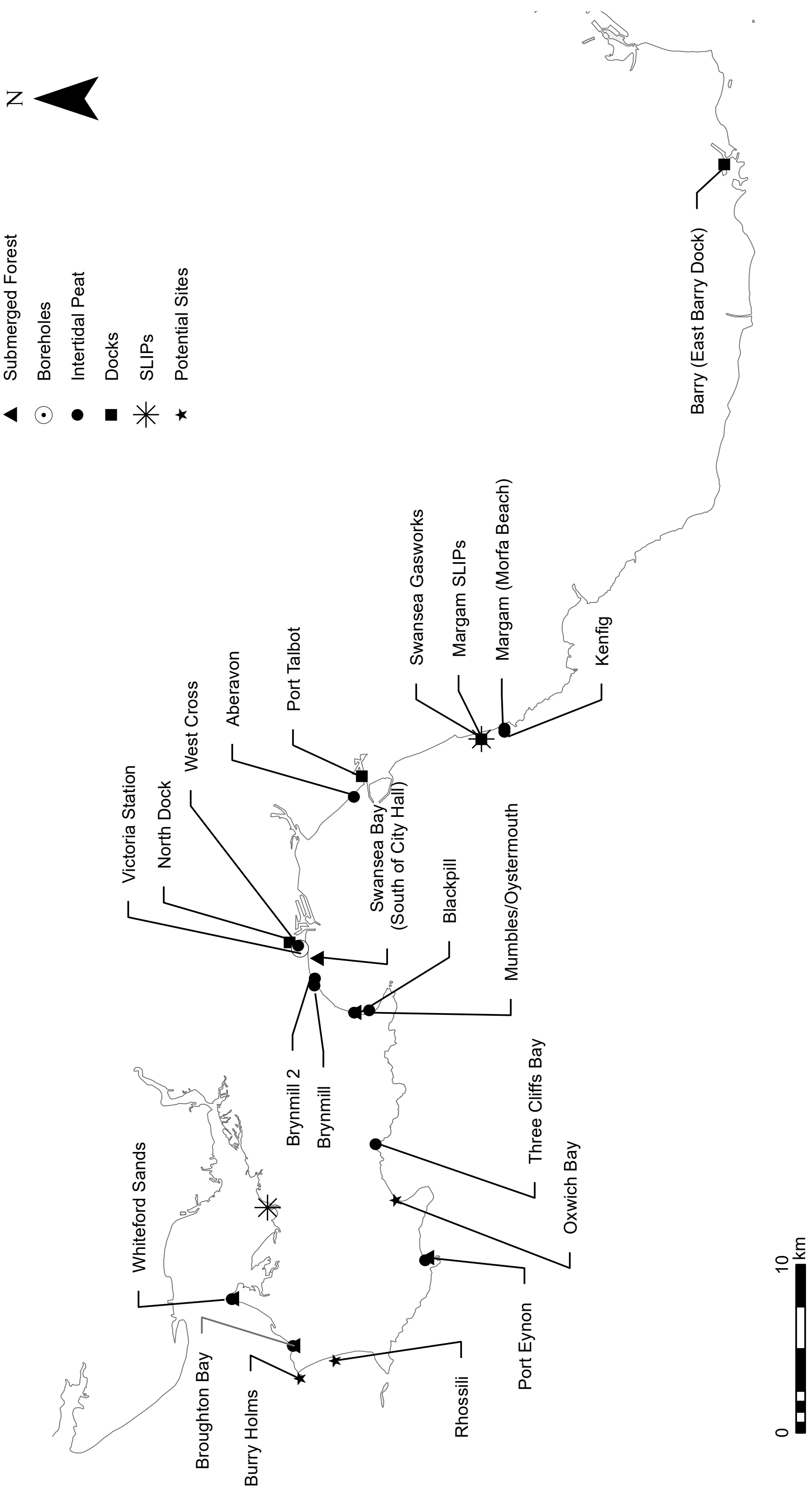

Figure 12: Map showing location of all known and potential peat from preliminary desk-based assessment

SITE	DATED	ARCHAEOLOGICAL EVIDENCE	ENVIRONMENTAL EVIDENCE	ACCESSIBLE	VISITED	CHOSEN	REASON
Aberavon	NO	YES	NO	YES	NO	NO	No in situ evidence
Barry (East Barry Dock	NO	YES	YES	NO	YES	NO	No longer accessible
Broughton Bay	**NO**	**YES**	**YES**	**YES**	**YES**	**YES**	**Evidence present. Not previously investigated.**
Burry Holms	AWAITING PUBLICATION	YES	NO	YES	YES	NO	No exposed palaeoenvironmental deposits present
Kenfig	YES	YES	YES	YES	NO	NO	Previously investigated
Margam (Morfa Beach)	NO	YES	YES	NO	NO	NO	Privately owned, potentially hazardous site.
Margam SLIPs	YES	NO	YES	NO	NO	NO	Not accessible
Oxwich Bay	NO	NO	NO	YES	YES	NO	No exposed palaeoenvironmental deposits present
Port Eynon	**NO**	**YES**	**YES**	**YES**	**YES**	**YES**	**Evidence present. Not previously investigated.**
Port Talbot	NO	YES	YES	NO	NO	NO	Not accessible
Rhossili Bay	NO	NO	NO	YES	YES	NO	No exposed palaeoenvironmental deposits present
Swansea Bay (Blackpill)	NO	YES	YES	NO	NO	NO	No exposed palaeoenvironmental deposits present
Swansea Bay (Brynmill 2)	NO	NO	YES	YES	YES	NO	Excluded from study (see below)
Swansea Bay (Brynmill)	YES	YES	YES	YES	YES	NO	Excluded from study (see below)
Swansea Bay (South of City Hall)	NO	NO	YES	YES	NO	NO	Excluded from study (see below)
Swansea Bay (Mumbles/Oystermouth)	YES	YES	YES	YES	YES	NO	Excluded from study (see below)
Swansea Bay (West Cross)	NO	NO	YES	NO	NO	NO	No longer accessible
Swansea Bay (North Dock)	NO	NO	YES	NO	NO	NO	No longer accessible
Swansea Bay (Victoria Station)	NO	NO	YES	NO	NO	NO	No longer accessible
Swansea Gasworks	NO	NO	YES	NO	NO	NO	No longer accessible
Three Cliffs Bay	NO	NO	YES	YES	NO	NO	Poor Access
Whiteford Sands	NO	YES	YES	YES	YES	NO	Poor Access

Table 2: Summary of results from initial survey

4.1.4 Site selection

Several of the sites investigated in the initial survey were discounted from further analysis for the following reasons. All the sites initially discovered during dock excavations were no longer accessible. Where access to the beaches adjoining the entrance to the docks was possible, for example at Barry, the area was surveyed for potential intertidal deposits, but none were identified. The sites at Port Talbot and Margam were not accessible due to being under private ownership and in hazardous locations. Rhossili Bay, Burry Holms and Oxwich Bay were surveyed, but no intertidal deposits were identified. At Kenfig, a substantial investigation had already been undertaken addressing both the palaeoenvironmental and archaeological evidence (Bennett et al. 2010). The site was therefore not investigated directly as part of this research, but the results from the previous investigation was used as a comparative case study.

Substantial intertidal deposits were identified at several sites in Swansea Bay and on the Gower Peninsula. Though work on the deposits in Swansea Bay would be beneficial in furthering the understanding of the archaeological and environmental development of the bay, a number of factors led to the decision to discount it from this research project. The bay itself covers an expansive area and intertidal deposits cover substantial areas of it. This would have made transportation of equipment difficult and decreased the amount of working time available within the tidal window, while increasing the risk of being cut off by the tide. Swansea Bay also presents hazards in the form of areas of quicksand and the risk of unexploded ordnance. Also, as research had been conducted on a number of the deposits in the recent past (Nayling 1998a; Sherman 2009b,2010,2011), it was decided to incorporate previous research and discount Swansea Bay from this study, focussing instead on previously unstudied sites in more manageable locations.

The remaining four potential sites were all situated on the Gower Peninsula. Gower has been highlighted as an area lacking in palaeoenvironmental analysis (Caseldine et al. 1990, 123) despite having a high density of archaeological sites (Davidson 2002, 5; Nash 2015, 35). Of the four sites identified as potential candidates, two were discounted. Three Cliff's Bay was deemed difficult to access with equipment due to the distance between the beach and the nearest car park. Whitford Sands was also eventually discounted due to its large size and difficulty in reaching deposits within the tidal window. This left Broughton Bay and Port Eynon, which are described in the next section (Figure 13).

Figure 13: Location map of chosen study sites

Broughton Bay

Intertidal Deposits

Peat deposits were first recorded at Broughton Bay by T. Neville George (1930) who noted peat from just below the high water mark to around the mid-tide point. George suggested that the peat was similar in character to that which he had seen both at Port Eynon and Swansea Bay. There is no mention of intertidal peat or submerged forest remains in the historic landscape characterisation or the local HER, however an online blog post by a local inhabitant from 2009 suggests that the peat and submerged forest became exposed during the 1980s (Winder 2009).

No modern palaeoenvironmental investigation has been carried out, but tree stumps, branches and plant remains found on the surface of the peat have been identified as birch, hazel, alder, oak and reeds (G. T. George 2015, 135).

Archaeological Evidence

The historic landscape characterisation mentions “a few prehistoric finds” being discovered on the beach and mainly consisting of animal bone (GGAT 2006c). One example is listed on the HER as an Aurochs bone, suggesting the peat to be prehistoric in nature (GGAT 2015b), but unfortunately very little else is listed. Gareth (George 2015, 135-6) describes finding potential evidence for a Neolithic occupation site in 2008, consisting of a thin layer of clay with three sharpened wooden posts, deer rib bone fragments with butchery marks, tooth and flint microlith alongside a flat stone with evidence of charcoal and bivalve shells. It is unclear whether this interpretation has been confirmed or how dating was determined. It is also unclear as to where on the beach this observation was made.

Dating

Local archaeologists have previously confirmed that no research has been undertaken to date the submerged landscape at Broughton Bay (Hill 2014 pers. comm.), though G. George's observations may suggest a Neolithic date for the submerged forest deposits, this claim remains unverified. Further to the west, at Whiteford Sands, wood from within similar peat deposits has been radiocarbon dated to the late Mesolithic/early Neolithic (Huckfield 2017 pers. comm.).

Accessibility

The beach was easily accessible and access to the lower intertidal zone was not hampered by the risk of quicksand or unstable deposits, with clear sightlines and escape routes during an incoming tide.

Initial Observations

When initially surveyed in December 2014 peat deposits were identified in four distinct exposures extending from the top of the beach for around 300m. Tree stumps were visible in the two uppermost exposures on the beach, but not in any exposures lower in the intertidal zone, potentially indicating a difference between the deposits (Figure 14).

On a second visit, the expanse of exposure was much reduced due to sand movement, indicating a dynamic environment within the intertidal zone. To negate difficulties finding the deposits due to further sand accumulation, GPS points were taken around the periphery of all four exposures and mapped (Figure 15).

Figure 14: Peat extending from the top of the beach at Broughton Bay in November 2014. Tree stumps can be seen within the peat.

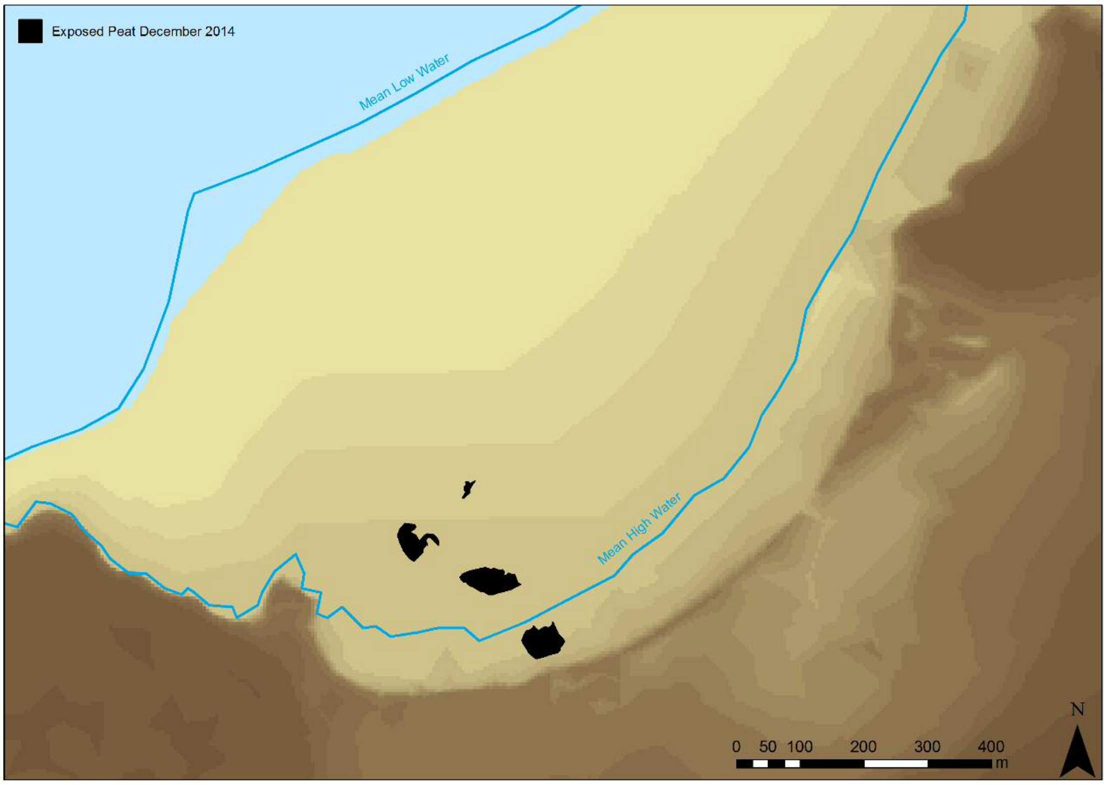

Figure 15: Visible extent of peat at Broughton Bay - December 2014

Port Eynon

Intertidal Deposits

The first official record of a peat shelf at Port Eynon was made by T. Neville George (1930, 104) who described peat extending from the high tide line for 30ft (9m) into the intertidal zone. He suggested that they were similar to deposits at Swansea, though with slight variation. Deposits were recorded in the local HER in 2009 (GGAT 2009) after locals reported an exposure of peat in excess of 340m on the beach. Tree stumps and root systems were identified along with a number of large fallen tree trunks, the largest measuring 9m in length (Sherman 2009c). There are a series of submerged forest and peat deposits listed at Port Eynon by the RCAHMW, but other than their position no further information is recorded and it is difficult to ascertain if these are the same records that reside in the HER (RCAHMW 2013). The deposits are not discussed in the Historic Landscape Characterisation of this area (GGAT 2006b), which would suggest that they were not exposed in 2006 when the survey was undertaken. No modern palaeoenvironmental analysis has been undertaken at the site.

Archaeological evidence

The HER records that a mini bronze socketed axe was reportedly found by a metal detectorist in the vicinity in 1989, however, again there is no information regarding the context in which the item was discovered (GGAT 1989a). Other finds at Port Eynon have a flint flake and debitage, likely to be earlier in date, recovered from clay deposits underlying peat though this has not been directly dated (GGAT 2009). In 2014 human and animal footprints were discovered within peat deposits situated in the intertidal zone (GGAT 2014b). Due to lack of funding, the local archaeological unit could only record the prints; no further analysis or dating was possible (Hill 2014 pers. comm.)

Dating

It had been suggested that the deposits in which the human footprints sit are Bronze Age in date. This was reported in media coverage after their initial discovery (BBC 2014). However, there appears to be no absolute dating evidence for this. Local archaeologists also suggest intertidal archaeology discovered in Swansea Bay around the time of the footprints' discovery and radiocarbon dated to the Bronze Age (Sherman 2011) may have influenced the Bronze age interpretation (Sherman 2015 pers. comm.).

In 2012, a radiocarbon date was obtained on unidentified wood retrieved from an eroding peat bed between the high and low tide lines. The date returned (3530-3360 cal BC [95%]), placed the wood within the early Neolithic period (Brightman and Ridge 2012). However, it is unclear as to the exact positioning of sample.

Accessibility

Port Eynon beach is easily accessible, with the peat deposits situated in line with the main entrance to the beach reducing the distance to carry equipment. The risk from unstable beach deposits is low and there are good sight lines with little risk of being cut off from the tide. The beach is popular with the general public who visit throughout the year.

Initial Observations

When first surveyed in later 2014 and early 2015, the peat exposures at Port Eynon were present in both the upper and lower intertidal zones, with the area of beach in between scoured to rock. GPS points were taken to map the visible extent on the first viewing to allow identification should sand be redeposited between visits and to monitor for erosion (Figure 16). The deposits showed evidence of multiple sediment layers, suggesting numerous changes within the environmental history. Human and animal footprints were also identified during initial surveys showing direct human interaction with the environment.

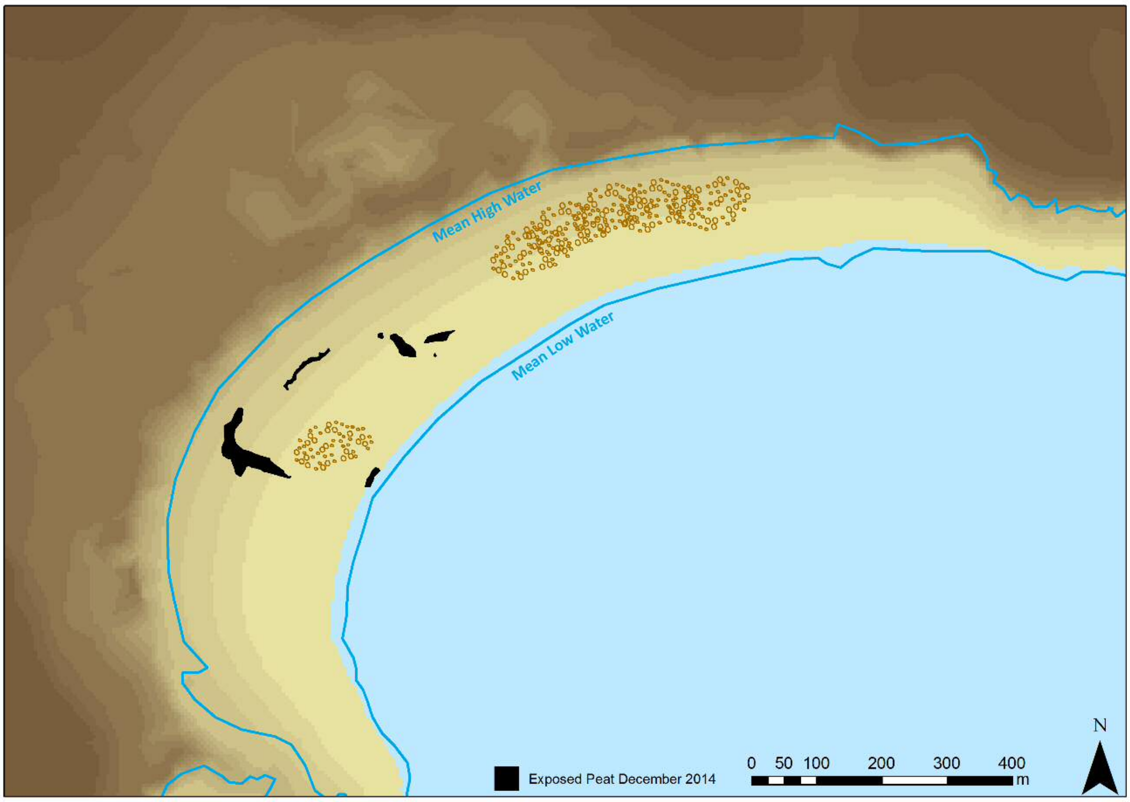

Figure 16: Visible extent of peat at Port Eynon - December 2014

4.2 Archaeological Survey

This research embraces the concept of a “seamless” approach to archaeological investigation. This approach was championed by Allen and Gardiner (2000a, 17) in their investigations at Langstone Harbour in Hampshire. It dictates that archaeology in the intertidal zone should be investigated in the same way as that inland, as it would at one point have been part of the terrestrial rather than inter or sub-tidal landscape. In this thesis, intertidal archaeological evidence will be investigated as part of the wider archaeological landscape, within the same categorical terms. The data collated below provides a baseline from which to compare any new archaeological evidence recorded during this study.

To place the selected sites in context, a desk-based survey of all published records of known archaeological sites located on Gower and in the immediate surrounding area was undertaken. The survey is focused on the prehistoric periods from the Mesolithic to the Iron Age. This date range was selected to encompass known sea level movements as evidenced by the information obtained in the Bell (2007d) intertidal survey.

The survey methodology including data source and characterisation is detailed below, followed by maps and summarised descriptions of the identified archaeology by time period.

4.2.1 Methodology

Data was obtained from the Glamorgan Gwent Archaeological Trust (GGAT) Historic Environment Record (HER) and collated into spreadsheets determined by period and site type (see Appendix 3). Evidence is displayed by period: Mesolithic, Neolithic, Bronze Age and Iron Age, as categorised in the HER and mapped by evidence type for each period.

Categories

The following categories of use were chosen to describe the archaeological evidence:

Settlement

Evidence detailing more sustained activity, including building remains, groups of similarly aged features, multi-activity sites and evidence for repeat use. Where sites have been determined as settlement within the HER, they have been listed as such, though, as will be discussed later in this chapter, there are issues with this approach.

Funerary

Any site with evidence of human remains or in a known funerary form, for example clearly defined burial tombs, will be included even if human remains are no longer present.

Monument

Sites with megalithic structures not associated with the burial of human remains. For example, standing stones and henges. Unless explicitly stated to be a monument after investigation, mounds are not included in this category, due to possible domestic and funerary uses for mounds also existing.

Special deposit

Finds deemed as special, including hoards, or deliberately placed items with potential for more specific meaning than everyday usage.

Defence

This category includes sites displaying evidence for banks and ditches and encompasses hillforts and promontory forts. Though a loaded description, it follows their interpretation and categorisation within the HER itself.

Activity

Evidence for short-lived human activity, which cannot be assigned to a specific category. This includes human made features of unknown provenance, flint scatters, finds related to the period in question with limited or no contextual information, evidence of direct interaction such as footprints and sites with no specific evidence to suggest type of use, but clear human interaction.

4.2.2 Maps

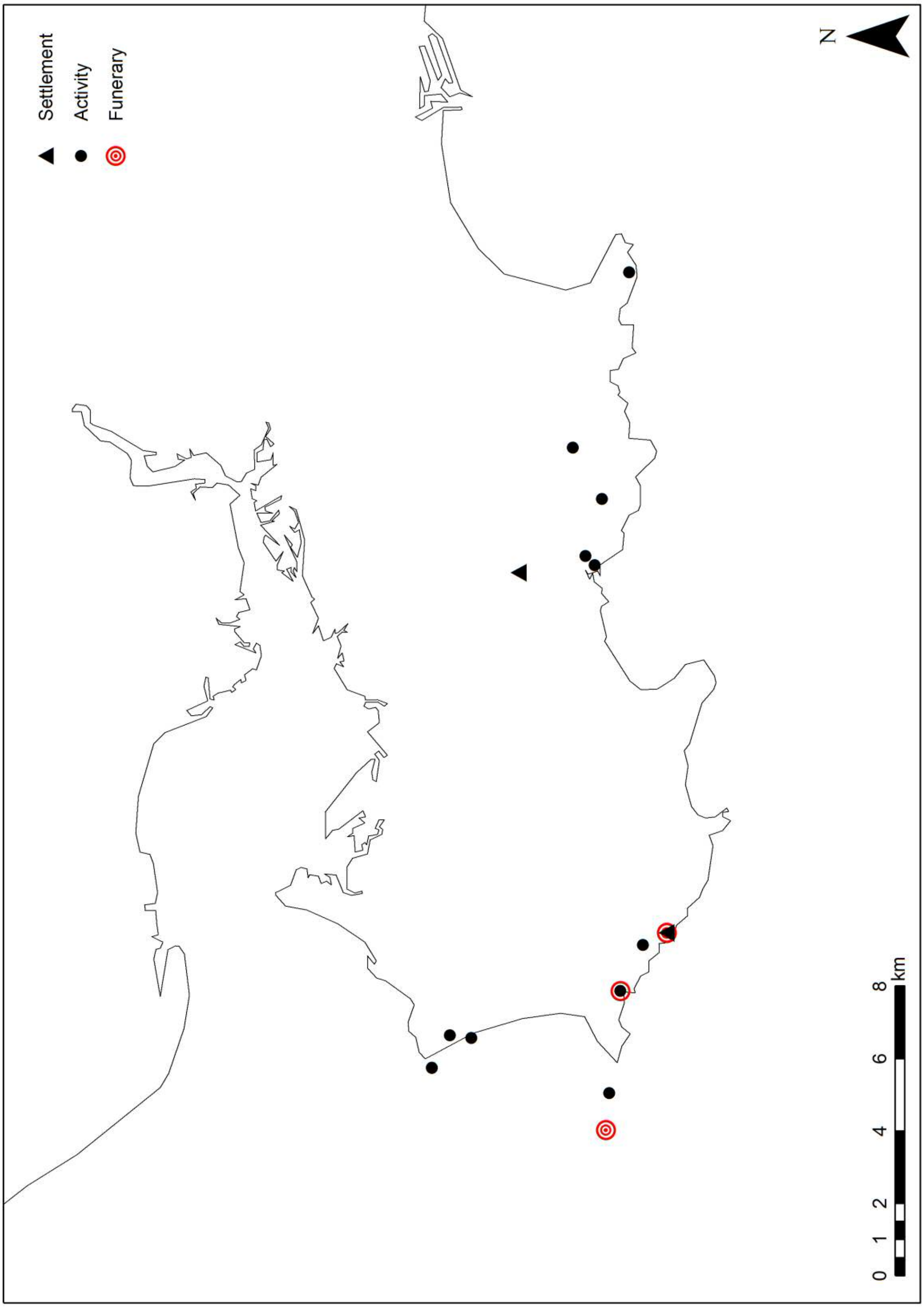

Figure 17: Mesolithic archaeological evidence on Gower derived from information held by the GGAT HER Charitable Trust Database Right

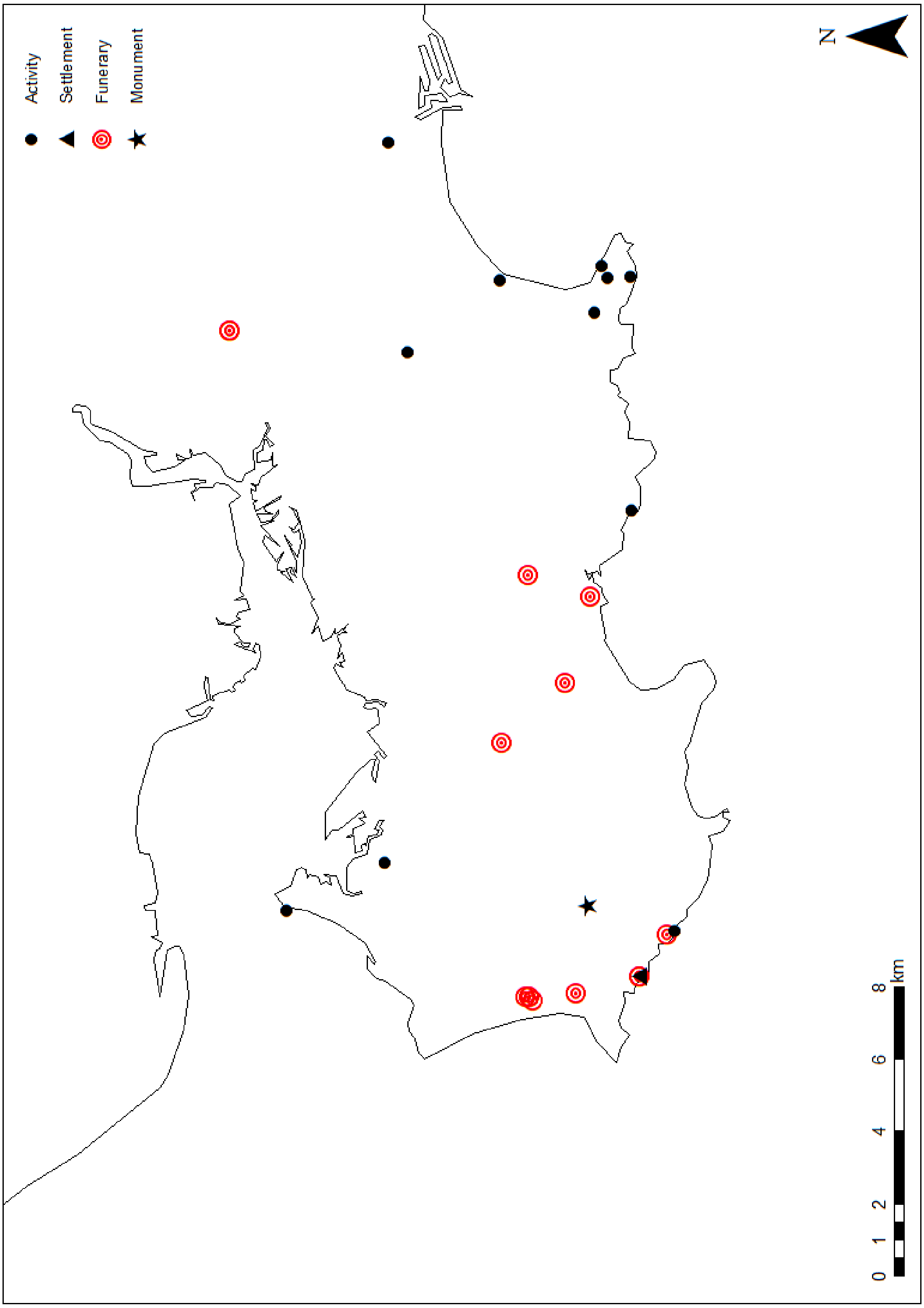

Figure 18: Neolithic archaeological evidence on Gower derived from information held by the GGAT HER Charitable Trust Database Right

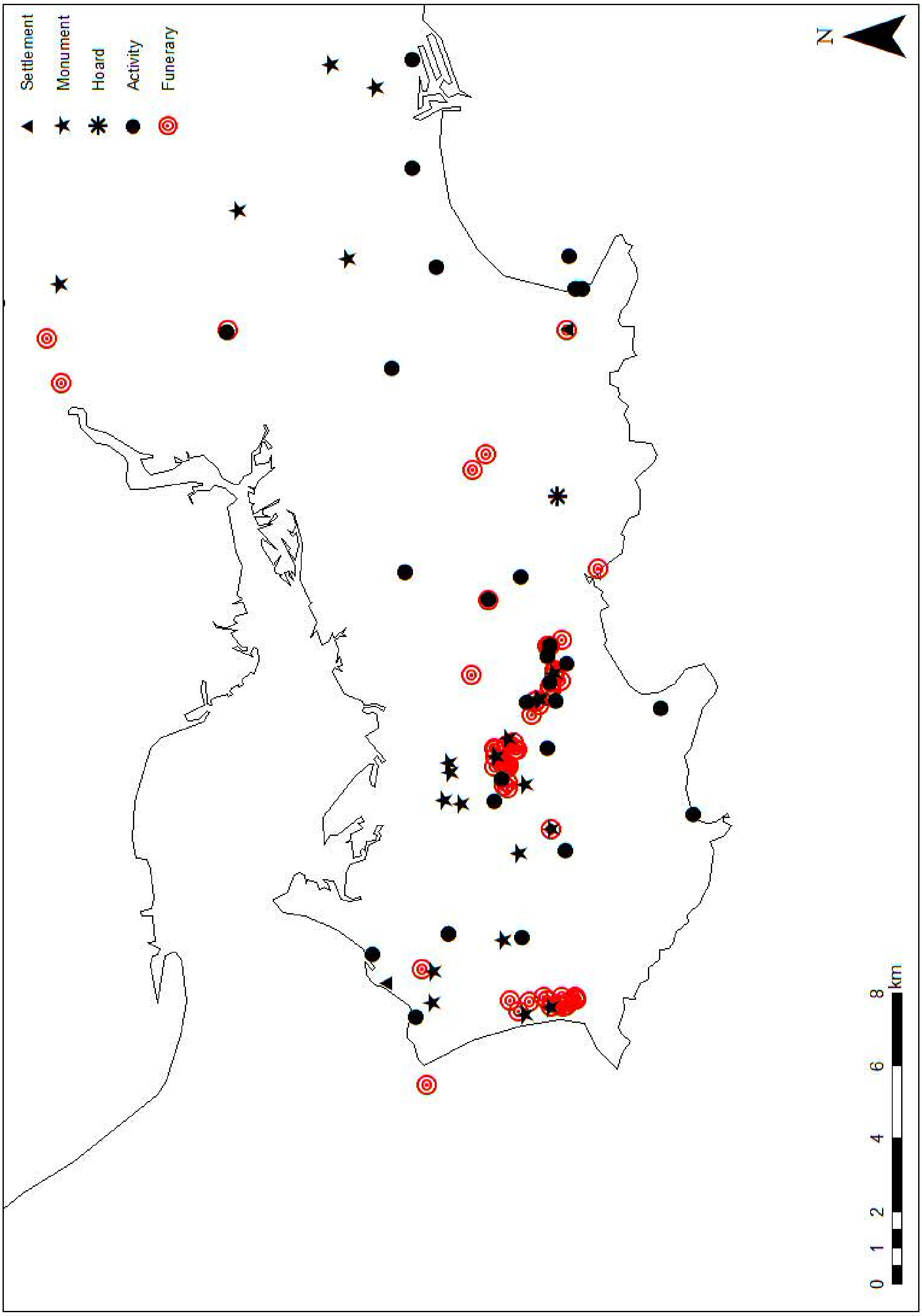

Figure 19: Bronze Age archaeological evidence on Gower derived from information held by the GGAT HER Charitable Trust Database Right

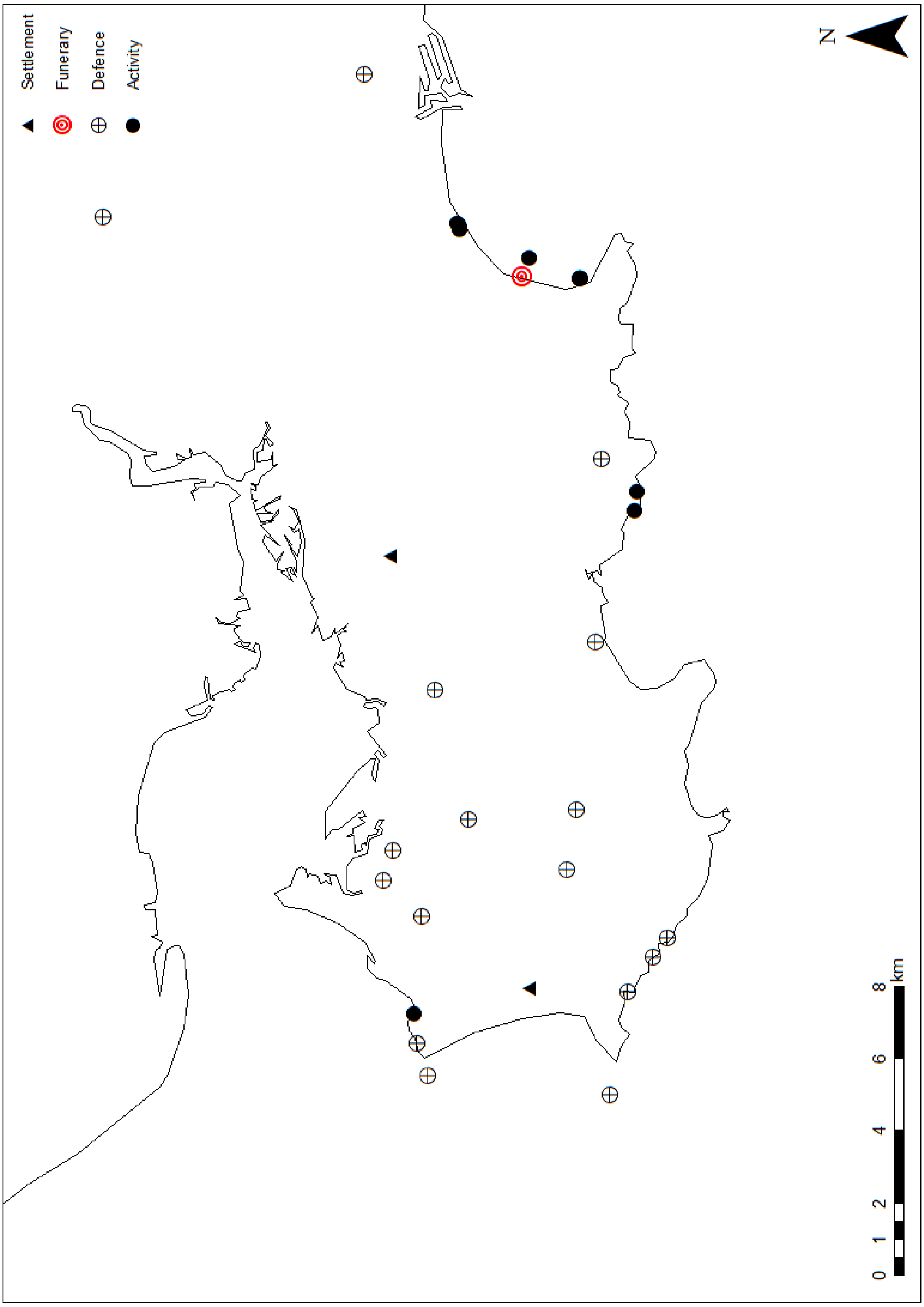

Figure 20: Iron Age archaeological evidence on Gower derived from information held by the GGAT HER Charitable Trust Database Right

4.2.3 The Prehistoric Archaeology of Gower

Mesolithic (Figure 17)

Much of Gower's Mesolithic archaeological evidence stems from individual find spots identified to the period but lacking in-depth contextual information. These sites consist mainly of either individual or small groups of lithic finds, indicating definitive presence in the form of short-lived activity, but providing little further information. The Mesolithic evidence is found predominantly on the modern-day coastal fringes of Gower with very little evidence from within the interior.

Two of the sites on Gower have been categorised as "settlement" sites, as there is evidence suggesting prolonged activity or multiple use. For example, at Foxhole cave, a selection of flint, burnt bone, faunal and microfaunal evidence, molluscs and the possible remains of a hearth are present along with human remains that have been radiocarbon dated to the late Mesolithic (Schulting et al. 2013). Though not necessarily a full time "settlement" in the traditional sense of the word, this mixture of activities over a period of time suggests a site that is revisited and used for a number of different uses, including domestic, industrial and funerary practices. At the second settlement site, Cathole Cave, Mesolithic flints and faunal remains were found within a series of horizons, suggesting repeated use of the site throughout the Mesolithic period (GGAT 1997; Walker et al. 2014).

Funerary evidence is also present on Gower in the form of a significant grouping of Mesolithic cave burial sites (Hellewell and Milner 2011, 63). Human skeletal remains have been found in Mesolithic contexts at four cave sites on Gower: Worms Head, Mewslade, Foxhole and Paviland.

Dating

The radiocarbon dated human skeletal remains represent the only directly dated Mesolithic archaeological evidence on the peninsula (Table 3).

Site	Date	Reference
Worms Head	c.8600 cal BC	(Schulting 2009)
Mewslade	c. 8500 cal BC	(Schulting 2009)
Foxhole	6096-5921 cal BC 5730 5560 cal BC 5615-5486 cal BC 5522-5375 cal BC	(Schulting et al. 2013)
Paviland	6160-5790 cal BC 5460-5295 cal BC 5230-5055 cal BC	(Schulting et al. 2013) (Schulting and Richards 2002)

Table 3: Radiocarbon dates from human skeletal remains in Mesolithic cave burial sites on Gower

The dating suggests a linked tradition of cave burial in the early Mesolithic that is picked up again in the late Mesolithic to early Neolithic period (Hellewell and Milner 2011). The absence of evidence from the period spanning 5000-4000 BC at the very end of the Mesolithic (Schulting and Richards 2002; Schulting et al. 2013), suggests a break in the cave burial tradition. It is openly acknowledged by Schulting et al. that this is based on very limited evidence, but is pertinent because it is also representative of the state of Mesolithic evidence on Gower as a whole.

Neolithic (Figure 18)

The Neolithic on Gower is represented predominantly by funerary evidence, with the presence of the South Eastern Wales Coastal Group burial monuments (part of the Severn-Cotswold Group (Daniel 2013, 25)) and a group of chambered tombs dominant in the landscape (Nash 2015, 36). Neolithic human remains have also been found in Red Fescue Hole (Schulting and Richards 2002) and Foxhole (Schulting et al. 2013) caves.

One potential settlement site has been identified at Red Fescue Hole where flint tools and animal bones were found as surface finds (GGAT 2004). However, no further investigation has been undertaken.

Most recorded Neolithic find spots on Gower are of Neolithic stone Axes. A total of seven stone axes have been reported on Gower. Two, both polished, were discovered in close proximity to each other at Whiteford Sands in northern Gower, (GGAT 1989b; Huckfield 2016). The majority of the axes lack clear contextual information, with many having been found during antiquity.

A more monumental site was potentially identified close to Port Eynon in 1964 in the form of crop marks interpreted as a Neolithic henge. The site was recorded in an aerial photograph, but more recent inspections could not confirm its presence (GGAT 1976).

Dating

The polished stone axes found at Whiteford Sand were both dated to between c.3500 and 2200 BC based on typology, but as was the case for the Mesolithic period, the only directly dated remains from the Neolithic on Gower come from funerary evidence. The cave burials at Red Fescue Hole and Foxhole provide early Neolithic dates. Dating has also been undertaken at Parc le Breos chambered tomb, one of the Severn Cotswold Group situated inland on the eastern side of Gower, where 12 samples of human skeletal remains dated to between 4000 and 2000 cal BC, crossing over with the cave burials and continuing into the later Neolithic (Table 4).

Site	Date	Reference
Foxhole	3912-3660 cal BC 3890-3640 cal BC 3779-3650 cal BC 3761-3637 cal BC 3710-3520 cal BC 3620-3140 cal BC	(Schulting et al. 2013)
Red Fescue Hole	3760-3540 cal BC	(Schulting and Richards 2002)
Parc le Breos	3780-3540 cal BC 3780-3530 cal BC 3690-3520 cal BC 3650-3380 cal BC 3620-3370 cal BC 3610-3370 cal BC 3600-3370 cal BC 3520-3360 cal BC 3510-3350 cal BC 3310-2930 cal BC 2290-2040 cal BC 2200-2030 cal BC	(Whittle and Wysocki 1998)

Table 4: Radiocarbon dates pertaining to the Neolithic on Gower

Bronze Age (Figure 19)

There is an increase in the concentration of archaeology in the Bronze Age. Several large cairn fields and cemetery sites indicate the importance of this area in terms of funerary activity during this period. Monumental evidence in the form of standing stones and non-funerary cairns is also prevalent on Gower during this time. Settlement evidence is once again relatively sparse, with only two sites in this category, a midden and hearth near Spritsail Tor (GGAT 1932) and the potential remains of a round house beneath a funerary monument at Colts Hill (GGAT 1969). The presence of trackways in the intertidal zone in Swansea Bay (Sherman 2010) indicates activities engaging in waterlogged and waterside environments during the Bronze Age, though these are not technically on Gower itself. Further evidence for Bronze Age Activity includes several burnt mounds, the purpose of which is unknown. A hoard is also listed as having been found in the 19th century comprising of a socketed axe, spearhead, leaf-shaped swords and an arrowhead (Grimes 1951, 187).

Dating

Despite an increase in density of archaeological evidence during the Bronze Age there is still a distinct lack of direct dating evidence. Two sites are listed in the HER as having radiocarbon dating evidence (Table 5). The dates are taken from cremated human remains and charcoal from two confirmed funerary sites.

Site	Date	Reference
Pentre Farm, Pontardulais	1520±70BC (1964-1620 cal BC)	(Ward 1978)
Great Carn Ring Cairn 2 (Cefn Bryn)	3510±60 BP (Birm-1179) cal 1750-1925 BC (1 sigma) and 1685-1990-2030 BC (2 sigma)	(Ward 1988)

Table 5: Radiocarbon dates from Bronze Age Sites on Gower

Iron Age (Figure 20)

The Iron Age archaeology on Gower is dominated by hillforts and promontory forts. 17 sites are listed in the HER. These defensive sites are situated both on the coast and within the interior of Gower. Two potential Iron Age settlements are recorded in the form of small enclosures at Llanrhidian (GGAT 2001) and Rhossili Down (GGAT 2002) . Unlike the preceding periods, only one piece of funerary evidence pertaining to the Iron Age is recorded. This takes the form of a human skull found on the foreshore at Blackpill in Swansea Bay.

Dating

The only direct dating evidence related to the Iron Age data was discovered just outside Gower itself in Swansea Bay and consisted of samples taken from brushwood and part of a trackway (Table 6). None of the Gower specific Iron Age evidence is recorded as having been radiocarbon dated at present. The human skull found at Blackpill (again in Swansea Bay) was suggested to date to around 2000BP, but has not been directly dated (GGAT 1993).

Site	Date	Reference
Swansea Bay Brushwood	103 cal BC – cal AD 118	(Nayling 1998a)
Brynmill Trackway	2140-1930 cal BC	(Sherman 2011)

Table 6: Radiocarbon dates pertaining to the Iron Age near Gower

4.2.4 Summary of Prehistoric Gower

Though the evidence is sparse, it is clear that people were present on Gower throughout prehistory. The evidence presented above focuses on the Holocene period, but human presence on Gower extends much earlier into the Palaeolithic period evidenced by the 26,000 year old human remains known as the “Red Lady” discovered in Goat’s Hole cave at Paviland in the late 19th- early 20th century (Aldhouse-Green and Pettitt 1998).

Gower appears to have been a preferred place to bury the dead from the Palaeolithic through to the Bronze Age. It also has a significant number of monumental sites including standing stones, potential henges and cairns. In the Iron Age, defence appears to have been a major factor of human activity, with very little evidence pertaining to other interactions. There is very little "settlement" evidence recorded on the HER, and the sites that fall into this category lack in-depth investigation. Thus, Gower has limited evidence of domestic, day to day activity throughout the prehistoric periods. Although evidence such as flint knapping sites were present, other indicators of domestic activity, such as pits, hearths and structural features, are rare. This is to be expected during the Mesolithic but is more surprising in the later prehistoric periods. The available evidence suggests a prehistoric Gower with occasional, and perhaps activity specified, human presence, however this may not tell the whole story.

4.2.5 Limitations

The sparsity of evidence places limitations on the interpretation of prehistoric Gower. There are however a number of key factors that may be affecting the visibility of archaeological monuments in this area. These include both legislative and research-based factors and are discussed below:

Legislative Protection from Development

Gower is a designated Area of Outstanding Natural Beauty (AONBs) (Figure 21) and large areas are also designated Sites of Special Scientific Interest (SSSIs) (Figure 22). This means that development on the peninsula is rare and leads to less archaeological investigation being required. A large amount of Gower has therefore not been subject to archaeological investigation.

HER Limitations

There are several limitations that have become apparent from using the HER data. The database includes all known archaeological evidence within the area but does not distinguish between sites that have been fully investigated and those that have had little or no investigation. Many of the entries have been noted in antiquity, but other than occasional acknowledgement of remaining presence during walkover surveys, further direct investigation is not recorded as having been undertaken. More recent discoveries are often also the result of a walkover survey with no follow up investigation. Furthermore, even when investigation has been undertaken, absolute dating evidence is rare. Much of the dating and interpretation in the HER is based on association with features elsewhere that are similar looking or similarly placed, which may limit understanding. This lack of direct dating is specifically mentioned within the Archaeological Research Framework for Wales as an area in need of improvement (IFA Wales/Cymru 2014; Caseldine 2017).

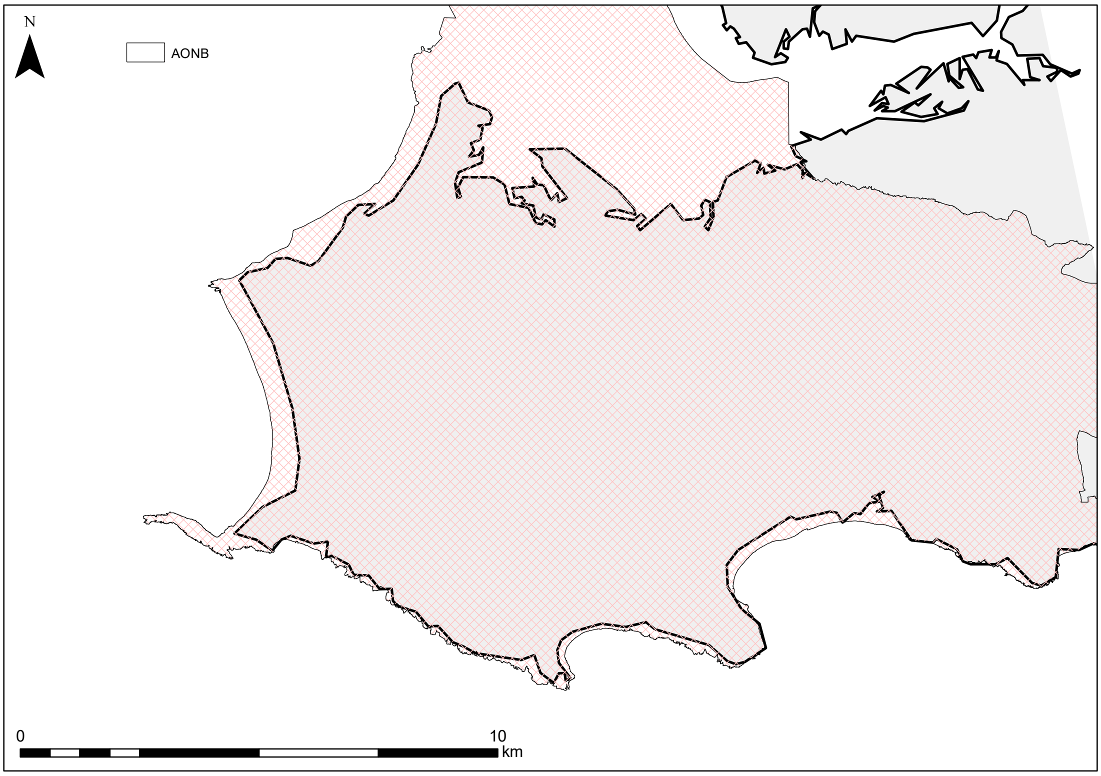

Figure 21: Areas of Outstanding Natural Beauty, Gower. Shapefile courtesy of Natural Resources Wales (NRW 2018)

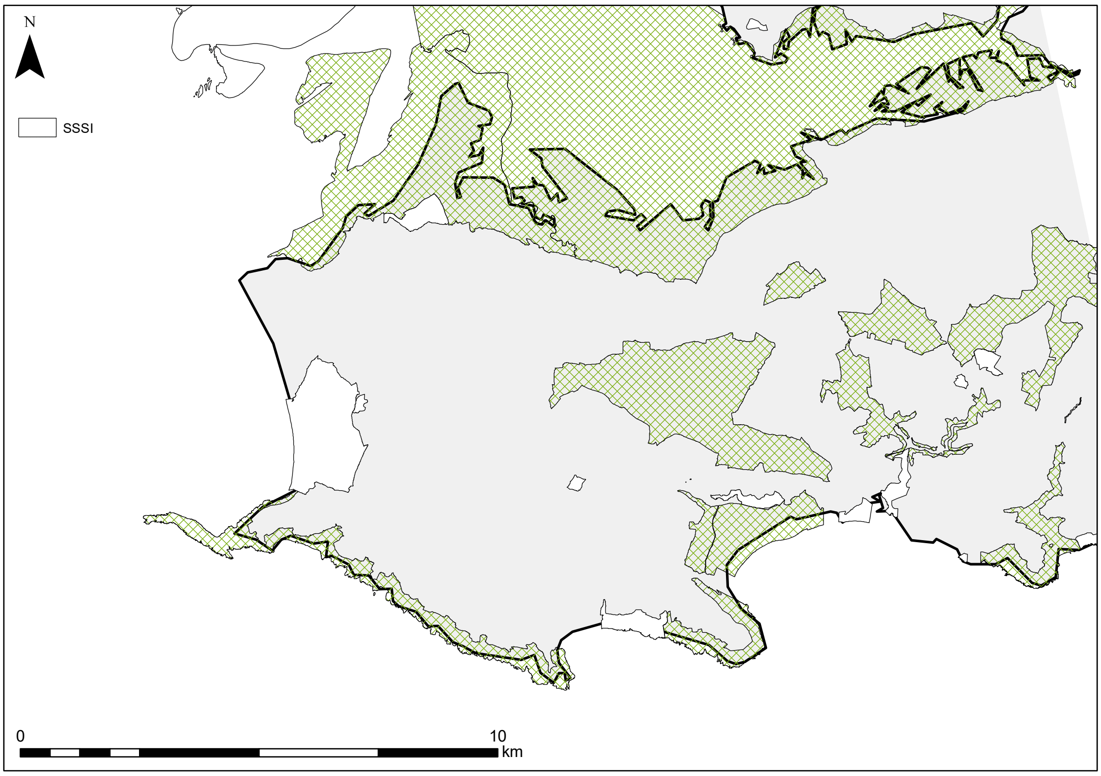

Figure 22: Sites of Special Scientific Interest, Gower. Shapefile courtesy of Natural Resources Wales (NRW 2018)

A clear example of these issues can be seen in the interpretation of "burnt mounds" attributed to the Bronze Age. Within the HER, some have been interpreted as cooking mounds due to the presence of fire cracked stones. However, a lack of dating evidence means that there is potential for these mounds to be more modern in construction. Ward (1989) suggests that of the c.230 recorded cairns at Cefn Bryn on west Gower, only a small proportion are likely to be Bronze Age monuments, with the rest representing clearance piles from much later agricultural activity. Evidence within the HER suggests many of these mounds have been verified purely on proximity to other examples, which places less credibility on the identification.

Research Bias

Research bias also plays a part in the dominance of certain site types. Much of the monumental and funerary evidence was recorded in the Prehistoric Funerary and Ritual Sites survey in 2001 (Smith 2001) and many of the Iron Age defensive sites feature in the Prehistoric defended enclosures in Glamorgan report (Gerrard et al. 2006). While these reports are welcome in their recording of sites, they have led to an imbalance in the available data, creating a dominance in the literature which is not proven to be representative of the actual distribution of activity in the area.

4.3 Summary

The initial survey provided an updated overview of the known intertidal peat deposits on the southern Welsh coastline, expanding on Bell's 2007 survey and highlighting sites that required further work. The survey concluded that the Gower Peninsula hosted a number of sites that lacked modern analysis but held high palaeoenvironmental and archaeological potential. Two sites were chosen for in depth analysis: Broughton Bay to the north of the peninsula and Port Eynon to the south east and the extent of the peat deposits at each location was recorded.

The archaeology of the Gower study area was reviewed. All archaeological sites recorded on the peninsula from the Mesolithic to the Iron Age were identified and the available data reviewed within temporal constraints set by dating evidence from the intertidal peat deposits recorded in the Bell (2007d) survey. This archaeology has demonstrated that there is still much to learn about Gower's prehistoric inhabitants. The limited archaeological evidence may be more the result of the lack of archaeological investigation or projects that focus only on particular site types or chronological periods.

Both surveys have identified issues with analogous interpretation leading to precarious conclusions being drawn about the age of intertidal deposits and age and purpose of certain archaeological evidence. This has identified

The following chapters present the multifaceted approach taken in order to investigate the archaeological and palaeoenvironmental histories of Broughton Bay and Port Eynon and the results of each of the separate analyses.

5 Methodologies

The methodologies for each of the approaches taken during the investigation of the intertidal archaeological and palaeoenvironmental deposits at Broughton Bay and Port Eynon are presented in this chapter. In section 5.1, the considerations made in preparation for fieldwork are outlined. Section 5.2 describes the methodologies undertaken in the initial topographic surveys at each of the sites. This is followed in section 5.3 by the methodology for the archaeological investigation undertaken at Port Eynon (no such investigation was undertaken at Broughton Bay because no archaeological evidence was identified during the initial surveys, or indeed at any point in the investigation). 5.4 presents the sampling methodology used in preparation for the radiocarbon dating (5.5) and palaeoenvironmental (including pollen, non-pollen palynomorphs, microcharcoal and diatoms) investigations (section 5.6). The chapter is summarised in section 5.7.

5.1 Fieldwork Preparation

The following section outlines the preparations and considerations that were taken prior to the onset of fieldwork.

5.1.1 Tides

The initial fieldwork dates were specifically chosen for their extreme low tides and subsequent visits were made on Spring tides to ensure the lowest available tides. These occur every two weeks and were monitored using the National Tidal and Sea Level Facility website (NTSLF 2015b) in order to select the most suitable. The closest tidal gauge to the sites under investigation is Mumbles. Although further east than both study sites it gives a reasonable estimate for the tidal level reaching its lowest point at Broughton Bay around 30 minutes before Mumbles with Port Eynon occurring part way between the two.

Tides can only usually be monitored up to 28 days in advance, meaning fieldwork was conducted at relatively short notice to take advantage of the conditions. The extreme low tides were easier to plan for, as these have been predicted on an 18 year cycle (currently between 2008-2026) (NTSLF 2014).

2015 hosted the lowest tides until 2026, so it was important to take advantage of this. Visits were made in February and March 2015 when low tide reached 0.14m at its lowest. Further visits were made in May 2015 and May 2016. All fieldwork dates chosen had low tides under 1m. By choosing the lowest tides, the time window for investigation of the intertidal zone was extended allowing for a more comprehensive survey. The lower tides also meant the survey area was increased and the optimum amount of evidence could be analysed. This was particularly important when taking samples, as it was expected that samples further into the intertidal zone had been subject to better preservation due to less exposure to drying conditions during low tide and in some cases greater protection from overlying sediments (Richer 2015 pers. comm.).

This is not to say that conditions were guaranteed on every visit. Local residents have suggested that low spring tides can be 0.5m lower than predicted due to high pressure atmospheric conditions (John Cooper 2015 pers. comm.). Conversely, we were also warned that if wind conditions were such on a predicted low astronomical tide, the tide could be pushed inland and so the full extent of the low might not be seen. Fortunately, conditions were such on each visit that the proposed work could be achieved.

5.1.2 Ordnance and Chart Datum

When working within the intertidal zone, two separate height datasets are required. Sea levels are recorded in Chart Datum (CD), whereas Ordnance Datum (OD) represents height on land relative to sea level. Terrestrial mapping and GPS data are recorded in OD. In order to make these datasets comparable, a conversion needs to be made. By converting Chart Datum to Ordnance Datum, it is possible to relate sea level directly to features on land. The heights of CD relative to OD are different across the UK and as such certain tidal gauges are used as control markers. The closest gauge to the chosen study sites is situated at Mumbles, Swansea (as stated above). CD relative to OD here is -5.00m. In order to convert CD to OD one must add this value to the CD value (NTSLF 2015a). For example:

On the 21st March 2015, the tide was predicted to reach a level of c.0.14m CD in the area of the sites being investigated (NTSLF 2014). To convert from CD to OD:

$$0.14 + -5.00 = -4.86\text{m (OD)}$$

This allows the low tide line to be applied to the beach itself and any features on the beach to be recorded in relation to it. Though this does not directly assist in the investigation of past sea levels, it enables the selection of fieldwork dates in relation to when features are situated above the level of the tide.

5.1.3 Health and Safety

The intertidal zone is a high-risk study area. The conditions are constantly changing and there are many dangers to those undertaking fieldwork. A risk assessment was created highlighting all possible risks (see Appendix 5).

Tide times were monitored daily along with weather conditions. All team members were made aware of the predicted time of turn of tide and a latest time to turn back up the beach. Other studies have highlighted the need to work up the beach from the lowest point towards dry land (Allen and Gardiner 2000a, 19). Whilst this is an important safety point, in order to do this, the furthest point of study would need to be accessible before investigation began, meaning work would need to start at the tides lowest point from which the tide would be incoming. This would create a race against time, which could be dangerous and not very efficient when trying to cover a large area. To be as efficient and safe as possible, work was conducted following the tide down and then returning to the top of the beach once the tide had turned.

No investigation was undertaken past the lowest tideline. This would have required resources unobtainable by the project at this time and would have far more safety implications due to the dangerous sea conditions within the Bristol Channel.

Lone working was avoided and all team members stayed within sight of each other at all times. Most fieldwork tasks required at least 2 people to complete, and having extra workers allowed for more efficient data collection, along with extra pairs of hands to carry the substantial amount of equipment needed and to talk to members of the public when approached. All fieldwork was conducted within daylight hours.

All team members carried mobile phones and regular contact between team members was maintained. Emergency service numbers were held by all participants and emergency scenarios agreed on in briefings prior to each fieldwork session.

Towards the low tide level, it was important to assess underfoot conditions. Where water and sand or basal sediments mix there can be a risk of quicksand forming. Underfoot conditions were assessed cautiously and areas deemed dangerous avoided. This was especially important towards the turn and on the incoming of the tide. An exit strategy was always kept in mind.

5.1.4 Fieldwork methodology considerations

The methodology for fieldwork within the intertidal zone does not differ from that which might be undertaken further inland, despite the more challenging conditions faced within this research context. The deposits to be investigated were, in the past, dryland and therefore should be seen as an extension of the land rather than a separate submarine zone. Results, therefore will need to be comparable with inland examples in terms of recording conventions and quality of samples. This approach was promoted by the Langstone Harbour Project team (Allen and Gardiner 2000a, 17) where it became known as the "*seamless* strategy." Topographic and palaeoenvironmental surveys were conducted in a co-ordinated programme in order take advantage of low tide events and gather as much data as possible from the available study zone.

The methodology also takes lead from the approach taken as part of the Lyonesse Project in the Isles of Scilly, which used a gridded auger survey and sampling approach. This involved test augering at regularly spaced intervals to determine presence of peat and then the use of GPS to establish the position of peat in relation to the British National Grid and Ordnance Datum (Mills 2016, 29).

5.2 Topographic Survey

5.2.1 Aims

The aim of the topographic survey was to establish the full extent of the peat outcrop(s) at each location, reconstruct the topography of the past landscape and to acquire accurate height measurements from the peat surface for later sea level reconstructions. At both locations, the survey aimed to establish if deposits in the upper and lower tidal zones were physically linked beneath surface sediments or whether they represented distinct deposits of varying age and/or environment.

5.2.2 Ground Survey

Equipment

A Trimble survey grade RTK GPS system (with a Trimble 4700 base station and a Trimble 5800 Rover) was used to collect point data, recording British National Grid eastings and northings and height in metres above (or below) Ordnance Datum (Figure 23). GPS data were logged by the Trimble 4700 base receiver and later converted to RINEX format using Trimble´s `RinexConvert´ utility. They were then backdated, together with RINEX files from the five closest OS passive net stations, using the `RinexDates´ utility. This permitted baseline processing to achieve cm level precision relative to British National Grid and OD in `Trimble Geomatics Office´ (TGO) (Tim Young 2015 pers. comm.). The processed data was then exported into an Excel spreadsheet and imported into a GIS project using Environmental Systems Research Institute ArcGIS 10.2.2.

Figure 23: Trimble 4700 base station and Trimble 5800 Rover in use at Broughton Bay

An Edelman auger was used for general sediment prospection in order to identify the presence and depth of peat deposits. It was chosen after successful use in a similar survey conducted for the Lyonesse Project on the Isles of Scilly (Charman et al. 2016c, 5). This type of auger cuts through deposits without taking a fully intact sample. It allows deposits to be identified and by measuring the distance from the point on the auger shaft in line with the surface to the top of the identified sediment within the auger head, it is possible to assess the depth at which they lie. The Edelman cannot be used to take stratigraphically intact samples due to a high risk of contamination.

Methodology

GPS was used to set out transects at each site, from which to work systematically down and across the beach (Figure 24 and 25).

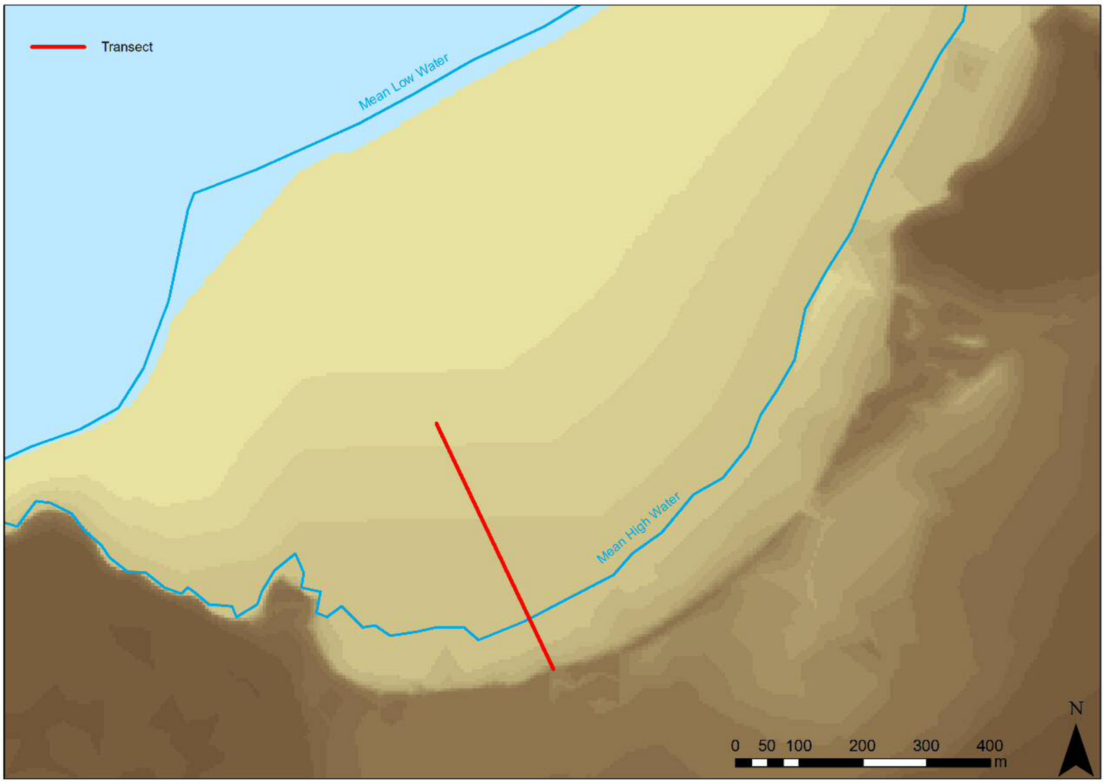

Figure 24: Broughton Bay transect

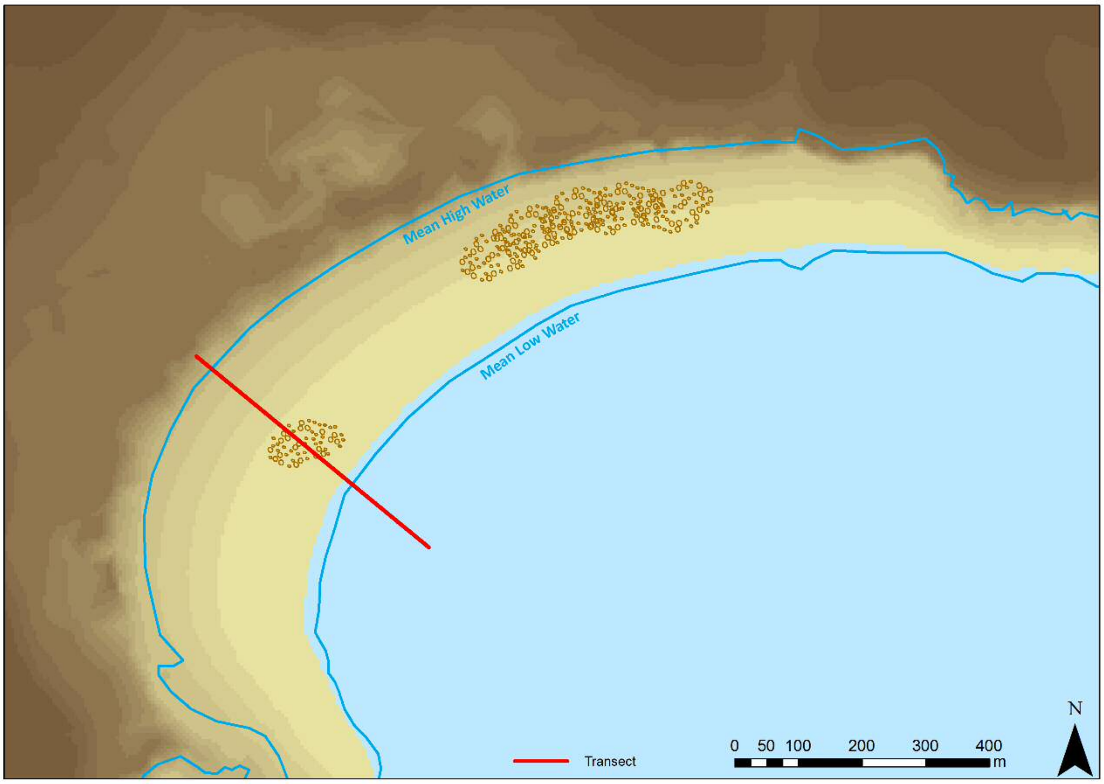

Figure 25: Port Eynon transect

Initially, a grid was proposed, in line with the methodology utilised during the Lyonesse Project (Mills 2016), but it soon became clear that the scale of the beaches at both Broughton Bay and Port Eynon was much larger than the surveyed sites on the Isles of Scilly. The Gower sites were also affected by widespread and in places extremely deep sand deposits, which made prospective augering difficult. Therefore, a gridded survey would not have been possible within the tidal window. Instead the transect data was combined with a visual extent survey using the GPS in order to record as much of the deposit as possible. At specified increments (initially 5m at Broughton Bay, changed to 20m at Port Eynon – this is discussed more fully in the following results chapter) along each transect the presence (or lack of) peat was recorded along with the depth below the surface at which it was found. Where peat was present at the surface this was recorded in the GPS data.

5.2.3 Aerial Survey

A prospective aerial survey was undertaken at both Broughton Bay and Port Eynon. Aerial photographs of the sites were taken using a Phantom II drone with a GoPro Hero 3 Black camera attached (Figure 26 and 27). A flight plan was programmed using the DGI Ground Station application, sending the drone on parallel transects across the peat exposures at a height of 20m (Figure 28-30). Photographs from a height of 50m were also obtained. The camera was set to take a photograph every five seconds in order to cover the entirety of each peat exposure. The drone was only used when no other members of the public were present on the beach and in line with the guidelines and regulations laid out by the Civil Aviation Authority (CAA 2018).

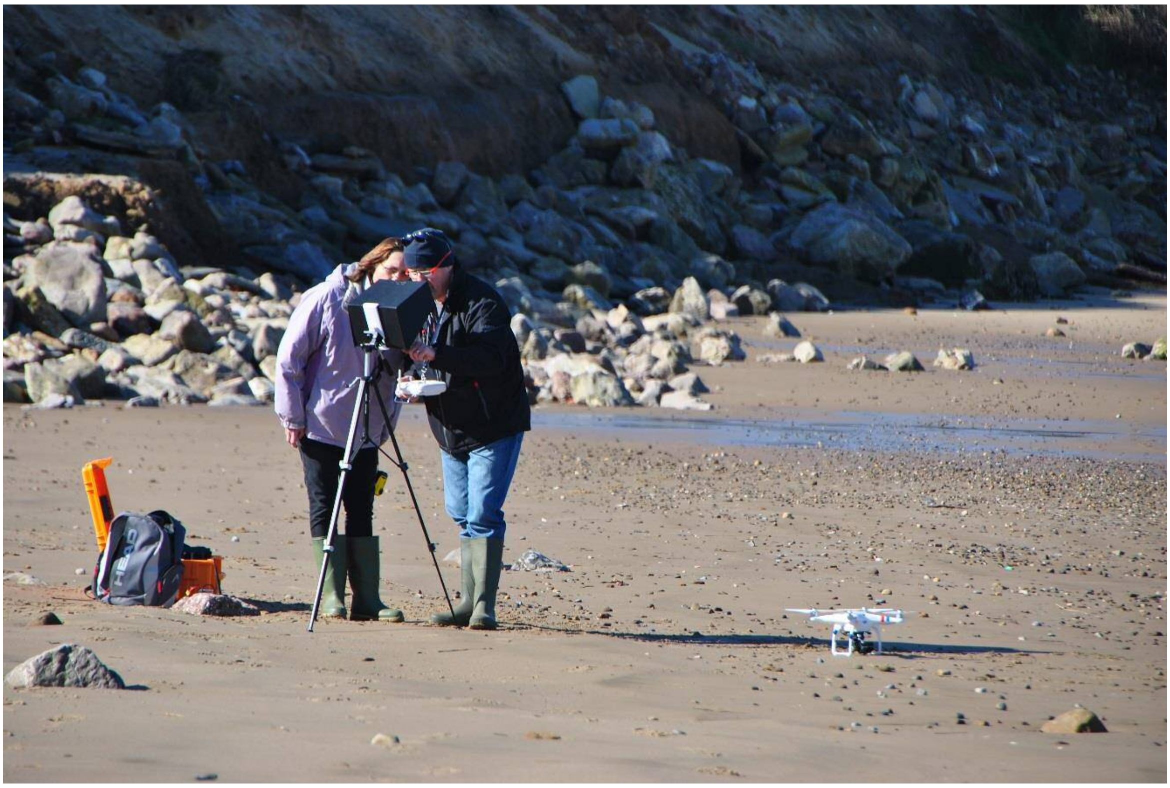

Figure 26: Drone control setup with operators Carolyn and Graeme Philp

Figure 27: Phantom II drone in the air

Figure 28: Flight plan for drone survey of upper beach peat exposure at Broughton Bay created using the DGI Ground Station app

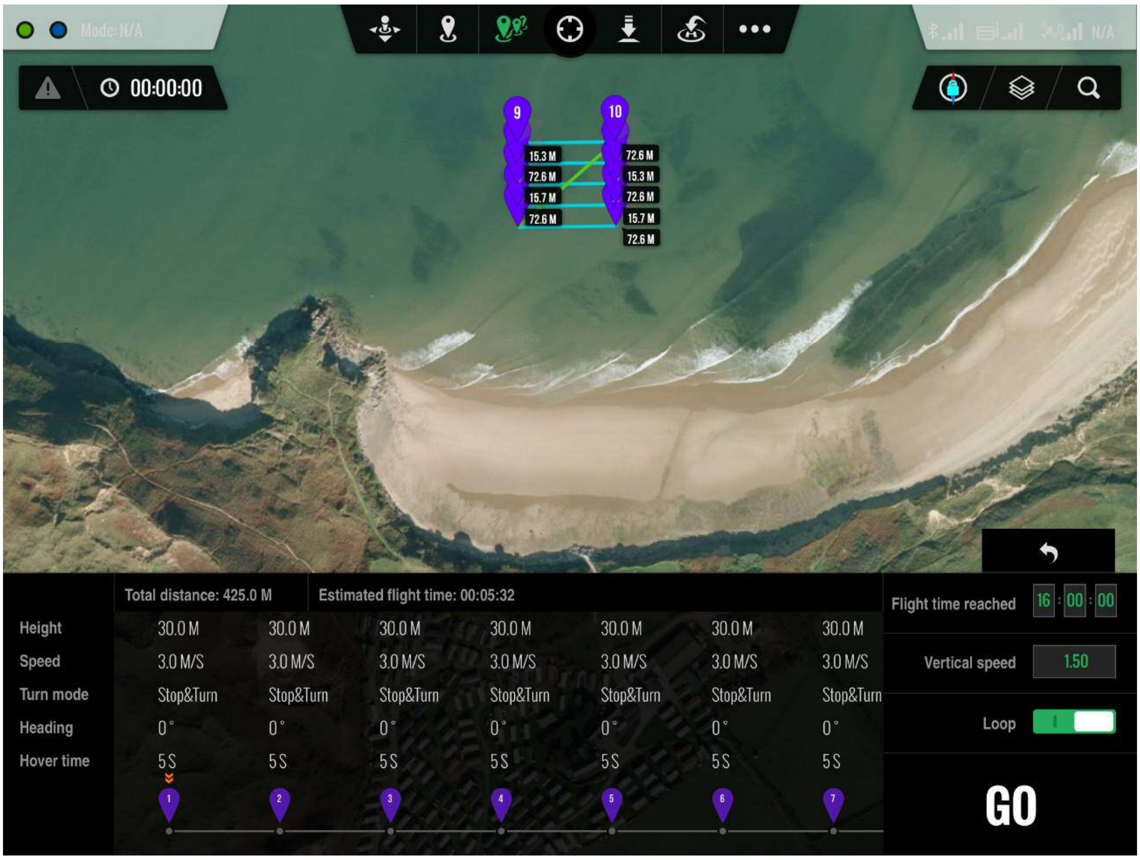

Figure 29: Flight plan for drone survey of lower beach peat exposure at Broughton Bay created using the DGI Ground Station app

Figure 30: Flight plan for survey of Port Eynon peat exposure in the lower intertidal zone created using the DGI Ground Station app

5.3 Archaeological Investigation

No new direct archaeological evidence was identified during fieldwork at Broughton Bay. However, in February 2015 the human footprints at Port Eynon, initially discovered in early 2014 (BBC 2014; GGAT 2014b) and referred to in Chapter 4, were re-identified during fieldwork associated with other aspects of this project. In April 2016, due to reports from local residents of further exposure and a very low estimated tide, it was decided to return to create a comprehensive plan of the deposit.

5.3.1 Methodology

The field methodology employed for the investigation of the human and animal footprints at Port Eynon takes lead from the methodology used at Goldcliff (Scales 2003,2007).

Once the deposit had been exposed by the tide, excess sand remaining on the surface was removed using buckets of water and sponges (Figure 31). Work was conducted from the seaward end of the deposit, up the beach in order to allow as much time as possible before the tide returned.

Figure 31: Field team members remove excess sand

In accordance with (Scales 2007), clear plastic sheeting was used to create the plan. The sheeting was pre-cut into metre squares, each being given a number, with each corner labelled A-D. It was then pinned over an area of interest, with each corner being recorded with a GPS point using the Trimble RTK Rover unit. This enabled the plan to be geo-referenced back in the laboratory so that it could be reconstructed using ArcGIS. 16 squares were recorded in all.

Using waterproof markers, the outline of any prints within the metre square were traced through onto the plastic (Figure 32). This was more difficult than had been expected. Despite fair conditions, the plastic sheeting inevitably got wet, making it difficult to draw on the sheeting.

Figure 32: Using plastic sheeting to trace footprints directly

The reflective nature of the sheeting also proved problematic. Though clear, once placed on the ground, the bright conditions meant it was difficult to see through to the deposit below (Figure 33). The outlines of all identifiable prints, both human and animal, were eventually recorded. This included newly discovered prints to the north of the previously known exposure. Due to the eroded nature of the peat, depth and skid marks were not recorded as per Scales' methodology (2003, 38), as it was unclear whether these were related to the creation of the footprint or later erosive processes.

At this point it would have been useful to take individual technical photographs of all of the prints, but due to time constraints only a small selection was taken, focussing mainly on the human footprints. This is something that should be factored into any future investigations.

Figure 33: Visibility difficulties when tracing from the wet beach through plastic sheeting

The plastic sheeting squares were laid out in the laboratory, with a baseline set between corners A and D for each (Figure 34). They were then planned according to archaeological drawing conventions. This process took far longer than the tidal window would have allowed in one visit and attempting to split the task across multiple visits risked the loss of evidence between tides due to erosion or sand deposition.

Each individual square was then scanned and digitised into a vector file using Adobe Illustrator. In ArcGIS, the data from the GPS was imported and displayed as British National Grid eastings and northings (Figure 35). The vector files were then imported individually and georeferenced to their corresponding corner points, creating an overall plan of the exposure (Figure 36-38).

Unfortunately, due to the compression applied to files being imported and exported from ArcGIS, the resulting plan was not of publication quality. To rectify this, the plan was opened in Adobe Illustrator and the original vector images were scaled and overlain in a separate layer, creating a much clearer plan.

Figure 34: Planning in the lab

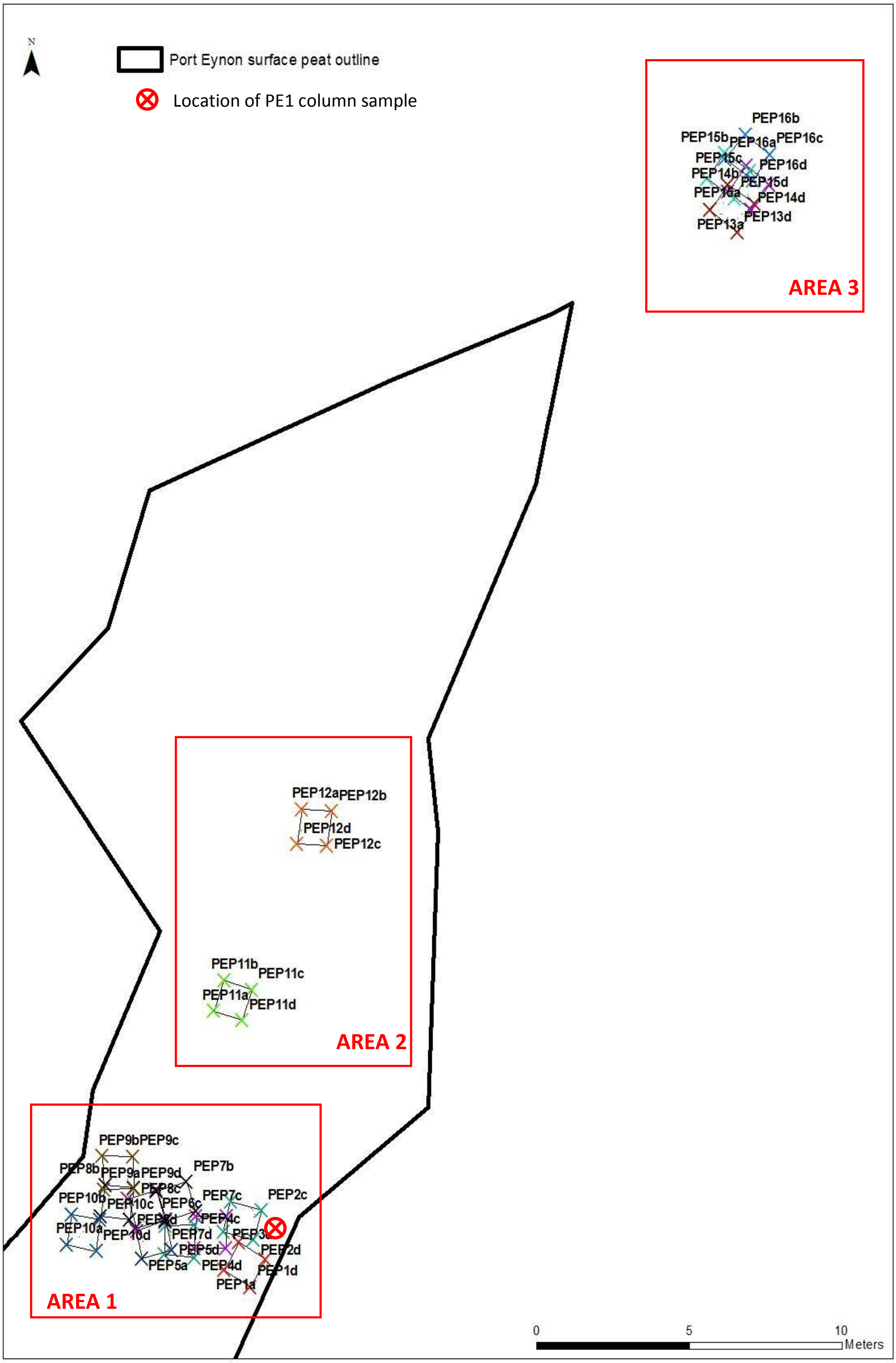

Figure 35: British National Grid eastings and northings data from the corner of each square displayed in relation to the peat edge recorded in 2015 (Note the new area of exposure to the north east in Area 3)

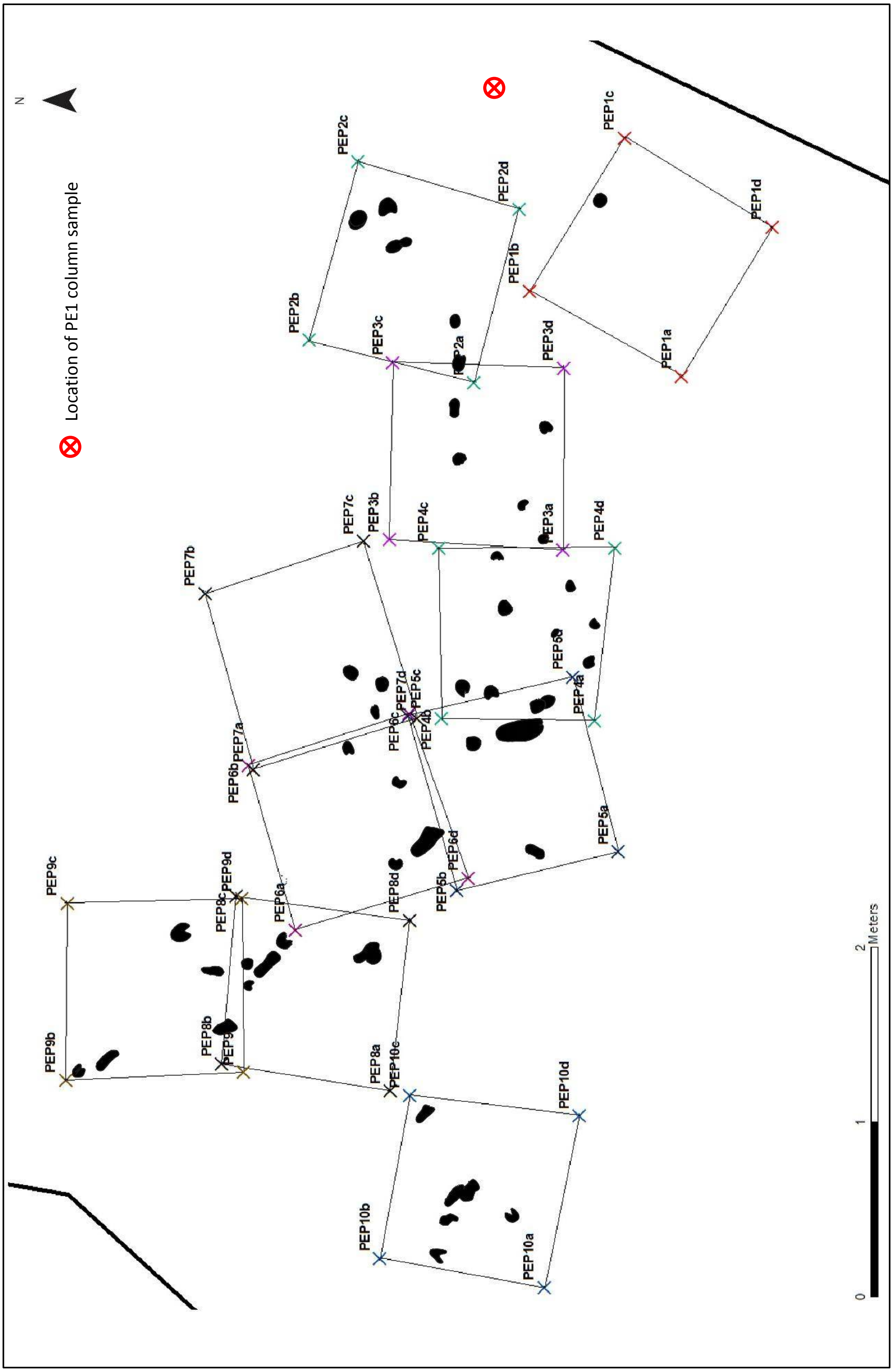

Figure 36: Georeferenced plan squares with their corresponding corner data (Area 1)

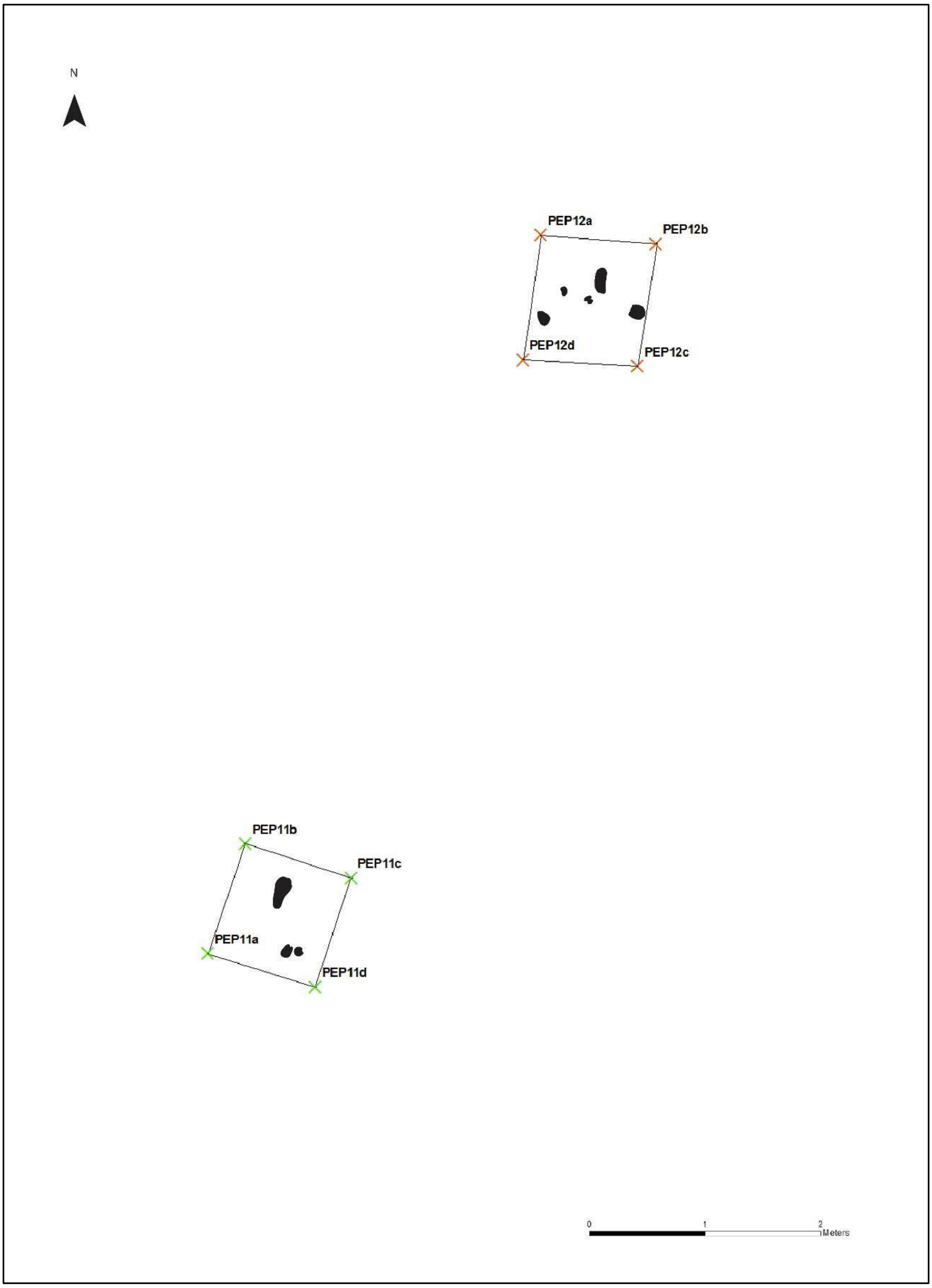

Figure 37: Georeferenced plan squares with their corresponding corner data (Area 2)

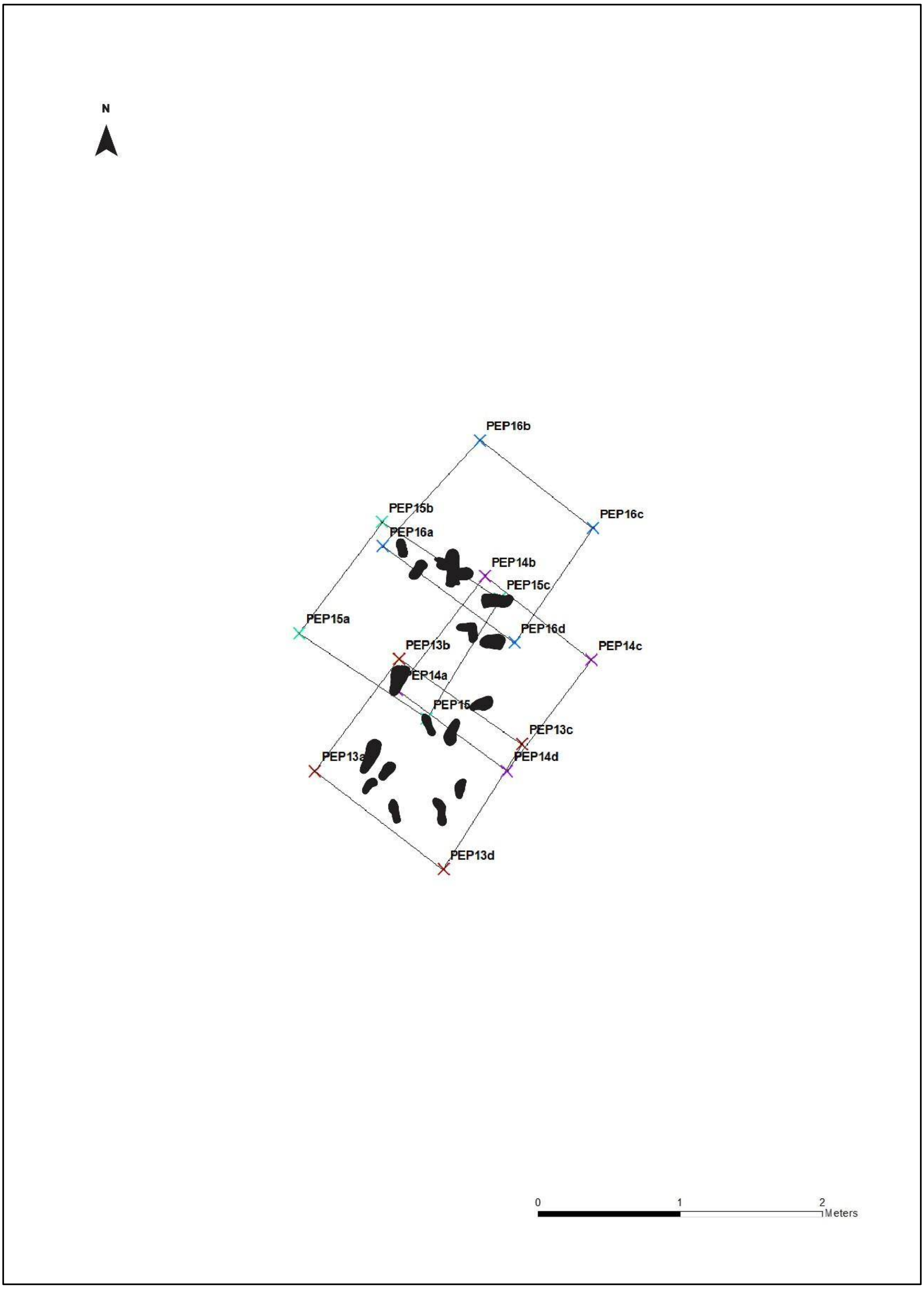

Figure 38: Georeferenced plan squares with their corresponding corner data (Area 3)

5.3.2 Nomenclature

Footprint nomenclature used in this study takes lead from (Allen et al. 2003). The predominant term used is ***Footprint***, referring to the imprint left within the surface of the sediment on which the human or animal was moving. ***Trail*** has been used to denote a sequence of footprints left by an individual. Further terms outlined by Allen et al. were not applicable at Port Eynon due to the nature of the site, for example ***Footprint-track*** would be used in other contexts to describe where the lower sediment and the overlying preserving layer were maintained. The erosive processes at Port Eynon have removed any trace of overlying material.

5.3.3 Human Characteristics

Each identified human footprint was measured in the field from heel to the end of the big toe. Measurements were rounded to the nearest 0.5cm as the degree of erosion made exact measurement difficult. Foot lengths were then compared to a dataset, which consists of foot length and height data collated from two different sources. The first is from a practical session created by Professor Jacqui Mulville that has been run intermittently as part of a First Year undergraduate Archaeology module at Cardiff University since 2006, consisting of 300 adult participants. The second is from an activity run as part of the City Region Exchange funded Footprints in Time Project, which was delivered by the author and Guerilla Archaeology at public events during the summer of 2016 (Philp 2016). This consisted of 52 participants, involving adults and children. Overall the sample consists of 134 adult males (over 14 years old), 194 adult females (over 14 years old) and 26 children. The source data for this dataset is in Appendix 6.

All data collated was completely anonymised and data was only obtained once permission had been granted from the participant or in the case of children, a parent or guardian. Participants were asked to measure their own foot length, from heel to big toe, and height. Children were asked for their age up to the age of 14. Adults and children over 14 were listed as biologically male or female. This is due to the fact that children grow at a uniform rate and before puberty, sexual dimorphism is minimal (Fessler et al. 2005). This means age can be estimated relatively accurately from their foot length, but past the age of 14 this becomes more difficult (Scales 2007, 141). In adults suggestions can be made on the sex of the individual based on overall foot length due to sexual dimorphism (Fessler et al. 2005, 55).

Once foot length data was recorded, height was estimated using the 15% foot length to height ratio suggested by Robbins (1986), based on a study of 550 individuals aged 3-79 years. Though not integral to the specific research questions asked of the footprints, an estimated height allows the Port Eynon data to be compared directly with the modern sample. The Port Eynon Data was then plotted onto the modern dataset map to create a visual comparison.

In order to create a meaningful comparison, the modern data was split into the following categories: ≤3 years, 4-6 years, 7-10 years, 11-12 years, Adult Female and Adult Male. The age range groupings were chosen to give an indication of the mix in ages present at the site, with the 11-12 category specifically chosen in order to isolate the rest of the child data, as it overlaps significantly with the female adult population within the study.

Probability distribution curves were then created for each category and standard deviation calculated to 1 and 2-sigma in order to calculate 68.2% and 95.4% confidence parameters (see Appendix 7). Each of the prehistoric footprints was then compared with these values by comparing the measured foot length against the confidence limits for each of the categories. The footprint was assigned to a category where it was within a higher confidence limit than any other category, or assigned to multiple categories if each had a similar level of confidence.

The results, presented in Chapter 6, were then used to highlight footprints pertaining to similar age groups to suggest related groupings.

5.3.4 Animal Characteristics

Animal footprints were identified using Lawrence and Brown (1973) in combination with prehistoric observations by Scales (2007). Each footprint was categorised by type: cloven hoof; non-cloven hoof; paw; and then measured for length and width. Splaying was also recorded where present by measuring the distance between toes and the footprints were visually compared with the identification guides.

Cloven footprints over 10cm in length and 9cm in width with little evidence for splaying were identified as potential juvenile aurochs in line with Scales (2007, 154). This is smaller than the expected size of an adult, but in keeping with the size of modern adult cattle (Lawrence and Brown 1973, 152). Cloven footprints with lengths ranging between 6-11cm in length and between 4-10cm in width (with the upper widths linked with clear evidence of splaying) have been categorised as likely to be red deer, with the very largest suggested to be representative of red deer stags as is suggested by Scales (2007, 156). Cloven footprints less than 6cm in length and 4cm in width were suggested to belong to either roe deer or juvenile red deer. Other species were identified using the characteristics outlined by Lawrence and Brown (1973).

5.3.5 Photogrammetry and 3D Printing

An opportunity arose to try an experimental recording approach at Port Eynon. Photogrammetry and 3D modelling and printing of a footprint were undertaken aided by Cardiff undergraduate Paul Smith as part of experimental research for his dissertation.

Consistent lighting was required to reduce the amount of shadows and reflections. To achieve this a tarpaulin was held to cast a shadow over the footprint being recorded. A quadrat was placed around the footprint to act as a fixed point of reference. 70 photographs were taken from positions surrounding the footprint (Figure 39), with significant overlap between each photograph to accurately record the depth within the model.

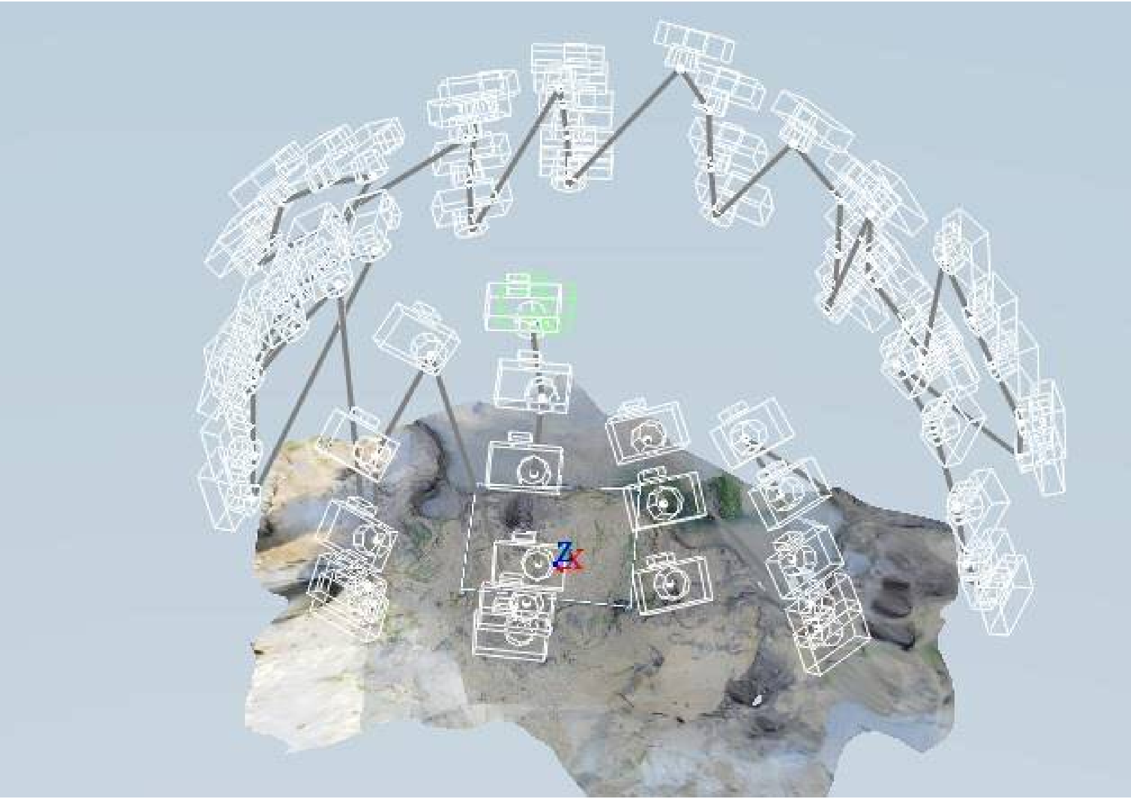

Figure 39: Position of camera around area of survey (Paul Smith 2015)

Photographs were then processed using freely available 3D modelling software packages. MeshLab was used to convert files between the different formats needed for each different software package. Autodesk 123D Catch was used to align and merge the photographs and create a 3D mesh. Where photographs could not be automatically merged, they were manually aligned using the four corners of the quadrat as control points. Netfabb was then used to fill any gaps left within the mesh by joining the closest vertices within the model together. This created a solid 3D surface file, which is required to be able to print the model. Next Google SketchUp was used to create a box beneath the surface mesh layer to turn the model into a physical object. Finally, MakerBot was used to digitally slice the model into the horizontal layers, to instruct the 3D printer. The 3D object was then printed at 1:1 scale, consisting of layers measuring 0.1mm in order to create the highest resolution model possible using a MakerBot Replicator 3D printer (Figure 40 and 41) (Paul Smith 2015, pers. comm.).

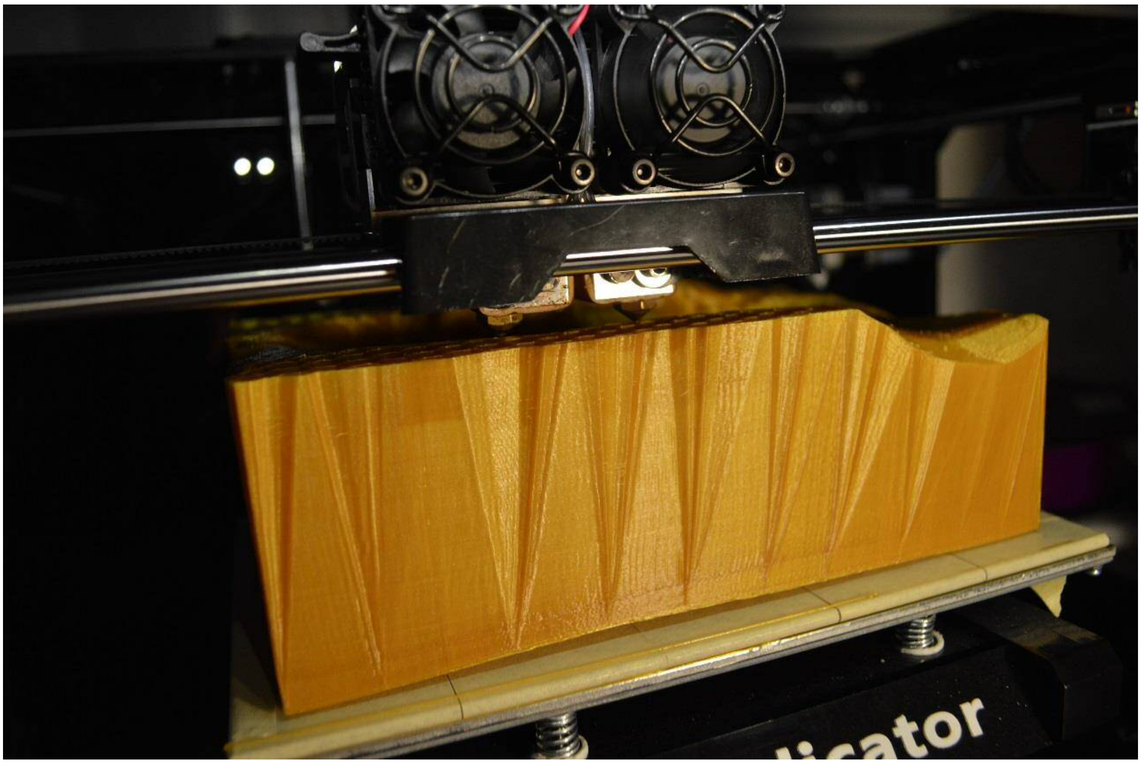

Figure 40: Side view of footprint being printed on a MakerBot Replicator 3D printer (Paul Smith 2015)

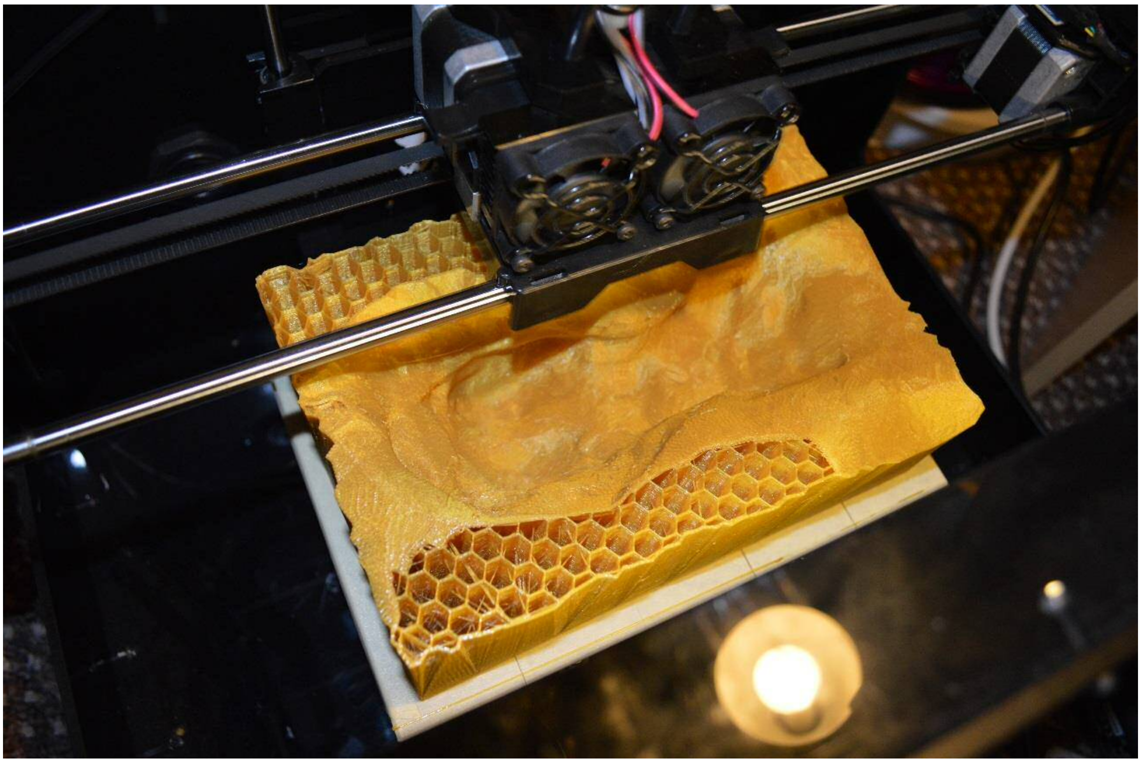

Figure 41: Overhead shot of footprint being printed. The inside of the model was designed to be honeycomb in structure to reduce the amount of material needed, while maintaining the object's strength (Paul Smith 2015)

5.4 Sampling

This section presents the techniques used to obtain the initial samples of the environmental sequence from which all subsamples for subsequent analysis were obtained.

5.4.1 Equipment

It was proposed to use a Russian auger where possible to prevent compaction and contamination and obtain accurate and secure stratigraphic samples. The auger must be pushed directly into the sediment and then turned 180˚ to enable the chamber to close around the sediments. The advantage of this equipment is that the sediments are not churned as they would be using an auger that requires a twisting motion to insert. This means they are kept stratigraphically intact and once the chamber is closed, can be removed cleanly without any risk of contamination.

The Russian auger is limited to fairly soft materials meaning it is well suited to upland peat environments, where it is widely used (Moore et al. 1991, 32), however the conditions presented in this investigation were not idea due to the solidity of the upper peat layers in the sediment sequences and the large amount of wood and fibrous material within them (a known issue highlighted by Moore et al. (1991, 32)). It was therefore not possible to take all the samples in this way, though the Russian auger was used in the softer lower deposits interspersed with clay at Port Eynon

Monolith tins were the main source of sample acquisition at both sites and were used to extract column samples. To begin with a 0.10m diameter square plastic drainpipe cut into 0.25m segments with one face removed was used. However, these proved difficult to use effectively due to the high flexibility of the plastic. On subsequent occasions samples were taken using 0.08m diameter metal monolith tins, 0.25m in length. These proved much more efficient and meant the samples were better contained, because they were enclosed at each end.

Gouge and power augers were not used to collect samples due to the risk of inaccuracies when sourcing radiocarbon dates from samples due to compaction and contamination and in line with guidelines set by the NERC Radiocarbon Facility (NERC 2015). However, a 20mm diameter gouge auger was used to prospectively gauge depths of deposit prior to sampling.

5.4.2 Methodology

Vertical sections were cut into the sediment sequences (Figure 42) as deep as the tidal water table would allow, with the aim to at least sample the extent of the exposed peat deposit itself and where possible the underlying sediments. Monolith tins were pushed into the vertical section (Figure 43) with an overlap where two tins were used (Figure 44). Surface height was recorded using GPS. Tins were then carefully cut out of the section using a knife and spade.

Figure 42: Cutting a vertical section through intertidal deposits at Port Eynon

Figure 43: Inserting monolith tins into peat deposits at Port Eynon

Figure 44: Overlapping monolith tin placement

Monoliths were used for sample extraction from all sample sites at Broughton Bay and the sites situated in the upper intertidal zone at Port Eynon (Figure 45 and 46).

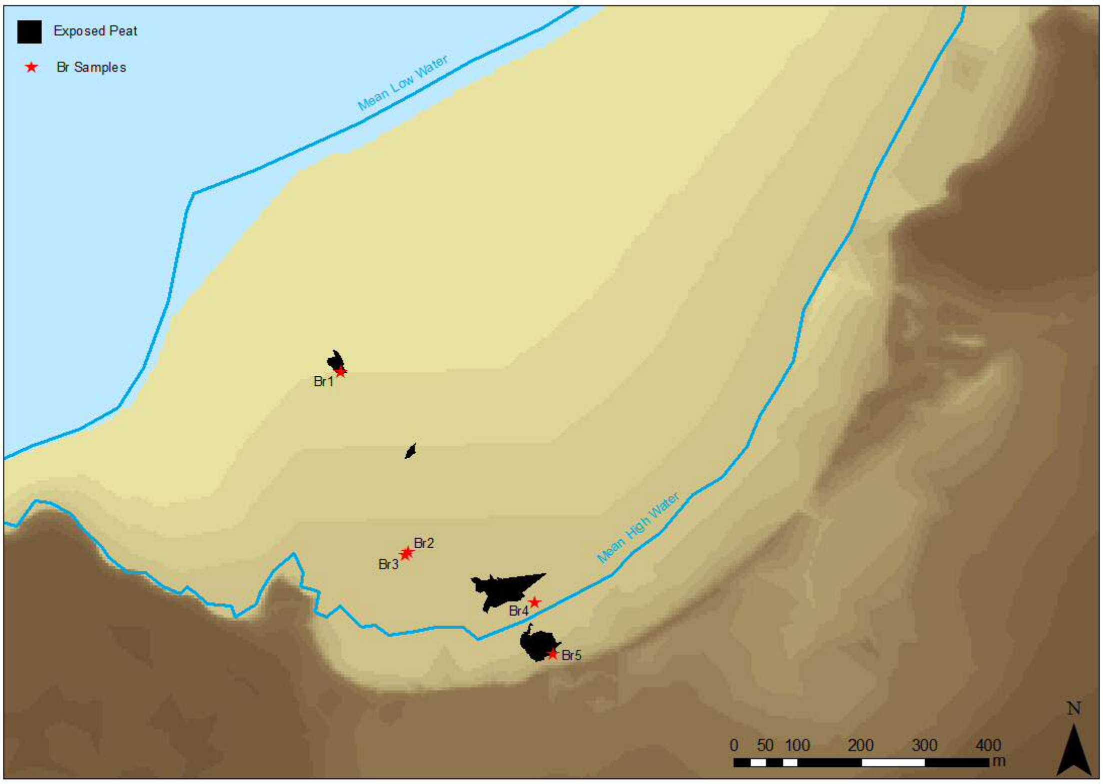

Figure 45: Sample locations at Broughton Bay

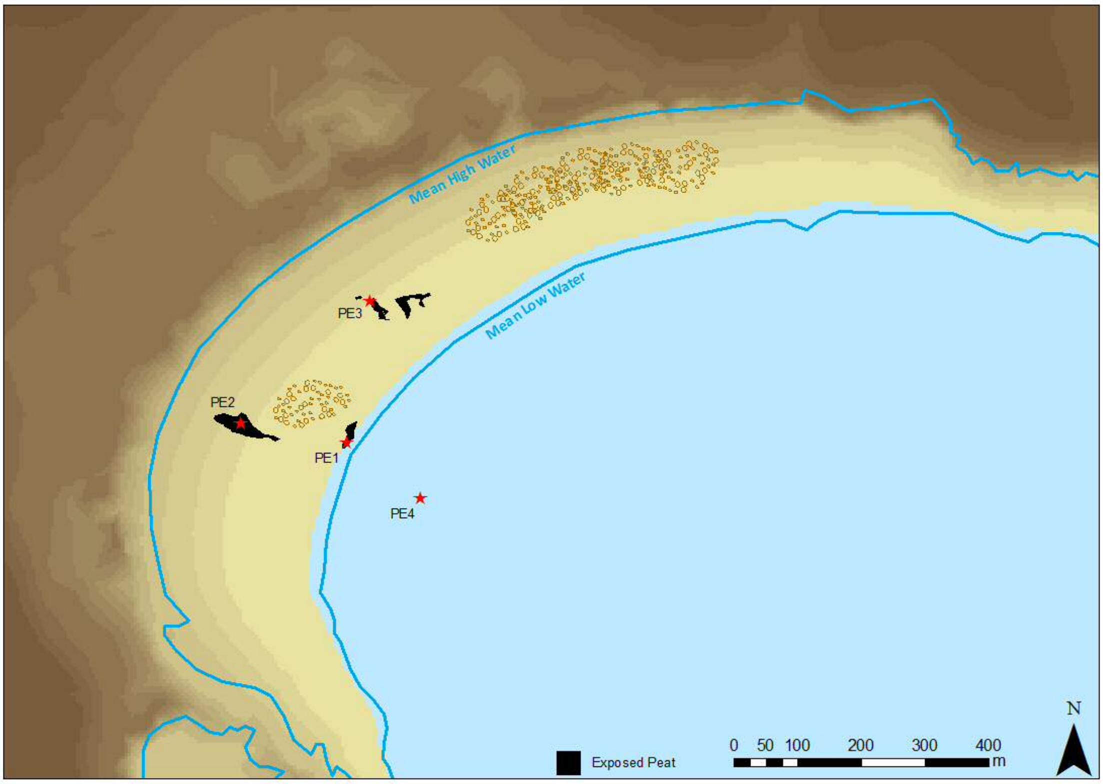

Figure 46: Sample locations at Port Eynon

The position of the lower Port Eynon deposits in relation to the tide meant that the depth of the section cut into these deposits was limited. In this case a monolith was taken from the upper 25cm. The lower sediments were soft and clear of fibrous woody material, which allowed the Russian Auger to be used at this location with reasonable success, allowing for a further 40cm of material to be recovered (Figure 47). A further spot sample was also obtained from a prospective auger point at the lowest point of the tide, which represented the deepest organic deposit identified during fieldwork.

Figure 47: Russian core from lower Port Eynon intertidal organic deposits

Post-extraction, the monoliths and cores were wrapped and stored in a fridge to prevent microbial activity. Some of the samples were spread over two monoliths and in one case a monolith and a sediment core. To cover the entire sequence accurately, these samples were taken with an overlap. The positions of the samples were mapped in ArcGIS using the GPS data, as can be seen in Chapter 6.1.

5.5 Radiocarbon Dating

Due to financial restrictions a full radiocarbon analysis could not be undertaken. Instead a range finding approach was undertaken.

5.5.1 Methodology

Sampling Strategy

Due to the archaeological interest provided by the presence of human footprints at Port Eynon, it was decided to focus predominantly on this site. Samples were selected from the uppermost and lowermost organic peat deposits within the sequences identified related to the footprints and those further up the beach. One sample was also taken from upper peat deposits in the most seaward part of the intertidal zone at Broughton Bay in order to compare the deposits with those at Port Eynon. The dates obtained would act as range finding dates. In total six samples were obtained for dating.

Sample extraction

Initial subsamples were taken from the selected deposits and wet sieved for plant macrofossils. Although plant macrofossils were obtained, they were deemed unsuitable for dating due to the fact they were an aquatic species (*Potamogeton*) (Marty and Myrbo 2014). Therefore, though not ideal, bulk samples were submitted for dating.

2cm³ bulk samples were extracted from the specified deposits using a clean leaf trowel and placed in sealed plastic bags, as specified by the radiocarbon lab (14CHRONO 2017). Samples were then weighed and labelled before being sent to the ^{14}CHRONO Centre at Queen's University, Belfast, where they were pre-treated prior to dating.

Pre-treatment

Combined humic and humin acids (bulk peat) were selected for dating. The material was pre-treated to remove calcareous contamination and fulvic acids. 4% hydrochloric acid was added and the sample heated to 80˚C for 2 hours prior to rinsing until the pH returned to neutral (Reimer et al. 2015, 5).

Calibration:

Dates were calibrated using OxCal v4.3 (Bronk Ramsey 2009) and the IntCall13 and MARINE13 radiocarbon age calibration curves (Reimer et al. 2013). Calibrated dates were rounded to the nearest 10 years, as recommended by Mook (1986) due to the conventional radiocarbon ages having error margins >25years.

Bayesian Modelling

Bayesian modelling was undertaken using OxCal v4.3 (Bronk Ramsey 2009) on the samples from Port Eynon in order to construct an age-depth model. The lone sample from Broughton Bay was not included in this round of modelling, but should further dates become available for the site, this would be an avenue to pursue in the future.

The *P_Sequence* function (Bronk Ramsey 2008) was used due to the essentially random nature of peat deposition (known as a “Poisson” process (Bronk Ramsey 2008, 44)). The prior for the deposition rate was determined as log_10 (k/k_0) where k_0=1, allowing k to take any value from 0.01-100. A low interpolation was set at every 10cm. This was due to the limited depth of peat and low number of dates available and follows the approach taken by Griffiths et al. (2015, 246) with samples from the intertidal zone at Hinkley Point. A similar approach was also used when modelling dates for the Lyonesse Project in the Isles of Scilly (Marshall et al. 2016, 90).

5.6 Palaeoenvironmental Investigation

5.6.1 Environmental Proxies

Pollen has been chosen as the main proxy with which to investigate the layers of sediment within the submerged intertidal deposits at both the chosen study sites, but it will be used alongside Non-pollen Palynomorphs, Microcharcoal and Diatoms in order to provide a full palaeoenvironmental picture. No modern palaeoenvironmental studies have been conducted at either of these sites prior to this study. This investigation takes the form of a successional study (Moore et al. 1991, 191), which provides a record of direct local changes at each of the study sites.

5.6.2 Subsampling

At the point of subsampling, the monoliths were laid out and the overlap identified and lined up. Each sample was photographed, and the section drawn. Subsamples of 2cm³ were extracted using a square ended leaf trowel and then shaped into a compact pellet using an adapted oral syringe. The subsample volume was derived from discussions with a professional palynologist regarding worries about pollen preservation in the intertidal zone (S. Richer 2015 pers. comm.). Similar investigations further east on the South Wales coast at Kenfig had revealed poor pollen preservation in the intertidal peat deposits analysed (Bennett et al. 2010, 72-3). The standard measure for pollen subsamples is 1cm³ or less (Moore et al. 1991, 39), but in this case it was decided to process a larger subsample in order to stand the best chance of pollen collection. Subsamples were then placed directly into labelled centrifuge tubes ready for processing. Polystyrene spacers labelled with the sample number were placed within the remaining void to maintain the integrity of the column and a physical record of sampling to date. Subsampling diagrams can be found in Appendix 8.

Sample Resolution

Due to financial constraints, the decision was made at this stage to focus more resources on Port Eynon than Broughton Bay. This was due to the nationally significant human footprints exposed within the peat deposits under investigation at this site. Therefore, palaeoenvironmental data collected from Port Eynon was of much higher resolution than that at Broughton Bay.

Subsamples were initially taken from the top and bottom (where possible) of each distinct layer within the deposit. This provided a reasonable coverage for columns such as PE1, where 22 subsamples were taken over a 60cm depth. However, in other samples containing less layers, the resolution was as little as 4 subsamples over a 25cm depth and within PE1 there were areas that were deemed to benefit from further subsampling and analysis. After consulting the methodologies of a number of similar investigations including the Hullbridge Survey (Wilkinson and Murphy 1995), Langstone Harbour Survey (Allen and Gardiner 2000a) investigations at Goldcliff (Dark 2007), Lydstep (Murphy et al. 2014) and Kenfig (Bennett et al. 2010), it was decided that a higher definition was needed for the thicker layers of sediment, but that this did not necessarily mean a centimetre by centimetre approach. Instead subsamples were taken at even intervals, with the distance between each subsample dictated by the thickness of the sediment itself. If substantial changes were identified within the layer, the situation would then be reassessed and further subsamples could be taken to increase the resolution.

Figure 48: Subsample positions for PE1

5.6.3 Preparation

Pollen

The pollen preparation procedure was derived from standard methods set out by Erdtman (1960) and Moore et al. (1991). Lycopodium tablets were added to samples prior to treatment to act as an exotic marker. Each tablet contains a known quantity of lycopodium spores. These are counted along with the native pollen and spores and used to calculate pollen concentrations. Samples were chemically treated to remove carbonates and silicates, break down humic acids and remove any remaining cellulose. They were then sieved to remove any further unwanted coarse components and suspended in glycerine prior to mounting on microscope slides. A full procedure for sample preparation can be found in Appendix 9.

Pollen were counted using a Leica DME microscope at x400 (or x1000 where needed for identification). A sum of Total Land Pollen (TLP) was obtained from each sample. This included arboreal, shrub and herb species, but excluded spores and aquatic species, which were counted alongside separately. TLP counts were set dependent on the stage of analysis (see below). From these counts, it was then possible to calculate pollen percentages. Three percentage sums were calculated using the Tilia software package (Grimm 2015): Total Land Pollen (herbs, shrubs and trees), Total Land Pollen + Spores and Total Land Pollen + Aquatics.

Pollen and spores were identified using a combination of Moore et al. (1991) and Beug (2004). The latter was not used for initial identification due to it being primarily designed for central European studies, however it served to provide extra clarification where identity could not be acquired using Moore et al alone. Pollen and spore nomenclature used in this thesis follows Bennet (1994) and vascular plant nomenclature follows Stace (2010). In this investigation, *Corylus avellana* type is assumed to represent hazel in line with suggestions by Edwards (1981). Poaceae pollen grains with a diameter over 40 are classed as cereal type (Andersen 1979), but it should be noted that these may also include some wild grasses such as Glyceria (Moore et al. 1991, 100). This is an important consideration due to the geographical context of this study, as Glyceria is a species native to coastal environments. Decisions regarding Poaceae vs Glyceria have been made based on the environmental context indicated by the pollen record.

Non Pollen Palynomorphs (NPPs)

Non pollen palynomorphs survive the pollen preparation procedure and are viewed and counted alongside pollen grains. In this investigation, NPPs were counted until the specified TLP count was reached and are expressed as counts rather than percentages. NPPs were identified using Van Geel (1978) and Van Geel and Aproot (2006).

Micro Charcoal

Micro charcoal also survives the preparation procedure. In accordance with Mooney and Tinner (2011), only completely opaque, black, angular fragments over 10µm in size were counted. Once again counting continued until the specified TLP had been reached and results are expressed as counts rather than percentages.

Diatoms

Diatom analysis was attempted by Einir Smith (2017) as part of an undergraduate research project in conjunction with this investigation. Sample choice was informed by similar analysis undertaken during the Lyonesse Project (Charman et al. 2016b). Samples were obtained from minerogenic sediments within the sequence that also contained high levels of Chenopodiaceae pollen, as these inferred direct relationships to marine transgressive periods. Samples were prepared using the water bath methodology outlined by the Oxford Long-Term Ecology Laboratory (OxLEL 2016):

5ml of hydrogen peroxide was added to 0.1g of sediment. The samples were then heated to 80˚C in a water bath until all organic material had dissolved. After being removed from the water bath, 1-2 drops of 50% hydrochloric acid were added to neutralise the hydrogen peroxide. Samples were then topped up with distilled water and left overnight to settle, before the liquid was poured off. This process was repeated four times and the remaining suspension mounted on slides.

A minimum total sum of 200 diatoms was sought in line with the approach taken by Hill et al. (2007) in the Severn Estuary.

5.6.4 Assessment

To assess the viability of the study and test the methodologies, a preliminary pollen assessment was conducted on one of the sample cores. Following advice from a professional palynologist (Suzi Richer 2006 pers. comm.) it was decided to assess the top and bottom of each sedimentary layer and count until 100 TLP grains was reached per sample to quickly ascertain viability by providing a low-resolution interpretation of the deposits. This allows a general overview of the changes in the environment that have occurred and gives an indication of the state of preservation within the deposits. A short assessment report can be found in Appendix 10. The results showed reasonable pollen preservation, allowing the investigation to proceed to full analysis.

5.6.5 Analysis

Pollen

A sum of 500 Total Land Pollen (TLP) were sought for each sample during the analysis stage. Where preservation was poor, either a sum of 300 TLP was obtained or 4 slides were scanned (whichever came first). This procedure follows similar studies undertaken by Dark (2007) and Timpany (2005) on intertidal deposits in the Severn Estuary.

5.6.6 Data Presentation

Pollen diagrams were plotted using the TILIA and TILIA*GRAPH programmes (Grimm 2015) displaying pollen, NPP and Microcharcoal values. Zoning was accomplished using the CONISS (Constrained Incremental Sum of Squares) function within the TILIA software package. Pollen percentage diagrams are displayed within the following results chapter (6).

5.7 Summary

This chapter has presented the methodologies used in each separate part of the investigation into the intertidal archaeological and palaeoenvironmental evidence present at Broughton Bay and Port Eynon on the Gower Peninsula. The differing sources of evidence have called for a multifaceted approach to fully understand the archaeological and environmental histories of each of the sites.

The methodologies were inspired by approaches developed specifically for the intertidal context by previous studies including investigations in the Severn Estuary (Bell et al. 2000b; Bell 2007d), Langstone Harbour (Allen and Gardiner 2000a), the Isles of Scilly (Charman et al. 2016c) and the Pett Levels (Timpany 2018).

The combined results of each of the methodologies outlined above will be presented in the next chapter and will be used in subsequent chapters to provide an in-depth discussion of key changes in the environmental and archaeological history of the study sites, including the effects of sea level change on the now drowned landscapes and their inhabitants.

6 Results

This chapter outlines the results of each of the methodological approaches taken during this investigation. In section 6.1 results of the initial topographic surveys at both Broughton Bay and Port Eynon are presented. This is followed by results from the archaeological investigations in 6.2, focussed on the footprints found at Port Eynon; the only direct archaeological evidence recorded during this investigation. Sediment characterisations are outlined in section 6.3, followed by the results of the Radiocarbon dating in 6.4. The palaeoenvironmental investigation including the pollen, diatom, non-pollen palynomorph and microcharcoal analysis is contained within section 6.5, which is concluded with full summaries of environmental change, the effects of human interaction on the environment and sea level change at both study sites.

6.1 Topographic Survey

6.1.1 Visible extent of intertidal peat exposures

The visible extent of the intertidal peat exposures at Broughton Bay and Port Eynon are displayed in the maps below (Figure 49 and 50), constructed using ArchGIS version 10.2.

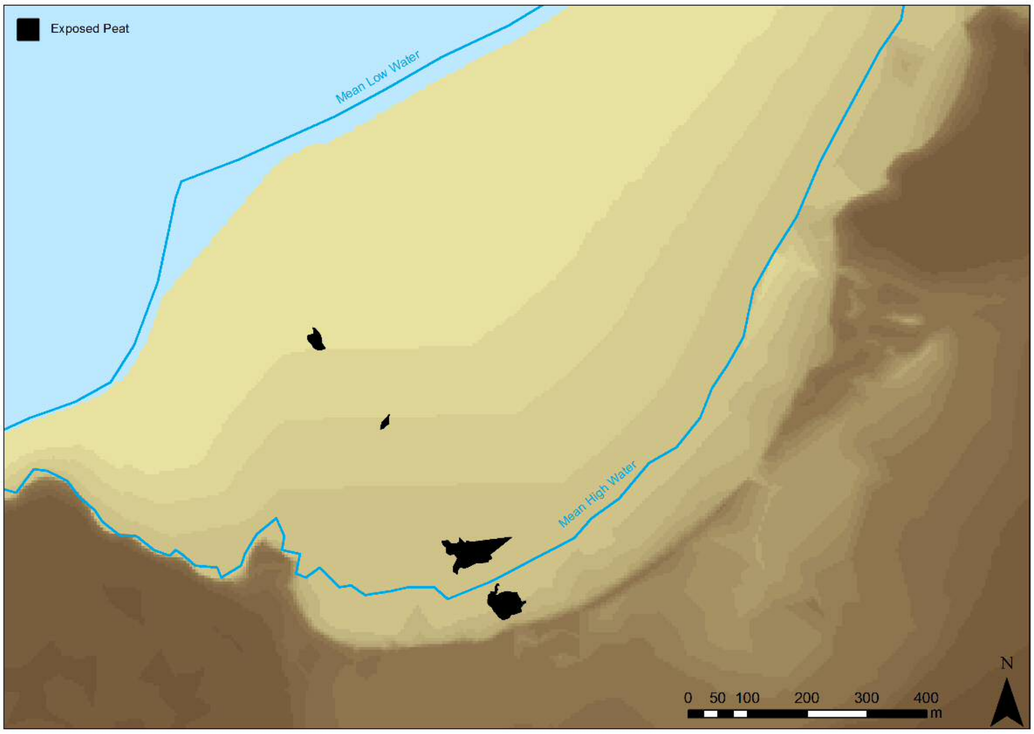

Figure 49: Locations of peat exposures at Broughton Bay following the GPS survey

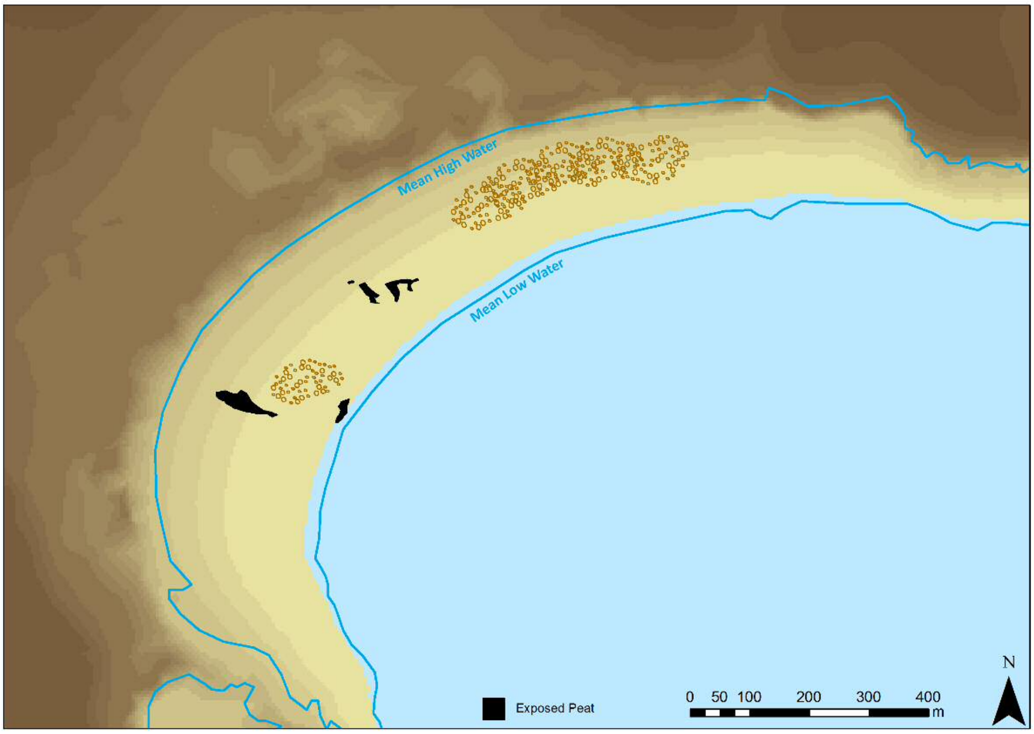

Figure 50: Locations of peat exposures at Port Eynon following the GPS survey

It is important to note that this was the extent visible in March 2015 and is known to have become more and less exposed on regular occasions since the survey due to the highly mobile sand deposits on both beaches.

Aerial photographs of the peat deposit were obtained using the drone set up outlined in the methodology chapter (Figure 51). Unfortunately, due to both hardware and software restrictions, it was not possible to stitch the captured images together to create images of a sufficiently high quality for mapping purposes. These issues are outlined in the following discussion chapter. The images produced were however of use in planning and engagement related activities.

Figure 51: Sample aerial photograph from a height of 50m at Broughton Bay. Black and green areas are part of the peat shelf.

6.1.2 Transects

The location maps for the transects below can be found in the methodology chapter (5).

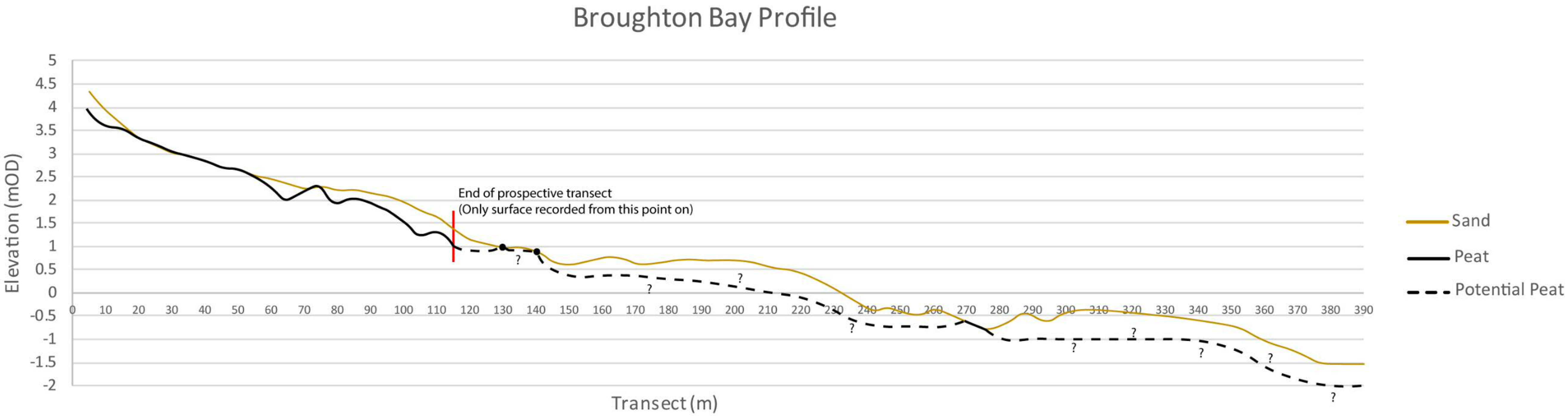

Figure 52: Profile of Broughton Bay beach showing the results of the auger survey and surface measurements

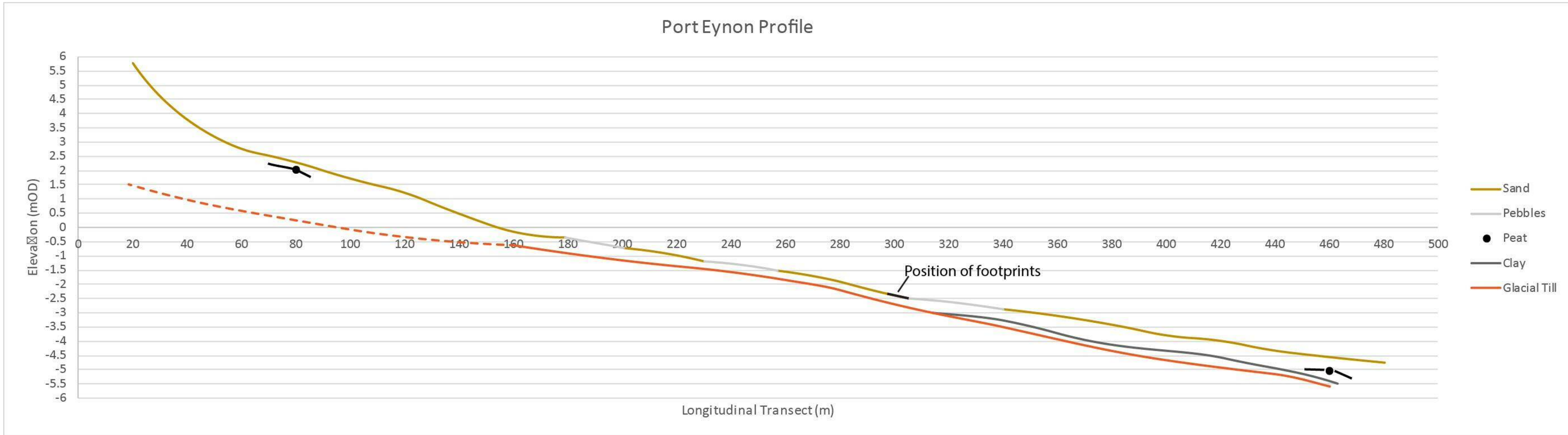

Figure 53: Profile of Port Eynon beach showing results of auger survey and surface measurements

6.2 Intertidal Archaeological Evidence

No archaeological evidence of any kind was identified in the intertidal zone during fieldwork at Broughton Bay. No material remains were identified at Port Eynon, but survey revealed the remains of human and animal footprints impressed into the peat itself.

6.2.1 Human Footprints

Overall thirty-two human footprints were identified and recorded using the methodology outlined in Chapter 5.3. A plan of the footprint exposure can be seen in Figure 54-56. Figure 59 show the prehistoric footprint length measurements plotted in relation to the modern dataset, introduced in Chapter 5.3, in. Basic statistical analysis has been employed to compare the prehistoric footprints to the modern dataset. This has revealed the presence of both adult individuals and children. The range in sizes of the smaller footprints indicates that children of varying ages under 12 were present.

Each individual footprint length was assigned to its most probable age categories using the derived confidence levels from the probability density curves and standard deviation calculations outlined in Appendix 7, (in most cases where the length falls within the 68.2% confidence range). This is not to say that the footprint could only belong to an individual of that age/sex, just that the selected category is the most likely, given the data available for comparison.

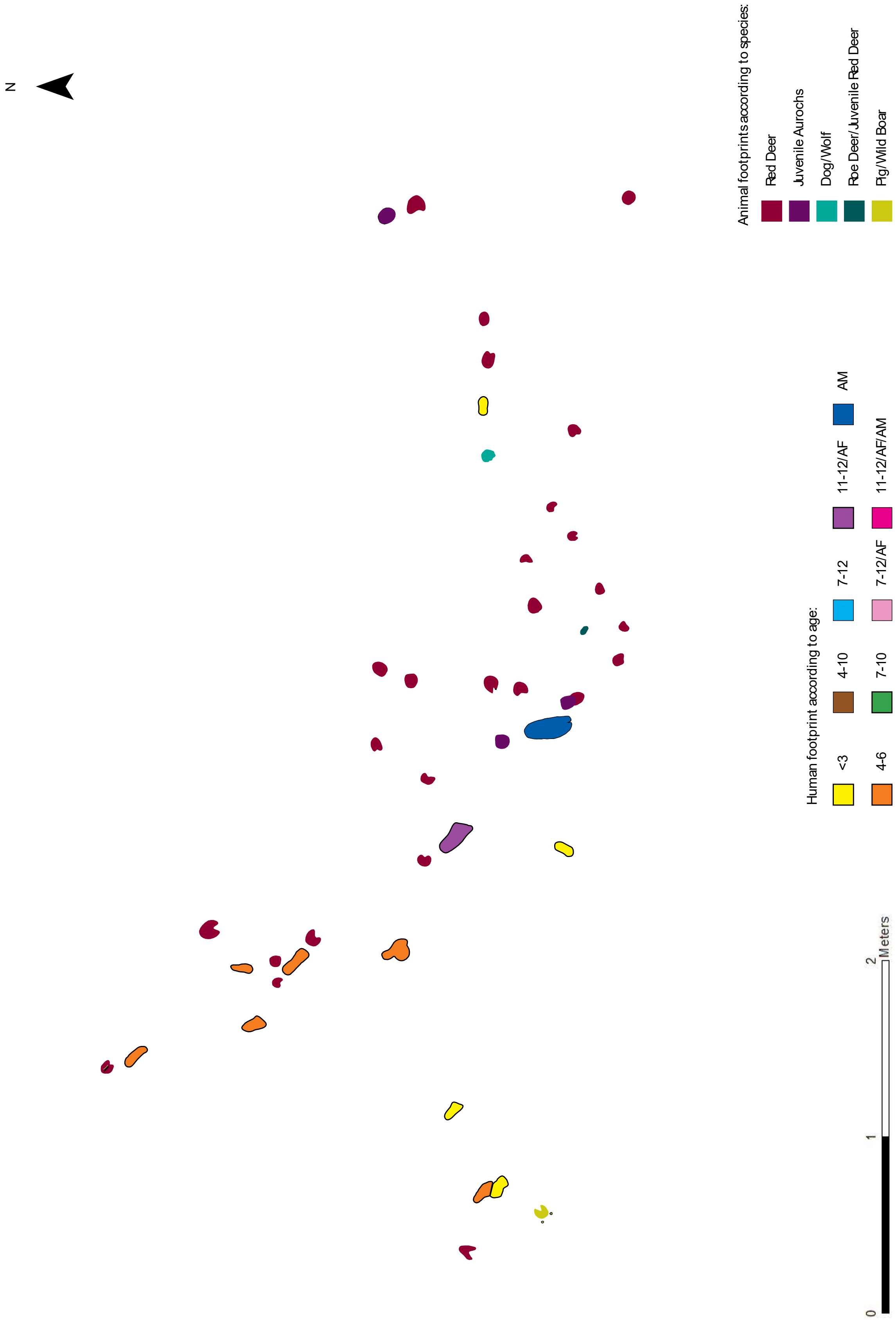

Figure 54: Colour coded plan of footprints in Area 1

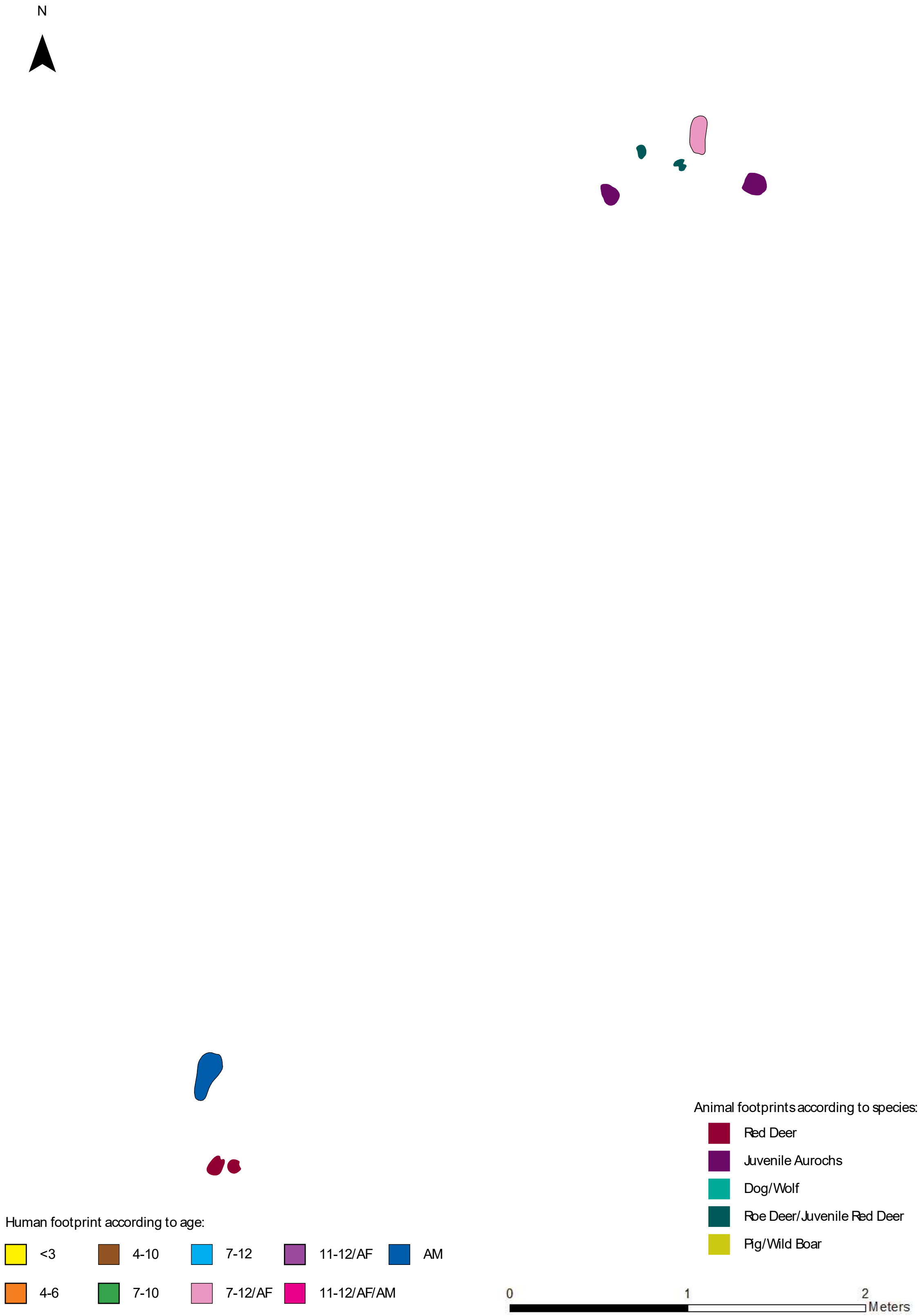

Figure 55: Colour coded plan of footprints in Area 2

Figure 56: Colour coded plan of footprints in Area 3

Figure 57: A modern six-year-old places her foot next to the print of a potential Prehistoric peer

Figure 58: Footprint belonging to an adult male in Area 1 with clear distinction of the big toe

Table 7 displays the probability in relation to confidence levels defined by standard deviation calculation to 1- and 2-sigma for each of the age or sex categories chosen for this investigation. Of the thirty-two prehistoric footprints identified, twenty-six were aligned with a specific category. Figure 60 plots the number of footprints that fall into a specific category based on these probability estimates. Of these, seven align with modern children of three years old or younger, fourteen with children between the ages of four and six and one between the ages of seven and ten. There are no footprints that align with a modern adult female specifically and four footprints are comparable with a modern adult male. The remaining six footprints fell between the selected distributions parameters. In these cases, the categories have been combined as can be seen in Figure 61. A high degree of overlap between older children (c.11-12) and adult females in the modern dataset can be seen. This indicates that identification of smaller adult females or larger children is difficult.

Prehistoric Footprint Length	3	4-6	7-10	11-12	AF	AM
11	<3					
12	<3					
14	1-SIGMA	2-SIGMA				
14	1-SIGMA	2-SIGMA				
14	1-SIGMA	2-SIGMA				
14	1-SIGMA	2-SIGMA				
14	1-SIGMA	2-SIGMA				
15		2-SIGMA				
15		2-SIGMA				
15		2-SIGMA				
16		1-SIGMA				
16		1-SIGMA				
16		1-SIGMA				
17		1-SIGMA				
17		1-SIGMA				
17		1-SIGMA				
18		1 SIGMA				
18		1-SIGMA				
18		1 SIGMA				
18		1-SIGMA				
18		1-SIGMA				
19		2-SIGMA	2-SIGMA			
20		2-SIGMA	1-SIGMA			
22			1-SIGMA	1-SIGMA	2-SIGMA	
22.5			1-SIGMA	1-SIGMA	1-SIGMA	2-SIGMA
23			2-SIGMA	1-SIGMA	1-SIGMA	2-SIGMA
23.5			2-SIGMA	1-SIGMA	1-SIGMA	1-SIGMA
24			2-SIGMA	1-SIGMA	1-SIGMA	1-SIGMA
27					2-SIGMA	1-SIGMA
27					2-SIGMA	1-SIGMA
28						1-SIGMA
28						1-SIGMA

Table 7: Confidence levels of each prehistoric footprint length against the age/sex categories

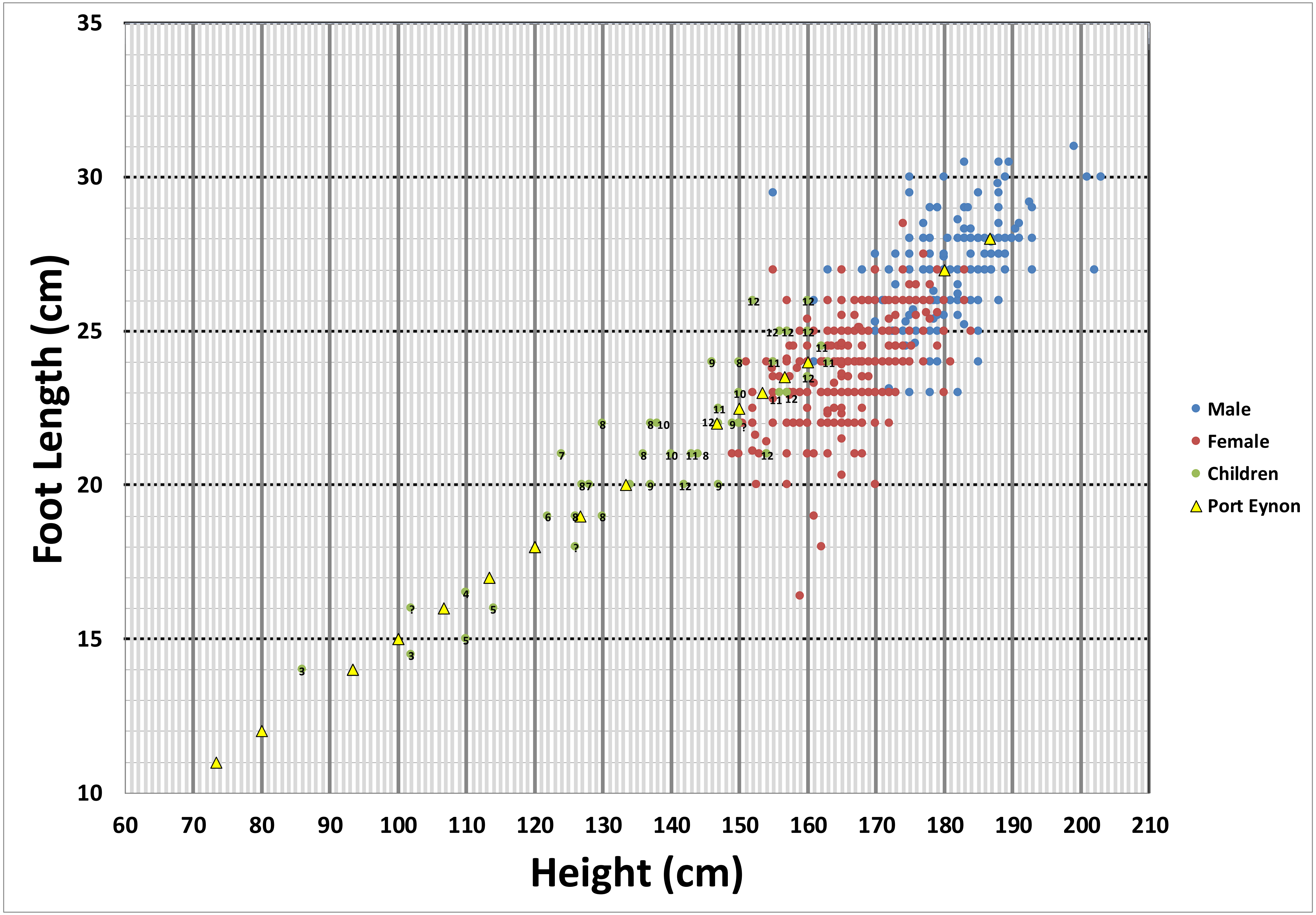

Figure 59: Graph showing prehistoric footprint length data (with 15% height ratio calculation as per Robbins (1986)), plotted against height and foot length data collated as part of a Cardiff University 1st Year Archaeology module devised by Professor Jacqui Mulville and run intermittently between 2004-Present, as well as data collected as part of the Cardiff City Region Exchange funded Footprints in Time outreach project, run in collaboration with Guerilla Archaeology in 2016. The numbers on child data points relate to age of individual.

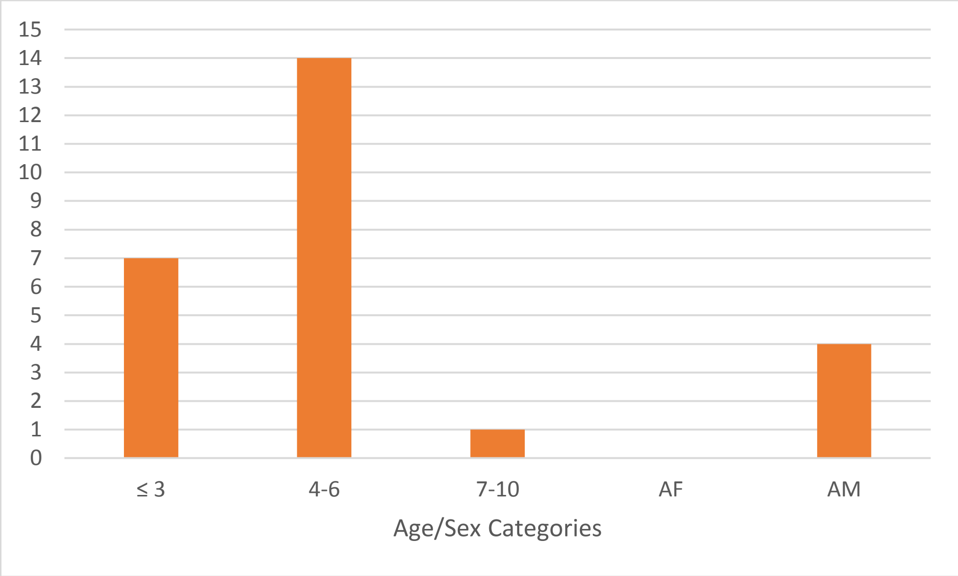

Figure 60: Number of prehistoric footprints relating to original age/sex categories

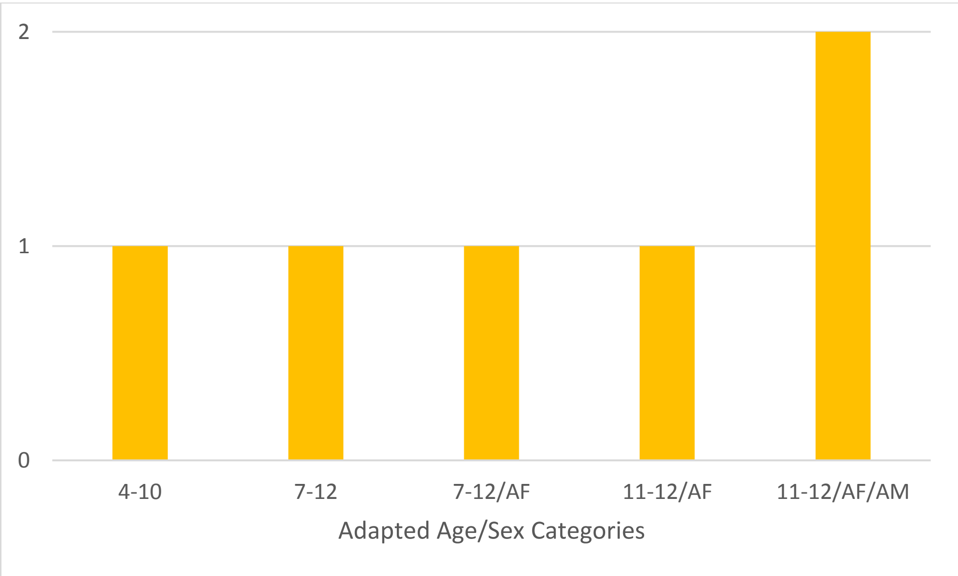

Figure 61: Number of remaining prehistoric footprints relating to adapted secondary age/sex categories

Due to the disparate layout and variations in size of the prehistoric footprints, it was difficult to identify trails within the exposure. It is possible to identify footprints ascribed to a single age category in the plan (Figure 54-56), and to link similarly sized prints within the same area. This gives an idea of where an individual may have been active, but not a clearly identifiable series of linked footprints or trail. At one location in Area 1, a potential trail has been identified with four similarly sized individual footprints in a line (Figure 62). However, the siding is only clear on one of the prints and the metrics indicate that the footprints belong to two different age groups. The footprints within this area are all pointing in the same direction however, which could indicate a group of people walking together.

Figure 62: A possible child's footprint trail

Area 2 contains just two individual adult human footprints, which are spread across a large area and cannot be related to any other human prints (Figure 55). They were situated in a highly eroded area of the exposure and accompanying prints are likely to have been lost due to this.

In Area 3 (Figure 63), the footprints appear to lie in opposite directions and overlay each other in places (Figure 64). This area is the most confused in terms of individuals represented, as the size measurements could be indicative of a range of ages according to the standard deviation calculations. It is highly likely that erosion has caused this discrepancy in sizing and that fewer individuals are represented than appear according to the data. However, a similar demography is represented in Area 3 as in Area 1, with the presence of young children and adults and is likely to be the same group of individuals. The evidence shows use of the same paths to get to and from a location, suggesting a return to a known place, rather than a one-way journey.

Figure 63: The newly exposed human footprints in Area 3

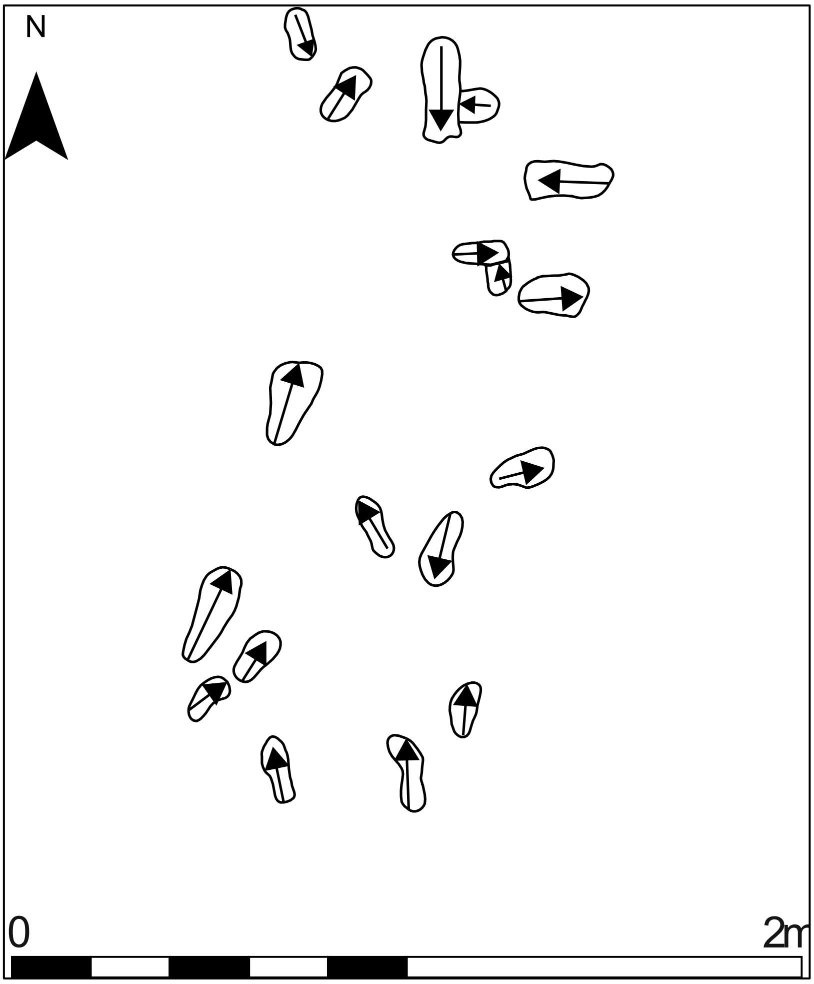

Figure 64: Area 3 footprint directions

6.2.2 Animal footprint results:

The animal footprints can be seen in plan in Figure 54-56, with metrics and observations displayed in Table 8. Identifications of potential faunal impressions were made in the field using (Lawrence and Brown 1973), with the likely presence of juvenile aurochs, red deer, roe deer/juvenile red deer, pig/wild boar (Figure 65) and a potential dog/wolf indicated (Figure 66). The presence of aurochs and roe deer is supported by faunal skeletal remains found on the beach during the 1930s (George 1930).

Figure 65: Wild boar print showing dew claw imprint. Roe deer prints are also visible.

Figure 66: Potential dog/wolf footprint

ID	Length (cm)	Width (cm)	Cloven?	Splay (cm)	Species	Comments
1	10	8	?	0	Juvenile Aurochs	
2	11	10	Y	8	Red Deer (Stag?)	Eroded
3	9	7	Y	4	Red Deer	
4	8	6	?	?	Red Deer	
5	8	7	?	?	Red Deer	
6	6	5	Y	3	Red Deer	
7	6	6	Y	4	Red deer	
8	7	6	Y	3	Red Deer	
9	10	8	Y	2	Red Deer	
10	9	8	Y	5	Red Deer	
11	10	7	?	?	Red Deer	
12	8	9	?	?	Red Deer	
13	5	7	Y	6	Red Deer	
14	6	3	?	?	Roe deer or Juvenile Red Deer	
15	7	6	Y	4	Red Deer	
16	5	6	Y	4	Red Deer	
17	6	6	Y	4	Red Deer	
18	8	8	?	0	Juvenile Aurochs	
19	8	8	?	0	Juvenile Aurochs	
20	8	6	Y	3	Red Deer	
21	5	8	Y	7	Roe deer or Juvenile Red Deer	
22	6	8	Y	4	Red Deer	
23	9	7	?	?	Red Deer	
24	7	7	?	?	Red Deer	
25	6	6	Y	4	Red Deer	
26	6	6	?	?	Red Deer	
27	9	8	Y	6	Red Deer	
28	7	6	Y	4	Red Deer	
29	11	10	Y	5	Red Deer (Stag?)	Eroded
30	10	6	Y	6	Red Deer (Stag?)	
31	7	7	Y	4	Pig/Wild Boar	Dew claw indents
32	11	8	Y	3	Juvenile Aurochs/ Red Deer (Stag?)	
33	6	8	Y	4	Red Deer	
34	13	11	?	0	Juvenile Aurochs	
35	6	6	Y	4	Roe deer or Juvenile Red Deer	
36	5	7	Y	5	Roe deer or Juvenile Red Deer	
37	12	9	?	0	Juvenile Aurochs	
38	?	8	Y	4	Red deer	
39	9	8	N	0	Dog/Wolf?	Paw with potential claw marks

Table 8: Animal footprint observations from Port Eynon

6.2.3 Photogrammetry and 3D Printing

A physical 3D model was produced of a footprint pertaining to a child now shown to be aged between 4 and 10 years old (Figure 67). The footprint lies within Area 1 of the recorded exposures. The model highlighted a feature that had not been noted while in the field. Within the ball of the human footprint, a roe deer footprint is visible. The edges of the footprint are sharp, suggesting that the roe deer stepped into the child's footprint a short time after it had been made.

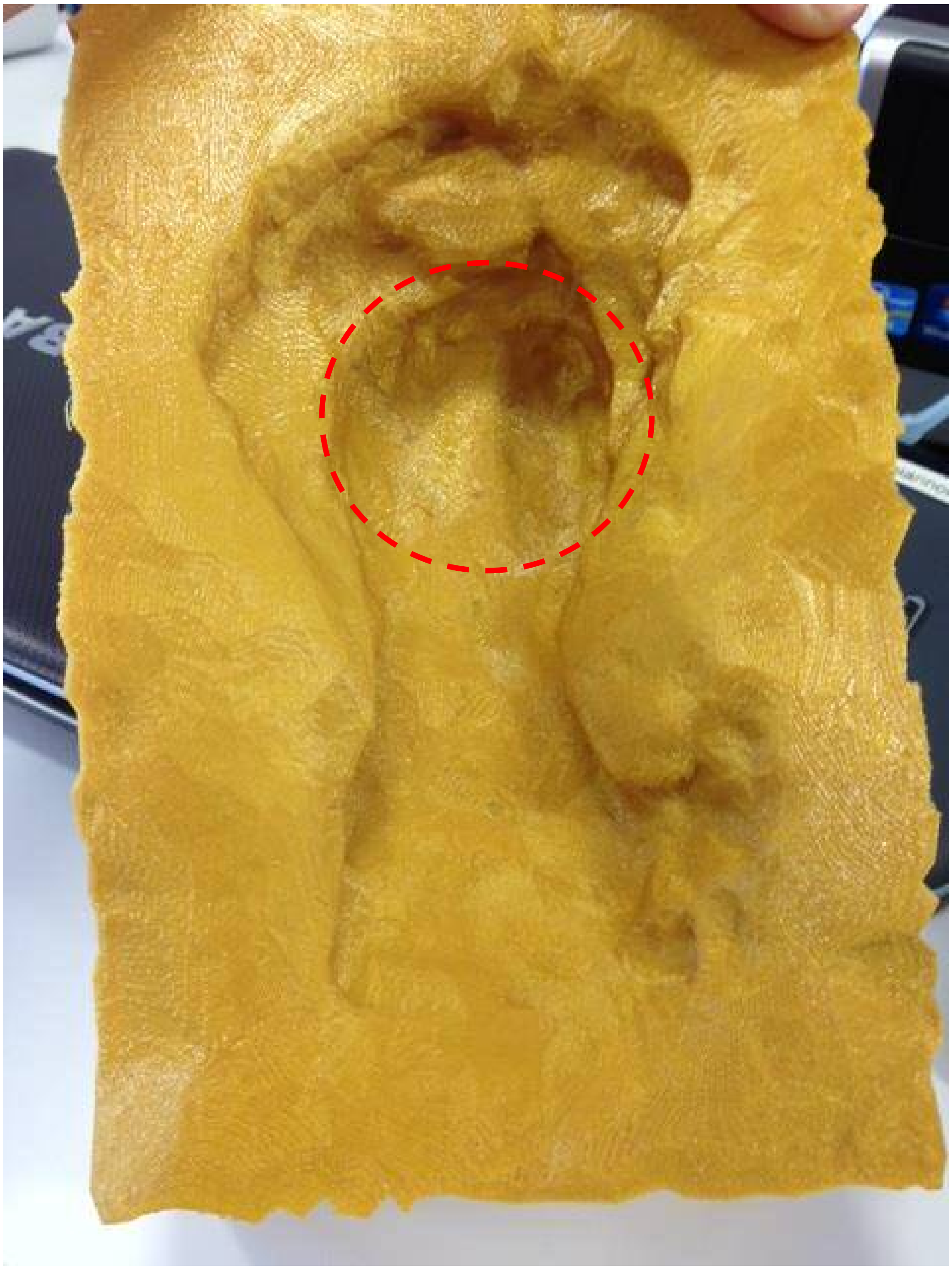

Figure 67: Resultant 3D print of a child's footprint from Port Eynon. The red circle indicates the position of the roe deer footprint

6.3 Sediment Categorisation

6.3.1 Broughton Bay

Br1 (Figure 68)

A column sample was taken at position Br1 to identify whether a link could be drawn between the lowest and highest peat exposures at Broughton Bay. The tidal time restrictions at this position, which sits very low in the intertidal zone, only allowed for the top 25cm of the intertidal sediment sequence to be sampled using a monolith before the tide flooded the sample site. The sediments sampled consist of a dark homogenised friable peat overlain by a thick, fibrous, dark brown peat with frequent wood inclusions. Bioturbation is apparent in the top 4cm of the monolith. A 20mm diameter gouge auger was employed to explore the deeper sediment deposits at this location. Peat was present to at least 1.5m below the surface, but no interface with an earlier organic or minerogenic deposit was identified.

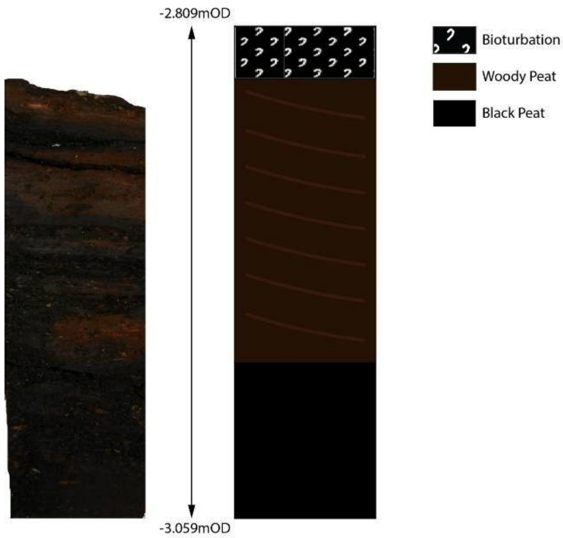

Figure 68: Sediment column sample Br1

Br2 (Figure 69)

The sediment sequence sampled at location Br2 using monolith tins amounted to 40cm depth of material comprising of three distinct layers. The lowest sediment consisted of a grey clay with organic inclusions, overlain by a mixed layer of peaty clay measuring c.5cm in thickness. This was subsequently overlain by c.25cm of a dark brown woody peat similar in character to that at the top of column Br1. The sequence was sampled as part of a further distinct peat exposure to investigate the relationship between all exposures in the bay.

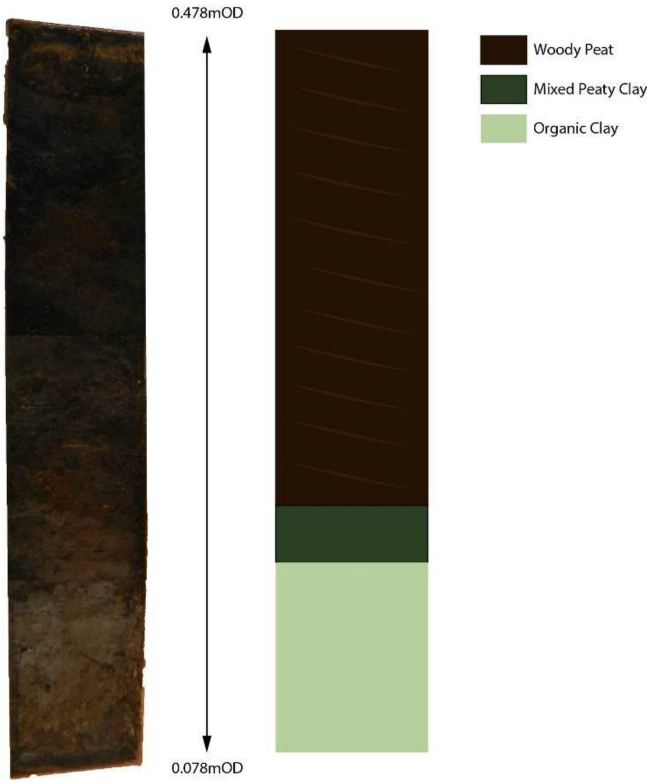

Figure 69: Sediment column sample Br2

Br3 (Figure 70)

At this location, the deposits exposed on the beach were clay rather than peat based, despite being only c.5m away from Br2. A single 25cm column sample was obtained using a monolith tin to investigate whether a difference in environment could be identified through further analysis. The sediment sequence consists a dark friable peat layer overlain by c.7cm of a sandy yellowish-grey clay. This in turn was overlain by c.12cm of a light grey clay followed by c.7cm of a darker mixed grey clay with light grey clastic inclusions. A thin c.1cm layer of a mixed peaty clay was present at the top of the sequence and could be indicative of a potential tidal inlet, due to the minerogenic nature of most of the recorded sediments.

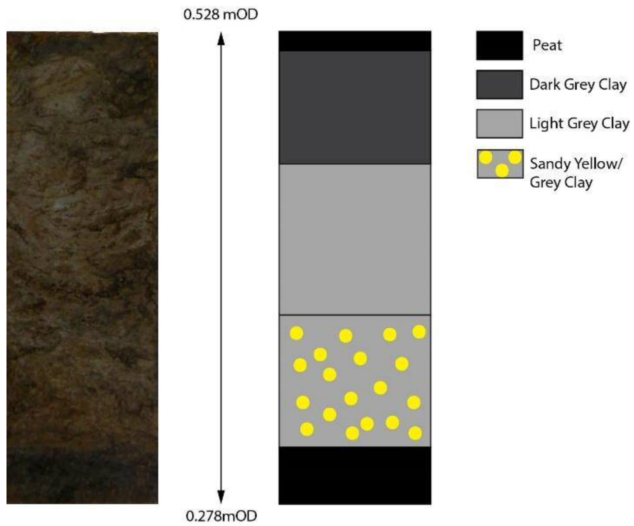

Figure 70: Sediment column sample Br3

Br4 (Figure 71)

This column was extracted using a 25cm monolith tin from the lower of the two upper beach exposures at Broughton Bay, which consisted of a dark brown/black fibrous peat throughout the sampled column. The underlying sequence was not investigated at this location. The sample was taken to establish whether a relationship existed between the two upper beach exposures by comparing the palaeoenvironmental record within the column with that of the sample at Br5. The top 6cm of the column included a large amount of sand suggested bioturbation or reworking of the deposit.

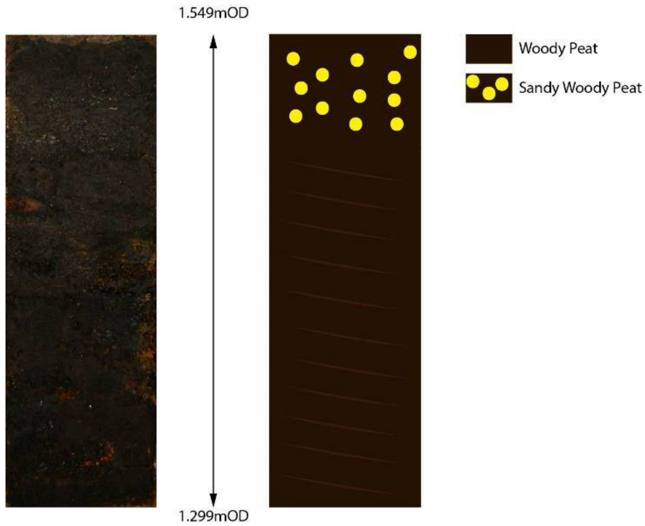

Figure 71: Sediment column sample Br4

Br5 (Figure 72)

A 44cm column sample was obtained from the highest peat exposure on the beach at Broughton Bay using two monolith tins. A friable black peat was identified at the base of the column, overlain by 28cm of a dark brown woody peat. Above this lies a disturbed black peat layer, c.7cm in thickness and containing lots of sand and potentially indicating mixing or bioturbation. A very thin (1cm) red-brown peat layer is present at the top of the column.

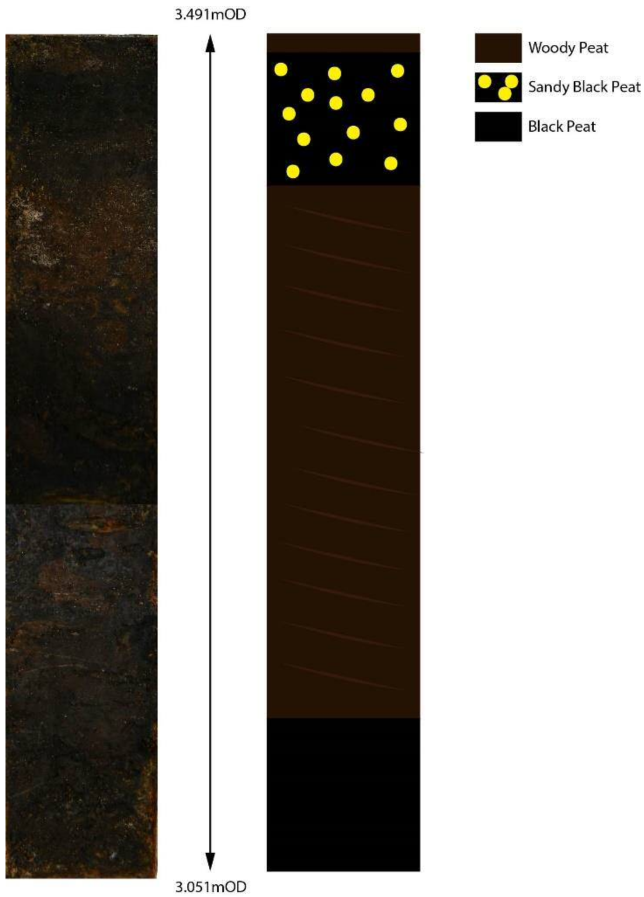

Figure 72: Sediment column sample Br5

6.3.2 Port Eynon

PE1 (Figure 73)

A column of 64.5cm depth was taken from the lowest peat exposure at Port Eynon using a combination of a monolith tin to 25cm depth and a Russian Auger for the lower 39.5cm. A total of 25 deposition events are identified with a series of peats interspersed by minerogenic sediments. The earliest deposit is a dark friable peat of which the top c.7cm has been obtained, followed by c.32cm of organic clay. Above this lies a c.4cm layer of very friable dark peat, followed by c.6cm of mixed peaty clay. A c.18cm layer of dark organic clay develops above this, followed by a very thin (c.2mm) peat layer, 6cm of dark organic clay, another very thin peat layer and a further 2cm of dark organic clay. Above this a lighter coloured clay, still with organic components has developed (c.4cm), followed by a 1cm thick peat layer and then c.8cm of the lighter organic clay. This is followed by seven thin layers of between 2-4mm in thickness in the following sequence: sand, grey clay, sand, grey clay, sand, grey clay, sand. After this an organic clay develops for c. 5 cm, followed by 1cm of sand and another c.6cm of organic clay. Above this c.6cm of black fibrous peat is followed by 2cm of sandy peat suggesting a mixing of material. The uppermost layer within the column is a further 10cm of dark fibrous peat.

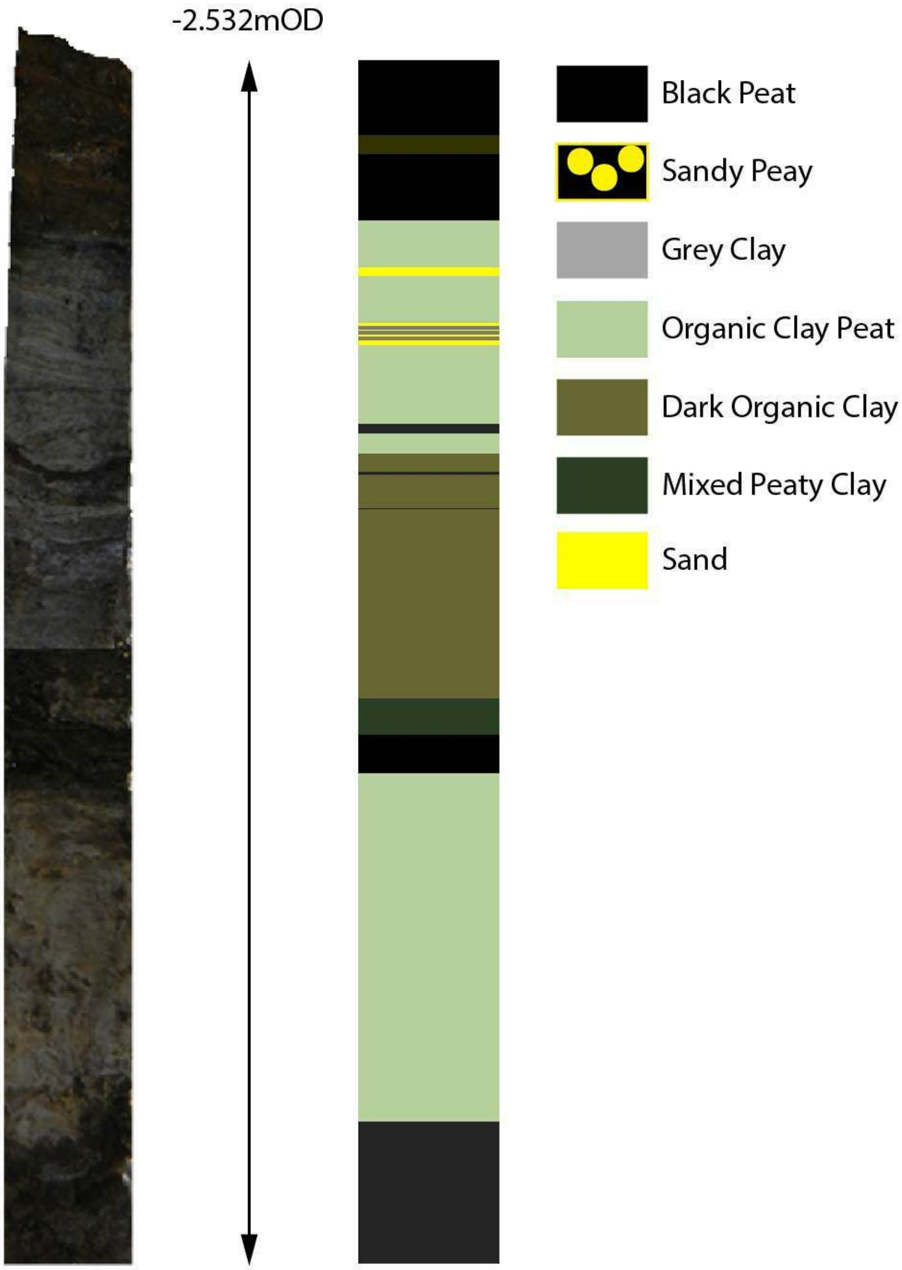

Figure 73: Sediment column sample PE1

PE2 (Figure 74)

The 49cm column was taken from one of two exposures identified in the upper intertidal zone at Port Eynon using two monolith tins. The lowest material sampled was a coarse, grey coloured sand. Above in order of deposition is c. 15cm of brown fibrous peat with frequent wood inclusions overlain by 1cm of slightly finer grained sand, 3cm of a dark fibrous peat, 2cm of sand and c.17cm of black fibrous peat. The top 6cm of the column is a continuation of the preceding peat, but showing clear signs of bioturbation.

Figure 74: Sediment column sample PE2

PE3 (Figure 75)

This column sample of 46cm in depth obtained using two monolith tins is from the second upper beach peat exposure located towards the middle of the bay. It consists of a homogenous black fibrous peat with potential reed inclusions throughout. The upper 8cm of the column shows evidence for bioturbation, including *in situ* worm action.

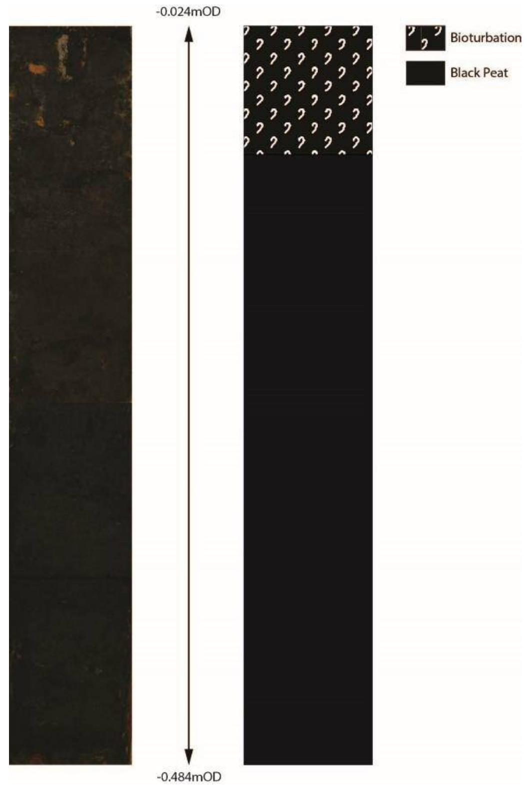

Figure 75: Sediment column sample PE3

PE4

A deep mixed peaty clay deposit overlain by over 50cm of sand was a revealed during auger prospection. Though the deposit appeared to be directly overlain by sand, it was positioned much deeper than the other recorded exposures. A spot sample was collected for palaeoenvironmental analysis to investigate whether the deposit represented the same environment as the surface exposures on the beach or whether it could be evidence of an earlier landscape.

6.4 Radiocarbon Dating

A series of samples from the top and bottom organic peat deposits at PE1 and PE2 on Port Eynon beach and the top of the lowest sampled peat exposure at Broughton Bay were submitted for radiocarbon dating in order to create a chronological framework for the archaeological and palaeoenvironmental evidence collated in this investigation. The radiocarbon dates are presented in Table 9 in stratigraphic order, from lowest to highest, with Port Eynon dates listed first. They are stated first as conventional radiocarbon ages in accordance with recommendations made by Stuiver and Polach (1977, 363) using the Trondheim convention (Stuiver and Kra 1986) and then as calibrated ranges at 68% and 95% probabilities.

Sample	Sample Type	Conventional Radiocarbon Age	Calibrated Dates			
R_Date PE1-3 UBA-33263	Bulk Peat	6415±42 BP	5470-5360 cal BC	68.2 %	5480-5320 cal BC	95.4 %
R_Date PE1-2 UBA-33262	Bulk Peat	6599±48 BP	5610-5490 cal BC	68.2 %	5620-5480 cal BC	95.4 %
R_Date PE1-1 UBA-33261	Bulk Peat	6180±51 BP	5220-5050 cal BC	68.2 %	5300-4990 cal BC	95.4 %
R_Date PE2-2 UBA-33715	Bulk Peat	5548±56 BP	4450-4340 cal BC	68.2 %	4500-4270 cal BC	95.4 %
R_Date PE2-1 UBA-33469	Bulk Peat	5088±35 BP	3960-3800 cal BC	68.2 %	3970-3790 cal BC	95.4 %
R_Date Br1-1 UBA-33468	Bulk Peat	5196±34 BP	4040-3960 cal BC	68.2 %	4150-3950 cal BC	95.4 %

Table 9: Calibrated radiocarbon ages at 68.2% and 95.4% probabilities.

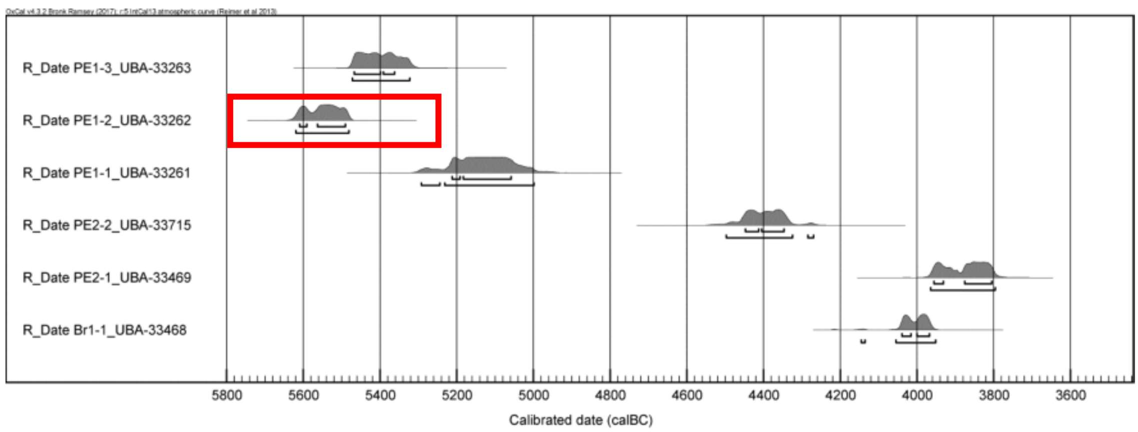

Figure 76: Calibrated radiocarbon dates plotted using OxCal v4.3 (Bronk Ramsey 2009). The red box highlights the anomalous date that will be excluded from further modelling at this stage.

Figure 76 plots the calibrated dates in stratigraphic order at Port Eynon. Broughton Bay is included for comparison. Sample PE1-2, stratigraphically situated between PE1-1 and PE1-3 presents a date earlier than PE1-3, despite being stratigraphically younger. To investigate this issue the column was re-examined visually where it became clear that the area sampled was more mixed with sand inclusions than initially identified and is suggestive of movement and mixing of materials and potential contamination with older carbon sources. This could explain the anomalous result, but without further sampling and dating it is not currently possible to present a full explanation. For the purposes of this study the PE1-2 date will be removed from further modelling attempts, but it acts as an indication that peat accumulation was not necessarily linear and that numerous additional factors must be taken into account when investigating these deposits.

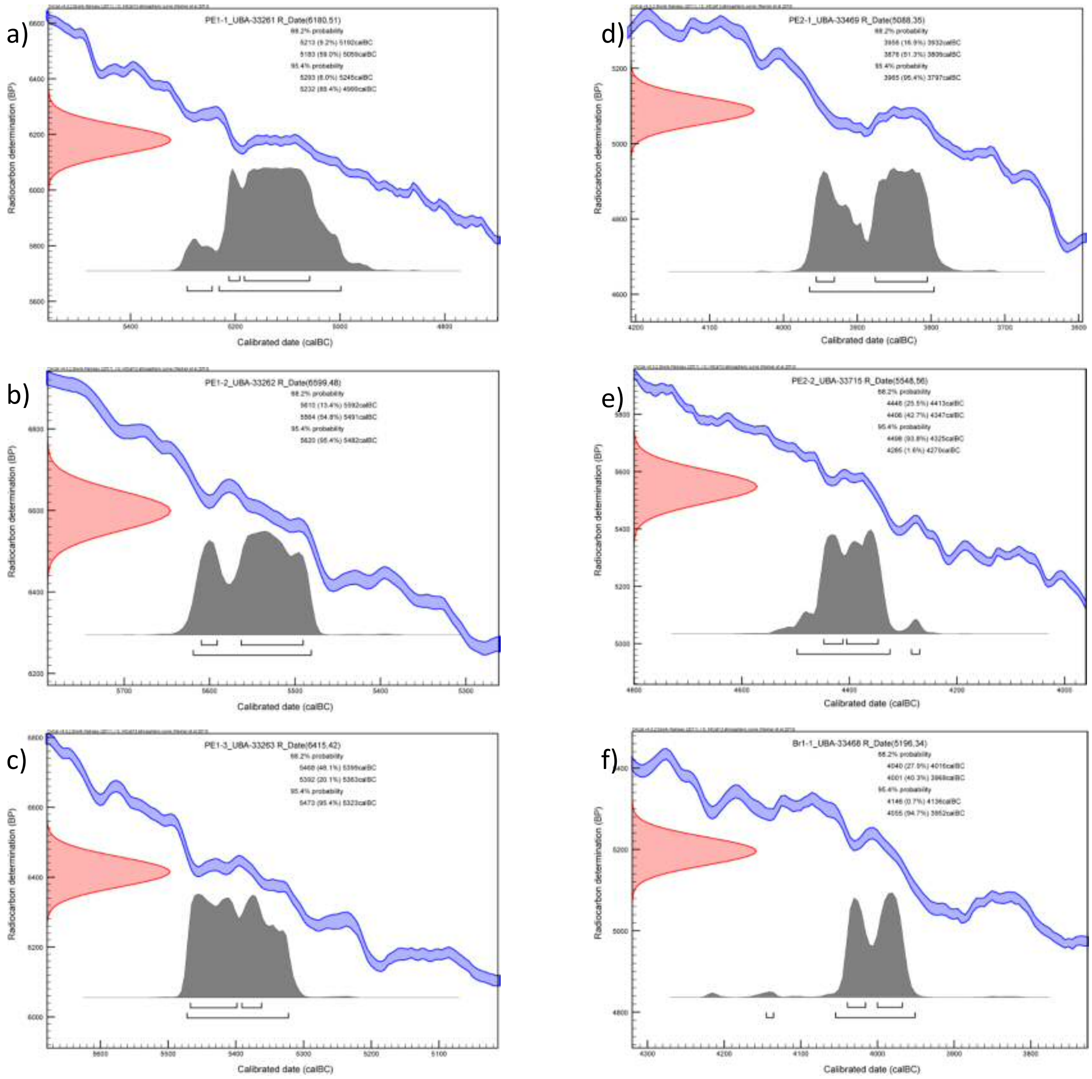

Figure 77: Calibrated radiocarbon dates displayed alongside the corresponding section of the radiocarbon calibration curve: a-c = PE1 (please note the discarded PE1-2 is included here for full disclosure), d-e = PE2, f= Br1. Graphs are created in OxCal c.4.3 (Bronk Ramsey 2009) using calibration datasets IntCall13 and MARINE13 (Reimer et al. 2013).

The radiocarbon calibration curve has been inspected at each of the date ranges measured (Figure 77). The curve has a general downward trend during the total period covered and the upper samples from columns PE1 and PE2 have dates that fall on slight plateaus of the curve (PE1-1 and PE2-1) (Figure 77: a and d). As a result, the probable date range is wider than it would be at other points on the curve. This may be an issue if dating was focussed on the identification of narrow date ranges, however these dates remain appropriate for this range finding exercise and allow an overall chronology to be developed for the sites.

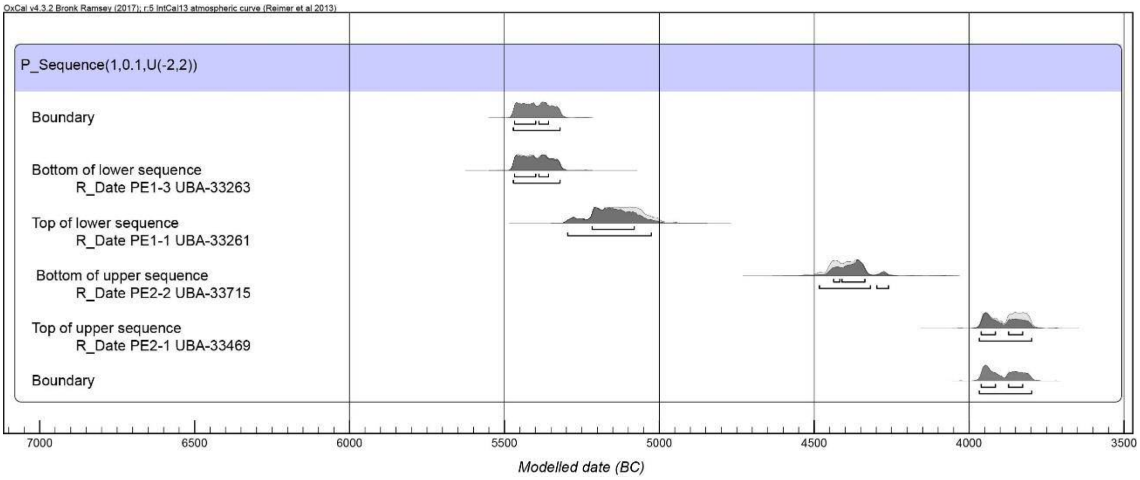

Figure 78: P_Sequence model log_10 (k/k_0) where k_0=1, allowing k to take any value from 0.01-100

The age-depth model output (Figure 79) indicates that the lower sequence (PE1) formed over a time period of up to 460 years between 5480 and 5020 cal BC, with 65cm of varied material deposited. The upper sequence (PE2) formed at a slower rate, depositing 45cm of more homogenous material over a maximum of 530 years between 4490 and 3790 cal BC. Between the formation of these two sequences, there is a hiatus of up to 700 years. Without further radiocarbon dates, more in depth analysis of accumulation rates is not possible, as the layers within the sequence would have formed at different rates dependent on environmental conditions. For example, freshwater peats will take longer to accumulate as they are a very low energy environment, reliant on the introduction of vegetation matter over a long period. Minerogenic sediments related to sea level rise are more likely to accumulate quickly, particularly once they are part of the daily tidal cycle, and more so within the lower saltmarsh zones (Pratolongo et al. 2009, 93). The effects of erosion must also be taken into account. These are not visible within the sequence, but can account for missing periods of time within the accumulation record. Without direct dating evidence, however, these occurrences cannot be identified and although a slowing or speeding up of accumulation can be inferred from the lithological and palynological records, they cannot be proven.

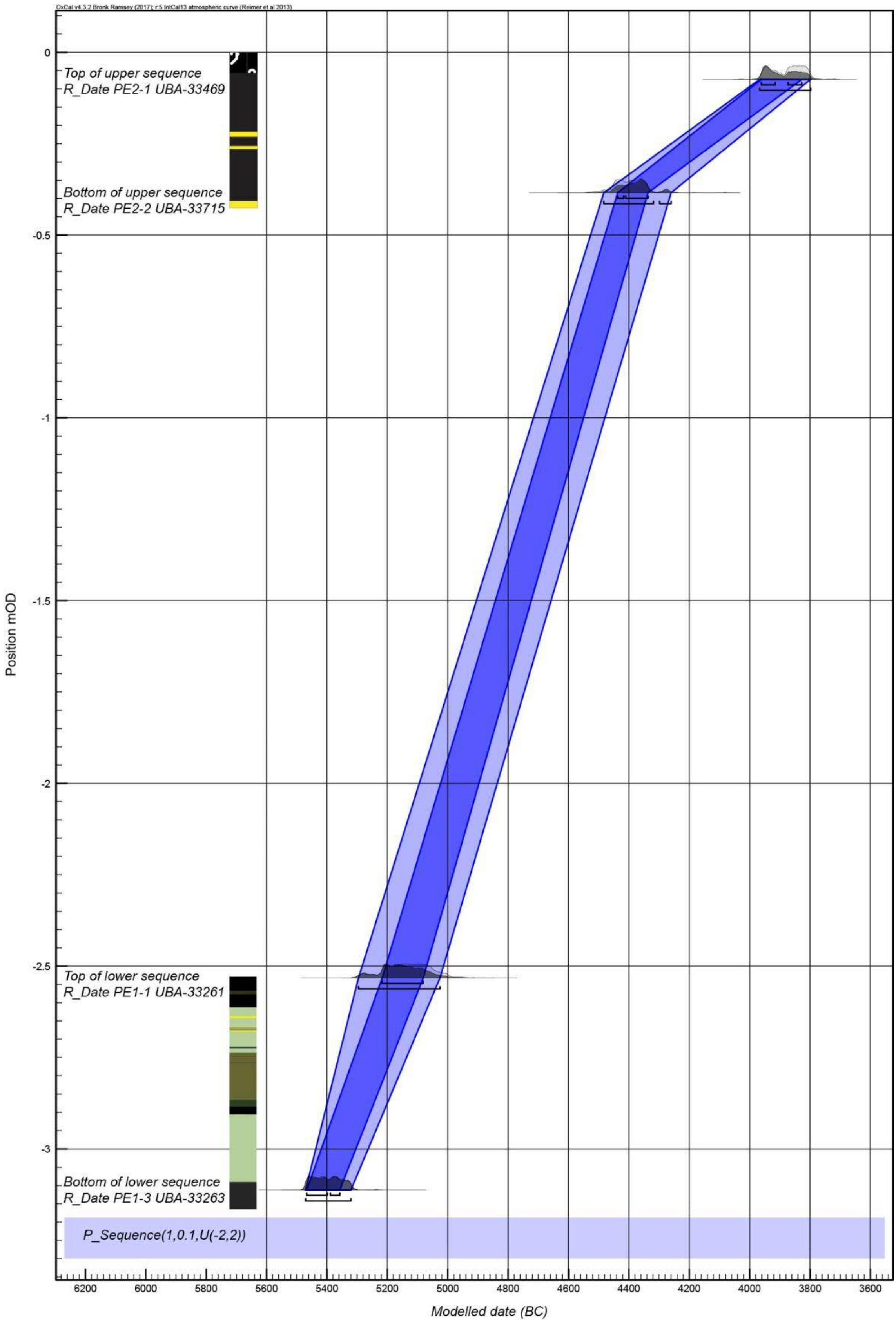

Figure 79: Bayesian age-depth model of the chronology of the sediment sequence in the intertidal zone at Port Eynon. Dark blue indicates the estimated date of sediment at the corresponding depth at 68% probability, light blue at 95% probability.

6.5 Palaeoenvironment

In the following section, the results of the palaeoenvironmental analysis are displayed in pollen diagram format, showing levels of pollen, non-pollen palynomorphs and microcharcoal relative to depth within each of the column samples from the separate sample locations at each site. Raw pollen counts are included in Appendix 11. The diagrams are then described in the following tables. The evidence indicates the changes that happened within the environment through time at each site. Where applicable, radiocarbon dates have been attributed to their position in the column. The Broughton Bay evidence is displayed first – this evidence is relatively low in resolution due to the need to focus resources on Port Eynon due to the discovery of the archaeologically significant human footprints in the lower tidal zone and the evidence for multiple deposition events, which was not seen in the sampling at Broughton Bay.

6.5.1 Broughton Bay

Br1:

This 25cm sequence is divided into three pollen zones, described in Figure 80.

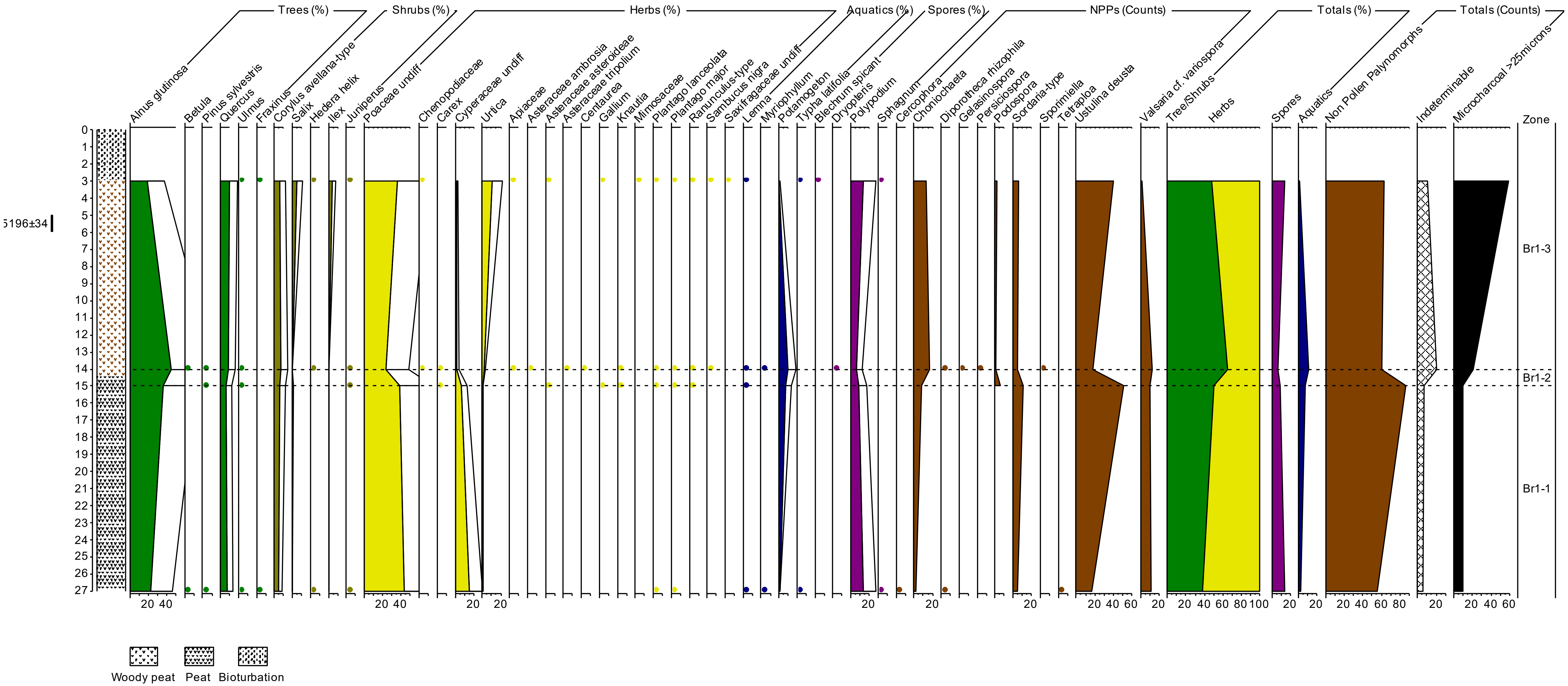

Figure 80: Br1 pollen percentage diagram with added counts for NPPS, Indeterminable and Micro charcoal. Depth bars show an exaggeration of x2, dots represent presence less than 5%

Table 10: Pollen descriptions from Br1

Zone	Associated Radiocarbon Date	Description	Interpretation
Br1-1		*Poaceae* dominates, but reduces slightly over the duration of the zone. *Alnus* is also prevalent and increases slightly as *Poaceae* falls. Cyperaceae levels are relatively high, but fall slightly by the end of the zone. Aquatic species *Potamogeton* becomes more prevalent, while *Polypodium* spores remain constant. There is a steady low signal from *Quercus* and *Corylus* throughout the zone. Low levels of coprophilous fungi such as *Sordaria* are noted along with larger quantities of NPPs such as *Ustulina deusta,* (which increases steadily), *Choniochaeta* and *Valsaria*. Levels of micro charcoal remain constantly low throughout the zone.	**Environment:** The pollen record suggests a damp environment, comprising of freshwater fenland dominated by grasses and sedges, alongside Alder Carr with a potential understorey of ferns and the increased presence of pooling water indicated by the increase in pond weed. There is a background woodland signal predominantly consisting of Oak and Hazel. The low levels of coprophilous fungi could indicate the presence of grazing animals in the vicinity, but this is unlikely to be intensive. The other NPPs present are related to wood decay and suggest the presence of decaying vegetation within the peat, likely to be related to the Carr environment. **Human Impact:** There is very little specific human related evidence in this zone. The low levels of micro charcoal could represent a background clearance signal, however the low definition sampling means it is unclear whether these levels are maintained steadily throughout, or whether changes in levels occur between the samples analysed. As the upper levels of this column are dated to the Neolithic period it is possible that nearby animal grazing could be related to domestic herding, however there is no dating evidence available from this zone to support this. **Sea Level Change:** There is no indication of a marine influence within this zone.
Br1-2		*Alnus* rises sharply causing *Poaceae* to fall in a corresponding fashion. There is also a sharp decline in *Cyperaceae*. *Potamogeton* reaches its peak and there is a slight fall in *Polypodium*. *Quercus* and *Corylus* remain constant. At the end of this zone a very small presence of *Chenopodiaceae* is detected. More generally, there appear to be more herbaceous species appearing, though in very small amounts. Coprophilous fungus *Sordaria* declines, but another species *Podospora* appears in small quantities. Most other NPPs also decline sharply apart from *Choniochaeta*. There is a steep rise in micro charcoal.	**Environment:** Alder Carr becomes more dominant, though there are still elevated levels of grass and an increase in herbaceous species indicating areas of open landscape. The peak in pond weed, identifies the nearby presence of standing freshwater. The background woodland signal remains constant, dominated by Oak and Hazel. The decline in Coprophilous fungi suggests a lesser impact from grazing and the reduction in most wood decay related NPPs may indicate a change in the composition of the peat itself. **Human Impact:** The spike in charcoal is likely to be related to human activity, but there is very little other evidence within the pollen record. **Sea Level Change:** The appearance of salt marsh indicators such as goosefoot (albeit in very low quantities) indicates a marine influence is closer than it was previously, but is unlikely to directly affect the site at this point.
Br1-3	5196±34	*Poaceae* remains constant while *Alnus* levels drop substantially. *Cyperaceae* and aquatic species reduce to negligible amounts. There is a notable appearance and rise in *Urtica* and continued presence in very small amount of other herbaceous species. Once again *Chenopodiaceae* is present in very low quantities. *Polypodium* spores remain constant, rising slightly towards the end of the zone. *Quercus* and Corylus continue to remain stable, and are joined by *Salix* (willow) and *Ilex* (holly). Coprophilous fungi remain low, but steady in number and there is a clear rise once again in *Ustulina deusta*. There is a dramatic peak in micro charcoal during this phase, climaxing at the top of the column.	**Environment:** The alder domination recedes slightly and more open environment indicators are present with the increase in herbaceous species. The decrease in aquatics and sedges denotes a dryer environment. In the surrounding dryland areas, the woodland diversity develops with the addition of Willow and Holly. **Human Impact:** The appearance of nettles may be indicative of disturbance and higher nitrates in the soil. This coupled with the substantial charcoal spike indicates human influence in the area. **Sea Level Change:** Again, the small amount of goose foot detected indicates a salt marsh environment in the general area, however it is unlikely to have affected the site directly.

Br2:

This 40cm sequence is divided into two pollen zones outlined in Figure 81.

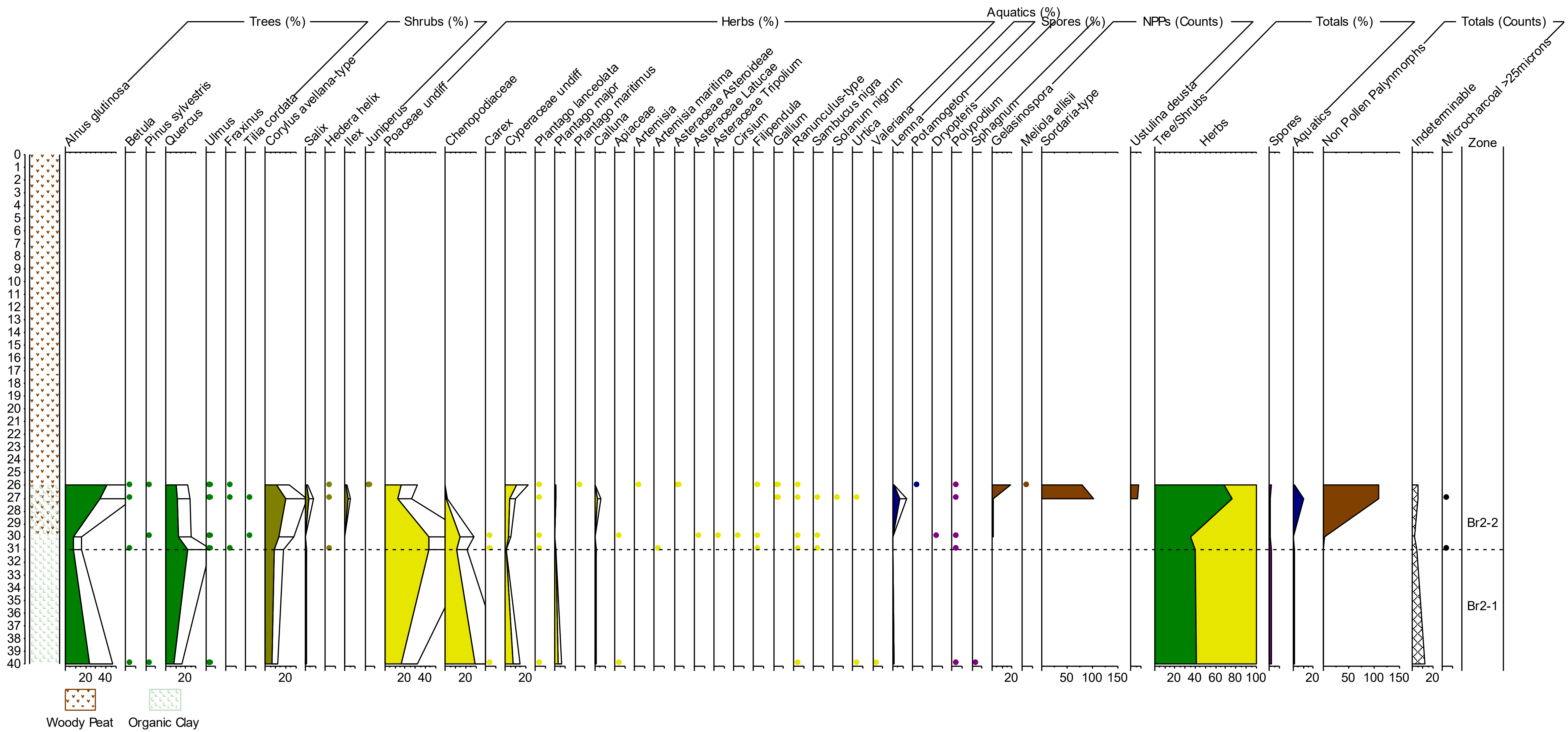

Figure 81: Br2 pollen percentage diagram with added counts for NPP, Indeterminable and Micro charcoal. Depth bars show an exaggeration of x2, dots represent presence less than 5%.

Table 11: Pollen descriptions for Br2

Zone	Associated Radiocarbon Date	Description	Interpretation
Br2-1		*Poaceae* and *Chenopodiaceae* dominate along with elevated levels of *Alnus*, *Quercus* and *Corylus (Alnus* falls as *Quercus* rises). There is a reducing signal of *Cyperaceae* and very low levels of *Lemna*. No NPPs are noted in this zone and micro charcoal is present, but in very low quantities.	**Environment:** The goosefoot and grasses indicate a saltmarsh environment. The reduction in alder pollen and corresponding increase in oak could signify a potentially drying episode, although more likely is that this is related to alder carr being drowned by rising sea levels allowing the oak pollen from further away to be seen more clearly in the record.
			Human Impact: Other than a very low micro charcoal signal, evidence for human activity is sparse
			Sea Level Change: The site is tidal, indicating that sea levels have risen and that the coast is in the very near vicinity.
Br2-2		There is a fall in the herbaceous species. After a short secondary peak, *Chenopodiaceae* falls away until completely absent. *Cyperaceae* increases slightly and there are a greater variety of herbaceous species present in small quantities. *Alnus* increases dramatically, while *Quercus* reduces and then maintains a steady reading. *Corylus* increases, as do *Salix* and *Ilex* albeit less dramatically. There is also a small peak in *Lemna.* A very small quantity of coprophilous *Gelasinospora* is present along with a spike in *Sordaria.* Micro charcoal levels fall to zero.	**Environment:** The environment returns to a freshwater basis, with sedges and aquatic species making a comeback. The increase in alder suggests a redevelopment of alder carr, with the reduction in oak not necessarily representing a change in the surrounding dryland woodland within the landscape, but rather a symptom of filtering due to the influx of alder pollen.
			Human Impact: Presence of coprophilous fungi could be aligned with human activity if deposits are Neolithic, as the radiocarbon date from Br1 suggests, but there is no dating evidence from this column. There is very little micro charcoal to suggest sustained activity in the area.
			Sea Level Change: Sea levels recede as the site returns to freshwater dominance.

Br3:

This 25cm sequence is divided into three pollen zones described in Figure 82.

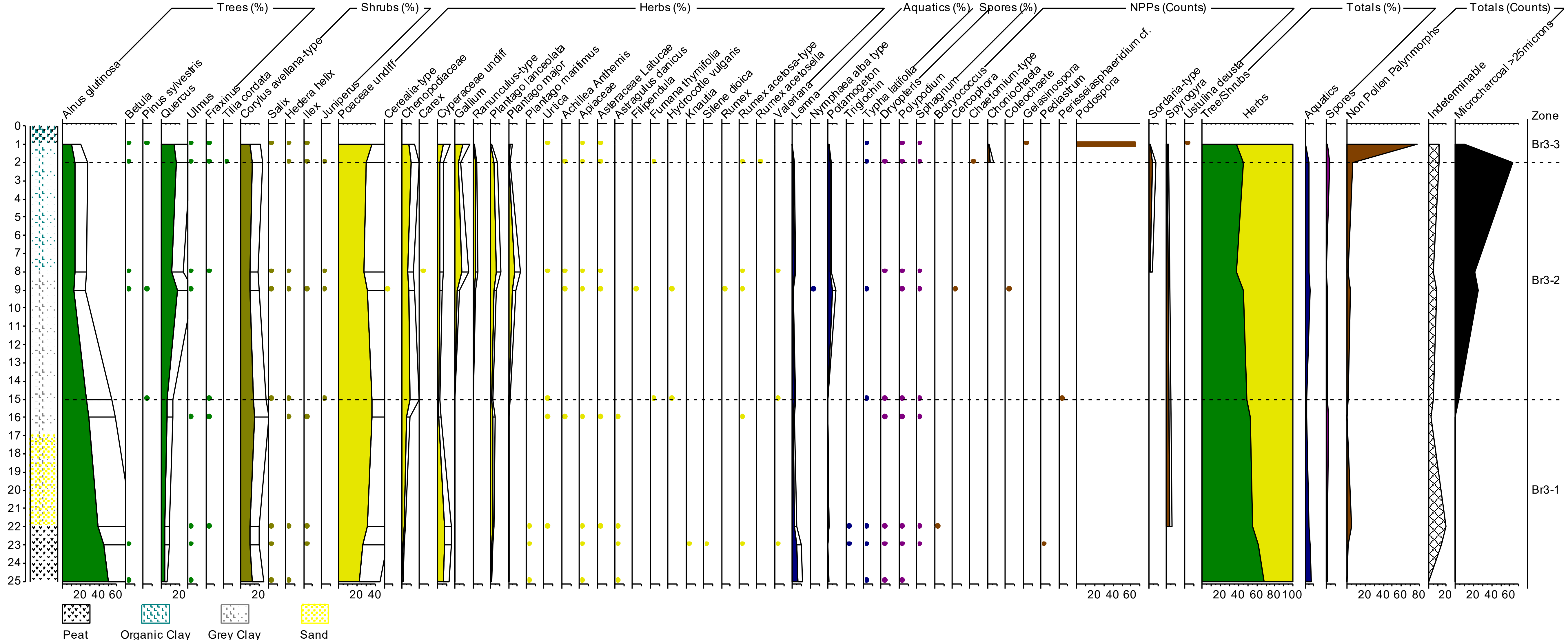

Figure 82: Br3 pollen percentage diagram with added counts for NPP, Indeterminable and Micro charcoal. Depth bars show an exaggeration of x2, dots represent presence less than 5%, bar indicates singular occurrence over 5%.

Table 12: Pollen descriptions for Br3

Zone	Associated Radiocarbon Date	Description	Interpretation
Br3-1		*Alnus* dominates with c.50% TLP along with *Poaceae* at 20%. However, this dominance decreases as the zone continues. There are low, but increasing levels of *Chenopodiaceae* and decreasing levels of *Cyperaceae*. Of the aquatic species, *Lemna* is most dominant, albeit in small numbers and this too reduces as the zone progresses. *Spirogyra* (green algae) occurs during this phase and maintains a stable low level. *Quercus* and *Corylus* are a steady presence. There is no micro charcoal detected at all within this zone.	**Environment:** The dominance of alder combined with wet environment indicators such as duck weed indicates an alder carr environment with standing water alongside sedge fenland. The surrounding landscape included woodland consisting predominantly of oak and hazel. **Human Impact:** There are very few indicators of human activity within this zone and the complete lack of charcoal would appear to support this observation. **Sea Level Change:** As the zone progresses, the rise in salt marsh indicator goosefoot suggests a marine influence is approaching the site. The damp conditions preceding this change would therefore be indicative of increased groundwater levels due to sea level rise.
Br3-2		*Poaceae* levels are maintained, but *Alnus* continues to fall. Levels of *Chenopodiaceae* stabilise at their highest point and a similar pattern is seen with *Cyperaceae* stabilising at lower levels. The *Plantago* species reach their peak in this zone and *Lemna* is replaced by *Potamogeton* as the most prevalent aquatic species. *Spirogyra* continues to be present in very low quantities and there is a small amount of *Sordaria* present during the second half of the zone. There is an increase in *Quercus*, but *Corylus* levels remain similar to the previous zone. Micro charcoal increases dramatically during this zone.	**Environment:** The alder signal becomes less prominent as levels of herbaceous species rise, but grasses maintain at a similar level as in the previous zone. The fall in sedges indicates a potentially dryer period, although there is still evidence of standing water, with the presence of green algae and pond weed. The vegetation in the wider area still consists of a mainly oak and hazel woodland, with oak increasing in dominance **Human Impact:** The dramatic increase in micro charcoal is a likely indicator of human activity in the surrounding area. The peak in Plantago species represents a period of disturbance, which could be associated with cultivation. **Sea Level Change:** Salt marsh species are maintained at stable levels, indicating sea levels are static during this zone.
Br3-3		*Poaceae* begins to rise along with *Cyperaceae* as *Alnus* continues to fall. *Chenopodiaceae* levels also drop off, as do all aquatic species. Quercus and *Corylus* continue at the same steady rate. There is a significant increase in coprophilous fungi *Podospora*. Micro charcoal levels fall to much lower quantities.	**Environment:** The environment moves back towards a sedge based fen with fewer areas of pooling water indicated by the drop in aquatic species. On the edges, the same oak and hazel dominated woodland continues to exist. **Human Impact:** Though there is a sharp decline in micro charcoal, it is still present within the column and could still be related to human activity. The significant spike in coprophilous fungi may be indicative of domestic grazing, possibly related to more favourable grazing conditions due to dryer pasture. **Sea Level Change:** Salt marsh indicators decline once again, indicating a reduction in sea levels.

Br4:

This 25cm sequence is divided into two pollen zones described in Figure 83.

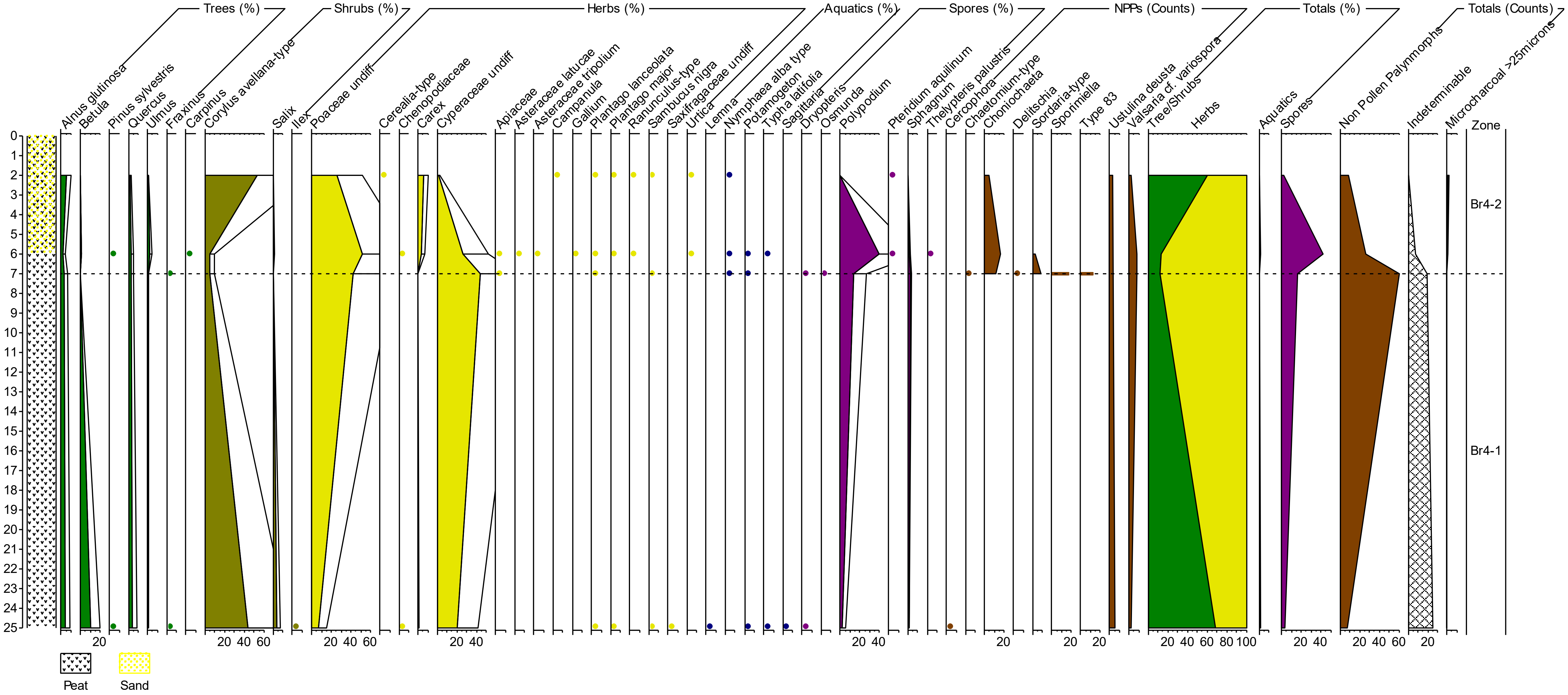

Figure 83: Br4 pollen percentage diagram with added counts for NPP, Indeterminable and Micro charcoal. Depth bars show an exaggeration of x2, dots represent presence less than 5%, bar indicates singular occurrence over 5%

Table 13: Pollen descriptions for Br4

Zone	Associated Radiocarbon Date	Description	Interpretation
Br4-1		*Corylus* and *Cyperaceae* dominate this zone along with *Poaceae*. *Corylus* declines as the zone progresses. In terms of other woodland species, *Betula* dominates, with low levels of *Quercus, Ulmus* and *Alnus*. *Polypodium* is present, increasing during this zone. A very small amount of *Chenopodiaceae* is noted at the beginning of the zone, but not the end. NPPs *Ustulina deusta* and *Valsaria* are also present. There is no micro charcoal detected within this zone.	**Environment:** The environment represented within the pollen record is that of a sedge dominated fen. Low levels of tree pollen show that tree cover is sparse in the near vicinity. The NPPs present indicate the presence of rotting vegetation, reflecting the formation of the peat itself. **Human Impact:** There is no direct evidence for human interaction with the environment in this zone. **Sea Level Change:** The very small amount of goosefoot present at the beginning of the zone suggests tidal levels are beginning to rise, but there is no direct marine influence on the site at this point.
Br4-2		*Poaceae* and *Cyperaceae* levels fall and *Corylus* increases dramatically. There is a very small amount of *Chenopodiaceae* present at the beginning of this zone, but this disappears by the end. More generally, more herbaceous species become present in low quantities. Woodland species noted in the previous zone are maintained at low levels with a slight rise in *Alnus*. There is a peak followed by a fall in *Polypodium*. NPPs *Ustulina deusta* and *Valsaria* are still present, along with *Choniochaeta* and coprophilous fungi *Sordaria* and *Sporomiella* in small quantities. A very small micro charcoal signal is detected during this zone.	**Environment:** Though grasses reduce in dominance, they are still predominant within the environment. The sedge influence is greatly reduced; however, a greater variety of herbaceous species appear, indicating a dryer fen or grassland. The general woodland signal contains oak, elm and alder as its main constituents, but is low in dominance indicating a peripheral source. **Human Impact:** The very low charcoal signal could be construed as human influence, though while it is maintained across the zone, it does not represent a substantial burning phase. The large quantity of hazel could be related to preferential land management, as it is much more prevalent than other woodland species. The increase in coprophilous fungi also suggests an increase in grazing, which could be attributed to human action. **Sea Level Change:** As in the previous zone, the small presence of salt marsh species such as goosefoot indicates a marine source in the wider area, but there is little evidence for direct marine influence.

Br5:

This 44cm sequence is divided in four pollen zones described in Figure 84.

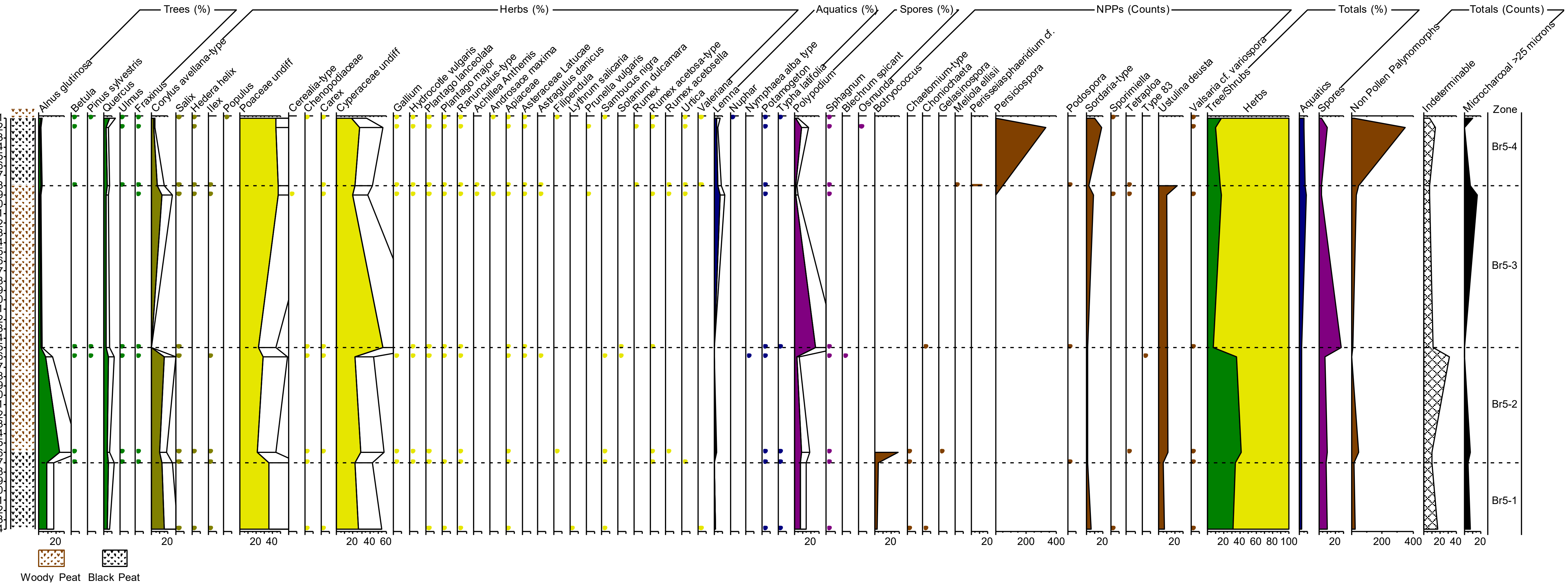

Figure 84: Br5 selected pollen percentage diagram with added counts for NPP, Indeterminable and Micro charcoal. Depth bars show an exaggeration of x2, dots represent presence less than 5%, bar indicates singular occurrence over 5%.

Table 14: Pollen descriptions for Br5

Zone	Associated Radiocarbon Date	Description	Interpretation
Br5-1		All species maintain stable levels. The environment is dominated by *Poaceae* and *Cyperaceae* with a notable woodland signal comprising of *Alnus*, *Quercus*, *Corylus* and *Salix*. *Chenopodiaceae* is present in very low levels (<5% TLP). Micro charcoal counts are low.	**Environment:** Sedge dominated fenland with deciduous and potentially alder carr woodland on the periphery. **Human Impact:** There is a very low micro charcoal signal and few other indicators of human activity. **Sea Level Change:** Very low levels of salt marsh species represent a potential marine source some distance away.
Br5-2		There is a jump in *Alnus* and *Polypodium*, while other species are slightly fluctuating, but with similar levels to the previous zone. *Alnus* declines as the zone progresses. *Chenopodiaceae* still present in low levels.	**Environment:** The sedge fenland is still maintained, but alder becomes more dominant, which along with the increase in ferns, indicates a wetter environment and more widespread alder carr within the peripheral landscape. **Human Impact:** There are no obvious human indicators in this zone. **Sea Level Change:** The low levels of goosefoot indicate that a marine source is present, but not in the immediate vicinity.
Br5-3		*Poaceae* increases steadily as *Cyperaceae* jumps to a highpoint at the beginning of the zone, followed by a steady decent. The *Alnus* signal is very low after decreasing in the previous zone and maintains this status. There is a spike in *Polypodium*, which proceeds to decline steadily. A slight increase in aquatic *Lemna* is notable. Chenopodiaceae is not present during this zone. Micro charcoal increases, apparently corresponding with a rise in *Corylus.* NPPs related to decaying wood and coprophilous fungi are maintained at low levels.	**Environment:** Sedges become more dominant, maintaining the fenland environment. Alder signal decreases significantly suggesting it is less dominant on the periphery. The immediate area appears to become wetter, with increase in aquatic plants such as duckweed suggesting pooling water. **Human Impact:** The rise in micro charcoal coupled with increase in hazel indicates potential human presence within the vicinity. **Sea Level Change:** There are no salt marsh indicators within this zone, suggesting the marine source has moved away from the pollen catchment area. This indicates the local sea level has fallen.
Br5-4		*Poaceae* and *Cyperaceae* levels settle before dropping off slightly towards the end of the zone. Tree and shrub species maintain low levels, though there is a very small peak in *Quercus*, right at the end of the zone. There are small peaks in *Hydrocotyle vulgaris* (marsh pennywort) and *Potamogeton* along with reducing levels of *Lemna*. Chenopodiaceae occurs once again in very low quantities at the top of the column. A substantial peak in NPP *Persiciospora* occurs along with lower levels of coprophilous fungi *Sordaria.* Micro charcoal levels fall once again, with a small, short-lived peak right at the top of the column.	**Environment:** Sedge dominated fen is maintained and increases in fen related herbaceous species such as marsh pennywort support this observation. The site is still relatively wet, with pooling water indicated by the presence of both pond and duck weed. Deciduous woodland is present on the periphery of the site. The peak in *Persiciospora* indicates elevated levels of decaying vegetation. **Human Impact:** With low micro charcoal and coprophilous levels, there is little specific evidence for human interaction, though both may still indicate low levels of activity. **Sea Level Change:** The return of goosefoot indicates a possible return of the marine source to within the pollen catchment area, meaning a rise in sea levels, but this does not affect the site directly.

6.5.2 Port Eynon

PE1

This 65cm sequence is divided into five pollen zones described in Figure 85.

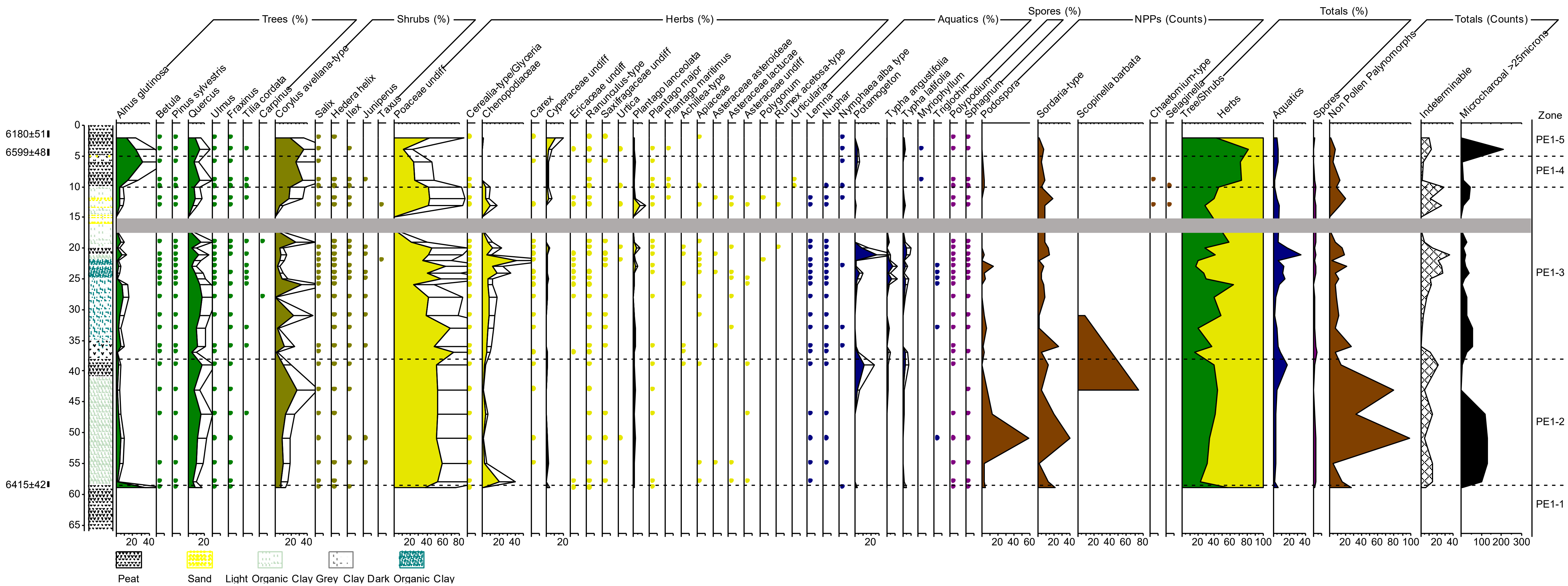

Figure 85: PE1 selective Pollen percentage diagram with added counts for NPP, Indeterminable grains and Micro charcoal. Depth bars show an exaggeration of x2, dots represent presence less than 5%, grey bar indicates no data.

Table 15: Pollen descriptions for PE1

Zone	Associated Radiocarbon Date	Description	Interpretation
PE1-1	6415±42 BP	Elevated levels of *Alnus* (alder) and *Poaceae* (grasses) are present at the very base of the column within a dark woody peat. They reflect a relatively equal split between herbs and trees/shrubs. There are low levels of *Quercus* (oak), *Corylus* (hazel) and *Ulmus* (elm) and very small quantities of aquatics such as *Typha latifolia* (bulrush), *Potamogeton* (pond weed) and *Nymphaea alba* (water lily). There are low levels of coprophilous Non-Pollen Palynomorphs such as *Podospora* and *Sordaria* present. No micro charcoal was noted.	**Environment:** Dominated by alder and grasses, this zone represents an alder carr environment, with pockets of open marshland or grassland, as indicated by the presence of aquatic species and very low levels of coprophilous fungi, which could be attributed to grazing animals. The low levels of dryland species are likely to represent a deciduous woodland environment in the periphery. **Human Impact:** The lack of micro charcoal indicates very little evidence for human interaction within the environmental record. **Sea Level Change:** There are no indicators of marine influence present within this zone, signifying the coastline is not within the near vicinity. However, the damp conditions indicated by a carr environment may indicate a rise in ground water levels, which can be attributed to sea level rise. This is further supported by the events seen in the following zones.
PE1-2		Levels of *Alnus* decrease dramatically while *Poaceae* increases along with a short-lived spike in *Chenopodiaceae* (goosefoot) *of around 20%*. After these initial changes, *Alnus* and *Poaceae* stabilise at these new levels, while *Chenopodiaceae* fluctuates, all be it in lower amounts of between 0-5%. There is a significant spike in NPPs *Podospora* and *Sordaria* coinciding with the fall in *Chenopodiaceae*. Freshwater aquatic species remain at very low levels. Herbs such as *Ranunculus* (buttercup) and *Saxifragaceae* (saxifrage family) are notably present during this zone along with small quantities of spores including *Polypodium* (fern) and *Sphagnum* (moss). Species such as *Quercus*, *Pinus* (pine), *Ulmus*, *Fraxinus* (ash) and *Corylus* maintain stable levels throughout this zone. Low levels of potential *Cerealia* (cereals) are also present throughout this zone. During this zone, there is a dramatic rise and then relatively high and steady level of micro charcoal detected, which falls away steeply towards the end.	**Environment:** This zone displays a complete change in environment. The increase in herbaceous species indicates an opening out of the environment and a loss of the dominant alder carr. The occurrence of salt marsh indicating species such as goosefoot signifies the arrival of a marine influence within the near vicinity. The spike towards the beginning of the zone represents a significant marine incursion event, with the fluctuating lower levels thereafter representing a continued changes related to sea level. The apparent occurrence of cereal pollen are unlikely to represent cultivated cereals, given the date, but may represent *Glyceria* or coastal grasses with pollen grain sizes and forms very similar to cereal species (see chapter 2.4.2). The appearance of herbaceous species such as buttercups and saxifrage during periods of reduced salt marsh indicators could suggest short periods of drying allowing for grassland vegetation to take hold. Overall, the environment remains relatively stable, with background levels of deciduous woodland from the periphery of the area maintained throughout. **Human Impact:** The sustained background levels of micro charcoal indicate a likely prolonged episode of human activity in the area. **Sea Level Change:** There is a clear marine influence within this zone. The pollen record combined with the change in the sediment sequence to grey clay indicates this location becomes salt marsh. Changes in vegetation apparent in the pollen record alongside the sediment record indicate sea levels fluctuate allowing drying out and re-establishment of freshwater and terrestrial species on several occasions.
	6599±48 BP* *Identified as unreliable date, but included due to interpretation value.	Pollen levels for most species begin to fluctuate dramatically. There are several short-lived spikes in Aquatic species such as *Potamogeton* and *Typha Latifolia*. *Chenopodiaceae* rise steadily and then reach a peak before declining again. During this zone, there is a section where no pollen was present (represented by the grey bar).	**Environment:** This zone represents a more tumultuous period. Salt marsh indicators rise, but this time the surrounding environment is also affected. It must be noted that this part of the column appears quite disturbed. Multiple changes in sediment occur and sand is included in many of these layers. Therefore, these pollen changes might not represent specific changes in vegetation, but rather, the physical forces enacted on the site itself, changing preservation conditions and potentially introducing or removing material. This suggestion is supported by the radiocarbon date obtained from within this zone, which is older than the date from PE1-1, situated lower in the column. It is likely that this represents older material that has been washed in. Peaks in aquatic species indicate short periods of freshwater conditions with pooling water and reed beds. Levels of NPPs are much lower in this zone, which could be related to a less accessible environment for grazing animals. **Human Impact:** There are much lower fluctuating levels of micro charcoal present within this zone. These could relate to human intervention in the environment, but could just as easily be attributed to natural causes. **Sea Level Change:** The rise and then substantial peak in salt marsh species combined with the potential in-washing of material is indicative of a high energy marine inundation event, such as a tidal surge related to sea level change.

Zone	Associated Radiocarbon Date	Description	Interpretation
PE1-4		Small rises in freshwater aquatic species such as *Lemna* (duck weed), *Nuphar* (pond lily), *Potamogeton* and *Typha Latifolia* are followed by a substantial increase in *Alnus* levels. *Salix* experiences small increases directly before and after the peak in *Alnus. Poaceae* and other herbaceous species subsequently fall. *Chenopodiaceae* falls to 0% and *Cyperaceae* are present in low levels. *Quercus*, *Pinus*, *Ulmus* and *Fraxinus* remain relatively stable, but higher levels of *Corylus* are noted. Low levels of NPP *Sordaria* are also present. Micro charcoal is maintained at low, but notable levels, though drops off as *Alnus* reaches its peak.	**Environment:** This zone reflects a return to freshwater conditions and the initiation once again of peat development. Low levels of sedges and freshwater aquatics indicate a waterlogged fenland landscape. This is succeeded by the onset of alder carr. The background woodland signal is still present, dominated by oak, elm and hazel. **Human Impact:** Rising hazel levels, following significant burning events indicates potential human activity. The subsequent drop in charcoal could be related to the development of alder carr making the landscape more difficult to navigate and reducing human interaction. **Sea Level Change:** The decline in salt marsh indicators and rise in freshwater and dryland species is indicative of a sustained sea level regression.
PE1-5	6180±51 BP	*Poaceae* begins to dominate directly after a substantial peak in micro charcoal. There is also a rise in *Cyperaceae* (sedges). Tree and shrub species fall, but low levels of *Quercus*, *Betula* (birch) and *Ulmus* remain. *Corylus* levels begin to drop, but remain relatively dominant. *Chenopodiaceae* remains almost absent, but there are small increases in aquatic species such as *Potamogeton*, *Typha latifolia* and *Nymphaea alba*. There is a small peak in *Urtica* (nettles) and low levels of NPPs *Sordaria* and *Podospora* are present.	**Environment:** The pollen record reflects an open, damp environment dominated by grasses and sedges with aquatic species indicative of pooling of water and reed beds within the near vicinity. This is representative of a freshwater fenland. Once again, a background signal from deciduous woodland is present. Low levels of Coprophilous NPPs signifies the presence of grazing animals. This is supported by the identification of deer and aurochs hoof prints within the top of the deposit. **Human Impact:** The substantial peak in micro charcoal is indicative of a specific burning event likely to be related to human activity. The persistently elevated levels of hazel, combined with the charcoal evidence, also present a convincing argument for human intervention. Nettles, indicative of higher nitrates in the soil and associated with clearance and human activity are also present, whilst the human footprints within the top of this deposit, (detailed in section 6.2.1 of this chapter) indicate direct human interaction with the site. **Sea Level Change:** Salt marsh indicators have all-but disappeared within this zone and the environment has returned to freshwater conditions. However, the high water table indicated by the marshland vegetation could be a symptom of higher sea levels, albeit retreating from a more inland position.

PE2:

This 49cm sequence is divided into six pollen zones described in Figure 86 .

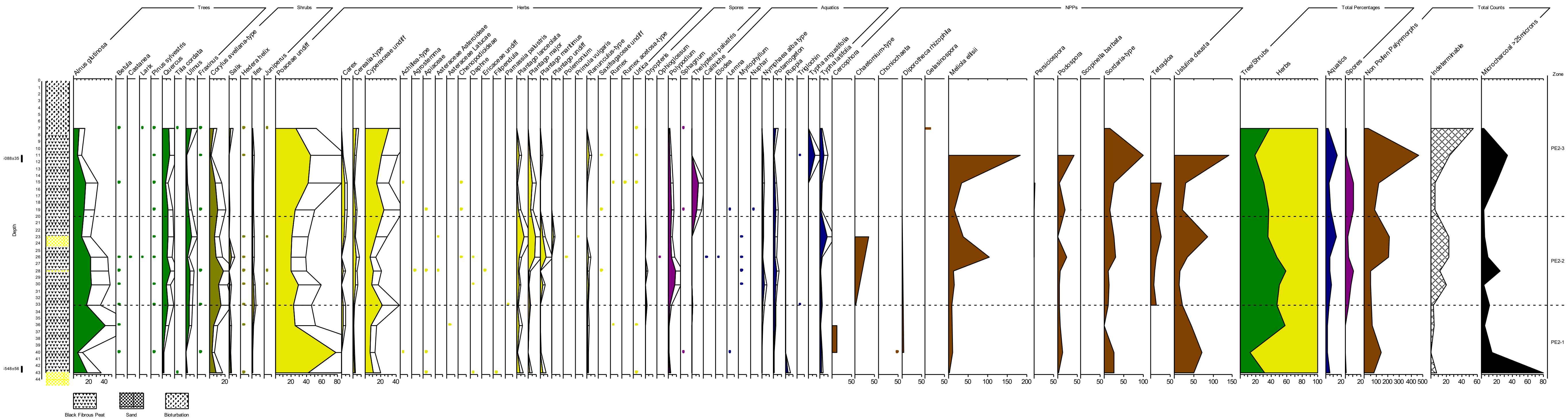

Figure 86: PE2 selected pollen percentage diagram with added counts for NPP, Indeterminable and Micro charcoal. Depth bars show an exaggeration of x2, dots represent presence less than 5%, bar indicates singular occurrence over 5%.

Table 16: Pollen descriptions for PE2

Zone	Associated Radiocarbon Date	Description	Interpretation
PE2-1	5548±56	*Poaceae* are dominant and peak dramatically at 80% TLP before falling back to c.25%. *Alnus* fluctuates in opposition to the grasses (decreasing in correlation with *Poaceae* peaks). There are notable levels of *Cyperaceae*, which rise to 20% TLP at the end of the zone. Tree and shrub species appear negligible, excluding *Corylus*, which represents 5-20% TLP through the zone and follow a similar pattern of reduction in relation to *Poaceae* levels. *Quercus*, *Ulmus* and *Corylus* all experience small increases towards the end of the zone. Very low, but constant levels of *Calluna* (heather) are present along with NPP *Meliolia ellisii.* These remain constant until the end of the zone where *Calluna* appears to drop out of the record briefly. Towards the end of the zone there is a small influence from aquatic species such as *Potamogeton*. Coprophilous fungi species *Sordaria* and *Podospora* are well represented, as is *Ustulina deusta*. They maintain a steady level before dipping towards the end of the zone. Low levels of *Plantago lanceolata, major* and *maritimus* (plantains) are also present. There is a substantial peak in micro charcoal at the beginning of the zone, which decreases to much lower levels almost immediately.	**Environment:** The pollen record indicates a predominantly open, damp landscape dominated by grass and sedges, but with pockets of Alder Carr. The alder influence fluctuates throughout the zone allowing for greater dominance of grasses and sedges. Low levels of heather combined with the parasitic fungi *Meliolia ellisii*, may relate to the initial stages of the formation of an ombrotrophic or raised bog within the local vicinity. There is no clear background woodland signal. This is possibly due to woodland pollen being drowned out by higher levels of localised pollen, rather than an actual lack of woodland species within the periphery of the site, however. There are notable levels of coprophilous fungi and other fungal species, such as *Ustulina deusta,* associated with rotting wood and vegetation, present, indicating the build-up of dead plant material. As the zone progresses, the rise in alder indicates that the environment was becoming more enclosed. This is supported by the fall in coprophilous fungi, indicating a decrease in grazing activity. The slight rise in aquatic species including pond weed, suggests waterlogged conditions in the vicinity. There is also a clear signal of deciduous woodland species, likely to represent pockets of woodland within the surrounding dryland area. **Human Impact:** The low levels of plantains are indicative of vegetation disturbance, which may be related to human activity. The single peak in the micro charcoal record could relate to a singular occurrence of human instigated burning, but in the absence of additional charcoal evidence within the column it could also just relate to a single episode of natural conflagration (e.g. lightning strike in the local vicinity). Charcoal levels then fall dramatically, but persist and could be aligned with background human activity, however there is no further direct evidence for this. **Sea Level Change:** There are no obvious salt marsh indicators present and most evidence reflects a freshwater environment. However, the damp nature of the environment may indicate higher sea levels raising groundwater levels, with slight fluctuations in dampness indicative of a fluctuating water table linked to sea level movements.
PE2-2		*Poaceae* and *Alnus* stabilise at equal levels of around 20% TLP and levels of *Cyperaceae* fluctuate rising and falling sharply initially and then moving towards a steady increase. *Polypodium* spores become notably present and there are peaks in *Plantago* species. *Calluna* peaks towards the end of the zone corresponding with a similar increase in *Meliolia ellisii*. Aquatic species such as *Nymphaea alba* and *Potamogeton* are present in low but steady numbers. There are also low levels of *Cerealia* detected throughout this zone. Relatively steady levels of *Quercus*, *Ulmus* and *Corylus* prevail (a drop is noted, but is related to a sand influx within the Lithology, which could affect preservation. Pollen levels above and below this layer remain relatively constant). Charcoal levels remain low, but constant throughout this period. *Chenopodiaceae* is present in very small quantities at individual points within this zone, but there is no apparent continuation through the column.	**Environment:** The environment stabilises at the beginning of this zone, encompassing open marshlands dominated by grasses and sedges, alder carr and peripheral deciduous woodland. There is a considerable peak in heather, and its associated fungal spores, towards the end of the zone, which indicates more substantial development of raised bog conditions. Both coprophilous and decaying wood related fungi are present signifying grazing animals are present and damp wooded conditions are close by. **Human Impact:** The presence of plantains indicates disturbed ground and could be associated with human activity. Levels of charcoal, while low, persist throughout, which suggests a continued campaign of burning in the background. **Sea Level Change:** The presence of *Chenopodiaceae*, albeit in individual occurrences, indicates a marine source in the wider vicinity, but there is little evidence of the direct effects of sea level within this zone.
PE2-3	5088±35	*Poaceae* levels rise once again, and the *Alnus* signal decreases. *Cyperaceae* levels continue to rise and there is another notable peak in *Calluna* and rise in *Meliolia ellisii*. *Cerealia* continue to be present in very low numbers. Coprophilous fungi, *Podospora*, *Sordaria* and *Gelasinospora* all reach their highest levels, as does *Ustulina deusta*. There is a distinct drop in *Ulmus* during this zone, but levels recover by the top of the column. *Corylus* is also seen to fall and then recover. *Quercus* maintains a steady level. A peak in micro charcoal is apparent during this zone. Late in the zone, *Poaceae* begins to drop off again. This is not matched with a rise in *Alnus*, but *Cyperaceae* become dominant. Micro charcoal and NPPs fall dramatically.	**Environment:** The increase in grasses and sedges reflects a dominance of open marshland with the second peak in heather pointing towards further developments in ombrotrophic bog. The background deciduous woodland signal is still present with some fluctuations. The notable drop in elm could be related either to the Neolithic elm decline, or be a symptom of masking by other species within the overall percentages. High NPP values indicate elevated levels of grazing and areas of rotting vegetation. By the end of the zone sedges are dominant indicating a damp freshwater environment. The low levels of most species may be symptomatic of the bioturbation that was noted within this upper deposit, creating unfavourable preservation conditions. **Human Impact:** The abundance of coprophilous fungi is representative of grazing animals. By this date, these might be domesticated species, however there is no evidence available to support this. The substantial peak in micro charcoal during this time could also relate to human intervention in the surrounding environment. **Sea Level Change:** No direct evidence for a marine influence exists within this zone.

PE3:

This 46cm sequence is divided into three pollen zones described in Figure 87.

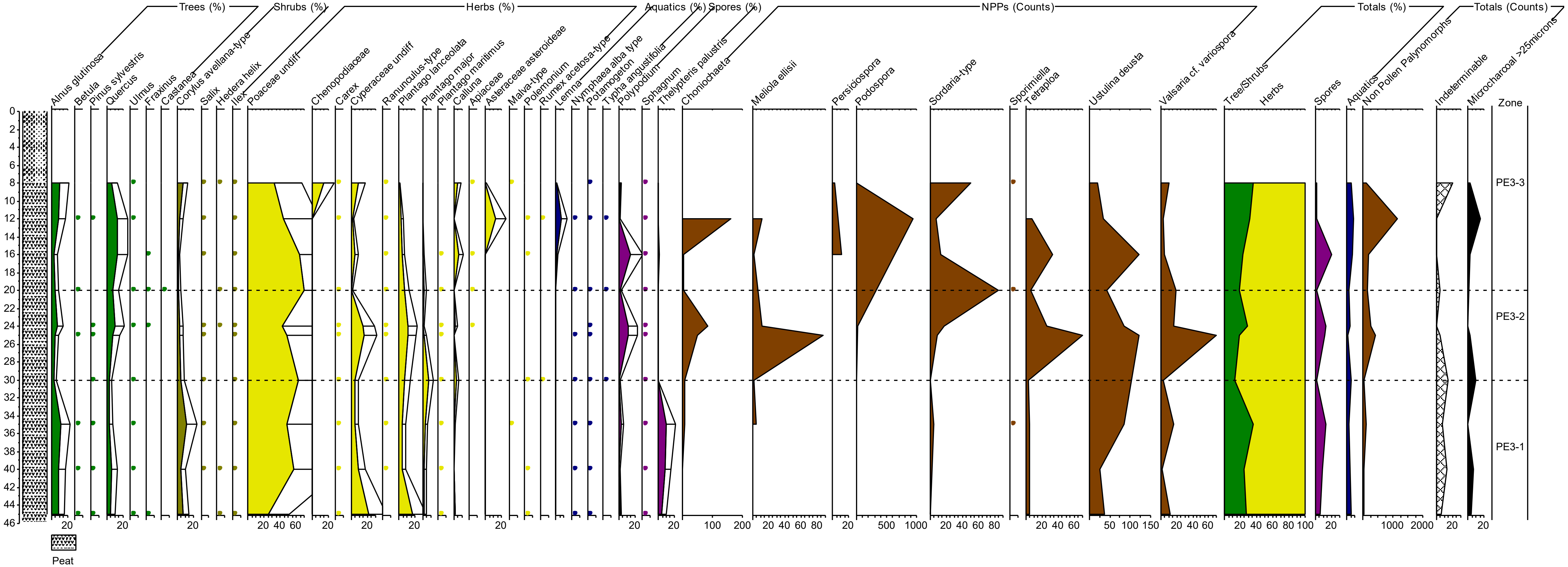

Figure 87: PE3 selected pollen percentage diagram with added counts for NPP, Indeterminable and Micro charcoal. Depth bars show an exaggeration of x2, dots represent presence less than 5%.

Table 17: Pollen descriptions for PE3

Zone	Associated Radiocarbon Date	Description	Interpretation
PE3-1		*Poaceae* dominates with notable levels of *Cyperaceae* and *Plantago* species in the beginning, these species drop slightly as the zone progresses. Thelypteris *palustris* (fern) is present in relatively high quantities, again dropping towards the end of the zone along with lower amounts of *Polypodium*. Very low levels of aquatic species *Potamogeton* and *Nymphaea alba* are noted and support the same trend. *Alnus*, *Quercus*, Corylus and *Ulmus* dominate the tree/shrub signal. *Calluna* and *Meliolia ellisii* are present in very low, but stable corresponding levels. There are low, but rising quantities of NPPs *Ustulina deusta* and *Valsaria* and stable, low levels of *Tetraploa*. There are two small peaks in charcoal during this zone, which seem to correspond with small rises in *Poaceae* and lower levels across tree and shrub species. They also occur either side of a spike in *Corylus*.	**Environment:** This zone is indicative of a freshwater fenland dominated by grasses and sedges which begins to dry out, indicated by the gradual drop in sedges, spores and aquatics, in the second half of the zone. The NPPs present indicate the presence of decaying wood and vegetation. There is a fluctuating background signal of deciduous woodland, which changes from oak to hazel and elm dominated, and an indication of raised mire development nearby. **Human Impact:** The charcoal peaks are associated with the opening of the landscape and an increase in hazel, which could be attributed to human influenced burning phases within the surrounding dryland woodland. The elevated levels of Plantago at the beginning of this zone may be indicative of disturbed ground related to cultivation, however there are no cultivated species noted. **Sea Level Change:** There is no specific evidence for sea level change within this zone, the apparent drying of the environment suggests a falling water table, linked to receding sea levels.
PE3-2		*Poaceae* is still dominant, but fall slightly as the levels of and *Cyperaceae* and *Plantago Lanceolata* increase. By the end of the zone, levels appear to be restored to those at the end of the previous zone. *Calluna* and *Meliolia ellisii* also rise. There are very small rises in *Potamogeton* and *Nymphaea* alba. *Sporomiella* is also present. Quercus becomes more dominant in the tree and shrub species, while there is a fall in *Corylus*. *Sordaria* increases dramatically. There is a peak and then fall in *Ustulina deusta* along with reduction in *Valsaria*. There is very little micro charcoal present within this zone.	**Environment:** This zone represents a continued wetter period, with the environment developing back into fenland. This is reflected in the increase in sedges and small rises in pond weed, water lilies and green algae, suggesting standing water nearby. The increased heather signal towards the end of the zone indicates further development of raised mire, while the surrounding dryland woodland becomes more oak dominated with a complete fall in elm. **Human Impact:** The rise in Plantago could be indicative of human disturbance through cultivation, however there is no further evidence of cultivation within this zone. The drop in micro charcoal suggests burning activity has reduced or even ceased during this time. An increase in coprophilous fungi might be the result grazing domestic animals, due to the assumed Neolithic date, but further evidence is not available. **Sea Level Change:** There is very little direct evidence of sea level change, but the increased wetness indicated in the pollen record may be indicative of a higher water table related to rising sea levels.
PE3-3		Poaceae begins to decline and there is a sudden sharp rise in *Chenopodiaceae* along with another rise in *Cyperaceae*. A peak in *Lemna* is notable just before *Chenopodiaceae* appears. A general fall in most herbaceous species and spores is visible. Levels within the tree species remain relatively stable, though there is a slight decline noted for *Quercus* and rise in *Corylus*. There are spikes in Coprophilous fungi including *Sordaria* and *Podospora*, which fall dramatically towards the end of the zone. There is another small peak in micro charcoal during this phase, which disappears towards the end.	**Environment:** There is a clear marine influence during this zone. A rise in salt marsh indicators is preceded by a peak in duckweed suggesting pooling freshwater associated with a rise in ground water levels. **Human Impact:** Within a Neolithic context, the early rise in coprophilous fungi could be construed as resultant from domestic grazing with the subsequent drop in NPP levels interpreted as a result of the landscape becoming less accessible as it became wetter. A spike in micro charcoal corresponding with a rise in hazel may reflect human activity through burning in the landscape. **Sea Level Change:** Marine influence is clearly detected in this zone. An episode of rising sea levels causes groundwater levels to rise followed by the development of salt marsh in the very near vicinity.

PE4:

The spot sample obtained from 50cm below the beach surface in the lower intertidal zone provides data for one zone, which is described in Table 18.

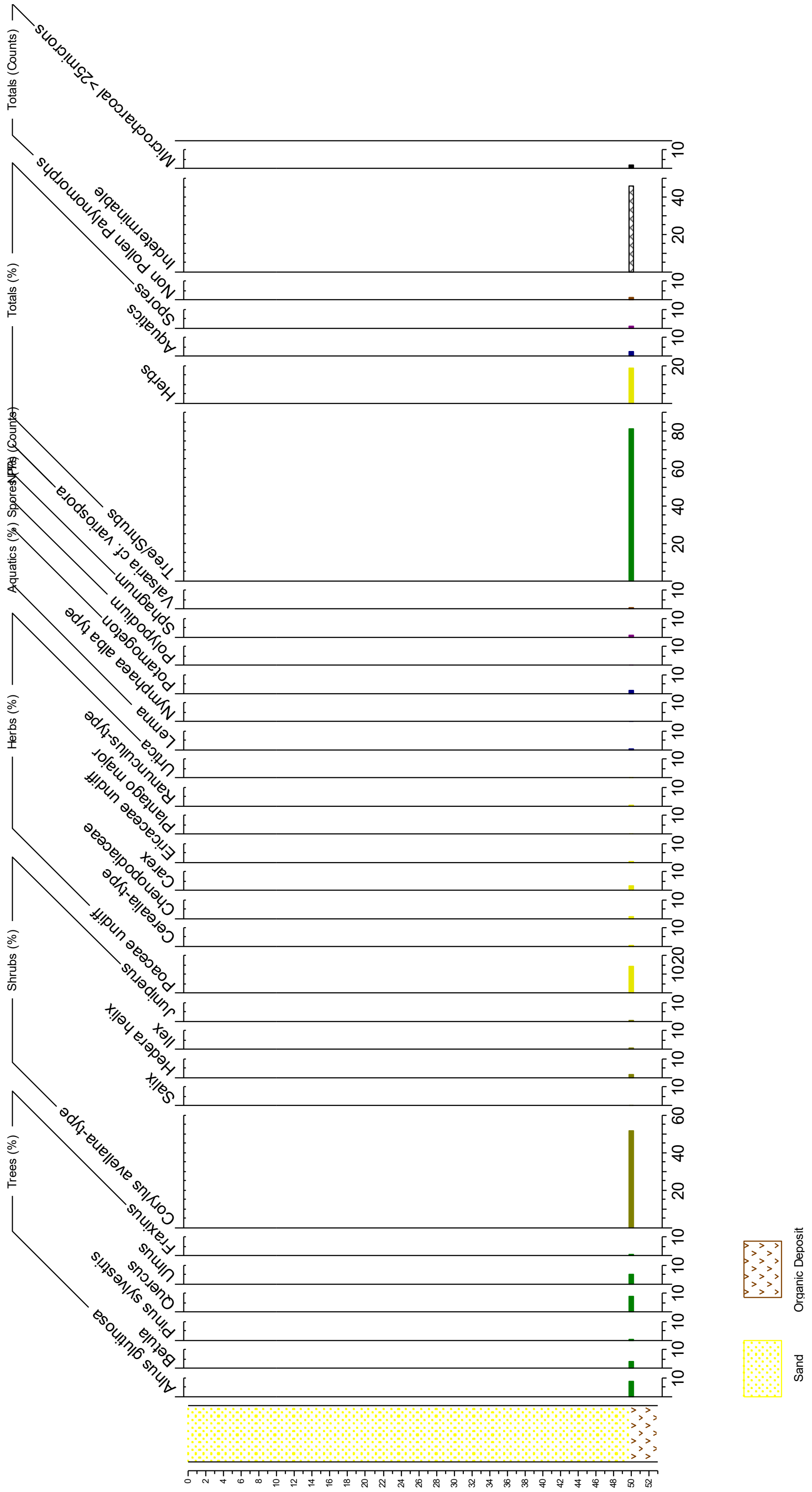

Figure 88: PE4 pollen percentage diagram with added counts for NPP, Indeterminate and Microcharcoal

Table 18: Pollen description for PE4

Zone	Associated Radiocarbon Date	Description	Interpretation
PE4-1	No dating evidence is available for this particular deposit.	*Corylus* is the most common species within the pollen record with smaller amounts of *Alnus*, *Quercus*, *Ulmus* and *Betula*. Other than *Poaceae* most herbaceous species are present only in very low percentages. These include *Chenopodiaceae*, *Carex, Plantago* and *Urtica*. There are very low levels of aquatic and spore species identified. This is also true of NPPs. The amount of micro charcoal present is negligible.	**Environment:** This is a tree and shrub dominated environment with a grass dominated understorey. The high levels of hazel suggests this species dominates, however *Corylus* is a hardy and high yielding pollen and low levels of almost every other species indicate poor preservation. Thus the pollen record may not be a true representation of the species present in the landscape. General trends within the samples indicate trees and shrubs were more predominant in the landscape than herbs.
			Human Impact: There is little evidence of human activity in this sample.
			Sea Level Change: There is no evidence of direct influence of sea level change in the pollen record. However, the very low levels of *Chenopodiaceae* pollen present indicates marsh has developed within the wider vicinity, indicating an encroaching marine influence.

6.5.3 Diatoms

Diatom analysis was only undertaken on the PE1 deposits as this was the only sampled column that contained waterborne sediments through tidal inundation. Despite multiple slides being analysed for each sample, no diatoms were identified within the analysed deposits (Smith 2017). A similar result was also encountered during the Lyonesse Project (Charman et al. 2016b, 181) and indicates that the conditions presented both at Port Eynon and in the Isles of Scilly did not provide an adequate preservation environment for diatoms. Diatoms have been successfully utilised during investigations in the Severn Estuary (Bell et al. 2000a), where sequences were obtained from low energy estuarine deposits, rather than high energy tidal zones and therefore would have been less affected by mixing and erosion. Foraminiferal analysis was used during the Lyonesse Project to greater success (Charman et al. 2016b, 181). It was not possible to undertake this kind of analysis during this investigation, but it is a proxy that should be explored in any further work undertaken in the future.

6.5.4 Summary of Environmental Change

Broughton Bay

Despite the low definition of data currently available for Broughton Bay, the environmental picture is broadly similar across all four of the identified organic exposures and indicates landscape that developed in the Early Neolithic period.

The deposits sampled at each of the exposed locations on the beach indicate a predominantly freshwater environment was present in the immediate vicinity of the sample site, dominated by sedge fenland and alder carr woodland. The dryland areas surrounding the identified wetlands were dominated by oak and hazel woodland. Slight fluctuations in groundwater levels are indicated in the freshwater wetlands by varying aquatic indicators, such as an increase in *Lemna* or Duck Weed, which indicates the presence of standing water. Indications from sample locations Br4 and 5 show low levels of saltmarsh indicators towards the bottom of the columns, denoting a marine presence within the wider area, but with no direct influence on the site itself at the time of deposition. Higher levels of salt marsh indicators are present in the lower section of column Br2, and at Br3, where the column is entirely minerogenic and maintains moderate levels of salt marsh indicators throughout. A radiocarbon date of 5196±34 BP (4150-3950 cal BC) has been obtained from the top of column Br1 suggesting the deposits developed in the early Neolithic period.

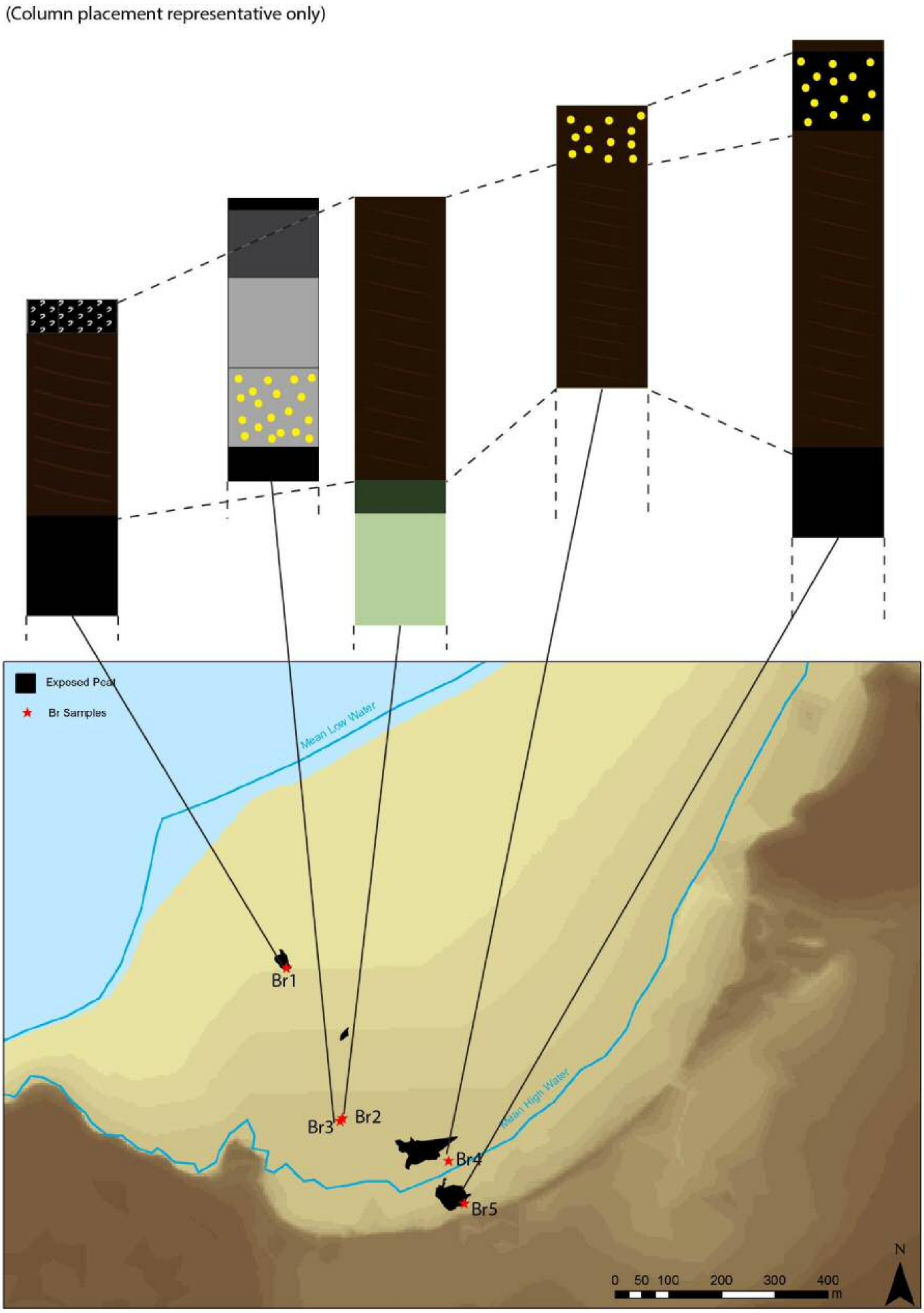

Figure 89: Combination column diagram and sample distribution map for Broughton Bay

The columns extracted from sample sites Br2, 4 and 5 all indicate a single sloping freshwater landscape, preceded by salt marsh within the Broughton Bay vicinity, which is directly identified the column at Br2. The discrete nature of the minerogenic deposit at Br3 could suggest the remains of a tidal inlet, though this would need to be further verified. At Br1, in the lower intertidal zone, the peat is much thicker than at any other location on the beach, reaching at least 1.5m in depth, as opposed to an average of c.40cm higher up the beach. However, the environment represented in the pollen record is very similar to that in the other locations and is likely to represent the same landscape. The additional depth may be caused by underlying topography or the presence of a palaeochannel, but this requires further investigation. Again, in the surrounding dryland environment, oak and hazel woodland predominates.

Port Eynon

A far more detailed environmental history can be identified at Port Eynon due to the highly varied sediment sequence and higher resolution pollen analysis. A substantial and varied history of environmental change is apparent. The series of radiocarbon dates obtained at this site has shown that these changes occurred during the late Mesolithic and into the early Neolithic periods and are likely to have been witnessed and perhaps even exploited by the human and animal inhabitants of the contemporary landscape.

The assumed earliest sampled environment at Port Eynon, recorded from a spot sample 50cm below the sand in the lowest accessible point in the intertidal zone, indicates an enclosed wooded dryland landscape dominated by trees and shrubs, with hazel being the most prominent species and very little evidence of herbaceous species. The presence of goosefoot, albeit in very low quantities, points to the presence of a marine influence at this stage in the much wider vicinity. No dating evidence is available, as the integrity of the sample could not be guaranteed, which means the pollen evidence cited should also be approached with caution.

The earliest dated deposit at the base of column PE1 indicates the end stages of an alder carr dominated environment in the immediate vicinity at 6415±42BP (5480-5320 cal BC). The deposit extends deeper than analysed, but due to tidal restraints, further material was not recoverable. There follows a sharp decrease in alder and increase in goosefoot, signposting the onset of a marine transgression, which is supported by a clear change from peat to a mainly minerogenic sediment. The peak in saltmarsh indicators is short-lived and the environment gradually returns to freshwater status, with high levels of Poaceae and an increasing variety of herbaceous species indicating a graduation to upper saltmarsh conditions and eventually reed-based fenland. In the outer dryland margins of the Port Eynon area, oak, hazel and elm dominate.

Peat accumulation is disrupted, as the environment moves into a much more unsettled phase related to a more substantial marine transgression. The immediate environment becomes wetter with an increase in aquatic species including pond weed and bulrushes. This is followed by rising levels of goosefoot culminating in a dramatic spike. Layers of clay, sand and organic deposits alternate in relatively thin layers indicating a rapidly fluctuating, and at times high energy environment. At least five separate sea level related deposition episodes are apparent. In the surrounding dryland margins, levels of the previously identified woodland species also fluctuate, though this is likely to be due to the spikes in the local wetland species drowning out the signal of the marginal dryland species, rather than a true representation of changes in the surrounding dryland environment.

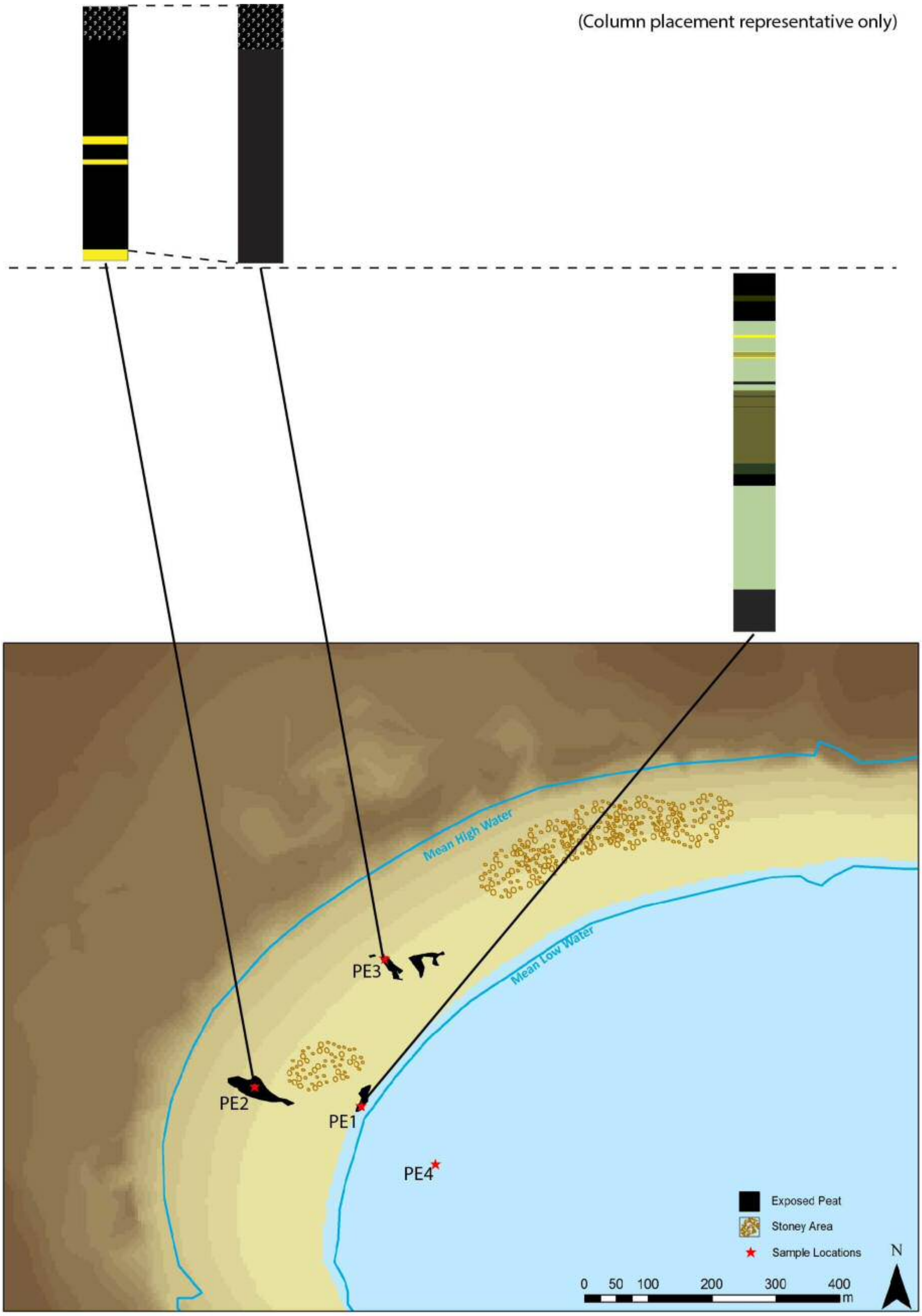

Figure 90: Combination column diagram and sample distribution map for Port Eynon

The unsettled environment is reflected in the pollen record where percentages fluctuate dramatically and also in the radiocarbon date taken from this part of the column, which provides a date much older than that of a deposit lower in the sequence. This implies the introduction of older material into the sequence, supporting the theory of a high energy tidal environment.

Following this period, sea levels recede, and freshwater environments begin to regenerate in the local vicinity. A short fenland period initiates peat accumulation, but increasing ground water levels, likely to be linked to rising sea levels, lead to the development of a willow-alder carr woodland, followed by a freshwater fenland comprising of sedges, reeds and aquatic species in pooling water. In the peripheral dryland, oak, hazel, and elm still preside in the drylands along with low levels of birch. This phase is dated to c.6180±51 BP (5300-4990 cal BC).

A relationship between the upper and lower peat exposures at Port Eynon has not yet been established. The sequence is re-joined in column PE2 at 5548±56 BP (4500-4270 cal BC). At this point the environment is dominated by freshwater fenland with high levels of grasses, reeds and sedges. Pockets of alder carr briefly become more dominant before reverting back to fenland, suggesting ground water levels are still being affected by fluctuating sea levels. As time progresses, the land begins to dry, but instead of woodland taking hold, the development of ombrotrophic bog is noted through an increase in the presence of heather and its accompanying fungus *Meliolia ellisii*. This indicates that the climate remains wet enough to provide moisture to the bog, but the soils remain nutrient poor and unable to sustain tree colonisation. This environment is maintained to the end of the dated sequence, dated to 5088±35 BP (3970-3790 cal BC). Throughout this column, the peripheral dryland pollen signal maintains the presence of oak, hazel and elm.

Pollen evidence from column PE3, which was taken from a further discrete peat exposure in the upper regions of the intertidal zone, indicates a similar environmental sequence to that of PE2, moving from sedge dominated fenland to ombrotrophic bog. The sequence is extended slightly in this column, indicating a further rise in groundwater levels leading back into a sedge dominated freshwater fenland. An increasing goosefoot signal indicates that this is due to another onset in sea level rise. In the peripheral drylands, an oak and hazel dominated woodland is apparent. Though there is no dating evidence for this particular deposit, the similarity in the pollen record suggests it is contemporary with PE2 and therefore this would indicate this rise to have occurred within the Neolithic period after 5088±35 BP (3970-3790 cal BC).

6.5.5 Human Impact on the Environment

Broughton Bay

Evidence for human impact within the palaeoenvironmental record at Broughton Bay is limited. Levels of microcharcoal are low or non-existent in the lower layers of the recorded sediment sequence, suggesting little evidence of humans within even the wider vicinity following the onset of freshwater fenland after a potential marine transgression. Microcharcoal becomes more prominent in the upper levels of the sequence, with the signal being particularly high where samples were taken at the top of the beach. Samples taken lower down the beach produced much lower microcharcoal signals. This may be indicative of the sample's proximity to the source, perhaps suggesting burning occurred further inland in dryer environments, though could also due to differing taphonomic processes within the intertidal zone.

The presence of coprophilous fungi in the upper sequence might also be aligned with human impact, as this can be indicative of grazing animals. The early Neolithic date ascribed to the later deposits means that grazing animals could be domesticated species, but without further evidence from the archaeological record, this is very difficult to prove.

Very low levels of Cereal pollen, (equating to one or two grains in a very low number of subsample locations), were identified during analysis. The date of the site would be too early for wide-scale cereal production and it is unlikely that this small amount of evidence equates to direct human impact in the immediate vicinity. Due to the environmental context, it would also be possible that these grains are actually representative of *Glyceria*, as described in Chapter 2, in which case their occurrence would be due to natural environmental factors and not human interaction.

Though there do appear to be some indicators that could be aligned with human interaction with the environment within the sequence at Broughton Bay, the environmental evidence on its own could not be used to prove direct human impact on the site.

Port Eynon

At Port Eynon, low, but constant levels of charcoal from the first marine episode indicate the likely presence of humans within the vicinity from around 5400 cal BC. Peaks in charcoal occur during fenland phases suggesting a potential increase in activity in these landscapes.

Charcoal levels drop during the second marine transgression, though it is unclear whether this is due to movement of sediment during this phase, as the pollen record suggests an incomplete record potentially due to high energy conditions. As freshwater conditions return, with the indication of reed swamp, so too does the charcoal signal. Peaks in charcoal appear to equate with increased levels of hazel. Potential disturbance indicators are also present in the vegetation record, including nettles and Plantago. These plants suggest higher nitrate content in the soil which can be aligned with human activity.

There is a continued presence of microcharcoal moving from the late Mesolithic into the Neolithic suggesting a continued background signal from human activity. There are three notable peaks during this transitional period, the earliest dated to 5548±56 BP (4500-4270 cal BC) and the latest to 5088±35 BP (3970-3790 cal BC). It is difficult to say whether these are due to specific human actions, however the latter two align with peaks in coprophilous fungi, which could indicate an increase in domestic grazing.

Disturbance indicators in the vegetation record such as nettles and Plantago species might also indicate human activity. However, the major influencer on the environment still appears to have been fluctuating ground water levels most likely caused by sea level change and direct evidence for burning other than micro charcoal fragments has not been identified, suggesting any burning that did take place was at a distance from the site itself.

6.5.6 Sea Level Change

Sea level change has been identified as the main driver of the environmental change recorded at both Broughton Bay and Port Eynon, with the effects reaching much further than the identified marine transgressions. The results of the palaeoenvironmental investigation in relation to sea level are discussed below.

Broughton Bay

A relatively stable freshwater environment was identified at Broughton Bay. It suggests a substantial period of stable sea levels during the early Neolithic period. The fact that ground water levels are maintained high enough for wetland environments to thrive suggests the coast remains nearby. The potential presence of a tidal inlet represented by the sequence analysed from Br 3 supports this hypothesis.

The deepest deposits analysed at Broughton Bay show minerogenic lithology with high *Chenopodiaceae* levels suggesting an apparent marine transgression, prior to the onset of this freshwater environment. No further marine indicators are present within the pollen or lithological records at Broughton Bay, though it must be acknowledged that the investigation at this site was of much lower resolution than at Port Eynon for reasons discussed earlier in this thesis.

Port Eynon

At Port Eynon, pollen evidence indicated two positively identified marine transgressions within the lower sequence (PE1) along with continuous evidence for fluctuating groundwater levels, which combined with the specific species evidence also indicates relation to sea level change. Pollen evidence has provided a definitive link between the presence of minerogenic sediments within the sequence and marine transgressive periods. At the base of the sequence and in line with a change in lithology from peat to minerogenic sediment a relatively short-lived, but substantial peak in *Chenopodiaceae* combined with open landscape taxa suggests sea levels rise and initiates the development of salt marsh at the site. The sequence then returns once again to freshwater wetland.

What appears to be a much more significant transgression is evident midway through the lower sequence. *Chenopodiaceae* levels build as the lithology once again returns to minerogenic sediment and spike at levels of 50% TLP, displaying a substantial majority within the land-based flora and supported by high levels of *Poaceae*. It is likely this indicates the onset of salt marsh once again. This is followed by a period of highly fluctuating pollen levels throughout all species, including a section of the sequence where no pollen survived at all. Accompanied by a highly mixed lithology with sand inclusions, this suggests the potential for a high energy tidal zone or at least a high energy tidal event such as a storm surge or barrier breach. Within the lithology in the lead up to this part of the sequence, there are thin deposits of peat within the minerogenic sediments, suggesting the path to saltmarsh is not linear, with short regressions in sea level causing freshwater conditions to reinstate locally, albeit briefly. Fluctuations in the pollen record also appear to support this.

After this period of marine influence, the pollen evidence suggests a return to freshwater conditions, albeit with fluctuating groundwater levels likely to be related to subsequent lower impact changes in sea level. There is a gap between the top of the PE1 sequence and the bottom of the PE2 sequence, which means there is also a break in the environmental evidence. This gap is representative of c.300 years according to the radiocarbon dating evidence. It is likely that this is due to erosion of later deposits in the lower intertidal zone, but the relationship between the upper and lower sequences is not clear within the evidence obtained. The presence of a grey clay beneath the upper sequence suggests a potential further transgression allowing for the formation of salt marsh prior to the onset of freshwater fenland.

Within the majority of the upper sequence, there is very little evidence for sea level change and the formation of ombrotrophic bog, which as previously explained, is fed primarily by precipitation, suggests ground water (and by extension sea level change) is not the controlling factor within the environment. At the very top of the sequence, however, sea level indicators appear once again, with the landscape becoming groundwater fed marshland and the reappearance of *Chenopodiaceae* within the pollen record. This suggests an encroaching marine influence, though is not direct evidence for a full transgression.

It is clear that a further marine transgression did occur, as the site eventually became the high energy tidal zone that is present today. What is still unclear is how many further transgressions and regressions occurred prior to this happening.

A suggestion for the high fluctuation in environment and sea level at Port Eynon specifically could be suggested to be due to the breaching and resealing of a back barrier system. It has been noted that no such prehistoric examples exist on the Welsh side of the Severn Estuary (Bell 2000, 19), but further west on the Pembrokeshire coast, it is suggested that intertidal deposits in bay locations were indeed formed in shallow freshwater lagoons behind barriers (Murphy et al. 2014, 24). This kind of back-barrier system is present on Gower today at both Oxwich Bay and Port Eynon (Pye and Blott 2009, 73 & 74), however there has been no evidence to date to suggest this kind of environment was present in the prehistoric period at these sites.

Dating

Direct dating of the identified marine transgressive periods was not possible within the financial constraints of this project, however the dates that have been obtained can act as limiting dates. This means that any changes that have been identified can be placed within a known time frame, even if they cannot be specifically dated.

At Broughton Bay it was only possible to obtain one radiocarbon date due to the reasons outlined earlier in this thesis. The sample was obtained from the top of the lowest exposed peat deposit in the intertidal zone and dated to 4150-3950 cal BC at 95% certainty. The sea level indicators identified in the pollen record are at a much greater depth in the sequence and cannot be specifically dated other than to say that they occurred prior to the date obtained.

The dates obtained from the Port Eynon sequence place both transgressions between 5480-5320 cal BC and 5300-4990 cal BC. The earliest date is taken from the last phases of the freshwater peat at the base of the sequence from which the first marine transgressive period emerges. This would suggest that the change occurred relatively closely to the obtained date, placing within the late Mesolithic period. The second transgression occurs stratigraphically in the middle of the lower sequence at Port Eynon, but cannot be more securely dated than between the dates listed above without further dating evidence. Due to the multiple changes in lithology, it is not possible to estimate accumulation rates without further radiocarbon dates. The sediments were formed in different environments, which will have affected the rate of accumulation. For example, freshwater peats will take longer to accumulate as they are a very low energy environment, reliant on the introduction of vegetation matter over a long period. Minerogenic sediments related to sea level rise are more likely to accumulate quickly, particularly once they are part of the daily tidal cycle. Material deposited due to storm surges will be deposited over a much shorter time scale.

The effects of erosion must also be taken into account. These are not visible within the sequence, but can account for missing periods of time within the accumulation record. Without direct dating evidence, however, these occurrences cannot be identified and although a slowing or speeding up of accumulation can be inferred from the lithological and palynological records, they cannot be proven.

Any potential marine transgression within the gap between PE1 and PE2 occurs prior to a date of 4500-4270 cal BC (95% certainty), as this is the date attributed to the beginning of the later freshwater marshland episode. A period of substantial regression occurs until the final sea level indicators in the sequence occur c.3970-3790 cal BC (95% certainty).

Limiting Index Points

The lack of specified dating creates a barrier to obtaining a SLIP within this phase of the project, but the dates obtained can act as range finders. Limiting index points can be assigned to freshwater peats based on modern local analogues. Employing this methodology is dependent on a similarity in tidal ranges in both prehistory and the modern day to provide accurate comparison. Conclusive evidence as to whether significant changes in tidal range occurred within the Bristol Channel during the Holocene remains elusive (Hill et al. 2007, 647), but coarse scaled observations at a national scale have indicated little change in the mid to late Holocene (Shennan et al. 2006, 596). As a result, it has been assumed that current tidal ranges are similar to those in prehistory.

Sea level has been calculated using the following calculation has been implemented after (Charman et al. 2016b, 182):

$$S = H - I + VD$$

Where S = sea level, H = current height above sea level (mOD), I = prehistoric elevation and VD = vertical displacement due to compaction.

Prehistoric elevation was estimated through the identification of contemporary freshwater coastal marshes within the vicinity of both research sites. The freshwater marsh at Oxwich was identified as closest to Port Eynon and the marsh at Cwm Ivy in the case of Broughton Bay. Both sites represent reclaimed land, and Cwm Ivy has recently developed into saltmarsh, after sea defences were breached in 2014 (National Trust 2015a) however they still represent good proxies as they maintain(ed) a freshwater environment at the current elevation. Elevation data for both marshes has been extrapolated from digital terrain mapping. An average height of 4mOD for both sites obtained, therefore I = 4.

The issue of vertical displacement via compaction in relation to the creation of reliable SLIPs was discussed in Chapter 2. As the bases of the sequences at both Port Eynon and Broughton Bay were not identified, it has not been possible to accurately predict the effect of compaction at either site. The presence of exposures of glacial till noted in the vicinity of the peat exposures at both Broughton Bay and Port Eynon (Campbell and Shakesby 1994 and this investigation) would suggest that the overlying sediments are not excessively deep and unlikely to reach the 7m overburden threshold. Thus, any effect from compaction is likely to be negligible and at a maximum 0.2m. As a result VD has been discounted in the following calculations, in line with the approach taken by (Charman et al. 2016b, 182).

Sample	Radiocarbon Date	Current Elevation (mOD)	Prehistoric Elevation (mOD)	Prehistoric Mean Sea Level (mOD)
PE1-1	4465±42 BC	-3.177	4	-7.177
PE1-3	4230±51 BC	-2.532	4	-6.532
PE2-2	3598±56 BC	-0.384	4	-4.384
PE2-1	3138±35 BC	-0.074	4	-4.074

Table 19: Limiting index points from dated deposits within the Port Eynon sequence.

Sample	Radiocarbon Date	Current Elevation (mOD)	Prehistoric Elevation (mOD)	Prehistoric Mean Sea Level (mOD)
Br1-3	3246±34 BC	-2.864	4	-6.864

Table 20: Limiting index points for dated deposits within the Broughton Bay sequence.

Table 19 and Table 20 display the limiting index point obtained from both Port Eynon and Broughton Bay. Mapping and discussion of these results are provided in the following chapter.

6.6 Summary

This chapter has presented the results from each of the individual archaeological and palaeoenvironmental analyses undertaken at Broughton Bay and Port Eynon.

The visible extent of peat outcrops at both sites in 2015 has been surveyed and mapped and will provide an analogue for future survey (a copy of the shape file will be sent to Glamorgan Gwent Archaeological Trust for use in future research).

Direct archaeological investigation has identified a group of both adult and child human individuals sharing the landscape with red deer, roe deer, wild boar, aurochs and a potential wolf.

Radiocarbon dates have placed the deposits at Broughton bay leading into the Neolithic period, while at Port Eynon the lower exposure represents a late Mesolithic exposure, whereas the upper exposure is late, representing the transition between late Mesolithic and early Neolithic.

The palaeoenvironmental analysis has provided evidence for a long-lived fenland/alder carr environment at Broughton Bay, which is similar in character to the later Neolithic deposits at Port Eynon. In the lower Mesolithic sequence at Port Eynon, a highly fluctuating environment driven by substantial sea level transgressions and regressions has been identified.

The results are discussed in the following chapter in relation to their local, regional and national context, as standalone outcomes and combined to enable further understanding of human experience of environmental and sea level change within the Gower landscape.

7 Discussions

Today Gower sits as a distinct peninsula on the South Wales coast, jutting out into the Bristol Channel and surrounded by a rugged and permanent looking coastline. However, the physical boundaries of Gower would not have been so clear-cut during prehistory. This chapter discusses the results obtained during the primary archaeological and palaeoenvironmental investigations of this research and contextualises the findings in terms of their local, regional and national settings.

The discussion is structured into two sections. The first (7.1) discusses the evidence for sea level driven environmental change on Gower and how the two investigated sites compare to their regional counterparts. Investigation has been hampered by the lack of comparable intertidal sites at a local and national level. While largescale research projects exist, they cover very specific geographic areas. Particularly of issue is the lack of comparable palaeoenvironmental and chronological data available for Wales, a problem that has been highlighted countless times by Caseldine (1990) and the Welsh Archaeological Research Framework (IFA Wales/Cymru 2008,2014,2017a). Other than the Severn Estuary, data is sparsely distributed around the Welsh Coast and not always easily accessible. A full synthesis of intertidal evidence in Wales has remained elusive since Bell's 2007 survey (Bell 2007d), mainly because very little new evidence has been published.

Effects on the Mesolithic and Neolithic human populations of Gower are considered alongside evidence for direct human interaction, management and movement in the landscape and the potential for seasonal patterns within this activity. The new chronological data is also used to draw synthesis between evidence for human presence on the wetland edge at Port Eynon and Broughton Bay with previously known directly dated archaeological remains on Gower.

The second half of the discussion (7.2) addresses approaches to intertidal archaeology. Firstly, the issue of sea level modelling is addressed using data direct from this investigation. The adaptation of intertidal methodologies is then discussed, highlighting the issues this project faced in terms of scale and budget in comparison with the larger scale projects its methodologies were based on. A short section follows discussing the experimental techniques that were trialled in low budget form during this research and how solutions have been found elsewhere. Potential solutions for ways to fill the gaps in intertidal palaeoenvironmental and archaeological knowledge in Wales are then proposed; through acknowledgement of the value of coastal monitoring schemes and by highlighting the importance of championing intertidal evidence as having wider implications to encourage standardised inclusion within developer funded schemes. The discussion ends with a justification for this research based upon public reaction to the project and the potential intertidal research holds for education and archaeological engagement purposes.

7.1 Changing Tides

7.1.1 Changing Coastlines

The new evidence obtained in this study has shown that sea levels on Gower fluctuated significantly during the late Mesolithic period and early Neolithic periods. At Port Eynon, a combination of palaeoenvironmental evidence and sediment characterisation sees five direct episodes of marine transgression on the site, between 5480-5320 cal BC and 5300-4990 cal BC in the form of intermittent instigation of mud flats and salt marsh accretion. Substantial regressive periods follow each of these early transgressions, evidenced in vegetation succession from salt marsh, to reed swamp, to fenland and carr woodland. A short period of higher energy tidal influence, evidenced by alternating sand and clay sediment deposits, follows the final transgression.

Later deposits at both Broughton Bay and Port Eynon point to a sustained period of lower sea levels. Deep deposits of sedge dominated fenland and in places pockets of alder carr develop in the period leading up to the early Neolithic period (prior to 4150-3950 cal BC at Broughton Bay and between 4500-4270 cal BC and 3970-3790 cal BC at Port Eynon). At Port Eynon, the sequence then continues with the development of a raised mire. This reflects a change in the main wetland driver from ground water, controlled by sea level to atmospheric precipitation, controlled by a climatic wet period.

Changing coastlines in South Wales – A regional narrative

The new environmental and sea level related data obtained during this study has contributed to an increase in resolution of data for South Wales over the Mesolithic to Neolithic transition. As identified within the initial surveys of this research outlined in Chapter 4, there is a dearth in prehistoric archaeological, palaeoenvironmental and temporal evidence from the South Wales. Bell has argued that wetland sites in South West “barely figure” within Mesolithic and early Neolithic literature in Britain (Bell 2007e, 1). This has impacted on sea level studies in the wider Bristol Channel area, and has led to an under representation in sea level knowledge related to South Wales. The data collated in this research provides new evidence for the region that can now be compared within its wider setting.

Figure 91 presents the main trends in environmental change at six sites on the South Wales coast, including the two investigated during this study. For ease of display, the singular uncalibrated BP format dates have been used for this particular visualisation rather than the calibrated date ranges. The figure cannot display the nuances of the changing environment due to the limited number of radiocarbon dates, so each date range has been categorised by the dominant change that occurred within that period that can help to inform on the effects of sea level change.

The figure reveals similarities in environment succession across the various sites. For example, the newly identified marine influences at Port Eynon occur soon after period of minerogenic accretion at Goldcliff, indicating that sea level rise affected the entire length of the South Wales coastline at this point. (Smith and Morgan 1989, 152) refer to multiple laminae of clay interleaved with peat layers at Goldcliff, which echoes the sequence at Port Eynon.

The predominance of Sedge fenland across the low-lying wetlands of South Wales during the late Mesolithic period and into the early Neolithic period is noted at all six of the sites. In most cases the development of this fenland occurs after marine incursions and follows the subsequent regression and reed swamp phase within the vegetation succession.

Ombrotrophic bog develops at Port Eynon around 5200 BP, echoing a similar change identified at Goldcliff, which continues through to the Roman period (Bell et al. 2000b; Bell 2007e). This development is indicative of a period of wetter climate affecting the region, with rainwater feeding the wetland environments rather than a rise in ground water due to sea level regression. Contemporaneous evidence from Lydstep does not identify ombrotrophic bog development, likely due to the occurrence of a localised marine transgression dated to within this period at the site (Murphy et al. 2014). Broughton Bay is also lacking in evidence for this development, but this could be due to localised environmental factors, such as the presence of a water source maintaining ground water levels. Raised mires are not identified at any of the other sites investigated, but comparable contemporaneous evidence is not available to verify whether this is a true representation. The similarities between Port Eynon and Goldcliff indicate a climatic wet period within the region, within a generally transgressive sea level period.

It is important to note that the wetland environments characterised within the sampled deposits represent the environment present within the immediate vicinity of the sample sites and that species pertaining to other environments, such as dryland woodland, are also present within the pollen record. This has been interpreted as representing dryland environments present at the periphery of the wetland areas. As explained in chapter 2 (section 4) of this thesis, pollen dispersal is affected by the method by which it is transported as well as the density of vegetation within the local environment. Due to the open nature of the wetlands, wind transported arboreal pollen can move freely through the landscape to be captured within the wetland environments. Therefore, despite the record providing evidence for open freshwater and saltwater wetlands at both Port Eynon and Broughton Bay, the presence of wind transported, dryland woodland species, seen in the relatively low, but steady levels of oak and hazel pollen throughout the pollen records of both sites, indicate the presence of dry woodland environments on the edges of the wetland environment. Whilst the full makeup of the peripheral dryland environments cannot be ascertained due to the signal being diluted by the localised open landscape and wetland species, it provides evidence of the wider environment, which is helpful in understanding human existence and experience of the immediate and adjoining landscapes and the resources available within the wetland edge environment, as is discussed later in section 7.1.2.

Whilst each site presents physically in a very similar way, with visually comparable exposures of peat or organic sediment, often in both the upper and lower intertidal zones, the figure illustrates the variability in deposits in age and formation and prove that even neighbouring sites are not necessarily comparable or even contemporary. It highlights the issue of analogous comparison so often used between intertidal sites in South Wales (as was also revealed in the initial surveys in Chapter 4) and identifies the danger of making surface-based conclusions of chronological origin, which can then impact on archaeological interpretation in the wider area.

Beneath the surface, while general trends in environmental change and deposit formation may be drawn across a number of the sites, within those trends lie localised fluctuations in vegetation and ground water levels that are not repeated across the group. It is the nuanced localised changes in vegetation and ground water levels that affect the availability of resources and land access, which in turn have an effect on the activities of the contemporary local inhabitants and their movement within the landscape, as discussed in the following section.

Displaying the data for South Wales in this manner also illustrates the amount of palaeoenvironmental evidence that is still missing from the majority of the sites identified in terms of understanding full environmental chronologies and conversely what can be achieved through large scale, comprehensive research projects such as those undertaken by Bell and his team in the Severn Estuary (Bell et al. 2000b; Bell 2007e).

Barrier Breaches

Whilst localised fluctuations in sea level are a possible interpretation of the palaeoenvironmental evidence collated during this study, the possibility of these changes occurring in response to the breaching of prehistoric sand barriers, a theory which has also been suggested at Lydstep in Pembrokeshire (Murphy et al. 2014, 24), must be taken into account. The minerogenic laminations present at Port Eynon suggesting sequential inundation followed by reinstatement of freshwater conditions may also be symptomatic of continuously breaching and reforming sand bar as a result of storm surges rather than sea level rise.

Large quantities of sand are common on the Gower coastline, with very large sand dunes formations found at Rhossili Bay, Oxwich Bay and behind the beach at Port Eynon. At Oxwich bay a back barrier system is present, with freshwater marshland situated behind the dunes (Pye and Blott 2009, 73). Shallow shelving, sheltered bays, such as Port Eynon are well suited to the formation of such barriers. There is no direct physical evidence available for past sand barriers on the Welsh side of the Severn Estuary (Bell 2000, 19), or continuing further round the coast including at Port Eynon, but their presence in the past is possible. If a barrier was present at Port Eynon, the changes in environment identified during this study could have been due to cyclical stormy conditions rather than specific sea level change. However, it is still maintained that sea level change continued to affect the Welsh coastline, in both transgressive and regressive phases, throughout this period and on in to the later prehistoric periods and similarities drawn between sites along the coastline as outlined above suggest that sea level trends may still have been related to some, if not all of the environmental changes identified.

Summary

The palaeoenvironmental evidence has illustrated that while similarities can be drawn in terms of sea level and environmental change at some sites, there is also a high degree of variation in how the local environment behaved during these periods. This highlights the importance in obtaining this data within archaeological investigations, as short-term changes could have highly significant consequences for the inhabitants of the landscape.

It is also clear that a complete picture of the palaeoenvironmental sequence is not yet available at all known intertidal sites to aid ease of comparison. The study has shown that a site-by-site approach to palaeoenvironmental investigation is needed in order to understand the effect of sea level change on localised positions and in turn on the local populations. In doing so, in depth environmental context will created for local archaeological evidence and interpretations based on analogous comparisons will be reduced, creating a much more accurate picture of the prehistoric landscape and its inhabitants. This will also help to improve the overall resolution of palaeoenvironmental data available in Wales as proposed by the archaeological research framework (IFA Wales/Cymru 2017a).

Please note: dates are in uncalibrated BP format for ease of display and comparison.

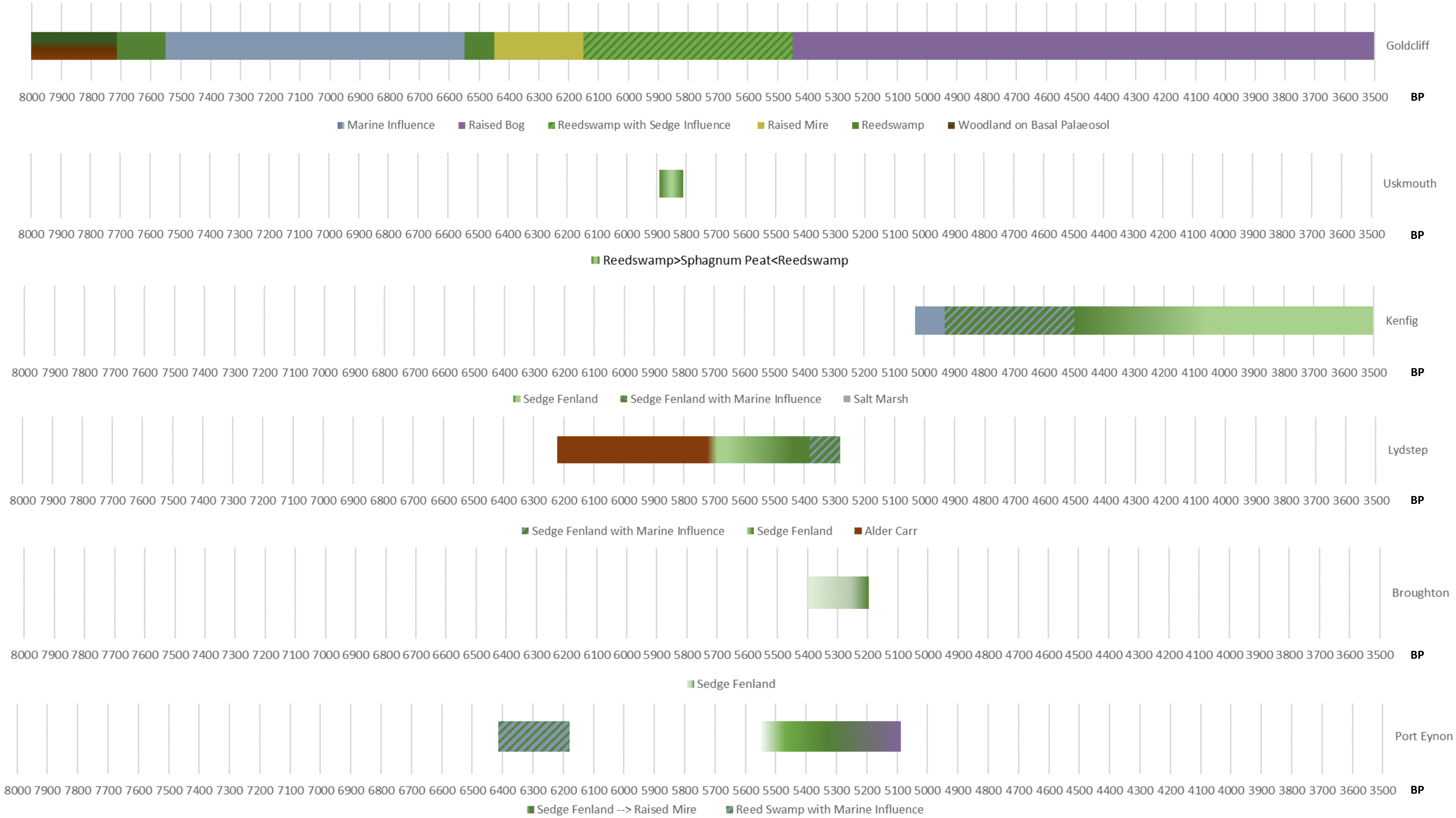

Figure 91: Comparative environmental time lines for investigated intertidal deposits in South Wales. Note dates are presented uncalibrated (BP format) to aid ease of comparison. This figure is intended to indicate general trends only. Sources for data obtained are as follow: Goldcliff: Bell et al 2000 and Bell 2007; Uskmouth: Aldhouse-Green et al 1992; Kenfig: Bennet et al 2010; Lydstep: Murphy et al 2014; Broughton Bay and Port Eynon: This study. Source data table can be found in Appendix 12.

7.1.2 Changing Interactions – Humans in the Landscape

The effect of fluctuations in sea level and subsequent environmental changes on the human populations of Gower is difficult to gauge. However, by interpreting the available archaeological evidence within its chronological and environmental context, a more reliable picture of humans in the landscape has been constructed. This section discusses how the evidence gathered has led to conclusions being draw about human management of and movement within the landscape, along with the concept of seasonality in relation to landscape use. Chronological ties are then drawn between evidence for human activity at the wetland edge (at Broughton Bay and Port Eynon) and the dated cave burial evidence from the Paviland Cave Complex.

Managing the landscape

The diverse wetland edge landscapes identified at Broughton Bay and Port Eynon reflect similar environments identified in the Severn Estuary (Bell 2000a; Brown 2007b; Timpany 2007), at Prestatyn in North Wales (Brayshay et al. 2007), Lydstep in Pembrokeshire (Murphy et al. 2014) and Langstone Harbour in Hampshire (Allen and Gardiner 2000b, 203). The evidence reveals that the wetland edge environments were attractive to both human and animal inhabitants and provided the opportunity for human inhabitants to control certain aspects of the landscape. The maintained background levels of microcharcoal at both Broughton Bay and Port Eynon are indicative of human presence in the surrounding area and are likely to represent everyday domestic burning. However, spikes in microcharcoal presence may be aligned with more deliberate and sustained burning episodes. At Port Eynon, microcharcoal spikes within reed swamp phases during the Mesolithic period (present in the lower sequence) are indicative of reed burning activities as noted at Starr Carr in Yorkshire (Mellars and Dark 1998), Goldcliff (Dark 2007) and a number of other sites in the Severn Estuary (Brown 2007b). Small amounts of microcharcoal in the shape of grass cell structures were noted during pollen analysis in this study, though preservation was limited meaning full quantification was not viable. Grass microcharcoal has also been seen at Goldcliff in similar intertidal deposits and used as further evidence for reed burning activities (Timpany 2005, 165). Seasonal burning of reeds may have been undertaken during the Mesolithic period in order to encourage regrowth of reed bed in an attempt to attract wild animals and improve hunting sightlines by clearing areas of vegetation (Dark 2007, 183).

The burning phases in the lower sequence at Port Eynon are accompanied by an increase in hazel, which has been interpreted as a further indicator of human environmental influence. By encouraging Hazel growth through fire clearance of competing vegetation, local inhabitants would have increased the potential yield of hazelnuts, an important dietary resource (Smith 1970).

Landscape management through burning can also be inferred by the rise in coprophilous fungi that appears to follow significant burning phases at both Broughton Bay and Port Eynon during the early Neolithic period. Together, these indicators suggest a cycle of clearance and burning, signalling the appearance and maintenance of cleared woodland areas in order to encourage herbivorous wild animals, or to keep domesticated livestock. Coprophilous fungi levels peak towards the top of the later sequences at both sites, suggesting grazing levels increase during the Neolithic.

Movement in the landscape

Indicators of human impact are rarer during phases of carr-woodland. A similar pattern was also noted by Dark at Goldcliff (2007, 185). She suggested that a high density of this type of woodland rendered the environment less profitable for hunting and resource availability due to the reduced species diversity in the available plant based resources. Dr. Peter Jones, Senior Peatland Specialist at Natural Resources Wales (pers. comm. 2016), suggests additional reasons for an avoidance of carr woodlands, based on the practicalities of exploring these environments on foot. His personal experience of field survey in carr woodlands has shown that movement through these environments is very difficult due to the boggy, unconsolidated and deep characteristics of the sediment in which the woodland grows. It may be that the Prehistoric inhabitants avoided these areas to save energy, particularly considering the limited resources available in return.

By contrast, direct evidence of human interaction within the reed swamp environment is identified in the human footprints present in the top layer of the lower sequence at Port Eynon. The survival of the footprints indicates that they were made within relatively shallow and consolidated sediments compared to those described above, which would have made movement through this type of wetland environment easier and less energy consuming.

Seasonality

Evidence has suggested that human interactions within wetland edge environments, while unlikely to have resulted in continuous occupation, would not have been limited to a single season, rather encouraging regular usage of the diverse resources on offer (Brown 2007b, 262). The evidence obtained in this investigation cannot directly support this suggestion, as the archaeological evidence is still relatively sparse. However, the human footprints were likely to have been made within the late summer months, as extended warm periods can reduce moisture content, increasing the stability of the sediment within which they made and so improving the prospect of preservation (Allen 1997, 498). The footprints at Goldcliff were also made within the late summer months (Bell 2007b, 334), which counters seasonality models that place people in the uplands during the summer months and lowlands in the winter (Jacobi 1980, 195; Simmons 1996, 215). Bell suggests two possible explanations: that the footprints represent a “subset” of the community left behind to take advantage of summer fishing and look after the younger members of the community (hence common presence of children’s footprints), or that they represent an early return to the lowlands to take advantage of calmer waters for fishing and travel before the winter storms set in. In order to investigate this theory fully, repeated layers of footprints within dated sequences would need to be found. Whilst this is an unlikely prospect, higher resolution dating and analysis focussing on human indicators within the palaeoenvironmental sequence would aid a move towards better understanding.

Archaeology in its contemporary landscape

As was discovered during the archaeology survey for Gower in chapter 4, there is only a small amount of radiocarbon dated archaeological evidence on Gower. For the Mesolithic and Neolithic periods, these dates are solely related to human skeletal remains, which allows specific individuals to be linked to specific times. The results from this investigation have created an environmental framework within which to interpret Mesolithic and Neolithic archaeological evidence.

Broughton Bay

Chronological understanding at Broughton Bay is less clear due to the lack of an early limiting date. All nine Mesolithic radiocarbon dates from the interior of Gower occur prior to the end point of the Broughton Bay sequence, which is dated to between 4150-3950cal BC, but at this current time it is impossible to say whether they fall within the recorded sequence or before.

If further chronological data was obtained, local archaeological evidence, such as the nearby Mesolithic evidence from Burry Holms could be contextualised within its contemporary environmental setting (E. Walker pers. comm.). Burry Holms is a (now tidal) island situated at the northern end of Rhossili bay and around the headland from the south western end of Broughton Bay. The evidence at this site includes buried land surfaces and flint assemblages dated to the Mesolithic period (Walker 1999,2000,2001). Radiocarbon and OSL dates from Burry Holms are due for publication(Walker 2001, 2017 pers.comm.), which will provide comparative dates, however the one date obtained from Broughton Bay so far would suggest the landscape represented by the exposed peat in the intertidal zone is later than the evidence at Burry Holms. Significance can still be gleaned from this observation, however. It shows that Burry Holms is very unlikely to have been a tidal island during the Neolithic period and it is possible that this could be the case during the time of Mesolithic occupation of the site. Instead, it is likely that Burry Holms was a topographic rise within a freshwater wetland landscape. It’s prominent position at the edge of a, likely expansive, freshwater lowland and solid ground compared to the surrounding boggy wetland would have made it a useful staging post for human activity and potentially a viewpoint over the lowlands. Whilst no long term settlement evidence has yet been found at the site, the presence of flint debitage suggests it was used as a flint knapping site, perhaps preceding hunting trips in the surrounding landscape.

In order to test this hypothesis, further radiocarbon dates would be needed from Broughton Bay throughout the sediment sequence to try to align the dates from Burry Holms (once made public) with the relevant environment. It would also be interesting to look for evidence of prehistoric landscapes at Rhossili Bay. Preliminary site surveys showed that there is little evidence on the beach itself, but potential for buried landscapes beneath the substantial sand dunes behind the beach is high. This is something that unfortunately could not be achieved during this study.

Port Eynon

At Port Eynon, dated archaeological evidence falls within the ranges represented in both the lower and upper sequences. The footprints identified at Port Eynon, now known to date to c.5000 cal BC, indicate direct human interaction with the environment in the late Mesolithic period. The creation of the footprints followed the c.460 year period of environmental turbulence that included marine transgressions, along with a continuously fluctuating water table causing the vegetation to change between salt marsh, reed swamp, and fenland with occasional carr woodland.

Footprints

Prehistoric human footprints are incredibly rare and often short-lived sources of archaeological evidence. Yet they are also some of the most direct and tangible evidence for human-environment interaction that can be observed. They are evidence for a specific moment in time and can provide a wealth of information. The size and shape of the prints can offer clues as to the age, height and sex of the individual, as well as whether or not they were wearing shoes. The deposits in which the prints sit provide evidence for the environment in which the individual was interacting and the distance between each print can suggest how the individual was moving through the landscape.

Recently, our own changing climatic conditions have led to more severe storms and tidal surges affecting our coastlines. This has been particularly apparent in South Wales, where within the last decade, a number of new sites have been revealed, many showing rare evidence for direct human interaction with this now drowned environment in the form of footprints. There are currently eleven recorded intertidal sites containing Holocene (post ice age) era human footprints in the UK; six are found in South Wales. However, while revealing evidence such as this, the current climatic conditions are also contributing to their destruction. This means that importance of this work is now matched by its urgency.

Formation

Many of the footprints in British intertidal contexts are made within peat or silty clay deposits. These have been shown to represent freshwater and saltwater marsh conditions, which would allow easy formation of footprints in the first instance, providing little resistance due to their high moisture content (Allen 1997, 482). Whether or not these prints would survive long enough to become preserved would depend on factors including the depositional environment, seasonal weather patterns, moisture content of the sediment and the general popularity of the area in terms of footfall (Allen 1997, 498). If the site is originally within an intertidal or high energy fluvial environment, for instance, it is less likely to survive. Likewise, if there is a constant throughput of people or animals, then individual prints and tracks may not survive to be easily identified. (Allen 1997, 498) suggests seasonality can also play a part. Heavy winter storms can wash prints away, but extended warm periods can reduce moisture content, increasing the stability of the material within the deposits. This is not a certainty however, as dry periods can occur throughout the year and so further seasonal evidence, such as the presence of seasonally related plant remains, is needed to confirm time of formation.

Though intertidal zones do not provide an appropriate formation environment, a tidal influence is an important factor to consider. Even though the deposits being investigated often represent a point further in land at the point of formation, many are still recognised as being at the edge of the environment, often in close proximity to salt marsh (Bennett et al. 2010; Murphy et al. 2014). Though perhaps not affected on a daily basis, it is possible that these deposits come into contact with tidal changes during spring tides, when the water is at its highest. If conditions have allowed the footprints to maintain their form, these tides can deposit large amounts of suspended sediment, filling the prints and increasing the likelihood of preservation (Allen 1997, 497). If conditions remain calm, material will accrete slowly above, sealing the prints from outside influences. However, if the coastal zone encroaches as sea levels rise, the high energy conditions can cause erosion of these sediments, eventually revealing the prints within the old land surface below. Again seasonality is suggested to play a part, with accretion being more likely in the summer months and erosion in the winter (Allen 1997, 497). This can be seen at Goldcliff, where human footprints were preserved in fine clay sediments within an annually banded sequence. These layers were attributed to high summer seasonal deposits through the combination of particle size analysis, sedimentary modelling and pollen analysis (Bell et al. 2009, 625-626)

Prevalence

Worldwide, it has been reported that there are just 40 sites recorded with Holocene era human footprints (Lockley et al. 2008, 122). A quarter of those can be found on the British mainland, where there are currently 11 recorded intertidal footprint sites of Holocene origin (Aldhouse-Green et al. 1992; Huddart et al. 1999; Bell 2007d; Brayshay et al. 2007; Bennett et al. 2010; Eadie and Waddington 2013; Murphy et al. 2014; RCAHMW 2014, Sherman 2016 pers. comm.).

Wales

Wales hosts the majority of recorded intertidal footprint sites in Britain. These are mostly situated on the southern coastline, but as is outlined by Bell in his coastal survey (2007d, CD 1.2), intertidal peat deposits are situated at numerous sites around the Welsh coastline. This would suggest that there is a high probability that more tracks are waiting to be uncovered, particularly given the recent increase in stormy winter conditions.

A potential reason for this prevalence of evidence may be as a result of research bias. The largescale research project in the Severn Estuary has identified three of the nine UK sites and has sparked great local interest, with an active public research committee (SERC 2014), which also attracts representatives from local archaeological units to its meetings. This will have resulted in a greater awareness of the archaeological potential within intertidal sediments. Wales is also fortunate in having a highly motivated volunteer base. The Arfordir project, which ran between 2010 and 2015, was highly successful in training willing volunteers to survey the coastline and report any findings to local units, resulting in many new prehistoric sites being identified (GGAT 2015a). Though none of the examples cited below result directly from this programme, it is likely that if there are more to be found on the Welsh coast, they will be found, due to there now being a considerably larger team of enthusiastic trained surveyors available.

Comparable Sites

Formby: Situated on the north-west coast of England, Formby hosts a large number of human and animal footprints within intertidal silt and sand deposits dating to the late Holocene. This includes 145 recorded human footprint trails alongside red deer, aurochs, and unshod horses (Roberts et al. 1996, 647). Prints were first recorded by (Tooley 1970) who identified cattle footprints, which were attributed to the Iron Age. The first human footprints were identified in the 1980's sparking a more systematic investigation of the deposits (Roberts et al. 1996, 647). Investigations have highlighted two separate groups of footprints, the youngest dating to 3649±109 placing them broadly in the Neolithic-Bronze Age periods (Roberts et al. 1996. 650). The second set, which is lower in the stratigraphic sequence and so assumed to be earlier, remains undated due to lack of organic dating material (Huddart et al. 1999). Foot length analysis has indicated a large number of the footprints belong to children, with a smaller number of female adults and fewer again male adults (Roberts et al. 1996, 648).

Uskmouth: After initial discovery in 1986, human footprints were officially investigated and recorded by (Aldhouse-Green et al. 1992). The footprints were recorded as being set within estuarine clay. Although stratigraphic relationships are not known absolutely, it is believed that this deposit sits between two peat layers, the overlying of the two providing a *Terminus ante quem* of 6250±80BP for the prints. This coupled with the discovery of a Mesolithic antler mattock in close proximity (Aldhouse-Green et al. 1992, 46), led to the footprints being attributed to the Mesolithic period. Animal footprints within the vicinity were loosely identified as "probably cervid," but were not deemed to be in direct association (Aldhouse-Green et al. 1992, 16). The footprints formed three identifiable trails including two adult males and a child (Aldhouse-Green et al. 1992, 33-34)

Magor Pill: Further human footprints were discovered just along the shore from Uskmouth in 1990. These were also included in the (Aldhouse-Green et al. 1992) report. The prints consist of a single trail close the high water mark, associated with a number of discreet prints, where full trails had been eroded (Aldhouse-Green et al. 1992, 43). The trail was attributed to an adult male, but there was also evidence in the individual prints of a child. The rest of the prints were not clear enough to provide statistically viable measurements (Aldhouse-Green et al. 1992, 46). Radiocarbon dates were used to infer that the footprints could have been made no earlier than 5720±80BP (Aldhouse-Green et al. 1992, 14) placing them slightly later than those at Uskmouth, but once again within the Mesolithic time frame.

Splash Point, Rhyll: In 2005 three human footprint tracks were discovered in peat overlaying estuarine silts at Rhyll in North Wales alongside deer prints. The prints were poorly preserved and by the following year were no longer visible. It is suggested that these prints are Mesolithic in date, due to artefacts of similar age believed to have been found within the same deposits, but no direct radiocarbon date of the deposits exists (Brayshay et al. 2007, 307).

Goldcliff: (Scales 2007) undertook a comprehensive review of the footprint tracks at Goldcliff in the Severn Estuary. The tracks were mainly, though not exclusively, found within banded silt contexts on the low foreshore. They occur between two peat deposits dated between c. 5600BC and c. 4800 BC, placing them within the Mesolithic period (Scales 2007, 139). Systematic excavation and recording of footprints was undertaken employing innovative techniques in order cope with small tidal windows and difficult working conditions (Scales 2007, 140). Some of these techniques have been employed within this study (see below). After further analysis, using comparisons from modern datasets, 270 footprints were assigned to 21 individuals, who were categorised into Adults (over 14 years), sub adults (11-14), children (7-11) and young children (3-6). Interestingly, as at Formby, a large majority of the tracks belonged to children. Most of the individuals appeared to be bare, foot, though evidence from one individual suggested they may have been wearing possible soft footwear. (Scales 2007, 153). Once again, animal tracks were found alongside the human. These included species such as red deer, large cattle (potentially aurochs), roe deer and dogs (Scales 2007, 154-5).

Kenfig: In 2007 human footprints were identified in the intertidal zone at Kenfig (Evans 2007a; Bennett et al. 2010) within a peat deposit that had first been recorded by (Nayling 1998b). "Several groups" of human prints were situated within an exposure of degrading peat (Bennett et al. 2010, 67). As with many of the other examples listed here, the prints sit within the lower of two peat exposures. Radiocarbon dates have been obtained from both deposits, allowing the prints to be dated between 5110±40 BP and 3810±40BP, although caution is advised due to insecure stratigraphic records (Bennett et al. 2010, 67). This broadly dates the footprints to the Neolithic period.

During the 2007 investigation, footprint lengths were recorded between 25-30cm (Evans 2007a), suggesting they belonged to a number of different adult individuals. No further analysis leading to information about the individuals themselves was undertaken, however.

The 2010 investigation's main focus was to determine whether these were in fact footprints belonging to humans, due to their heavily eroded nature and unusually wide width (Bennett et al. 2010, 69). Laser scanning was implemented in this investigation and scans were compared with casts taken from the footprints at Formby (Bennett et al. 2010, 68). The results suggested the footprints were likely of human origin, though they did not supply an ideal example, as they were not well defined due to subsequent erosion (Bennett et al. 2010, 71). They were however confirmed as being substantially broader than other notable examples (Bennett et al. 2010, 72), as suggestion for which, provided by (Evans 2007a, 8) could have been the presence of some kind of footwear, though (Bennett et al. 2010, 72) state there is no evidence available at Kenfig to confirm or deny this. A print from a possible red deer was identified in the same deposit in 2007, but was no longer visible by 2010 (Bennett et al., 69).

Low Hauxley: Human and animal footprints within intertidal peat deposits were first exposed at Lower Hauxley in 2010 before being recovered by sand. They were re-exposed and subsequently recorded in 2013 by Archaeological Research Services Ltd (Eadie and Waddington 2013, 3). 90 human footprints were recorded, with both adults and children identified along with 88 animal footprints representing species such as red deer, wild boar and large cattle or aurochs (Eadie and Waddington 2013, 6). Radiocarbon dating was undertaken on twigs from just below the surface of the peat deposit in which the footprints sit. This provided dates of 5330-5210 cal BC and 5220-4990 call BC, placing the deposit in the late Mesolithic period and suggesting that the footprints were formed soon after this time (Eadie and Waddington 2013, 8). Possible worked timbers were also recovered from the same deposit within close proximity to the footprints (Eadie and Waddington 2013, 6).

Lydstep: Also exposed in 2010 were the human and animal footprints at Lydstep in Pembrokeshire. Human prints were identified as belonging to both adults and children alongside animal prints potentially representing red deer (Murphy et al. 2014, 29). The peat in which footprints were found was dated to between 4230-3400 cal. BC, corresponding with the late Mesolithic (Murphy et al. 2014).

Borth: In 2012 footprints were found in peat deposits at Borth in West Wales and are reported to have been investigated and recorded by researchers from, University of Wales Trinity St David assisted by the Royal Commission (BBC 2012). However as of yet, no publication appears to have been released detailing these findings. A short addition to the RCAHMW record does confirm the survey having taken place, however (RCAHMW 2014).

Cleethorpes: Most recently, potential human footprints have been identified at Cleethorpes in the North East by members of the CiTIZAN project (Sherman 2016 pers. comm.). However no further information is currently available.

Port Eynon

The human footprints at Port Eynon were situated within a solid peat exposure that was clearly of great age due to its compact nature. No depressions were made by the team working on the surface on the surface, leading to the conclusion that the footprints must have been made at a time when the peat was of a softer consistency, most likely when it was being formed. The presence of animal hoofprints pertaining to species no longer existing in Britain, for example juvenile aurochs also supported this interpretation.

The footprints at Port Eynon were laid down in a reed swamp environment and are suggested to have been formed in the late summer after an extended warm period for the deposits to be stable enough to hold their form (Allen 1997, 498), however, as noted above, further seasonal indicators would be needed to confirm this.

It is theorised that the deposit containing the footprints has not been exposed continuously since its formation, but rather was overlain by softer, likely minerogenic sediments, potentially related to marine incursion, allowing the footprints to maintain their form and protecting them from erosion. It is proposed that these sediments have been gradually eroded as the landscape became part of the intertidal zone and that the later deposits identified in columns PE2 and PE3 on the upper beach area may overlie the same deposits. Unfortunately no direct link was identified during fieldwork due to tidal scouring reducing the area of beach between the upper and lower exposures to glacial till.

The Mesolithic date has been arrived at due to fact that although footprint itself cannot be dated, the peat material in which it is situated can and has been radiocarbon dated to c.5000 BC securely within the late Mesolithic period. It is not possible to say how long after peat formation the footprints were created, however if the theory about overlying deposits is correct, the lowest dated deposit in the upper beach sequence, which is believed to have overlain the lower beach sequence is late Mesolithic in date. This would mean the footprints were made after 5220 cal BC and before 4340 cal BC, placing them in the late Mesolithic period. This must remain a hypothesis currently, as further investigation is needed below the peat deposits in the upper beach area to determine if material related to the lower beach deposits can be identified.

The footprints represent a group of people ranging in age from adult to very small child. The degree of erosion made it difficult to interpret the footprints fully, as sizes could not be accurately recorded. Scales (2007) suggests an error margin of 20% from the act of recording via tracing alone, which combined with the likelihood of loss of clarity due to erosive events means any measurements should be treated cautiously. However, there are groupings of similarly sized footprints within the exposed peat deposit. Comparisons with modern datasets indicate the potential presence of an adult male and adult female, along with a child or children between the ages of 4 and 6, a child or children between the ages of 7-12 and a child or children of toddler age.

The presence of footprints belonging to children at Port Eynon is particularly important, as they provide a rare acknowledgement of children within the archaeological record (Scales 2007, 153). With the exception of skeletal human remains, which are incredibly rare in Mesolithic contexts, children are rarely seen within the archaeological record in terms of material culture (Baxter 2005, 3). Footprints allow children to be placed directly in to the landscape as active participants. Ethnographic evidence suggests children from modern day hunter-gatherer societies are actively involved in everyday activities such as foraging (Scales 2007, 154). Scales draws attention to the fact that the presence of children's footprints in deposits pertaining to wetland environments such as marshes or reed swamps is common in Britain. Within the eleven recorded footprint sites in Britain, at least seven have footprints belonging to children, always alongside adult examples (Aldhouse-Green et al. 1992; Huddart et al. 1999; Scales 2007; Eadie and Waddington 2013; Murphy et al. 2014). (Scales 2007, 154) suggests that at Goldcliff, children followed adults into the marshlands to take part in foraging or fowling. It is also suggested that there is a separation between younger and older children, with the younger staying close to camp, but the elder (c.10 years old or over) venturing further out. At Port Eynon there appears to be a full mixture of ages from very young toddlers to older children and adults. If Scales' theory is to be used this might suggest that a base camp may not be far away, though evidence for such a site has yet to materialise.

While it has not been possible to identify specific trails of single individuals due to the disparate nature of the footprints and the level of erosion present, the evidence shows that the group of people are moving in varying directions. This potentially indicates that they are walking back and forth over the same tracks, which has added to the difficulty in identifying trails.

Animal hoof and paw prints within the same deposit indicate that aurochs, roe deer, red deer, wild boar and even potentially a dog or wolf passed through this area of reed swamp, very soon before or shortly after, the human group. Direct evidence for this can be seen in a roe deer hoofprint overlying a human child's footprint. The relative order of presence for human and animals is not clear from the other prints. The species present are also represented at Goldcliff (Scales 2003), Low Hauxley (Eadie and Waddington 2013) and Lydstep (Murphy et al. 2014), all of which represent very similar dated exposures and a wetland edge environment. The number of different species present indicates a highly productive landscape, which would have provided many valuable resources to its human inhabitants. Although the reason for the group being in the landscape cannot be clearly determined, the presence of animals, and previous discoveries of animal bones pertaining to the species indicated by hoof prints (Rutter 1949, 34), suggests that this area would have been a place where hunting was undertaken.

Wider Relationships

Within the wider Gower area, human skeletal remains discovered at both Paviland Cave and Foxhole Cave have returned radiocarbon dates that fall within the Mesolithic limiting dates obtained from the lower sediment sequence. The caves are located within the Paviland cave complex to the east of Port Eynon on the south west coast of Gower (Figure 92).

Figure 92: Location of Paviland Cave Complex

The dated remains include two adult humeri dating to 5460-5295 cal BC and 5230-5055 cal BC at Paviland and a single adult lumbar vertebrae dating to 5522-5375 cal BC at Foxhole (Schulting et al. 2013). Further human remains have been dated from both caves, but these are all earlier in date than earliest dated sequences identified in this investigation (Schulting and Richards 2002, Schulting *et al.* 2013).

The human remains from the later Mesolithic period at Foxhole and Paviland were buried during the same c.460 year period of significant environmental change identified in this research. The oldest adult human humerus from Foxhole and the adult human lumbar vertebrae from Paviland both fall within the date range of the lowest calibrated date from Port Eynon. This would place these individuals on Gower around the time of the first recorded marine transgression in the sequence. The date of the second humerus from Foxhole cave falls within the date range attributed to the top of column PE1, raising the possibility that the individual placed in Foxhole was contemporaneous with the group of people represented by the footprints. It could even be possible that the people at Port Eynon were related to and/or placed the remains of this adult within the cave at Foxhole, though this cannot be proven. The cave is just over 3.5km from the position of the footprints, and lies well within range proposed for Mesolithic territories by Schulting (2009). Schulting compared isotopic indicators of diet from individuals from Gower and Caldey Island and found a distinction in diet between the inhabitants of each area. The Caldey Island inhabitants exhibiting a much higher marine diet signal than those on Gower and as a result Schulting postulated the occurrence of two distinct communities each with a 15-30km range territories.

Human remains from cave sites can also be aligned chronologically with the later period represented in the second environmental sequence at Port Eynon in PE2, which ranges from 4500-4270 cal BC and 3970-3790 cal BC. The human remains all align with the upper part of the sequence. They include an adult cuboid from Foxhole dated between 3912-3660 cal BC and a phalange from Red Fescue Hole dating to between 3760-3540cal BC, within the early Neolithic period. During this time the palaeoenvironmental evidence shows that the climate was becoming wetter, while the sea levels were in a regressive phase, leading to the development of raised mires at Port Eynon. The significant amounts of microcharcoal throughout the PE2 column indicates the continued presence of humans within the landscape surrounding Port Eynon during the early Neolithic period.

The persistent use of the same cave complexes on Gower demonstrated by Schulting suggest a continuation of tradition throughout the period represented in the environmental record at Port Eynon. It indicates suggests a system of communal knowledge/memory maintained throughout the Mesolithic and into the Neolithic by the people who inhabited the landscape. This means it is not beyond the realms of possibility that knowledge of the changes in sea level and subsequent changes in environment would have also been maintained.

A hiatus in cave use between c.5000 and c.4000 BC across Britain has been proposed due to a lack of archaeological evidence from cave contexts during this period (Schulting et al. 2013). Incidentally, this gap is also reflected in the lack of archaeological evidence in any form from this period. The validity of this theory has been questioned. Researchers employing evidence of continued use from the 10th to the 4th millennium BC at a different Fox Hole Cave in Derbyshire, have argued that the proposed hiatus in cave use was not present across Britain, (Hellewell and Milner 2011, 64). The hiatus has also been narrowed, having initially been argued to have spanned two millennia (Chamberlain 1996), it was adjusted in 2013 as a result of the emergence of new evidence and recalibration of older radiocarbon data from the Gower caves indicated a narrower gap (Schulting et al. 2013). Schulting et al. (2013, 19) acknowledge a high likelihood that further human remains exist within the Gower cave complexes, indicated by the minimal elements per individual that have so far been identified. There is therefore a high probability that the identified hiatus is indicative of preservational or research bias rather than representative of an actual pause in activity.

The appearance of Neolithic chambered tombs around this time has also been suggested to have links to the cave burial tradition. Human remains within the Parc le Breos chambered cairn have been radiocarbon dated and returned dates comparable to Neolithic human remains deposited in Foxhole cave and Red fescue hole (see chapter 4). Similarities have also been drawn between the diets of the contemporary individuals within Foxhole and Parc le Breos chambered cairn, showing a lack of marine influence within the diet, despite being situated within close proximity to the coast (Schulting et al. 2013, 19).

It has been suggested that comparisons can be made between caves and chambered tombs in terms of their form and use (Barnatt and Edmonds 2002; Schulting et al. 2013, 19). At Parc le Breos, faunal remains of late glacial date were also present, suggested to have been taken from nearby caves (Whittle and Wysocki 1998, 177). While Barnatt and Edmonds (2002, 126) suggest that caves and chambered tombs were not necessarily interchangeable, on Gower it is clear similarities in use can be drawn. The argument for a continuation or even adaptation of a long held tradition might therefore be extended further, as at Parc le Breos, human remains continue to be deposited until the late Neolithic period, though successive deposition cannot as yet be identified (Whittle and Wysocki 1998, 147). The presence of human remains during this period provide direct evidence of human presence on Gower following the Mesolithic period, despite the lack of settlement evidence in the archaeological record. This is supported by the persistent microcharcoal signal within the early Neolithic environmental record at Port Eynon, indicating a maintained human presence on Gower throughout this time despite lack of archaeological evidence, supporting the potential of further evidence coming to light in the future.

Summary

The archaeological evidence presented in this section has demonstrated the likely continuation of human presence within the Gower landscape throughout the mid-late Mesolithic period and into the Neolithic period. This occurred despite a fluctuating environment caused by rising and falling sea levels throughout this time.

The palaeoenvironmental and footprint evidence indicates that Gower had a wide variety of plant and animal resources available throughout the Mesolithic and Neolithic periods. While these resources fluctuated with the changing environment on Gower, sea level was not the only driver for this. Long-lived human occupation is apparent in continuous background microcharcoal signals, with evidence for episodes of more directed burning of reed beds and vegetation indicating human driven environmental change for the purposes of vegetation clearance to encourage the presence of animals and the growth of hazel. Whilst the new resources provided by changes in environment were readily exploited, the prehistoric inhabitants of Gower were also well accustomed to managing the environment when needed and were not beaten back by encroaching tides or loss of landscape.

It is now possible to compare the archaeological and palaeoenvironmental evidence from within Gower's intertidal zone with previously examined archaeological evidence situated inland on the Gower peninsula. In doing so, the inland archaeology has been further contextualised in terms of its surrounding environment and the changes that were occurring within that environment, including sea level change. The combination of the new environmental data alongside the archaeological data has shown a continued human presence on Gower throughout the Mesolithic-Neolithic transition despite gaps in the archaeological record. It has also been possible to identify potential chronological links between individuals buried in the caves to the north west of Port Eynon with the group of people represented by the footprints identified in the present inter-tidal zone.

The sustained human presence on Gower indicates a resilient prehistoric community. While sea level transgressions may have caused damage or loss of landscape, the evidence suggests that the human populations, adapted to and exploited new environmental conditions to suit their own purpose. This falls in line with the research undertaken at Goldcliff (Bell 2007b), but also further afield in the North Sea, where both Coles (1998; 2000) and Leary (2009,2015) draw attention to positive outcomes and resilient inhabitants (as discussed in Chapter 2). This is not to say that the prehistoric inhabitants were not affected by such changes. Leary (2015, 66-67) stresses the importance of place and the emotional relationship between a landscape. Personal attachment, memory and tradition are all tied up in human experience of a place, and a loss of somewhere with meaning can be an emotive experience. However the overriding response appears to have been a pragmatic one, far from upheaval and displacement often attributed to prehistoric sea level change (Gaffney et al. 2007, 8). The degree of fluctuation within short periods of time would have meant that flooding events would have become part of regular life (as has been noted in Doggerland (Leary 2009, 231), to the point that changing tides may have been expected as part of a wider world view.

7.2 Changing Approaches

7.2.1 Investigating Sea Level Change from an Archaeological Perspective

This thesis argues that the use of sea level models on a national or regional scale as interpretive tools for archaeological investigation is problematic. The models lack the necessary resolution needed to understand the contemporary environmental context within which specific archaeological evidence existed. The most recent attempts at increasing the resolution of sea level modelling (which incidentally does not include data from the Bristol Channel due to concerns about its integrity) still only reduces the time slices in change to 500 years (Sturt et al. 2013). The evidence in this study, on the other hand, demonstrates that multiple episodes of environmental/landscape change can occur within c.460 years. As stated in the introductory chapters, for the interaction of prehistoric individuals with their environment to be fully understood, we must strive to consider changes to the environment on a time scale that an individual would perceive. In addition, the focus placed on sea level rise fails to recognise the fluctuating nature of sea level change the effect such fluctuations may have had on the local human inhabitants.

Modelling sea levels on Gower

The limiting index points obtained at Port Eynon and Broughton Bay have been used to create maps (Figure 93 and 95) modelling the sea level limits according to the limiting index points. They should be interpreted as snapshots of the mean sea level at specific points in time. As was explained in chapter 2, it should also be acknowledged that more modern sand movement may have affected the representation of the sea floor, particularly in the Broughton Bay area, and so these reconstructions may not be completely accurate.

Figure 95 depicts the limiting index points plotted against the sea level index points from the South Wales coastline used in Bell's (2007c) most recent sea level models for the Severn Estuary. This was the data closest in distance and date to that obtained in this investigation. A combination of this model and one from the Loughor Estuary, which refers to later evidence were combined and mapped in chapter 2.5. The Port Eynon limiting index points appear to plot slightly higher than the SLIP based curve, though it must be remembered that the limiting points are not absolute data points. The model points towards a positive trend in sea level on a similar scale to that in the Severn Estuary, rising just over 3m over a period of up to c.1500 years at the end of the Mesolithic and into the early Neolithic period. There is then a clear stall in sea level movements during the early Neolithic period in both areas. However, the fluctuations in sea level identified in the palaeoenvironmental sequence are not visible within the modelled data due to the lack of chronological resolution. For example, just over half a meter difference is shown in tidal level between 4465±42 BC and 4230±51 BC. This places the contemporary coastal edge nearly 2km further out to sea than the current coastline. However, marine transgressions are apparent in minerogenic deposition just 300m from the current mean high water mark, around 5m above the sea level indicated by the limiting index points.

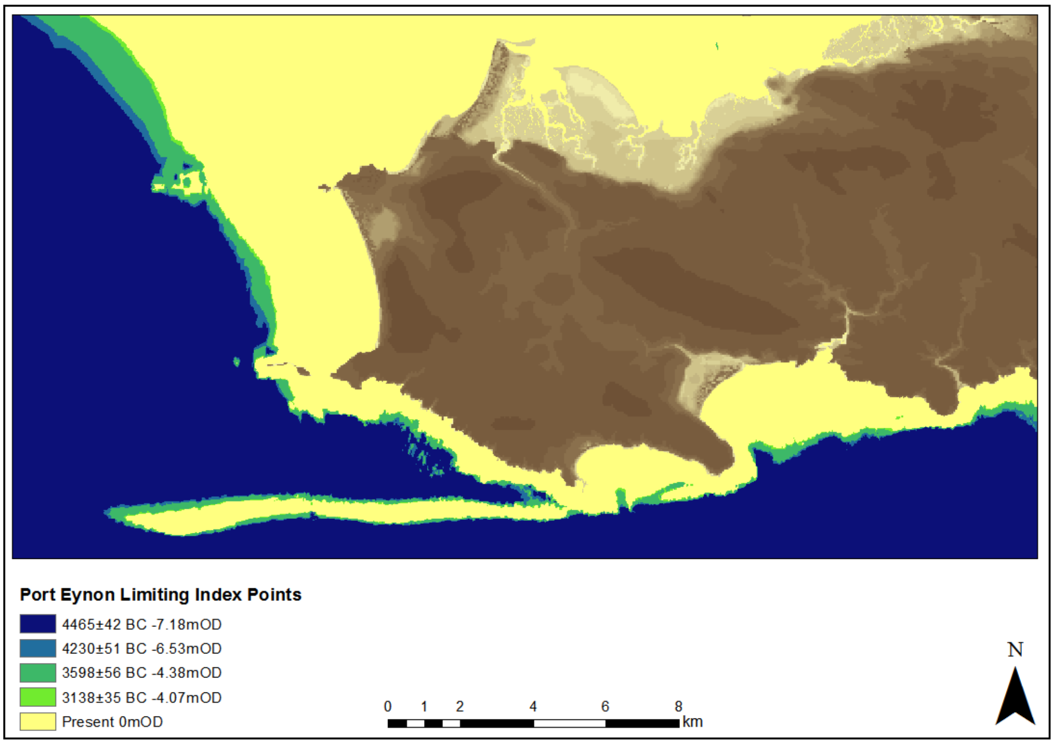

Figure 93: Sea levels as indicated by limiting sea level index points obtained at Port Eynon.

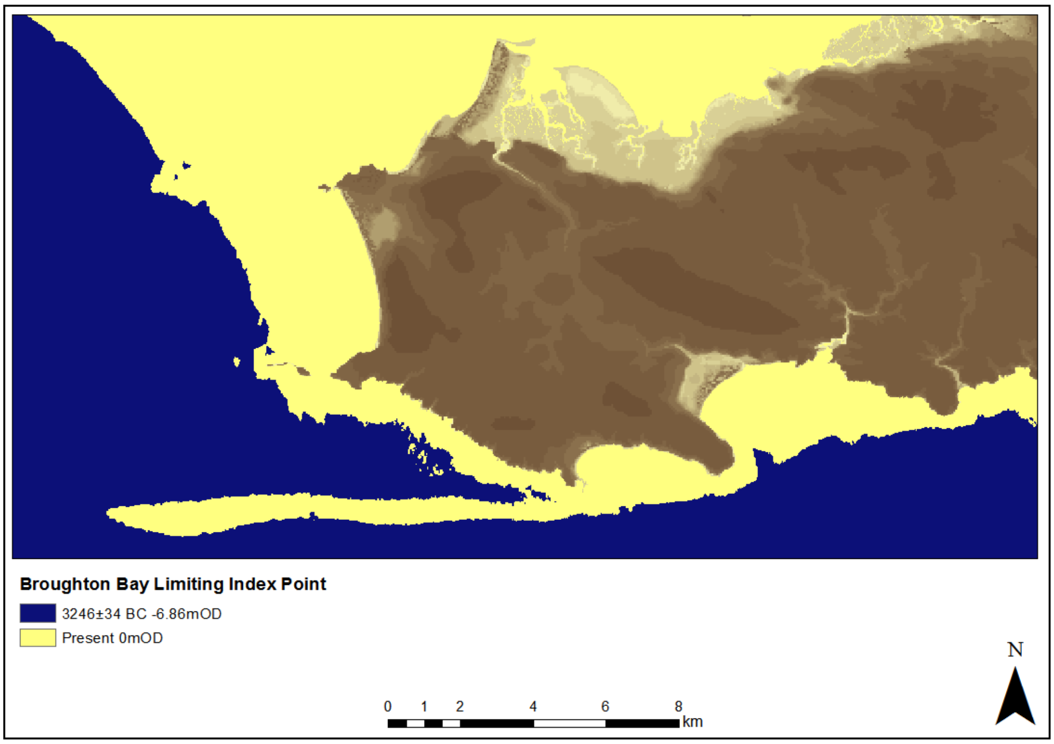

Figure 94: Sea levels as indicated by limiting sea level index points obtained at Broughton Bay

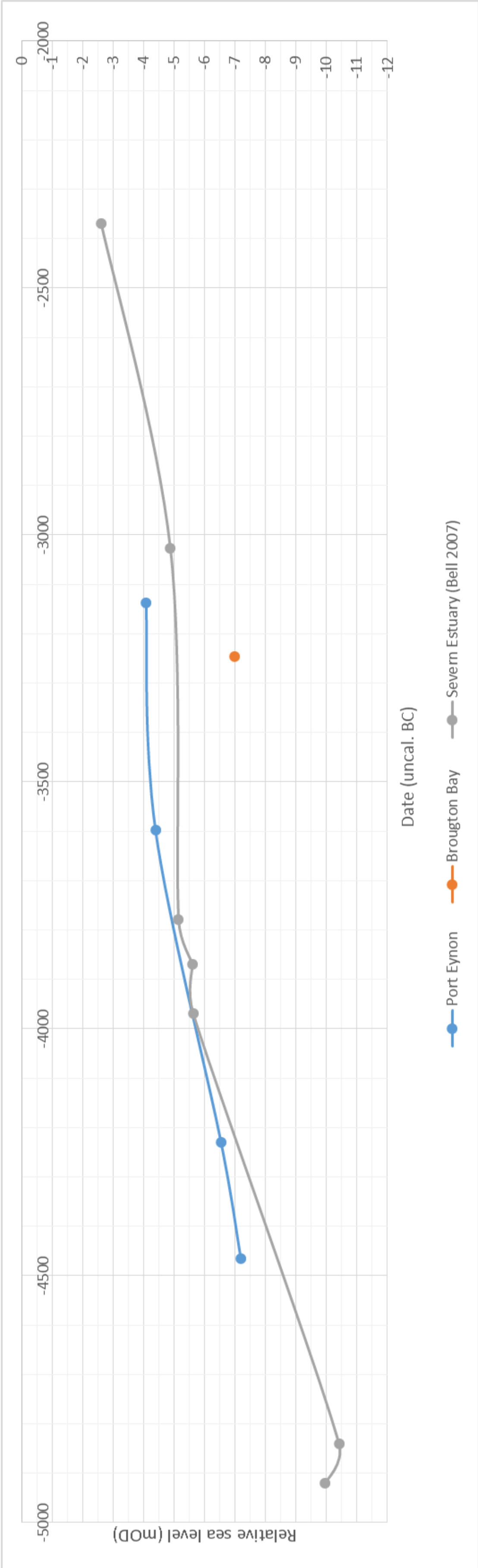

Figure 95: Sea level curves based on limiting index points at Port Eynon and Broughton Bay in comparison with the curve constructed from sea level index point data from (Bell 2007c).

The one data point from Broughton Bay places sea level at almost the same level in the early Neolithic as it was in the Mesolithic at Port Eynon. The reason for this is unclear, but as this interpolation is based on a lone radiocarbon date, it would be risky to apply a definitive conclusion prior to further investigation.

By using the limiting index points without any further context provided by site specific palaeoenvironmental evidence, a misleading picture is formed. This is also an issue with the use of SLIPs in full-scale sea level modelling, as can be seen in the regional and national sea level models (Jennings et al. 1998; Shennan et al. 2006). Unless full chronological understanding of a sedimentary sequence is obtained, relatively short-lived sea level events will not be identified. While not necessarily an issue for wider scaled chronologies, from an archaeological point of view, detailed understanding of localised sea level fluctuations could provide key contextual information regarding the inhabited landscape.

Summary

The absence of full sea level index points in this study has not reduced the effectiveness of this research as, the limiting index points provided a framework within which to build a limited sea level model. The study has shown that sea level models do not provide the resolution needed in order to interpret effect of change on human inhabitants in particular periods. They can also be misleading in their portrayal of the environment, which can negatively impact archaeological interpretation by withholding comparatively short-lived environmental evidence, which at a human scale can have much more significance and impact.

7.2.2 Adapting intertidal methodologies

The fieldwork techniques used within this investigation were based on methodologies that had been successfully used in other British intertidal investigations. However, the application of these methodologies to the Gower beaches was problematic. Two major issues were encountered in the field investigation phase: scale and budget.

Scale

The initial peat surveys investigating the extent of peat present at each location using walkover survey and auger transects were based on methodologies used in the Isles of Scilly as part of the Lyonesse Project. One of the aims of the Lyonesse Project was to present a fieldwork exemplar that could be implemented elsewhere (Charman et al. 2016c, 18). The methodology had proved highly efficient in a small island context, but on Gower, the scale of the beaches created problems. Whereas on Scilly, the beaches were contained within small bays with a manageable tidal range, on Gower the selected beaches were more extensive and subject to the second largest tidal range in the world. This meant that at low tide the Gower beaches were extremely large in area, particularly as extreme low tides were targeted. Sand deposition also caused an issue, as sand overlying peat deposits was often thick and in places difficult to core through due to the suction created by underlying groundwater. These factors led to an issue with data resolution when it came to recording the intertidal peat deposits at both Broughton Bay and Port Eynon.

It was clear that in order to obtain meaningful data in a manageable way a more targeted approach was needed. At each location, instead of attempting to survey and auger the whole beach, focus was placed on exposed deposits, as these were at the highest risk from erosion. Sampling was spread sparingly across all deposits to allow for the best coverage possible in the time available.

The investigation has shown that though aspects of the Lyonesse Project methodologies were applicable and successful in the Gower setting, the differences in scale of the beaches and also the evidence being investigated meant that they could not be applied as effectively or efficiently.

Budget

Previous intertidal investigations in Britain have benefitted from being part of a wider established research project (Bell et al. 2000b; Bell 2007d), and/or funding from government bodies such as Cadw (Murphy et al. 2014) or Historic England (Charman et al. 2016c; Timpany 2018) or specific UK research councils such as NERC (Bennett et al. 2010). In rare cases intertidal investigations have been undertaken funded by local authorities, though these have also required additional funding from other sources for specific analyses (Wilkinson and Murphy 1995; Allen and Gardiner 2000a).

Funding for in depth intertidal research is difficult to obtain, partly due to the current highly competitive climate and low level of attributable funding within archaeological research and partly due to a lack of understanding in terms of the wider importance of in depth intertidal research that has been laid out in this thesis.

In this project, small grants were obtained for partial analysis of key deposits (see Appendix 16) but funding for full analysis was unfortunately not achieved. This resulted in limitations in terms of the breadth of research that could be achieved, as is described below:

Three generous grants from the Cambrian Archaeological Society, the Gower Society and Cardiff University School of History Archaeology and Religion Postgraduate Fund provided funding for six radiocarbon dates. Focus for dating was placed on Port Eynon due to the discovery of the human footprints with priority given to accurately dating the deposits in which the footprints sat with the aim of providing a secure chronology for this unusual form of archaeological evidence. As funding was limited it was decided to focus financial resources on providing a single chronology with as high a resolution as possible for the environmental fluctuations present. This could not have been achieved if the funding for radiocarbon dates had been shared equally between both study sites. Unfortunately this resulted in a lack of chronological resolution for Broughton Bay. This site still requires additional radiocarbon dates to identify the full prehistoric environmental chronology and verify the date already obtained.

Budget limitations also underpinned decisions made about pollen sampling and analysis. Again it was decided to focus resources on Port Eynon to reconstruct the most detailed record of the environmental history of the site to provide a setting for the archaeological evidence. The lower resolution data obtained from Broughton Bay provides a skeleton sequence, but further samples and analysis are required in order to fully understand the environmental development at the site.

Whilst scale and budget limited the amount of fieldwork and analysis that could be undertaken, the data obtained still provides new insights into the prehistory of the Gower Peninsula and places it within its wider archaeological and environmental context. The research demonstrates that, even on small budgets, multidisciplinary research can be achieved.

Summary

This research has demonstrated that methodologies used in intertidal archaeological, palaeoenvironmental and sea level investigations cannot be applied in a one size fits all approach, but rather individual strategies need to be developed on a site-by-site basis, tailored to the scale of the site and the state of the evidence present. Budget restrictions can place limitations on the types and amount of data collection and analysis that can be undertaken, but this study has shown that in depth understanding of particular research questions can be achieved through targeted analyses on key deposits.

7.2.3 Experimental Methodologies

Drone Survey

The drone survey employed in this investigation was undertaken to investigate whether civilian accessibly equipment could be used to record peat exposures from the air. The survey was successful in producing impressive aerial images of both sites, but an accurate georeferenced image could not be created using the tools available. This was due to insufficient points of reference being placed on the beach. This meant that sequential images the exposures could not be tied together effectively.

There were also intrinsic equipment limitations. The drone survey used a GoPro Hero3 camera, which has a fish eye lens. In post processing, it became apparent that the freely available GoPro Studio software was not able to counteract the effect of the fish eye lens effectively enough to be able to accurately stitch the images together. Other software options were explored, but were too expensive to entertain as a possibility. It was decided at this point to abandon the use of the drone as a mapping tool.

Despite the difficulties encountered, drones do have a future in intertidal research. New work undertaken by Historic England at Pett Level in Sussex has been recently undertaken using much more sophisticated drone and camera equipment, which has led to very high quality images that can be easily georeferenced (Hazell 2017 pers. comm.). The Cherish Project, which is outlined below in section 7.2.4, has also employed drones and produced georeferenced baseline image data for integration into GIS datasets (CHERISH 2017d). This shows the potential this kind of methodology has within the field of intertidal investigation and it is likely this form of survey will become more widely used in the future. However from a low budget position this kind of survey is still likely to be out of reach.

Photogrammetry and 3D Printing

Previous attempts to record footprints from intertidal deposits have involved the use of plaster to create casts of individual footprints. This technique has been successfully used at British footprint sites including Uskmouth (Aldhouse-Green et al. 1992) Goldcliff (Allen et al. 2003; Scales 2003,2007), Redwick (Bell 2013a), Lydstep (Murphy et al. 2014) and Low Hauxley (Eadie and Waddington 2013). At Port Eynon the position of the footprints in the lower intertidal zone meant there was insufficient time for a plaster cast to set in between tides. This led to the trialling of photogrammetry methodologies.

Photogrammetry has been identified as a useful tool within the intertidal zone for fast track recording (McCarthy 2014), however this is based on recording larger items such as wrecks and structures. The intricate nature of footprint remains makes the process more difficult as each footprint requires its own set of photographs. Also, where exposures of footprints cover large areas, it is very difficult to construct high resolution images encompassing the full exposure.

In this study one $50cm^2$ area containing a single human footprint was recorded within the available c. two hour tidal window. A large deposit of sand on the beach restricted visibility of this exposure, and the methodology used was time consuming and hampered by conditions in the lower intertidal zone, which meant it was difficult to maintain the constant conditions required for the photogrammetry. Although a tarpaulin was helpful in casting shadow, it was unwieldly on the exposed and windy beach and required at least two people to hold while the photographer worked. Because the site was low in the intertidal zone, light reflection from sea water was a constant issue as the area was difficult to keep dry. The amount of time required for each footprint meant that the technique was not suited to the short time window available between tides. While the resultant 3D print was very effective and even allowed further interpretation to be undertaken, the methodology was not practical given the scale and individual characteristics of the site.

A more accurate and time saving approach would be to use laser scanning. This was successfully employed to record the footprints at Kenfig (Bennett et al. 2010). However the same control issues are still present. Light conditions need to be constant, which is possible on an overcast day as was experienced at Kenfig, but cannot be guaranteed. Reflection remains an issue. The footprints at Kenfig were located towards the upper intertidal zone meaning they were less effected by surface water and could be kept dry for longer. Laser scanning is also much more expensive to achieve. The photogrammetry employed in this study was undertaken using freely available software and a standard SLR camera, whereas the laser scanning requires specialist equipment and software.

Summary

Though positive outcomes were gained in the use of drone survey and photogrammetry, a lack of budget and expertise meant that the results fell short of expectation. More recent research has shown that the use of drones and high resolution scanning techniques in the intertidal zone can be effective and produce valuable results for further research, but in order to achieve an accurate picture, more sophisticated equipment is required alongside suitable conditions on the beach itself.

7.2.4 Filling in the Gaps

Assessing sites within their own environmental, chronological and archaeological context has been a key theme within this research. However a major issue identified was the amount of gaps in our knowledge of the intertidal zone around Wales. Large research projects aside, much of the investigation of intertidal sites in Wales has been influenced by chance discoveries coinciding with a funding opportunity. There has been no specific drive to record and investigate intertidal evidence on a wider scale. The Arfordir Project came close, with systematic recording led by volunteers taking place on each of the Welsh coasts, but this was short-lived and fell short of full investigation of sites. This is one of the major issues with the community based intertidal survey projects across Britain.

On paper these community projects appear to be an innovative way of obtaining data while engaging the general public, and all three of the British coastline monitoring projects (Arfordir, SCAPE's Shorewatch and CiTIZAN) have been successful in gaining public support – the CiTIZAN project has even prompted a spin off television series: *Britain at Low Tide* (Channel 4 2018) based solely on archaeological evidence within Britain's intertidal zones. However, there are still issues related to this approach. Despite the success of the projects, they are often fixed term entities due to funding restraints. The Arfordir project ran for 5 years, but was disbanded in 2015 (GGAT 2015a) and little further research has been undertaken. Although Shorewatch and CiTIZAN continue to exist, their longevity is not a certainty, with both reliant on grants from funders such as the Heritage Lottery Fund (MOLA 2014; SCAPE 2018a). This means that there is often little scope for further analysis once sites are known. While knowledge of intertidal remains is a positive result, the very real threat of erosion means that without further investigation, the research potential of these remains can be lost very quickly.

While the fact that these sites are being monitored is a very positive outcome, the intertidal remains are a finite resource at constant risk of loss to the effects of increasingly stormy conditions and require fuller investigation.

The Cherish Project

Most recently a project has been launched with the aim to investigate the Welsh (and Irish) coastline on a much wider scale. The Cherish Project sets out to "increase capacity and knowledge of climate change adaptation for the Irish Sea and coastal communities" (CHERISH 2017a). Importantly, this involves an interdisciplinary approach which includes high definition survey and scientific analysis that has been built into the available funding.

Unfortunately there are still issues in the approach. Due to the conditions of the funding provided by the European Union as part of this cross border initiative between Wales and Ireland, the project will only cover coastline that is in contact with the Irish Sea (CHERISH 2017c). This excludes the entire southern and parts of the northern Welsh coastlines. The project is also limited to a 5 year duration, which means that although it appears to cover a large area, study sites have been selected based on threat to preservation (CHERISH 2017b).

The Cherish Project will add to the archaeological and palaeoenvironmental knowledge on the west coast of Wales (and east coast of Ireland), and perhaps more importantly provide the means through which to share that knowledge, with a major aim being to disseminate through online resources, public workshops and training schemes (CHERISH 2017a). Additional work is still required, however, to improve data resolution along each of the coastlines in Wales, and further afield in the rest of Britain. Only then can we create a joined up narrative of the prehistoric archaeological, environmental and sea level changes that are locked within the intertidal zones.

Commercial Contributors

As mentioned in chapter 3, the commercial sector looks to be a promising contributor to intertidal investigation. For example, I have very recently been involved in an intertidal investigation in mitigation of government funded construction work to improve sea defences at a site on the north-west coast of Wales. The project has involved a programme of field survey, radiocarbon dating and pollen analysis on the recommendation of the local archaeological trust (Philp 2018). This is an important step forward, with intertidal investigation being included within the pre-planning process and goes further than many of the previous developer instigated intertidal surveys in Wales, such as those undertaken in preparation for the (now ill-fated) tidal lagoon in Swansea Bay (Evans 2014), which were limited to walk over surveys, lacking further in-depth investigation.

If developer funded intertidal investigation is increased, it will contribute towards filling gaps in knowledge and potentially move towards standardising intertidal investigation as part of the commercial archaeological approach. The key then will be to make sure the knowledge is made available and not lost to grey literature. This move forward also relies on the availability of palaeoenvironmental expertise, currently an area in which a skills shortage has been identified (Hook et al. 2016, 24).

Summary

In order to understand the effects of sea level and associated environmental change on the prehistoric populations of Wales, localised data, which can be linked to archaeological evidence, from around the entire coastline is required. Currently data acquisition is sporadic, generally based on chance archaeological findings within the intertidal zone. By integrating data obtained through these means alongside larger scale projects, such as the Cherish Project, a more coherent understanding of the development of the Welsh coastline will be created, but gaps in knowledge will still be present. Provision of resources for further in depth scientific analysis for community based coastal monitoring programmes could also aid an increase in data resolution. Finally, the recognition that intertidal investigation must be a contributor to pre-planning development would provide another means of data collection, while also mitigating against the loss of intertidal evidence due a lack of understanding of its importance.

7.2.5 Justifying the Cause – The Lure of Submerged Landscapes

In undertaking this investigation it became very clear that submerged landscapes are still as fascinating to the general public as they were in the 12th and 13th centuries. From the moment fieldwork started members of the public approached the team to ask questions about the deposits and the research. Locals took ownership of the submerged forest at Broughton Bay, referring to it as "our forest" (pers. comm.) and provided information about how far back the beach had eroded and dates of previous major exposures. Some individuals made links between the intertidal remains and the legend of Silverwood outlined in chapter 3, though many were well informed as to the origin of similar deposits and guessed more accurately at the age.

At Port Eynon, it was a surprise to find that despite the footprints making the national news when they were initially discovered in 2014 (BBC 2014), very few people knew of their existence. This included the men using a mini digger to lay the line of buoys used by the sailing club to demarcate the boat launching slipway, which lies very close to the edge of the archaeological significant deposits. This is a clear example of how lack of information could have led to the loss of important evidence. Once people were made aware of their existence by the field team, the footprints became the main focus of interest. One of the most common reactions from visitors was to place a foot against the footprint of a prehistoric person.

The footprints also provided a vessel by which to educate: once their presence had been realised, many questions followed. Popular questions included how they could be identified, how they had survived and how long they had been there for. Visitors left the beach with an unexpected knowledge of past environmental change in South Wales and the idea that the beach they knew so well was once a completely different landscape.

The interest in the research presented a clear opportunity for further engagement. Having been approached by Tidal Lagoon Power, the company behind the Swansea Tidal Lagoon project, a proposal was put together to create an educational resource based on the archaeological science used to understand evidence such as the Port Eynon footprints. A pilot project: Footprints in Time (Cardiff University 2016), was funded by the City Region Exchange (see Appendix 16 for details) to develop workshops and activities to raise awareness of historic and current climate change and human response to it. The project summary and final report, which outline the workshops created and the results from the pilot project can be found in Appendix 14. The project engaged with three separate school groups covering Key stages 3, 4 and 5 and was also taken out in a roadshow format to a number of events across Wales including a Cadw open day at Bryn Celli Ddu on Anglesey in June 2016 and the National Eisteddfod in Abergavenny in July 2016. The roadshow events were particularly useful as they encouraged discussion about the possibility of intertidal deposits being found at other locations. On Anglesey in particular many conversations were had about prospective sites on the island. The project also presented the opportunity to work with Tidal Lagoon Power, one of the newer stakeholders in the intertidal zone, and to reiterate the importance of research prior to development.

The engagement experienced during the Footprints in Time project identified a clear public interest in intertidal remains and the reasons behind their existence. Interest was furthered by engagement from the media, which again focussed on the footprints. In September 2016, they were featured on the BBC series Coast (BBC 2016) (Figure 96). Once the radiocarbon dating had been obtained, which increased the age of the footprints significantly from original estimates, media interest was furthered and the research was featured by 14 national news outlets and televised by BBC Wales Today. A copy of the original press release and list of media inclusions is provided in Appendix 15.

Figure 96: Screenshot from "Coast: The Great Guide: 2. Southern Wales" aired 28th September 2016, BBC 2.

It has been possible to engage on many levels and to different age groups. As well as schools and public events, presentations to local interest groups, including the Gower Society, The National Trust and Cardiff University Continuing Professional Education have proven very popular. The footprints in particular provide a highly tangible link to the past, which when coupled with environmental evidence, allow people to place themselves in the position of the person who had stood on the same spot 7000 years earlier. Being able to provide answers as to why the remains now sit semi-submerged also seems to be popular. As much as audiences enjoy the mystery of myths and legends, it appears that the debunking of such stories is also valued highly. The research provides answers and helps to solve the mystery that has led to the formation of these myths and legends in the first place.

Engagement has also worked in the favour of the research. Promotion to the general public has led to potential new leads for further sites hosting archaeologically significant intertidal deposits and raised awareness about the types of evidence to look out for in the intertidal zone. In doing so members of the public are being trained to identify potential new lines of evidence, but are also more aware of the importance of this finite resource, which can help put pressure on local authorities and developers to do something when new evidence appears at risk.

Summary

Submerged landscapes still invoke intrigue, as they have done for hundreds of years. Enthusiastic involvement from the general public indicates a genuine interest in what intertidal evidence can tell us about past environmental and sea level change and their effects on prehistoric human inhabitants. This project has raised awareness, but also shown the value of involving members of the public in research reliant on often unpredictable factors in remote locations.

8 Conclusion

This research has shown that, by combining archaeological and palaeoenvironmental data at a localised level, the effects of sea level change on prehistoric landscapes and the human populations who inhabited them can be accurately placed within a chronological framework that helps to inform on the generational experience of the human inhabitants.

This thesis has argued that, to be archaeologically relevant, sea level change in the past should be investigated on a site by site basis. Wide scale sea level modelling cannot provide the resolution needed to relate archaeological evidence to its contemporary landscape setting and even modelling based on smaller regional areas is limited in its usability when it comes to archaeological time frames.

The research has found that there are geographical gaps in knowledge with regards to palaeoenvironmental and archaeological evidence within the intertidal zone around Wales. This has led to the interpretation of intertidal evidence, in terms of date, environment and human interaction, being based on analogies with neighbouring sites. However, evidence shows significant chronological and environmental variation from site to site, even within smaller regional areas, which would have impacted on human experience within the represented landscape.

To address these issues, an in-depth site-by-site approach has been taken at two locations on the Gower Peninsula, an area identified as having lacked investigation in the past. New and improved palaeoenvironmental and archaeological datasets have been obtained from the intertidal zones at Broughton Bay and Port Eynon along with a new radiocarbon dataset. This has created a chronological framework within which to contextualise the now submerged landscapes and the people who inhabited them.

The evidence has shown that sea level change affected Gower throughout the Mesolithic and Neolithic periods, but not in a linear fashion. Long-lived inundations did not affect either of the sites during timeframes represented in the studied environmental sequences. However, at Port Eynon in particular, there is evidence for at least five instances of direct marine influence during the late Mesolithic period. This led to the deposition of minerogenic sediments and salt marsh indicators within the pollen record. Importantly these transgressive periods were followed by regressions in sea level, leading to the reinstatement of freshwater environments represented by substantial peat deposits. At Broughton Bay, evidence for contemporary transgressions has not been directly identified in the stratigraphic record, although raised levels of salt marsh indicators in the pollen record towards the base of the organic peat deposits suggests an earlier marine phase. Additional radiocarbon evidence and higher resolution pollen analysis would be needed to further contextualise the Broughton Bay evidence and a current lack of clarity should not be read as a lack of variations in sea level.

In terms of human experience in relation to sea level change and the accompanying environmental responses, the continued presence of humans within the landscape on Gower during periods of intensive environmental fluctuation indicate that changes in sea level did not act as a catalyst for relocation. Moreover, the evidence for human management of the landscape through deliberate burning episodes during marine transgressive periods shows the ability of people to adapt to the environmental fluctuations and make the environment work for them. Changes in vegetation, instigated by fluctuating groundwater levels linked to sea level movements, also encouraged the growth of valuable plant resources and colonisation by wild fauna, which would have provided important sources of food, and materials. The mixture of environments encompassing wetland, woodland and open plain would have been a highly attractive combination to prehistoric inhabitants. This supports findings highlighted in previous research in the Severn Estuary, Pembrokeshire, North Wales and southern England (see chapter 7) that placed the wetland edge environment as a focus for human activity and intervention throughout the late Mesolithic and early Neolithic periods (Allen and Gardiner 2000a; Bell 2007b, 337; Brayshay et al. 2007; Brown 2007b; Murphy et al. 2014). The new dating evidence has also provided a potential temporal link between the, now known to be, Mesolithic footprint creators of Port Eynon and one of the burials within the Paviland cave complex. With the suggestion that Gower represented a singular Mesolithic territory (Schulting 2009), it is proposed that that the group who walked across the Port Eynon wetland landscape could have known of, or even been the individuals who placed, the adult in Foxhole Cave. There is even a slight possibility, given the error margins of radiocarbon dating, that the individual in the cave was one of the members of the group.

This research has also found that there is a healthy public appetite for investigating and understanding both submerged landscapes and the people who inhabited them. This can be harnessed for educational means, sharing knowledge about past and future climate change, archaeological science and British prehistory, but it can also be beneficial to future research, increasing the network of intertidal monitors. With forecasts predicting extreme rain and wind events to become ever more common in the coming years (Kovats et al. 2014), it is very likely that further exposures will continue to come to light. With more informed eyes on the ground, new intertidal sites can be brought to the attention of investigators.

By undertaking this project, lessons have been learnt regarding the methodologies and approaches taken to research within the intertidal zone. It is now clear that methodologies need to be tailor-made to the conditions presented by individual sites and cannot necessarily be directly transposed from one site to another, much in the same way that the evidence cannot be interpreted in this way. With limited resources it is better to focus on obtaining higher resolution results from one site, than spreading resources across multiple sites. By far the most important aspect of the investigation has been the acquisition of radiocarbon dates, without which the contextualisation of the palaeoenvironmental or archaeological evidence could not have been achieved. A chronological framework is essential to the interpretation of submerged landscapes, particularly when seeking to understand the effects of factors such as sea level change on contemporary human populations.

Moving forward, to address the current gaps in knowledge coverage, the importance of intertidal evidence needs to be acknowledged and communicated widely. The risk to remains within this environment from erosion and development is high and indicates an urgent need to put mitigation in the form of responsive recording and where possible in depth analysis in place. Investigation in the intertidal zone itself also needs to be standardised within both research and commercial based sectors. Evidence suggests this is beginning to happen, with the inclusion of intertidal investigation in pre-development works, but this is still a rare occurrence. Where possible, newly discovered intertidal peat deposits should be investigated in relation to environmental and archaeological evidence. Where funding is available, radiocarbon dating should be treated as a priority and palaeoenvironmental analysis should be used to compliment archaeological interpretation.

Within the study area specifically, while this research has provided new archaeological, palaeoenvironmental and chronological data, its resolution is still lower than it could be. A number of improvements and extensions to the research in this area are proposed:

- At both sites, further coring should be undertaken to ascertain the full depth of deposits at each beach and whether the exposures in the lower intertidal zone relate to underlying layers of the sequences in the upper intertidal zone. At Port Eynon, this would identify changes that occurred in the environment between the lower and upper sequences and, it is predicted, further marine transgressions. At Broughton Bay it would provide evidence for the environment that existed prior to the sustained mixed fenland and alder carr phase. A higher resolution survey of peat extent could also be undertaken at both sites. This would require a longer time frame for fieldwork than was available in this project and may need to be executed in stages.

- At Broughton Bay higher resolution pollen analysis is required, as the results presented in this thesis at this site amount to a low-resolution assessment. Further radiocarbon dating would also need to be undertaken to assess the validity of the one date obtained in this study. In doing so, more concrete comparisons could be drawn with Mesolithic and later archaeological evidence currently under investigation at Burry Holms (E. Walker, 2017 pers. comm.).

- A targeted high-resolution programme of radiocarbon dating at Port Eynon would allow the transgressive and regressive contacts to be dated within the highly fluctuating period during the Mesolithic. The resultant dates could then be compared with archaeologically obtained dates to allow a more accurate correlation of the sea level change episodes with the contemporary archaeological evidence.

- Continued monitoring of the Port Eynon exposures would allow any new footprint exposures to be identified. This could be an ideal project for local enthusiasts, which would enable regular monitoring of the site. By using the same recording methods outlined in Chapter 5, it would be possible to continue to add to the existing plan working towards a full representation, as and when new footprints became exposed.

- In the wider Gower setting, the extensive deposits at Whiteford Sands require further investigation. While they were surveyed as part of the "From Forests to Firing Line" project and samples for palaeoenvironmental investigation were taken (Huckfield 2016), the exposures cover vast areas and a sustained survey would be needed in order to establish the full character of the submerged landscape. Nearby Neolithic artefact spot finds (GGAT 1989b) and so far undated shell middens (GGAT 2003) also suggest that this site has high archaeological potential. The majority of the beaches on Gower have the potential for intertidal deposits and should be monitored for further exposures, particularly after large storm events.

- Within South Wales sites such as Swansea Bay require palaeoenvironmental study to compliment the archaeological work that has been undertaken in recent years. While the early pollen investigations are accessible, they lack the modern dating needed to contextualise them. Targeted palaeoenvironmental investigation is also needed in the areas surrounding archaeological features that have already been recorded in order to further contextualise them within their environmental setting. In doing so the effect of tidal influence on the bay and its inhabitants will be much better understood.

The effects of sea level change should always be considered when interpreting the palaeoenvironmental and archaeological evidence. In doing so, human experiences of sea level change can be proposed. Sea level models should not be used as an interpretive device for specific archaeological evidence. Whenever possible, sea levels must be considered alongside archaeological evidence at a localised level. Only when the resolution of archaeologically related sea level evidence is increased will a more informed picture of human experience of sea level change become available.

Further to the benefits this research provides for exploration of past sea level change and its effects in the past, it may also have a bearing on present and future reaction to resultant fluctuating environments. Modern day perception of sea level change is based on the fear of an imminent risk to our coastal communities. As recently as the week this thesis was submitted, a news article was published about American “climate change refugees” moving full communities to new locations on higher ground to escape the effects of sea level change in lowland locations (Milman 2018).

While coastal development is unlikely to be abandoned fully, the approach to coastal management, once heavily focused on defence and preservation, is now moving towards a less uncompromising position perhaps more resonant with our prehistoric predecessors. Within the study area, the Cwm Ivy marsh is a prime example, where, following a breach in sea defences in 2014, the decision was made to let nature take its course (National Trust 2015a). In doing so, while losing once valuable farmland, a biodiverse saltmarsh has instead taken its place, creating much more sustainable management prospects for this part of the coastline. The National Trust (2015b) “Shifting Shores” report, calls for more of this kind of management programme, arguing that it is unsustainable to continue to try to hold back the tide and championing a coastline “shaped by natural forces.”

On a more practical note, the National Trust uses past sea level data to predict the effects of sea level change on their protected coastlines (National Trust 2014). However, this is based on the more recent past, going back just a few centuries. By improving the resolution of data relating to periods of increased sea level fluctuation in prehistory, such as those identified in this research, a better understanding of environmental change in the coastal zone can be achieved, helping to inform decision making around coastal management.

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Changing Tides:
The Archaeological Context of Sea Level Change in Prehistoric South Wales

Volume 2

Appendices

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Appendix 1: Source data and descriptions from the South Wales preliminary peat survey

A1.1 Source Data

Table 21: Source data for desk-based survey of South Wales coastline

Site	Grid Reference	X	Y	Un-calibrated C14 Date	Calibrated C14 Date	Archaeological Evidence	Environmental Evidence	Site Type	References	Comments
Aberavon	SS745894	274500	189400	N/A	N/A	Axe in wood		Poss. IP	Savory 1971, Bell 2007	"Lumps of peat" observed nearby - suggested to be washed up and axe contained within. Possibility related to construction work at Iron Works near Port Talbot. Peat washed down coast from there? (Known to be peat under the foreshore due to being found during construction of the docks). Axe dated as Neolithic.
Barry (East Barry Dock)	ST 12041 67387	275732	188896	N/A	N/A	2 bone needles recovered from highest peat deposit - dated to Neolithic. Land being utilised in its final phase.	Higher the peat bed, the more vegetation evidence it contained - predominantly sedges, correlating with a period of increased wetness. Clays formed within a freshwater environment. Highest peat layer included Oak, Hazel, Hawthorn and Willow. Possibly estuarine environment.	D	Beaudette and Beaudette 1985	5 layers of peat within the dock section interspersed with blue clay layers. Highest peat identified -1.2m OD
Broughton Bay	SS 41900 93000	241900	193000	N/A	N/A	Aurochs bone	Plant species recorded include silver birch, hazel, alder, elder, deergrass, rushes, irises and spurges. (From tree stumps and branches recorded on the surface and within the peat. Not noted which exposure/deposit) - (Winder 2015, George 2008).	SF, IP	George 1930 GGAT 2015 Winder 2009	First recorded by George - noted peat from just below high water to around the mid tide point. Believed it to be similar in character to Port Eynon and Swansea Bay, though noted thicker deposits in places. No mention on the HLCA of IP or SF. Mentioned in *Jessica's Nature Blog* post from 2009. Suggested to be remains of "birch tundra woodland." Suggests the SF and IP remains began to become exposed during the 1980s. Plant species recorded include silver birch, hazel, alder, elder, deergrass, rushes, irises and spurges.
Burry Holms	SS 39953 92619	239953	192619	N/A	N/A		N/A	Potential		

Site	Grid Reference	X	Y	Un-calibrated C14 Date	Calibrated C14 Date	Archaeological Evidence	Environmental Evidence	Site Type	References	Comments
Kenfig	SS7857 8046	262214	190466	(Bennet et al 2010) Tree stump on top of Peat A: 5110±40BP Organics at bottom of Peat A 12-14cm from top: 4930±50BP Small tree branches (*Salix spp.)* on top of Peat B: 3250±40BP Organic rich sand lower contact of Peat B 20-25cm from top: 3810±40BP			(Bennet et al 2010) Diatom and Pollen analysis undertaken. Diatom results showed 2 distinct zones in Peat A - Zone I: Brackish - mixture of marine and freshwater species. Zone II: Decline in brackish and marine species. Rise in freshwater species. Pollen - preservation poor - low concentrations. Herb pollen dominates assemblage (c.90%): Cyperaceae, Poaceae and Chenopodiaceae. Small rise in Quercus and Alnus glutinosa observed in top sample. Peat B also has poor preservation. c.70% herb pollen - Cyperaceae and Poaceae and c. 30% tree pollen - Quercus. Very little shrub pollen. Range of herb and aquatic species occur in low frequencies. All evidence suggests lower part of Peat A formed in salt marsh. Diatoms in zone I - blue clay beneath peat suggest inter-tidal mud flat. Zone II shows movement to more freshwater environment, seen in Peat B. Sand in B suggests dune system nearby. Low levels of tree pollen in both might suggest cleared landscape or a patchy landscape with wet and dry areas.	IP	Nayling 1998 GGAT 2006 Evans 2007a, b Wales Online 2007 Bennet et al 2010	Less well defined exposure between Sker Point and Gwely'r Misgyl (Mussel Rock). Highly eroded. About 150m in length. No structural elements observed during 1998 survey. Human and animal footprints observed in 2007. Exposure of peat deposit described as rare by locals - probably due to stormy conditions leading up to discovery. Last officially recorded 2010 - extended 250m along shoreline and 50m towards tideline. Prior to 2010 - suggested to be 8000 years old (reported in the media). Probably due to generalised sea level models - no source cited by Wales Online. 2010 investigation obtained C14 dates - footprints suggested to be Neo in date. (Dated peat in which they were sat (Peat A) and a layer believed to be later and overlying further up the beach (Peat B)). Palaeoanalysis also undertaken.

Site	Grid Reference	X	Y	Un-calibrated C14 Date	Calibrated C14 Date	Archaeological Evidence	Environmental Evidence	Site Type	References	Comments
Margam (Morfa Beach)	SS 77008 85066	278570	180460	N/A	N/A	Frontal part of human skull. Small cast bronze flanged axe embedded in top of blue estuarine clay. Small looped bronze axe. 4 bronze axes. EAI ring-headed pin. Large mammal footprints. LBA bucket handle. 2 bronze axes. Axe fragment. Bronze needle. Bronze ring. Antler pick. Antler tool. Palstave. BA ring. IA pin. MBA palstave. Pre socketed axe blade. 4 BA socketed axes. BA socketed axe.	N/A	IP	Locock 1996 Nayling 1998	Most extensive exposure of peat (according to 1998 survey). Identified in 1991 on a Geonex sortie (aerial photography survey (Chisholm 1996). 2 peats separated by clay horizon.
Margam SLIPs	SS 77930 81823			Upper peat: -2.4m OD = 3402±108 BP. Middle peat: -3.1m OD = 5605±126 BP Lower peat: -3.2m OD = 6184±143 BP	N/A	N/A	N/A	SLIPs	Heyworth and Kidson 1982	Exact location unknown - Lat Long co-ordinates not accurate enough. Used as major SLIPs for the SW sea level change model.
Oxwich Bay	SS 50550 86917	250550	186917	N/A	N/A		N/A	Potential		

Site	Grid Reference	X	Y	Un-calibrated C14 Date	Calibrated C14 Date	Archaeological Evidence	Environmental Evidence	Site Type	References	Comments
Port Eynon	SS4697885148	277008	185066			Roe deer remains in clay beneath peat at low water. Ox remains in deposits at high water mark. Flint scraper on top of peat. Possible melted Iron ore found within peat and clay deposits in small area. Short row of wooden stakes recorded in 2009 aligned north-southwest and inserted through peat (no date). Core rejuvenation flake and small amount of burnt bone recovered from clay below peat. Debitage flake recovered from same location on a subsequent visit. 5 human footprints recorded on peat shelf suggested to be BA in BBC article. Also animal hoof prints discovered.		IP SF	George 1930 GGAT 2009 GGAT 2009 Sherman 2009 RCAHMW 2013 GGAT 2014 BBC 2014	In 1930, peat extended from just below high water mark to 30ft below. Small deposits also recognised just below low water mark. Suggested very similar to deposits in Swansea Bay, but with some slight variation. Recorded by the HER in 2009. Describes an extensive exposure of "firm brownish peat" containing tree stumps and fallen tree remains. Individual areas of peat separated by areas of shingle and pebbles.
Port Talbot	SS 75732 88896	246978	185148	N/A	N/A	Red deer antlers found by workmen in lower peat.	Upper peat bed includes Rubus idoeus (seeds), Phragmites, Atriplex (seeds), Rumex (seeds), birch, yew, elytra of beetles. Lower peat bed contains Phragmites and Scirpus lacustris (seed). (All identified by Reid for Strahan).	D	Strahan 1907	Buried peats noted in dock cutting section. Again 2 deposits recorded - 1 just below 0m OD (c.9m below surface) and a lower thin layer at c -8m OD. Lower peat layer exposed in the dock entrance and identified in well near Port Talbot inn.
Rhossili Bay	SS 41018 90544	241018	190544	N/A	N/A		N/A	Potential		

Site	Grid Reference	X	Y	Un-calibrated C14 Date	Calibrated C14 Date	Archaeological Evidence	Environmental Evidence	Site Type	References	Comments
Swansea Bay (Blackpill)	SS 62214 90466	261691	189367			Whetstone made of Pennant sandstone found embedded in 1927. Possibly Neo flint flake (possibly part of polished axe) near Vivian Stream Bridge. Possible IA human skull found buried at depth of 1.1m.	Boreholes taken on foreshore and analysed for pollen by Von Post.	IP SF	Sherman 2011 Cundall and Landman 1925 Von Post 1933 Nayling 1998	Exposures including tree stumps noted in the 1920s. Not visible during 1998 survey - suggested may have been obscured by sand.
Swansea Bay (Brynmill 2)	SS6371391702	263713	191702			N/A	N/A	IP	Nayling 1998 Sherman 2011	Located on the middle foreshore at Brynmill. Covered by a thin layer of clay (0.1m). Could be related to above, but no absolute OD heights to clarify. At a lower level than peats closer to the high water mark.
Swansea Bay (Brynmill)	SS 63308 91722	263308	191722	Brushwood trackway sat on top of peat = 1980±50BP north eastern roundwood lateral of 2009 trackway = 3710±40BP	Brushwood trackway sat on top of peat = 103-118 AD north eastern roundwood lateral of 2009 trackway = CAL BC 2140-1930	Red deer right metacarpal. IA/Roman brushwood trackway on upper shelf. LBA trackway on lower shelf.	Samples of brushwood from the trackway analysed. Oak and Alder - majority suggested to have been cut in the summer. Possibility that different elements came from different areas of woodland.	IP	George 1936 Sherman 2011 Williams 1993 Nayling 1998	Upper peat recorded in one of two boreholes by George - base height 2.4m OD. Poss. surface height of 1.5-4.6m OD. Lower peat also noted: base height = -1.4m to -1.8m OD and thickness of 1.2m. Fieldwork carried out by GGAT in 1993 following ID of brushwood trackway. Upper and lower peat shelf. In 1998 survey outcrop extended to max. 1.3km. Max width 30m. Surface height = 0.68m OD (1993) - suggested to be comparable with George's upper shelf despite apparent height difference.
Swansea Bay (Mumbles/Oystermouth)	SS6185288470	312041	167387	Wood related to Structure 2 = 2820±30BP	Wood related to Structure 2 = CAL BC1040-910	Polished diorite axe and a Pennard type BA sword found in vicinity (doesn't say if related to the deposits - 1998).Undated trackway. Second BA trackway identified in same shelf.	2 peat samples analysed by Caseldine (Sherman 2011) from directly above trackway and the peat directly to the south. Taxa found within suggests swampy/saltmarsh conditions.	IP	Nayling 1998 Sherman 2009 Sherman 2010 GGAT 2010 Charlton 2011 Sherman 2011	Thin peat exposure observed in 1998. Mirrors an outcrop identified by George in 1936 to the North of Mumbles. Level = between 0.2-2.4m OD. Thickness = 0.9m. Remains of submerged forest: at least three tree stumps and two fallen trunks. Possible footprint - suggested IA: clearly visible heel and ball print. "Date assigned due to presence in peat." Evidence for peat running inland between Mumbles and Clydach was discovered during work on new trunk sewer between 1932-35. Structure 1 recorded in 2009 eroding from previously unknown area of peat shelf. When investigated number of timbers recorded - unknown whether actually structural or part of submerged forest. Structure 2 recorded and dated in 2010.

Site	Grid Reference	X	Y	Un-calibrated C14 Date	Calibrated C14 Date	Archaeological Evidence	Environmental Evidence	Site Type	References	Comments
Swansea Bay (North Dock)		264900	191600					D	Moggridge 1856 Evans and Marvel 2000 Sherman 2011	North Dock: Peat identified in section of dock cut. 2 layers of buried peat identified. Lower layer contained tree remains. Elsewhere he noted up to 4 layers.
Swansea Bay (South of City Hall)	SS649916	261852	188470	N/A	N/A	N/A	N/A	SF	GGAT 2008	Remains of submerged forest (area of tree stumps) directly south of County Hall. About 100m beyond mean low water mark.
Swansea Bay (Victoria Station)	SS65659270	265500	192600	N/A	N/A	N/A	N/A	B	Stevens 1930 Nayling 1998 Sherman 2011	0.49m of peat overlying clay under made ground housing the engine sheds.
Swansea Bay (West Cross)	SS 61691 89367	265650	192700	N/A	N/A	N/A	N/A	IP	Cundall and Landman 1925 Sherman 2011	Peat noted and "submerged tree stools"
Swansea Gasworks	SS65509260	277930	181823	N/A	N/A	N/A	N/A	D	Sherman 2011	Tree trunks including oak and hazel along with nuts, fern roots and seeds found in peat 7.62m under the surface in 1892-3. Presented to the Royal Institute of South Wales.
Three Cliffs Bay	SS539881	253900	188100	N/A	N/A	N/A	N/A	IP	GGAT 2014	Two areas of peat on foreshore. Exposed after 2014 storms. Laid down in thin laminations in sequence with clay deposits.
Whiteford Sands	SS491942	249100	194200	N/A	N/A	Two timbers found within peat shelf possibly connected, could be structural.	N/A	SF, IP	Winder 2013 GGAT 2013	Submerged forest began to appear after winter storms in 2012/13. Interestingly the peat shelf itself is not recorded on the HER or the HLCA.

A1.2 Descriptions

Whiteford Sands and Broughton Bay

Whiteford Sands and Broughton Bay are situated on the North West coast of the Gower Peninsula. Broughton Bay is an enclosed bay, whereas Whiteford Sands is a more open environment leading towards the Lougher Estuary. The two areas are linked at low tide, but separated by a headland at high tide. The Royal Commission deals with the area as a whole, listing a series of submerged forest and peat deposits within the landscape (RCAHMW 2006). For the purposes of this investigation the sites will be approached as separate entities. They occupy an extremely large area and would have caused logistical problems in the field if combined into one site.

Whiteford Sands

Peat and submerged forest deposits were identified after storms during the winter of 2012/2013 (Winder 2013). The peat shelf is not recorded by the HLCA or HER.

Archaeological Evidence:

Two timbers have been identified within the peat, which have been recorded as “possibly structural,” however no further information is provided and no date has been applied (GGAT 2013).

Broughton Bay

Peat deposits were first recorded by George (1930) who noted peat from just below the high water mark to around the mid-tide point. George believed that the peat was similar in character to that seen both at Port Eynon and Swansea Bay. There is no mention of intertidal peat or submerged forest remains in the historic landscape characterisation or the local HER, however a blogpost by a local enthusiast from 2009 suggests that the peat and submerged forest became exposed during the 1980s (Winder 2009).

No modern palaeoenvironmental investigation appears to have been carried out, but Winder (2015 pers. comm.) suggests that plant species were identified by George from tree stumps and branches found on the surface of the peat, including species such as birch, hazel, alder, elder, deer grass, rushes, irises and spurges. Unfortunately no contextual information is provided, meaning it is unclear whether all the species existed at the same time or in the same place, however it does give an idea of the varied environment that existed through time within what is now the bay, with both woodland, grassland and wetland indicators.

Archaeological Evidence:

The historic landscape characterisation mentions "a few prehistoric finds" being discovered on the beach and mainly consisting of animal bone (GGAT 2006c). One such is example is listed on the HER as an aurochs bone, suggesting the peat to be prehistoric in nature (GGAT 2015b), but unfortunately very little else is listed. It has been confirmed by local archaeologists, however that no research has yet been done in order to date the submerged landscape (Hill 2014 pers. comm.).

Burry Holms:

No peat deposits have been recorded to date at Burry Holms, however after a discussion with Elizabeth Walker at the National Museum of Wales, it was decided to investigate the feasibility of such deposits existing within the vicinity. Burry Holms is a (now tidal) island situated at the northern end of Rhossili bay and around the headland from the south western end of Broughton Bay. At some point in its past however, the island would have been joined to the mainland, creating a headland.

Archaeological Evidence:

Recent investigations at Burry Holms have revealed Mesolithic activity via buried land surfaces beneath layers of later prehistoric activity (Walker 1999,2000,2001). The existence of these deposits proves there was a Mesolithic presence in the area and may act as an interesting comparison to the sites either side of the headland. It is understood that both Radiocarbon and OSL dates are forthcoming (Walker 2001, 2017 pers.comm.), which should provide some interesting comparative evidence.

Rhossili Bay:

Again no peat deposits have been recorded to date at Rhossili Bay, however as with Oxwich Bay, its landscape features would suggest the possibility of intertidal deposits. The bay is backed by sand dunes, which may offer protection to older landscapes and the beach slopes gently to the sea. However, the bay faces the south west and is therefore subjected to the full brunt of prevailing winds and tides, which may mean it has been subjected to harsher erosive forces than the more protected bays. The bay would require a prospective survey in order to deem whether it would be suitable for this study.

Archaeological Evidence:

Bronze age artefacts have been recovered from beneath the substantial sand dune system that backs the beach (Bridges 1997, 38). This could suggest that prehistoric land surfaces may survive beneath the sand dunes and could potentially extend out into the intertidal zone beneath the beach. Further investigation is required to determine whether any prehistoric archaeological evidence exists within the intertidal zone.

Port Eynon:

There are a series of submerged forest and peat deposits listed at Port Eynon by the Royal Commission, but other than their position no further information is recorded (RCAHMW 2013). Once again, the deposits are not referred to in the Historic Landscape Characterisation (GGAT 2006b), which would suggest that they were not exposed at this point. The first official record of the peat shelf was made by George (1930, 104) who described peat extending from just below to 30ft (9m) below the high water mark. He suggested that they were similar to deposits at Swansea, though with slight variation. Deposits were again recorded in the local HER in 2009 (GGAT 2009) after locals reported an exposure of peat in excess of 340m on the beach. Tree stumps and root systems were identified along with a number of large fallen tree trunks, the largest measuring 9m in length (Sherman 2009c).

Archaeological Evidence:

The 2009 HER record mentions the recovery of a core rejuvenation flake and a “small quantity of burn bone” from what was described as “marine clay” from beneath the peat, suggesting human interaction in the area before peat formation. No dates are applied to the exposure in this record (GGAT 2009).

More recently, the discovery of prehistoric footprints has provoked further interest in the site (BBC 2014), but due to lack of funds, the local archaeological unit has only been able to record the prints, no further analysis or dating was possible (Hill 2014 pers. comm.) . Animal hoof prints were also identified (GGAT 2014b).

Oxwich Bay:

Oxwich Bay was chosen as a potential site due to its topography and protective coastline. It is also situated within close proximity to Three Cliffs Bay, which is the site of recently recorded intertidal peat deposits. There were no previous records that could be found of peat exposures within the bay itself, however like many of the known peat exposure sites mentioned in this section, the bay is sheltered, curving inland with protective headlands at each end. The beach itself is broad and forms the mouth of a valley to the northwest. It backs on to established sand dunes in a similar fashion to sites such as Port Eynon, Broughton Bay and in places Swansea Bay, all of which host prehistoric peat deposits.

Archaeological Evidence:

The HLCA (GGAT 2006e) produced for the area highlights known prehistoric activity in the form of funerary monuments, suggesting a prehistoric presence, although settlement evidence appears to be lacking. No prehistoric archaeological evidence has as yet been recorded from the intertidal zone at Oxwich Bay.

Three Cliffs Bay:

Two areas of peat were exposed at Three Cliffs Bay after storms in 2014. The deposits are recorded as being laid down in thin laminations in sequence with clay deposits (GGAT 2014a).

Archaeological Evidence:

No specific archaeological evidence has been recorded in relation to the identified peat deposits.

Swansea Bay:

After the Severn Estuary, Swansea Bay has been the centre of the most investigation in South Wales. Interestingly, however, the last survey of Wales (Bell 2007d) made very little of the wealth of intertidal evidence that exists, despite overviews of the intertidal zone dating back to 1930 (George 1930) and a large scale investigation of the bay being undertaken in 1998 (Nayling 1998b), which identified numerous outcrops along with archaeological evidence within the intertidal zone. Since Bell's survey, further comprehensive overviews of the work carried out in Swansea Bay have been carried out as part of ongoing research related to the local archaeological trust (Sherman 2011) and also in preparation for the proposed Swansea Bay Tidal Lagoon (Tidal Lagoon Swansea Bay plc 2013).

Eight sites of interest were identified within Swansea Bay itself (in this case between Mumbles Head and Swansea Docks). A number of these sites represent some of the very first systematic investigation of submerged landscape deposits (Moggridge 1856).

Mumbles/Oystermouth:

The first recorded reference to intertidal deposits in Swansea Bay was that of Isaac Hamon in 1657 (Emery 1965, 98), who described seeing submerged tree and roots at Oystermouth and recognised that sea levels had risen.

An outcrop was recorded during the survey by Nayling (1998b, 8), which is said to mirror an outcrop identified by George (1936) to the north of Mumbles. Within the peat, both tree stumps and fallen trunks have been observed (GGAT 2010).

Off shore analysis was also implemented off Mumbles Head by Culver (1976). He identified deep peats underwater through a combination of offshore drilling and gravity coring (Sherman 2011, 3). Pollen analysis of these peats by Culver and Bull (1979) has subsequently been used towards the formation of the Swansea Bay sea level curve (Sherman 2011, 3).

Archaeological evidence:

Reference has been made to the discovery of a polished diorite axe prior to 1909 and a Pennard type Bronze Age sword in the vicinity (Nayling 1998b, 8), however it is unclear as to the context in which they were found.

Two possible timber structures have been identified within the peat shelf (Sherman 2009b,2010,2011). A sample from Structure 2 was radiocarbon dated, giving a calibrated date of CAL BC 1040-910, suggesting it to be Iron Age in construction.

A possible footprint has also been recorded in the HER with a "clearly visible heel and ball print" (Charlton 2011; GGAT 2011). It has been assigned an arbitrary Iron Age date due to its "presence in peat" (GGAT 2011). This may be related to the dating of Structure 2, however no official dating of the peat itself has yet been undertaken.

Blackpill:

In 1925, peat exposures including tree stumps were identified at Blackpill and West Cross and extending throughout the bay (Cundall and Landman 1925, 20). These deposits were identified again 5 years later by George (1930). He described an almost continuous deposit between "Vivian's Stream and Oystermouth Station" visible around the high water mark and passing under the sand and inland (George 1930, 101). This would suggest exposed peat from the Mumbles to Brynmill, around half of Swansea Bay.

The first pollen studies in Swansea Bay were conducted at Blackpill in 1930 (Von Post 1933). Three layers of peat were identified, deposited above marsh silts (Von Post 1933, 253). They showed an apparent progression from marsh to sandy peat, followed by the deposition of forest peat, which subsequently became sandy once again in the upper layers. This would suggest a transient environment, which became dryer, allowing for the forest to take hold. The pollen within showed species such as Birch, Alder, Oak and Hazel present throughout the layers, though fluctuating in concentration through time. Willow and Pine were found to disappear early on in the sequence and a very small amount of Elm was discovered in the uppermost marsh phase. Levels of Beech remain relatively steady from the second marsh phase onwards. Von Post used the presence of this species to surmise an Iron Age date for the forest, citing pollen diagrams created for Britain by Erdtman (1929).

Von Post's results were furthered by Godwin (1940), who carried out analysis between Crymlyn Bog and the King's Dock to the north east of Swansea Bay. Godwin recognised a similar sequence within his findings to that at Blackpill, though his own peat deposits extended much deeper than those closer to the shoreline (Godwin 1940, 317).

Interestingly, the deposits were not visible during the 1998 survey (Nayling 1998b, 8). Both Nayling and Sherman suggest two possible reasons: either they have been temporarily covered by shifting sand, or they have been destroyed by more recent beach management (Nayling 1998b, 8; Sherman 2011, 4). No further investigation appears to have been undertaken to confirm or deny these assumptions, however.

Archaeological evidence:

A number of archaeological finds have been recorded at Blackpill. In 1927 a whetstone made of Pennant sandstone was found embedded in the peat exposure. What is believed to be a Neolithic flint flake, possibly part of a polished ace was discovered near Vivian Stream Bridge at the top of the beach and a human skull, purported to be Iron Age in date was also discovered within the deposits at a depth of 1.1m (Nayling 1998b, 8). Again it is unclear where the Iron Age date has come from, as no radiocarbon dates have been obtained from the peat or remains found within, however it may reflect the assumptions made in other areas of the bay (Von Post 1933).

Brynmill:

An outcrop is clearly visible at Brynmill from the air (Sherman 2011, 4). The deposits extend for up to 1.3km along the coast, with a maximum width of c.30m (Nayling 1998b, 9). An upper and lower peat shelf have been recorded (Williams 1993), the upper having possibly also been identified in a borehole on the site of the Brynmill outfall by George (1936, 342), though there is a slight height difference.

Archaeological Evidence:

Seven sites of archaeological interest were identified by Williams (1993) during an evaluation of the upper peat shelf at Brynmill. These included four possible trackways, the most substantial of which was radiocarbon dated to 103-118 cal AD, suggesting it to be of late Iron Age or early Roman in date (Sherman 2011, 9).

Another trackway was identified in 2009 on the lower peat shelf. Radiocarbon dates were again obtained, giving a date of cal BC 2140-1930 and placing its construction within the later Bronze Age period (Sherman 2011, 11). The presence of these trackways suggests prolonged use of the landscape over 1000's of years and might suggest similar environmental conditions, at least at the point of construction of each of the trackways in order to warrant their existence.

Brynmill 2:

A small area of intertidal peat was identified by Nayling during the 1998 survey on the middle foreshore at Brynmill (Nayling 1998b, 9; Sherman 2011, 5).The deposits were covered by a thin layer (0.1m) of clay. It was suggested that this outcrop may be related to the main Brynmill deposits, but as of yet, no absolute height data has been obtained and so no direct comparison can be made (Nayling 1998b, 8; Sherman 2011, 5).

Archaeological Evidence:

No specific archaeological evidence has been recorded in direct relation to this outcrop, however it likely relationship with the other Brynmill deposits suggests a high archaeological potential.

South of City Hall:

An entry in the HER records the remains of a submerged forest c.100m below the mean low water mark, directly south of City Hall (GGAT 2008). The remains are recorded as being an area of tree stumps.

Archaeological Evidence:

No specific archaeological evidence has been recorded related to deposits in the area South of City Hall.

Victoria Station:

0.49m of peat was recorded within a sequence of deposits by Stevens (1930) beneath the made ground on which the engine sheds stood at Victoria Station (Nayling 1998b; Sherman 2011).

Archaeological Evidence:

No specific archaeological evidence was recorded in relation to the deposits identified beneath Victoria Station.

Swansea Docks:

During the construction of Swansea Docks in the 19th century, a number of peat layers were identified in section during the docks' excavation (Moggridge 1856). Tree species were also identified from the plant fossils found within the peat indicating the presence of Oak, Beech, Birch, Alder, Hazel and Crab-Tree (Moggridge 1856, 170). Moggridge also noted a lack of Coniferous trees and the presence of reeds and grasses, suggesting a mixed environment of open land and wooded areas. This appears to represent some of the first environmental assessment done in the bay.

Archaeological Evidence:

No specific archaeological evidence was recorded in relation to the deposits identified in section during the construction of the docks.

West Cross

As mentioned above, peat exposures at West Cross were identified in by Cundall and Landman (1925, 20) and again by George in 1930 (George 1930, 101). Cundall and Landman (1925, 20) also noted “submerged tree stools,” suggesting these deposits again form part of a submerged forest.

Archaeological Evidence:

No specific archaeological evidence was recorded in relation to the deposits identified at West Cross.

East of Swansea:

Aberavon:

“Lumps of peat” were observed washed up at Aberavon, suggesting a possible in situ intertidal peat, or at least nearby source (Savory 1971). It is suggested that the peat might be related to deposits found at nearby Port Talbot (see below) (Bell 2007d).

Archaeological Evidence:

An axe dated to the Neolithic with part of its wooden handle preserved was discovered on the beach at Aberavon between the high and low water marks in 1970. It was in the vicinity of the lumps of peat described above (Savory 1971, 296).

Port Talbot:

Two buried peat deposits were noted in the dock section during construction at Port Talbot (Strahan 1907). The upper layer was measured at 0m OD, and 9m below ground surface. The lower, thinner layer was situated at -8m OD. It was recorded that the lower layer was also exposed at the dock entrance, suggesting the peat may have been part of an intertidal deposit at this point. No further record has been logged since, however.

Archaeological Evidence:

Red deer antlers were discovered within the lower peat by workmen (Strahan 1907), however it is unclear whether these showed any sign of human interaction.

Swansea Gasworks:

Tree trunks of oak and hazel, along with nuts, fern roots and seeds were identified in peat 7.62m below the surface in 1892-3 at Swansea Gasworks. The samples were presented to the Royal Institute of South Wales (Sherman 2011, 2).

Archaeological Evidence:

No archaeological evidence is recorded as being found related to the deposits.

Margam SLIPs:

The only sea level index points in South Wales are situated at Margam. They comprise of three dates taken from a sequence of three peats. The upper peat (-2.4m OD) was dated to 3402±108 BP, the middle (3.1m OD) to 5605±126 BP and the lower (3.2m OD) to 6184±143 BP (Heyworth and Kidson 1982, 104). This suggests that the deposits formed over a period of just under 3000 years, beginning in the Neolithic period. The SLIPs were used along with 46 others from within the Bristol Channel in order to construct the sea level model for the area (Haslett et al. 1998, 197; Bell 2000b, 19).

Archaeological Evidence:

No archaeological evidence is recorded as being found related to the deposits.

Margam (Morfa Beach):

The peat exposure at Morfa Beach was the most extensive found during the 1998 survey. The exposure was first identified in 1991 during a Geonex aerial survey. Two peat layers were recorded separated by a clay horizon (Nayling 1998b, 10).

Archaeological Evidence:

Many archaeological finds have been found within the near vicinity of the exposures at Morfa Beach. These include an undated frontal part of a human skull, antler tools, a number of Bronze Age axes, Iron Age pins and large mammal footprints (Nayling 1998b, 10-11).

Kenfig Sands:

A peat shelf at Kenfig was originally recorded in 1998 as part of a survey of the Swansea Bay intertidal zone (Nayling 1998b). It was recorded again in 2007 (Evans 2007a,b) and 2010 (Bennett et al. 2010), but its exposure had been described as rare by locals and likely to have been a result of increased stormy conditions in the preceding winters (Bennett et al. 2010, 67).

When last recorded, the peat shelf extended 250m along the shoreline and 50m out towards the tideline, with smaller sporadic deposits just below the low water mark (Bennett et al. 2010,

66) as well as thicker sandier deposits further inland towards the top if the beach (Bennett et al. 2010, 67). Prior to 2010, the peat had been suggested in local media to be 8000 years old. This figure appears to be based on a generalised model of sea level change for the Bristol Channel, though the original source is not cited (WalesOnline 2007).

Radiocarbon dating was used to date the two peat layers and gave uncalibrated dates of 4930±50BP for the lower peat and 3810±40BP for the upper (Bennett et al. 2010, 67), suggesting a transition phase around the Neolithic period. Palaeoanalysis in the form of Diatom and Pollen analysis was also conducted on both peat deposit phases, suggesting a movement from brackish conditions consistent with salt marsh to more freshwater conditions (Bennett et al. 2010, 72). The results of this analysis will be discussed more fully later in this thesis in relation to the results gathered during this project.

Archaeological Evidence:

The lower peat at Kenfig contained both human footprints and cattle hoof prints (GGAT 2006d). The footprints were first discovered in 2007 (Bennett et al. 2010) and recorded along with the exposed peat shelf later in the same year by the local archaeological service (Evans 2007a,b). The 2010 investigation resulted in a possible Neolithic date being applied to the footprints through radiocarbon dating of the peat in which they were situated and the later overlying peat situated further inshore (Bennett et al. 2010, 67).

West of Cardiff:

Barry:

In 1895 during the excavation of East Barry Dock, peat deposits were recorded by Strahan (1896) within the dock section. It was believed that these indicated intermediate periods of submergence (Beaudette and Beaudette 1985, 22) The earliest deposit was a buried soil; 10.6m below present sea level. Above this lay a peat bed containing logs, many of which have been identified as oak. Above the lower peat layer lay 9 metres of blue clays and silts containing 4 layers of peat intermittently. The clays and silts indicated freshwater conditions (RCAHMW 2012). The highest peat identified was 1.2 metres below current sea level. There is evidence within this top peat layer for Oak, Hazel, Hawthorn and Willow. Above this layer lay sand and gravel indicating the final incursion of the sea. The deposits before this have indicated estuarine conditions, rather than coastal. It is suggest that this final incursion can be dated to the Bronze Age (Beaudette and Beaudette 1985, 24). During the Bronze Age the landscape would have turned to marshland with intermittent woodland. At this point Barry Island was still connected to the mainland as a peninsular, becoming fully isolated at the end of the Bronze Age.

Archaeological Evidence:

Two bone needles were recovered from this layer and have been dated to the Neolithic, indicating the land was being utilised by man in its final phase (Beaudette and Beaudette 1985, 24).

Appendix 2: Preliminary Site Visits

A2.1 Whiteford Sands:

Whiteford Sands was visited, in February 2015. The beach occupies an enormous area, especially when the tide is out. Access is difficult and required a long trek from Broughton Bay. The peat was substantial in terms of thickness and widespread, though heavily eroded in places. Roots were observed running through the peat in places (see Figure 97) along with areas that appeared to be full of cockle shells (see Figure 98).

Figure 97: Roots in the peat at Whiteford Sands

Figure 98: Cockle shells within the peat at Whiteford Sands

The presence of the cockle shells may be related to middens discovered within the sand dunes in Whitford Bay. These have been recorded during surveys undertaken by the National Trust and contain cockle and oyster shells alongside burnt stone. Similar deposits with more intact shells and possible burnt stones have recently been noted within the intertidal zone in close proximity to those in Figure 98, which could represent further evidence for midden like deposit

Whiteford Sands was used as a munitions testing area during the war, which means there is an added danger of unexploded ordnance on the beach. This was clearly demonstrated when, during the visit, the armed forces detonated a controlled explosion to clear an example of said ordnance (see Figure 99).

Figure 99: Crater caused by controlled explosion of wartime ordnance March 2015

The area was also chosen as the subject of a large scale community project in 2015, investigating the entire intertidal history of Whiteford Point, from the prehistoric forests to the war time remains (GGAT 2015c). As such and taking into account the logistical issues predicted in investigating such a large area of beach, it was decided not to include Whiteford Sands as a primary study site. However the findings from the community project may prove useful at a later stage.

A2.2 Broughton Bay

Broughton Bay (see Figure 100) was visited twice during this preliminary phase:

Figure 100: Broughton Bay

Visit 1 – November 2014

This visit was used to establish the existence of peat at the site and its general extent. Large peat and submerged forest deposits were identified from the top of the beach to around three quarters of the way down at low tide (see Figure 101).

Figure 101: Peat extending from the top of the beach in November 2014

No peat was visible closer to the water's edge on this occasion. The sand was deposited in deep peaks and troughs, suggesting the sea state had been heavy. Though this may have aided the exposure of the deposits further up the beach, it may also have caused large amounts of sand to be deposited within the lower intertidal zone. By talking to local residents, it was established that the deposits had only been revealed in the previous couple of weeks after a period of stormy weather. This is an important factor to take into account as it shows how quickly the character of the beach can change. In response to this information, rudimentary GPS points were taken using a smartphone in order to locate the deposits should they be covered by sand on a later visit. The accuracy of the GPS function on the phone is not precise enough for official record, but serves as a useful signpost to the overall area within which deposits can be found.

Visit 2 – December 2014

The peat deposits were still visible, particularly towards the top of the beach, however the exposure was less obvious with more frequent pockets of sand overlying. The sand only amounted to a few centimetres however and when removed, revealed the peat beneath. The beach was different in character from the previous visit. The sand moguls observed before did not exist on this occasion, suggesting the sea state had been calmer on the previous tide, though it was observed that substantial ridges of sand had been formed laterally across the beach and repeated between each of the peat exposures. These ridges were present during the first visit, but it was noted that they were more substantial on this visit. It is believed that the peat deposits may continue beneath them. This should be further understood once the topographic survey has been undertaken.

A handheld GPS unit was used for this visit, as it provides more accurate readings than a phone. Conditions on the day allowed for an accuracy of around 5m, which was deemed acceptable for this stage of the study. Points were taken at around 5m intervals around the edges of visible exposure. This does not constitute an exact portrayal of the peat deposits, but does serve as an indication of the visible exposures on that particular day. It is worth noting that height data was not utilised for this survey, as height can only be recorded to the metre by the handheld GPS device, meaning the information provided for this particular survey was deemed relatively worthless. The beach is of shallow gradient and so changes in elevation are small; determined in centimetres rather than metres. The data was applied to a GIS database to create a map of the points collected (see Figure 102).

Figure 102: Visible extent of peat at Broughton Bay - December 2014

A2.3 Burry Holms

Burry Holms was visited in December 2014. In order to reach the site it is necessary to navigate Llangennith Burrows; a substantial sand dune system. This was hard going even with limited equipment, so access for any fieldwork would need a lot of prior planning. Once we arrived at the site it was clear that any prehistoric landscape deposits on the beach had been scoured away by the tide down to the bedrock. The tide had turned by the time we reached the site and was coming in fast, so there was no chance to investigate the seaward side of the island, but from a distance it seemed to tell the same story. Burry Holms' exposed position on the north west coast of the Gower, with no protection from the surrounding coastline leaves it highly vulnerable to erosion.

A2.4 Rhossili Bay

During the visit to Burry Holms, Rhossili Bay was also briefly examined. On this particular visit it was difficult to ascertain the depth of the sand on the beach. A return visit will be conducted with an Edelman auger to investigate whether peat deposits remain beneath the sand, once landowner's permission has been attained.

A2.5 Port Eynon

On visiting the site in December 2014, the exposure was clearly identifiable, beginning to the eastern edge of the buoyed slipway belonging to the sailing club and extending 400m along the beach to the east. As at Broughton Bay, the peat and sand undulated and it is likely that the deposit continues beneath the sand layers. The visible edges of the exposure were again recorded using a hand held GPS and are mapped below (see Figure 103). The peat deposits appeared to be relatively void of features. None of the submerged forest remains recorded in 2009 (Sherman 2009c) or the human footprints discovered earlier in 2014 (GGAT 2014b)were identifiable on this visit. A later visit in February 2015 revealed the presence of the footprints in the lower peat deposits.

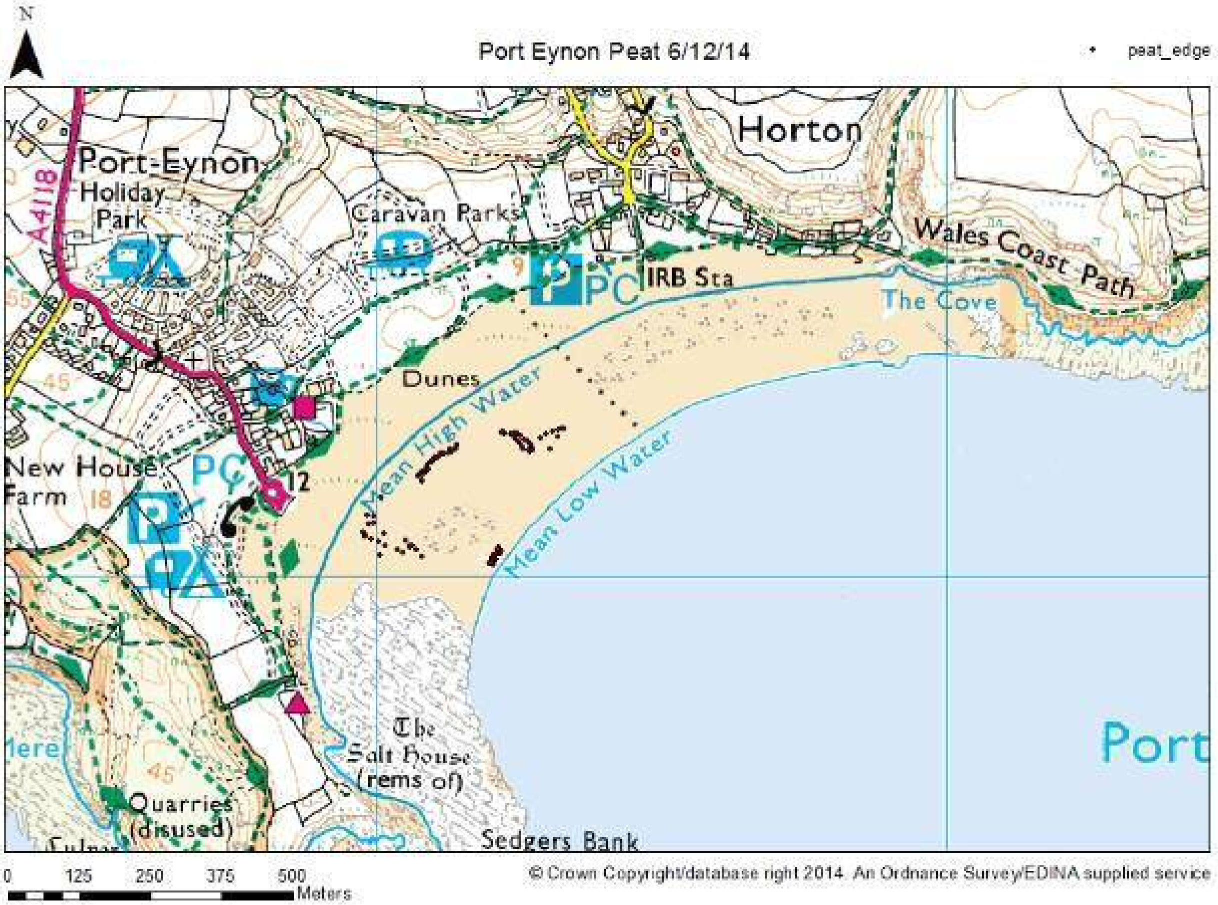

Figure 103: Visible extent of peat at Port Eynon - December 2014

A2.6 Oxwich Bay

On visiting Oxwich Bay no peat was discovered to be exposed, however the local conditions would be favourable for peat survival. It has been noted that the enclosed nature of the bay, as with many of the other Gower Bays, causes large amounts of sand to be deposited (Bridges 1997, 35). This could mean that peat is still present beneath the sandy deposits. A further visit with an Edelman Auger is required to test this hypothesis. Landowner's permission will need to be granted for this.

A2.7 Swansea Bay

A number of the noted sites in Swansea Bay were visited in April 2014. Deposits were identified at Mumbles and Brynmill, with many of the peat deposits appearing to extend across the bay. Sites highlighted in the survey such as the Docks and Victoria Station are no longer accessible and so must be used purely as an indicator that the peat extends in land.

The conditions in Swansea Bay were not ideal. There were areas of unstable ground with the danger of quicksand and the bay a large amount of unexploded ordnance is known to exist across the intertidal zone. A much larger team and more stringent safety measures would need to be applied in order to conduct fieldwork in the area. It is also acknowledged that a lot of work has previously been done in the bay, whereas other sites within the wider study area have been largely ignored. It was therefore decided to withdraw Swansea Bay from the sites set for fieldwork and to concentrate on less well investigated sites.

A2.8 Port Talbot

The deposits at Port Talbot were discovered during the building of the docks and so are no longer visible. The area itself is inaccessible to the general public.

A2.9 Swansea Gasworks

Again the deposits are no longer visible, as they lie beneath the ground, but their existence proves the extension of the peat deposits inland.

A2.10 Margam SLIPs

These deposits were recorded from a Borehole and are therefore no longer accessible. It is likely that they reflect the deposits recorded at Morfa Beach.

A2.11 Kenfig Sands

Kenfig provides a pre-existing comprehensive case study and as such will not be investigated as part of the primary fieldwork research. The evidence already provided, however, will be used in comparison with the chosen study sites in terms of radiocarbon dating and palaeoanalysis.

A2.12 Barry

Though the deposits were discovered in the docks, and are therefore unreachable, a visit was still made to Barry to assess the feasibility of intertidal deposits. Much of the Barry coastline is rocky and displayed no evidence of peat deposits. The only possible exception might be within Barry Harbour itself, or the bays on Barry Island. Further visits are required to assess this hypothesis.

Appendix 3: Gower Archaeology Survey Source Data

The following is the source data used when mapping the known prehistoric archaeology on Gower. The data is extracted and adapted from the Glamorgan Gwent Archaeological Trust Historic Environment Record (GGAT 2018)

A3.1 Mesolithic Sites

ID	X	Y	Code	Site Type	Description
Between Pobbles and 3 Cliffs Bay	254250	188250	Activity	Findspot	Possible Mesolithic flint tool. Surface find.
Burry Holms flint scatter	240100	192500	Activity	Findspot	Many Mesolithic flint artefacts and waste fragments some with fire damage. Include cores, scrapers, burin and series of microlith points of non-geometric type. Derived from beach pebbles. Most fragments recovered from cliff edge. Flints lie beneath humus. No other occupation debris reported.
Llangennith Findspot (Burry Holms?)	240100	192500	Activity	Findspot	More than 50 Mesolithic micro blades, cores and flakes.
Llangennith Findspot (Burry Holms?)	240100	192500	Activity	Findspot	Group of 21-30 Mesolithic micro blades, cores, flakes and graver
Bishoptston Valley Findspot	257250	188600	Activity	Findspot	Prehistoric finds mentioned in the GGAT Lithics survey (2001), marked as being on the border of National Trust land. The finds consist of Neolithic and Mesolithic worked flints, including a Mesolithic flint thumbnail scraper and a flint spokeshave.
Thistleboon Flint Scatter	262100	187050	Activity	Findspot	Mesolithic blades, flakes, microliths, More than one tool type, Group of 11-20.

ID	X	Y	Code	Site Type	Description
Flint Waste, Findspot	239400	187600	Activity	Findspot	Erosion from the tide and walkers continues to reveal flint and chert waste flakes, cores and microliths indicating that the occupation evidence seems confined to the Mesolithic and Iron-Age/Romano-British (Arch in Wales 1986).
Mewslade Cave	242230	187290	Activity	Cave	7 flint fragments (debitage?), blunted back microlith tool (dated to Mesolithic) and possible bone tool.
Llangennith Findspot	241000	192000	Activity	Findspot	Group of 2-10 Mesolithic blades, flakes and microliths.
Pennard Findspot	254000	188000	Activity	Findspot	Group of 2-10 Mesolithic blades, flakes and microliths.
Site Name Unknown	255830	187800	Activity	Findspot	Mesolithic flake, One tool type and material, Single item. No function ascribed.
Rhossili Findspot	243500	186670	Activity	Findspot	Flint blade dated to Mesolithic.
Llangennith Findspot (The Burrows?)	240920	191410	Activity	Findspot	Mesolithic microlith. Single find.

Table 22: Mesolithic Activity Evidence on Gower

ID	X	Y	Code	Site Type	Description
Cathole Cave, Gower	253800	190100	Settlement	Flint scatter	Mesolithic flint found within a series of horizons
Foxhole Cave; Paviland Cave Complex	243836	186014	Settlement	Settlement	Flint artefacts, human tooth (C14), possible hearth, burnt bone, microfauna, fauna and mollusca. Poss. hearth is at base of excavated area. Excavated by Aldhouse-Green in 1997. Suggested to be one of three Early Mesolithic.

Table 23: Mesolithic Settlement Evidence on Gower

ID	X	Y	Code	Site Type	Description
Worms Head	238380	187690	Funerary	Cave	HSR dating to c. 8600 cal BC
Mewslade	242230	187290	Funerary	Cave	HSR dating to c. 8500 cal BC
Foxhole	243836	186014	Funerary	Cave	HSR dating to 5522-5375 cal BC
Goat's Hole Paviland	243836	186014	Funerary	Cave	HSR dating to 5230-5055 cal BC

Table 24: Mesolithic Funerary Evidence on Gower

A3.2 Neolithic

ID	X	Y	Code	Site Type	Description
Arrowhead, Castle	265700	193670	Activity	Findspot	Neolithic arrow
Flint Find At Pennard East Cliff	255560	186950	Activity	Findspot	White flint arrowhead found close to cliff edge above Minchin Hole cave.
Neolithic Arrowhead	259930	193150	Activity	Findspot	Neolithic arrowhead
Neolithic Axe	261970	187640	Activity	Findspot	Neolithic axe
Mumbles Findspot	262000	187000	Activity	Findspot	Polished Neolithic chert stone axe
Swansea Bay Axe	261000	188000	Activity	Findspot	Polished diorite axe found in Oystermouth, in or before 1909. Exact find-spot unknown.
Swansea Bay Axe	262300	187800	Activity	Findspot	Probable Neolithic stone axe, but no details of location etc.
Swansea Bay Celt	261900	190600	Activity	Findspot	A small stone celt found in the 'neighbourhood' of Blackpill, on Swansea Bay. Undated.
Whiteford Reserve (Tor Gro Stone Axe)	245830	193780	Activity	Findspot	Polished stone axe dated to the Neolithic (c3500 - 2200 BC). Exact location of the find is unclear (labelled as coming from SS 4583 9378 but later marked as coming from SS 4627 9358).
Spring Squill Cave, Rhossili	243930	185780	Activity	Multiple Findspot	Animal bones and flint scrapers dated to Neolithic
Neolithic Hand Axe, Whiteford Sands	244475	196480	Activity	Findspot	Neolithic partially polished stone axe head of c.3500 to 2200 BC.

Table 25: Neolithic Activity Evidence on Gower

ID	X	Y	Code	Site Type	Description
Red Fescue Hole (Aka Red Chamber)	242660	186780	Settlement	Cave: potential inhabitation site	The cave is considered to represent a habitation and inhumation site, possibly Neolithic or Bronze Age, although the only dateable flint was found on the surface of the cave. Animal bones with evidence of human interaction.

Table 26: Neolithic Settlement Evidence on Gower

ID	X	Y	Code	Site Type	Description
Foxhole	243836	186014	Funerary	Cave	HSR dating to 3912-3660 cal BC. Three primary layers were recorded. Neolithic human finds were found in all three
Cefn Bryn Burial Chamber	250768	188800	Funerary	Chambered Tomb	Neolithic chambered tomb. Mound consisting of peaty layers. Remains of kerb stones and stone chamber. Contents had been removed previously. Fragments of oak and hazel charcoal remained between internal paving stones. Excavated by Williams (1940) in 1939. Monitored since, but no further investigation.
Sweyne's Howes Burial Chambers (North)	242119	189920	Funerary	Chambered Tomb	Remains of chambered tomb. Inter-visible with other tombs in the area. One of 2 within 100m of each other.
Sweyne's Howes Burial Chambers (South).	242103	189818	Funerary	Chambered Tomb	Remains of chambered tomb. One of 2 within 100m of each other.

ID	X	Y	Code	Site Type	Description
Parc Le Breos (Parc Cwm) Chambered Tomb.	253756	189828	Funerary	Chambered Tomb	N-S orientated passage grave excavated in 1869 and 1960-61. Contained human remains. 20-24 individuals - all, but 3 were adult. Disturbed by later burials. Small amount of animal bones and 'a few sherds of plain Western Neolithic pottery. Possibility barrow was 'decommissioned' at end of life in similar way to Gwernvale. C14 dating undertaken in 1998 of 12 HSR samples with dates that ranged between 4000-2000 cal BC (Whittle and Wysocki 1998).
Penmaen Burrows Chambered Tomb	253161	188127	Funerary	Chambered Tomb	Severn Cotswold group burial chamber. Animal and human bones found in disturbed layers, but lower levels appeared untouched. Possibility of more complete burials below? 3 pieces of 'undated brown pottery' close by on an 'early surface.' Possibly originally located on hillside, but formation of dunes on flanks of 3 cliffs bay now obscure natural topography.
Arthur's Stone (Maen Ceti).	249139	190556	Funerary	Chambered Tomb	Double chambered tomb. Orientated N-S. Orthostats supporting large boulder cap stone. Set within bowl shaped hollow (remnants of round cairn). No mention of any remains. Suggests formed by underpinning boulder (est. 30 tonnes).

ID	X	Y	Code	Site Type	Description
Red Fescue Hole (AKA Red Chamber)	242660	186780	Funerary	Cave	Human (fibula, fragment of femur with surviving articulation and a phalange) and animal bone, shell midden (limpets and mussels), 2 flints. Patinated half-moon shaped flint scraper dated to Neolithic or BA. In lower layer beneath the above: badger, red deer, ox and sheep/goat bones with gnaw marks and possible evidence for being smashed by human action. Apparently no stratification, but suggested detailed analysis not made.
Possible Burial Chamber, Rhossili Down	242222	188505	Funerary	Chambered Tomb	Remains comprise of 4 or 5 large blocks surrounded by large area of scattered blocks. Arfordir entry - does not appear to have been clarified by any authority so far.
Near Sweynes' Howse	242000	189700	Funerary	Cinerary Urn	Excavated by Sir Gardner Wilkinson Cinerary Urn fragments
Llangyfelach	260500	198100	Funerary	Cinerary Urns	Cinerary Urns
Llangyfelach; Carn-Goch	260500	198100	Funerary	Cinerary Urns	Cinerary Urn
Red Fescue Hole (Aka Red Chamber)	242660	186780	Funerary	Cave Burial	Potential Neolithic burial: The excavator (M. Davies) concluded that the human bones were the remains of an inhumation, he retained the finds. The archaeological material included a patinated half-moon shaped flint scraper, dated to the Neolithic or Bronze Age.

Table 27: Neolithic Funerary Evidence on Gower

ID	X	Y	Code	Site Type	Description
Newton Henge Site, Port Eynon	244600	188190	Monument	Henge	A crop mark in an aerial photograph taken in 1964 is interpreted by RCAHMW as a henge. It shows a ditch 5m wide and 53m overall in diameter, but there is now nothing to be seen in the field.

Table 28: Neolithic Monument Evidence on Gower

A3.3 Bronze Age

ID	X	Y	Code	Site Type	Description
Cefn Drum Cairnfield	261310	204390	Activity	Cairnfield	No evidence for use or dating, but suggested to be BA
Cefn Bryn, Cairnfield	250882	189223	Activity	Cairnfield	16 stone piles. No dating evidence or suggestion of use, but suggested to be BA.
Cefn Bryn, Cairnfield	251620	189300	Activity	Cairnfield	5 potential cairns plus further earthworks. No further evidence for usage or dating, but suggested to be BA.
Banc Llwyn Mawr Cairn Group	262650	206300	Activity	Cairnfield	Series of small cairns and structures composed of sandstone and quartzite blocks. No indication of funerary use. No further evidence of date or usage, but suggested to be BA.
Burnt Mound I on Druid's Moor	243890	189980	Activity	Burnt Mound	Two approximately circular 20m diameter mounds composed of burnt stones and blackened earth.
Burnt mound Llanrhidian lower	248240	190570	Activity	Burnt Mound	Roughly crescent shaped mound with intermittent heat cracked stone.
Burnt mound Reynoldston, Llanrhidian	247650	190750	Activity	Burnt Mound	Possible burnt mound indicated by a number of piles of burnt stones alongside a stream.

ID	X	Y	Code	Site Type	Description
Burnt Mound, Nicholaston	251407	188752	Activity	Burnt Mound	Recorded in antiquity and revisited later - now destroyed burnt mound, contained burnt stone.
Burnt Mound, Penrice	249100	189300	Activity	Burnt Mound	Mound located close to stream, burnt stone found within stream believed to be associated
Cefn Bryn Burnt Mound	251890	189220	Activity	Burnt Mound	Two mounds containing burnt stone material.
Cefn Bryn Burnt Mound	251880	189220	Activity	Burnt Mound	Probably burnt mound nearby to potential ring cairn.
Circular burnt mound Llanrhidian Lower	250340	189870	Activity	Burnt Mound	Burnt mound located next to stream.
Graig Fawr burnt mound	262950	207270	Activity	Burnt Mound	Described as Bronze Age cooking mound
Graig Fawr burnt mound I	262190	207210	Activity	Burnt Mound	Crescentic mound described as Bronze Age cooking mound
Graig Fawr burnt mound II	262190	207210	Activity	Burnt Mound	Smaller than mound 1, and set close to it. Concentric
Possible burnt mound Ilston	250390	189060	Activity	Burnt Mound	Piles of burnt stone along a stream noted.
Findspot BULWARK FORT SITE	244000	192000	Activity	Findspot	Bronze Age axe found on top of Bulwork fort site.
Llanrhidian findspot	253910	193190	Activity	Findspot	Middle to late Bronze Age axe fragment
Llanrhidian findspot	253910	193190	Activity	Findspot	Probable Bronze Age axe fragment.
Port Eynon Findspot	246270	188800	Activity	Findspot	Polished stone axe suggested BA in date.
Penrice Findspot	250170	186170	Activity	Findspot	Bronze Age stone mace head
Sketty Findspot	262310	192330	Activity	Findspot	Bronze Age flanged axe
St. Thomas Findspot	268000	193000	Activity	Findspot	Bronze flat axe
Broughton Bay Findspot	241700	192900	Activity	Findspot	Small Early Bronze Age flat axe
Bichgrove Findspot	270000	200000	Activity	Findspot	Gold Torc
Swansea Castle Findspot	265000	193000	Activity	Findspot	Bronze flat axe
Pentre Bach Findspot	260200	205200	Activity	Findspot	Bronze Palstave

ID	X	Y	Code	Site Type	Description
Whiteford Burrows Findspot	243430	194090	Activity	Findspot	Flint arrowhead with broken tang and single barb.
Oystermouth Findspot	262600	188690	Activity	Findspot	Tip of socketed bronze spearhead (1450-900 BC)
Oystermouth Findspot	261720	188320	Activity	Findspot	Bronze Age sword
Swansea Bay Findspot	261720	188320	Activity	Findspot	Intact leaf shaped sword similar to earliest leaf-bladed swords in Britain (Ballintober series).
The Manse Dunvant Findspot	259520	193550	Activity	Findspot	Flint arrowhead
Llangyfelach Findspot	260500	198100	Activity	Findspot	Pigmy cup
Cathole Cave Findspot	253800	190010	Activity	Findspot	Socketed axe
Port Eynon Bay Findspot	247280	185280	Activity	Findspot	Miniature socketed bronze axe
Bulwark Findspot	244000	192000	Activity	Findspot	Bronze Age Axe Hammer
Wooden structure on Oystermouth foreshore	261701	188516	Activity	Trackway	Potential trackway in the intertidal zone
Wooden structure on Oystermouth foreshore	261709	188518	Activity	Trackway	Potential trackway in the intertidal zone
Llethrid Tooth Cave	253170	190920	Activity	Findspot	Flint and bone tools with charcoal and animal bones. HSR also discovered (see funerary database)

Table 29: Bronze Age Activity Evidence on Gower

ID	X	Y	Code	Site Type	Description
Midden and hearth north of Spritsail Tor	242640	193720	Settlement	Midden and Hearth	Shell midden containing large amount of charcoal alongside rough hearth containing broken BA pottery.
Colts Hill	260570	188750	Settlement	Roundhouse	Potential early round house/hut beneath funerary monument

Table 30: Bronze Age Settlement Evidence on Gower

ID	X	Y	Code	Site Type	Description
Cairn, Rhossili Down	242180	190320	Funerary	Burial cairn	Partial circle of stones with orthostats within.
Cefn Bryn Cairnfield 1	249200	190400	Funerary	Round Barrow Cemetery	Group of 38 mounds including ring cairn, long mound and low oval or circular mounds.
Cefn Bryn Cairnfield 2	248580	190760	Funerary	Cairnfield	Group of 12 low mounds, all suggested to be sepulchral.
Graig Fawr Cairn Group	262900	207200	Funerary	Cairnfield	6 stony mounds, mostly circular, suggested to be sepulchral.
Mynydd Carnllechart Cairn Group	269320	206510	Funerary	Cairnfield	16 Cairns, mostly suggested to be clearance cairns, but potential remains of a ring barrow and other kerbed cairns.
Twyn Tyle North Cairn Group	262650	206300	Funerary	Cairnfield	Described as a "doubtful cairn cemetery," but some evidence to suggest bases of funerary cairns
Graig Fawr Round Barrow Cemetery (Pair)	261070	206520	Funerary	Cairnfield	Pair of possible funerary cairns
Barrow At Bolgoed Uchaf Farm	260360	203040	Funerary	Barrow	Possible BA barrow seen in crop marks
Bessie's Meadow	241876	190095	Funerary	Cairnfield	Numerous cairns some containing potential remains of internal cists.
Bishopston Burch	257180	190980	Funerary	Barrow	Potential barrow contained cinerary urns
Burry Holms Cairn	239867	192613	Funerary	Cairn	Cairn found to contain primary cremation burial with copper alloy pin
Burry Standing Stone	246886	189184	Funerary	HSR associated with Standing Stone	Two headless inhumations. No associated grave goods.

ID	X	Y	Code	Site Type	Description
Cairn In Cefn Bryn Cairnfield	249051	190190	Funerary	Cairn	Small circular mound likely to be funerary
Cairn In Cefn Bryn Cairnfield	249046	190110	Funerary	Cairn	Possible funerary cairn
Colts Hill	260570	188750	Funerary	Round Barrow	Cremated human remains within round barrow
Garn Goch	260563	198083	Funerary	Cairn	Funerary cairn containing primary and secondary burials, cinerary urns and charcoal.
Graig Fawr	262522	206954	Funerary	Cairn	Possible funerary cairn within cairnfield. Circular mound with neat circumference, but evidence of robbing on top.
Llanmadoc Hill	243027	192740	Funerary	Cairnfield	Funerary cairnfield containing 14 disparate and ill-defined funerary cairns. Produced 5 sherds representing 3 separate urns.
Mynydd Drumau 1	272450	200379	Funerary	Round Barrow	Large mound with trapezoidal central cist lined by upright slabs. Bones and celt recorded as being found in antiquity.
Pen Y Crug Round Barrow	251096	191376	Funerary	Round Barrow	Large roughly circular mound
Pennard Burch	256750	191360	Funerary	Round Barrow	Large mound containing urn fragments with cord impressions and primary cremation burial.
Pennard Burrows	254010	187890	Funerary	Cairns	Three potential cairns - not visible due to being covered by sand dunes
Pentre Farm, Pontardulais	259130	202630	Funerary	Round Barrow	Contained cremated remains and charcoal. Dated to c.1520±70 BC (Ward 1978)

ID	X	Y	Code	Site Type	Description
Ring Cairn Near Sweyne's Howes	242154	189781	Funerary	Ring Cairn	Assumed to be a sepulchral monument
Llethrid Tooth Cave	253170	190920	Funerary	Cave burial	Potential cave burial with BA finds
Cefn Bryn	248580	190500	Funerary	Round Barrow	Oval mound set around quartz conglomerate blocks and orthostats
Cefn Bryn	250680	189200	Funerary	Cairn	Badly disturbed cairn
Cefn Bryn 02	247996	190373	Funerary	Ring Cairn	Circular bank of ring cairn
Cefn Bryn 03	248061	190485	Funerary	Cairn	Oval ill-defined mound containing quartzite.
Cefn Bryn 04	248156	190379	Funerary	Cairn	Badly robbed cairn
Cefn Bryn 05	248555	190402	Funerary	Ring Cairn	Circular bank suggested to be part of ring cairn.
Cefn Bryn 06	248589	190396	Funerary	Cairn	Roughly circular mound
Cefn Bryn 07	248637	190340	Funerary	Cairn	Roughly circular mound
Cefn Bryn 08	248615	190409	Funerary	Cairn	Roughly oval mound
Cefn Bryn 09	248848	190704	Funerary	Cairn	Badly robbed circular cairn
Cefn Bryn 10 (Great Carn)	249031	190562	Funerary	Cairn	Structured cairn, proven through excavation with traces of bone within central pit
Cefn Bryn 12 (Maen Ceti Sse 1)	249270	190222	Funerary	Ring Cairn	Near circular stony ring bank
Cefn Bryn 14	250013	189717	Funerary	Cairn	Circular stony mound
Cefn Bryn 15	250278	189542	Funerary	Cairn	Amorphous stony mound
Cefn Bryn 16	250376	189614	Funerary	Cairn	Small ill-defined circular mound
Cefn Bryn 18	250398	189634	Funerary	Ring Cairn	Circular bank
Cefn Bryn 19	250400	189600	Funerary	Cairn	Roughly circular stony mound

ID	X	Y	Code	Site Type	Description
Cefn Bryn 23	250769	189206	Funerary	Cairn	Badly robbed round cairn, one of a pair
Cefn Bryn 24	250766	189223	Funerary	Ring Cairn	Small ring cairn with stony bank paired with Cefn Bryn 23.
Cefn Bryn 25 (Nicholaston Hall)	250951	188943	Funerary	Cairn	Roughly circular mound with some evidence of disturbance
Cefn Bryn 26	251094	189089	Funerary	Cairn	Low mound, part of cairnfield
Cefn Bryn 28	251164	189108	Funerary	Round Barrow	Small circular mound - difficult to determine whether funerary, but part of cairnfield and similar construction to those that are.
Cefn Bryn 29	251166	189112	Funerary	Cairn	Mound with potential kerb
Cefn Bryn 30	251260	189100	Funerary	Cairn	Small mound (nothing currently visible may be concealed by vegetation.
Cefn Bryn 31	251907	189230	Funerary	Ring Cairn	Badly disturbed ring bank
Cefn Bryn 32	251920	189280	Funerary	Ring Cairn	Now destroyed by road and groundworks associated with telegraph poles.
Cefn Bryn 33	252073	188906	Funerary	Round Barrow	Badly robbed circular mound on main ridge of Cefn Bryn
Graig Fawr Conjoined Group Cairn 2	262380	207180	Funerary	Cairn	Central in a group of cairns.
Great Carn Ring Cairn 1 (Cefn Bryn)	249070	190729	Funerary	Ring Cairn	Excavated ring cairn included deposits with charcoal and cremated bone.

ID	X	Y	Code	Site Type	Description
Great Carn Ring Cairn 2 (Cefn Bryn)	249080	190740	Funerary	Ring Cairn	Excavated ring cairn with kerbing. A radiocarbon date of 3510±60 BP (Birm-1179) cal 1750-1925 BC (1 sigma) and 1685-1990-2030 BC (2 sigma) obtained from charcoal (Ward 1988)
Rhossili Down South 10	242272	189385	Funerary	Cairn	Large circular robbed cairn
Rhossili Down South 11	242280	188529	Funerary	Cairn	Cairn with a central hollow. One of a pair.
Rhossili Down South 12	242276	188912	Funerary	Ring Cairn	Slight bank visible
Rhossili Down South 2	242019	189183	Funerary	Cairn	Mound of sandstone and quartz with potential orthostatic kerb
Rhossili Down South 3	242045	188775	Funerary	Ring Cairn	Rim marked by slight bank
Rhossili Down South 4	242054	188950	Funerary	Round Barrow	Mound with central hollow. Traces of a kerb present.
Rhossili Down South 5	242070	189033	Funerary	Round Barrow	Well defined by ring of quartz conglomerate ring of boulders. Little in way of mound remaining.
Rhossili Down South 6	242128	188687	Funerary	Cairn	Roughly circular stone covered mound.
Rhossili Down South 7	242170	189301	Funerary	Ring Cairn	Small ring cairn
Rhossili Down South 8	242190	188510	Funerary	Cairn	Tentatively identified indistinct cairn
Rhossili Down South 9	242195	188551	Funerary	Cairn	One of pair. Roughly circular mound with central hollow.
The Beacon (Rhossili Down South 1)	241999	188867	Funerary	Cairn	Possible remains of a kern beneath a now augmented summit cairn.

Table 31: Bronze Age Funerary Evidence on Gower

ID	X	Y	Code	Site Type	Description
Cairn Rhossili Down	241790	189940	Monument	Cairn	Robbed cairn - no indication of funerary use.
Cairn/Round Barrow, Rhossili Down	241970	189220	Monument	Cairn	Well preserved circular feature with dished centre, which potentially could be the result of robbing. No evidence of funerary use.
Graig Fawr	262040	206987	Monument	Cairn	Low roughly circular mound not thought to be funerary.
Tor Clawdd Ringwork	267030	206307	Monument	Ringwork	Ringwork of unknown use.
Graig Fawr (East) Cairn	262253	206539	Monument	Cairn	Circular cairn situated on local rise in undulating moorland. No clear use.
Bon Y Maen Standing Stone	267852	195250	Monument	Standing Stone	Rectangular sandstone standing stone with apparent pecking.
Burry Lesser Standing Stone	246216	190083	Monument	Standing Stone	Rectangular standing stone originally one of an alignment of 3 recorded in 1784. Same as Burry Menhir? Apparently reset in recent times.
Burry Standing Stone	246886	189184	Monument	Standing Stone	Triangular standing stone related to inhumation (see funerary table)
Carn Twyn (Pant-Y-Ffa)	261835	202708	Monument	Cairn	Largely robbed out cairn - nothing has been identified within it.
Cefn Bryn	248869	190718	Monument	Cairn	Oval grass-covered stone mound

ID	X	Y	Code	Site Type	Description
Cefn Bryn Hengiform Monument	249343	190375	Monument	Hengiform	Circular monument with ditch and external bank.
Cockett Standing Stone, Cockett	262533	194799	Monument	Standing Stone	Quartz conglomerate standing stone
Graig Fawr Cairn	262624	206691	Monument	Cairn	Ill-defined cairn
Graig Fawr Conjoined Group (Ring Cairn 4)	262334	207206	Monument	Conjoined cairns	Three conjoined circular earthworks in a line. Interior of cairns has been robbed out.
Hardings Down Cairn	243817	190533	Monument	Cairn	Well defined sub-circular cairn. No evidence of cist or ditch surrounding mound.
Kilvey Hill 1	267240	194026	Monument	Cairn/beacon platform	Potential cairn/beacon platform
Llancadle-Fach	263861	197795	Monument	Tumuli	One of two tumuli, heavily ploughed out. No accompanying archaeology. Second could not be verified.
Llanmadoc Hill 01 (Gm578)	242975	192426	Monument	Round Barrow	Potential inner revetment, but poorly defined barrow, no recorded accompanying archaeology.
Longstone Field	242110	192460	Monument	Standing Stone	Early maps show four standing stones. Depicted until 1948
Mansel Jack; Samson's Jack	247665	192148	Monument	Standing Stone	Rectangular standing stone now incorporated into field boundary.
Mynydd Garn Fach	265093	206438	Monument	Cairn	Large stone cairn on summit.
Mynydd Pysgodlyn Cairn	263410	204761	Monument	Cairn	Highly robbed cairn on summit

ID	X	Y	Code	Site Type	Description
Mynydd Y Gwair	266191	206882	Monument	Cairn	Roughly oval shaped cairn
Oldwalls Standing Stone 1	248427	191973	Monument	Standing Stone	Large standing stone
Oldwalls Standing Stone 2	248687	192011	Monument	Standing Stone	Smaller standing stone
Pen Y Cwar	263328	208250	Monument	Cairn	Severely robbed cairn
Penlle'rbebyll Ring Cairn	263507	204826	Monument	Ring Cairn	Roughly oval shaped cairn
Reynoldston Standing Stone, Site Of	248110	189940	Monument	Standing Stone	Large standing stone, no longer there.
Ty'r Coed Standing Stone	247568	191687	Monument	Standing Stone	Large trapezoidal standing stone
Cae'r Fynwent (Penlle'r Fynwent), Clydach	270100	202700	Monument	Possible ring ditch	Possible ring ditch
Cefn Bryn 21	250427	189516	Monument	Cairn	Slightly crescentic mound open at south side. Does not appear to be funerary
Cefn Bryn 22	250461	189555	Monument	Cairn	Pear shaped mound, does not appear to be funerary
Cefn Bryn 27	251134	189135	Monument	Cairn	Shapeless mound, unlikely to be funerary

Table 32: Bronze Age Monument Evidence on Gower

ID	X	Y	Code	Site Type	Description
Bronze Age Hoard, Langrove	256000	189000	Hoard	Hoard	Late Bronze Age weapons hoard: socketed axe, spearhead, leaf-shape swords and an arrowhead found in 1827 within in a limestone chasm.

Table 33: Bronze Age Hoard Evidence on Gower

A3.4 Iron Age

ID	X	Y	Code	Site Type	Description
Bacon Hole Cave, Pennard	256040	186820	Activity	Findspot	4 Iron Age rimsherds from urns decorated with horizontal lines found within the cave.
Brynmill Peat Shelf A	263308	191722	Activity	Trackway	Section of trackway made of roundwood within intertidal peat shelf.
Brynmill Peat Shelf B	263370	191740	Activity	Structure	Potential structure consisting of 4 exposed pieces of roundwood. Rest lies unexposed within intertidal peat shelf.
Brynmill Peat Shelf C	263374	191733	Activity	Structure	Potential structure consisting of three pieces of wood/planks some displaying cut marks and woodworking debris. Found within intertidal peat shelf.
Brynmill Peat Shelf D	263414	191758	Activity	Structure	Tangential plank found within intertidal peat shelf
Brynmill Peat Shelf E	263421	191769	Activity	Structure	Single sectional timber located on the edge of intertidal peat shelf.
Brynmill Peat Shelf F	263460	191787	Activity	Structure	Substantial upright timber driven into clay underlying peat.
Footprint In Peat, Swansea Bay	261930	188400	Activity	Footprint	Possible footprint within intertidal peat deposit (no direct dating)
Hollowed Log, Swansea Bay	261920	188420	Activity	Hollowed out log	Large partially hollowed out log dated due to presence in peat - no direct date (on log or peat).
Minchin Hole (Or Mitchin Hole)	255530	186880	Activity	Findspot	Number of Early Iron Age pot sherds, none earlier than 50AD.
Parallel Timbers, Swansea Bay	261930	188390	Activity	Structure	Two recumbent parallel timbers suggested to represent a jetty. Dated due to presence within the peat - no direct date.

ID	X	Y	Code	Site Type	Description
Possible Worked Timber, Swansea Bay	261930	188420	Activity	Findspot	Large timber eroding out of intertidal sediments possibly worked.
Site Name Not Known	241600	193000	Activity	Findspot	IA pottery found
West Cross	262500	189800	Activity	Findspot	Iron spear tip
Worked Wood, Swansea Bay	261920	188420	Activity	Findspot	Possibly worked wood embedded in peat. Dated due to proximity to peat - no direct date.

Table 34: Iron Age Activity Evidence on Gower

ID	X	Y	Code	Site Type	Description
Earthwork, Llanrhidian Higher	254250	193650	Settlement	Enclosure	Circular earthwork, suggested to be IA homestead enclosure
Enclosure on Rhossili Down	242300	189800	Settlement	Enclosure	Cashel'-like enclosure surrounded by low stone wall with some evidence of orthostatic facing stones inside the enclosure

Table 35: Iron Age Settlement Evidence on Gower

ID	X	Y	Code	Site Type	Description
Blackpill	262000	190000	Funerary	HSR	Human skull found on foreshore suggested to be 2000BP - no direct date

Table 36: Iron Age Funerary Evidence on Gower

ID	X	Y	Code	Site Type	Description
450m Southwest Of Llandewi Church	245570	188760	Defence	Hillfort	Bank and ditch remain, but site is well ploughed.
Berry Wood	247230	188470	Defence	Hillfort	Roughly circular, non-concentric ringwork.
Bishopston Valley Promontory Fort	256930	187800	Defence	Promontory Fort	Promontory defended by two deep rock cut ditches separated by a bank. No visible internal features.

ID	X	Y	Code	Site Type	Description
Blue Pool Bay	240780	192880	Defence	Enclosure	30m diameter enclosure deemed to be defensive due to position close to cliff.
Burry Holms Hillfort	239880	192580	Defence	Hillfort	Rampart and ditch cut across Burry Holms island. No further sign of occupation within the enclosure.
Carn Nicholas	267550	194340	Defence	Hillfort	Oval enclosure on N side of Kilvey Hill.
Cilifor Top	250550	192400	Defence	Hillfort	Strongly defended hillfort on the summit of an isolated ridge.
Crawley Rocks Promontory Fort, Nicholaston Burrows	251880	187960	Defence	Promontory Fort	Promontory fort on limestone outcrop in Crawley woods consisting of two banks and ditches across the neck of the promontory.
Earthwork Near Fforest Newydd	263630	201550	Defence	Enclosure	Oval enclosure defined by wide earthen bank.
The Bulwark	244300	192750	Defence	Hillfort	Hill slope fort protected by multiple banks and ditches.
The Knave Promontory Fort	243180	186370	Defence	Promontory Fort	Defended by ditch and bank.

ID	X	Y	Code	Site Type	Description
Thurba Head Camp, Promontory Fort	242200	187050	Defence	Promontory Fort	Complex promontory fort on irregular topography protected by 3 lines of defence in the form of earth and stone banks and ditches.
Tor-Gro	246100	193550	Defence	Hillfort	Small half oval enclosure on highest point of the ridge.
Worms Head, Promontory Fort	239350	187550	Defence	Promontory Fort	Faint remains of promontory fort on summit of the Inner Head protected by single line of defence.
Yellow Top Promontory Fort	243700	185960	Defence	Promontory Fort	Narrow promontory defended by naturally steep slopes on 3 sides and 4 ditch/bank lines of defence to the NE. 6 vague platforms visible inside defences.
Stembridge Camp	246970	191450	Defence	Promontory Fort	Protected by natural topography and bank and ditch.
North Hill Tor Camp (Ringwork)	245300	193810	Defence	Promontory Fort	Ringwork defended enclosure on promontory.

Table 37: Iron Age Defence Evidence on Gower

Appendix 4: Methods statement for the archaeological investigation of the prehistoric landscapes at Broughton Bay and Port Eynon – information for landowners following initial survey

Fieldwork will be undertaken at two locations initially; Broughton Bay and Port Eynon. The fieldwork will be split into two separate stages, beginning with a topographic exploratory survey to identify the full extent of the peat outcrops. The second stage will involve the taking of samples for analysis.

A4.1 Broughton Bay:

The Royal Commission lists the submerged forest and peat deposits at Broughton Bay, claiming they were first recorded in 1931 (RCAHMW 2006), but until now no official palaeoenvironmental or archaeological investigation appears to have been carried out.

A4.2 Port Eynon:

The exposure is again listed by the Royal Commission, but other than its position no further information is recorded (RCAHMW 2013). The recent discovery of prehistoric footprints has provoked interest in the site, but due to lack of funds the local archaeological unit has only been able to record the print and has been unable to conduct any further analysis or dating (Hill 2014).

Both sites have been visited to visually assess the extent of the peat exposures. At Broughton Bay they appear at the eastern end of the beach in front of the caravan site. There are 3 distinct exposures around 86m wide and extending 350m from the top of the beach into the intertidal zone (see Figure 105). It is plausible that these exposures are linked beneath the sand and may extend further down the beach as well width-wise than observed during the preliminary viewing. It is hoped that the topographic survey will assist in defining the edges of this exposure. At Port Eynon the peat was exposed from the eastern edge of the sailing club slipway extending 400m along the beach. Peat was visible between the mean high water and the mean low water marks (see Figure 105). Again pockets of sand covered areas, but it is likely that the deposit continues beneath the sand.

The visible edges of the exposure were recorded during the preliminary visits using a hand held GPS and can be seen in Figure 104 and 106. The proposed area of investigation is also outlined.

It is important to note that exact positions for the removal of samples will not be known until sediments have been assessed, but that they will be taken from within proposed area of investigation and therefore either on the beach or within the intertidal zone.

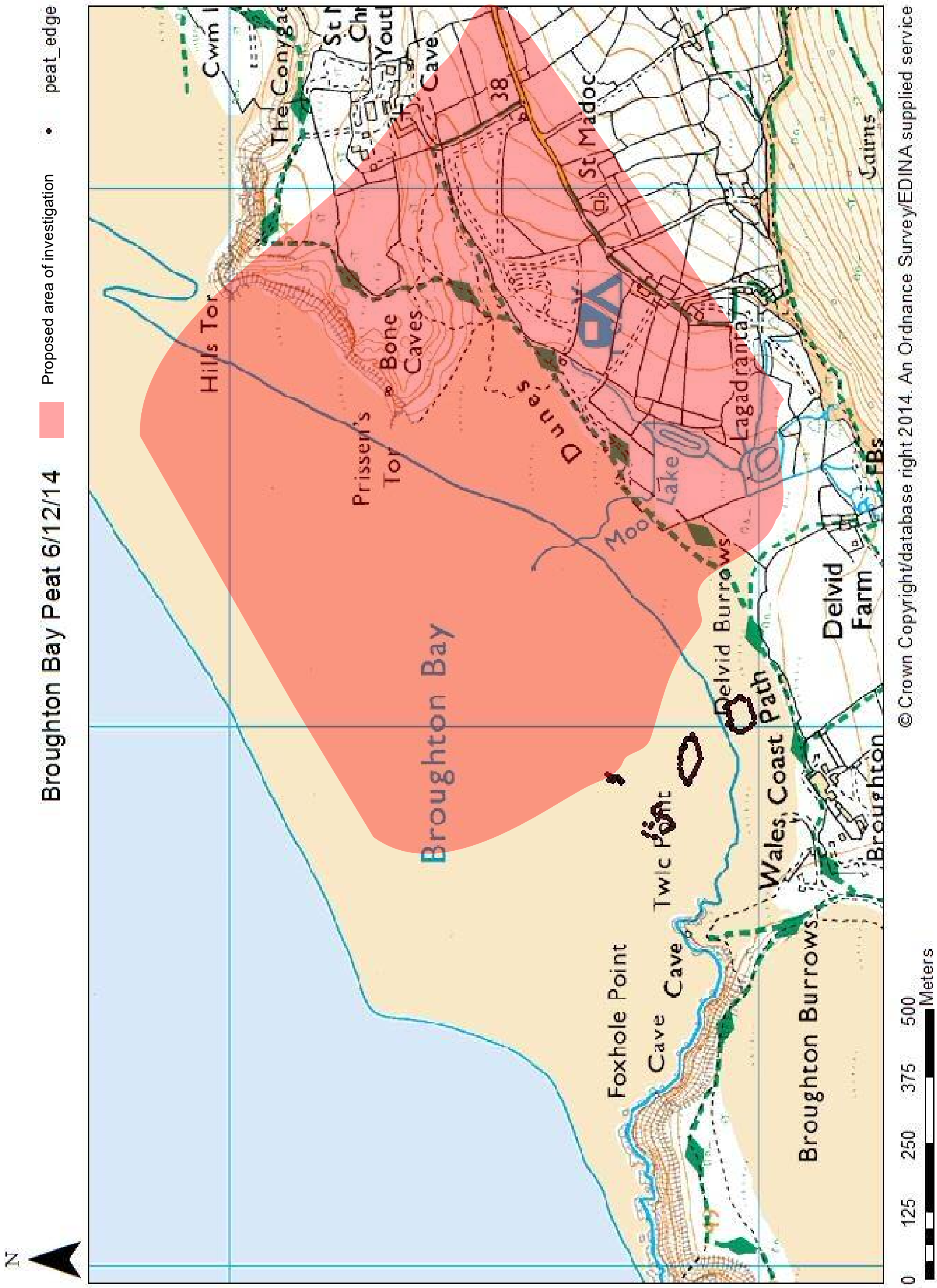

Figure 104: Peat extent on 6/12/14 and proped area of investigation at Broughton Bay

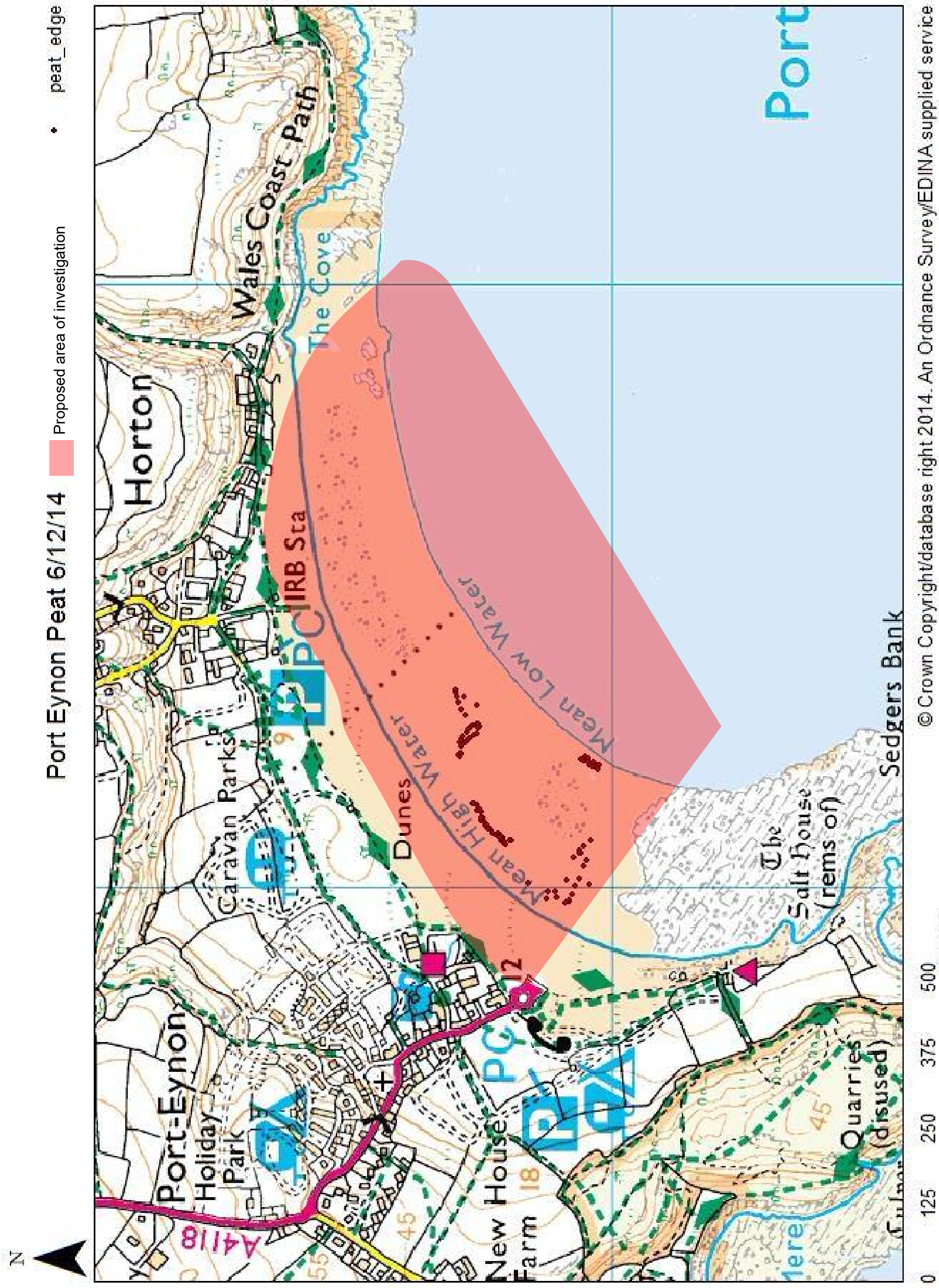

Figure 105: Peat extent on 6/12/14 and proposed area of investigation at Port Eynon

A4.3 Field Methodology:

Topographic Survey:

The aim of the topographic survey is to establish the full extent of the peat outcrop(s) at each location, reconstruct the topography of the past landscape and to acquire accurate height measurements from the peat surface for later sea level reconstructions.

In order to conduct the survey, a *survey grade* GPS base station and rover will be needed along with an Edelman auger (an exploratory auger used for initial sediment investigation – the auger does not take a core, but allows for quick spot testing).

The GPS will be used to set out a grid from which to work systematically across the beach. The topography of the beach will be recorded at the same time, applying the height data of the sand on that particular day at each point (note the topography of the beach will change after each tide so this will only create a snapshot for that specific low tide. It will be useful in measuring the height of buried peat deposits however as detailed below). Each grid point will be situated at 5m intervals and will have its own unique ID number. If peat is visible at surface level, the position and height will be recorded for that point using the GPS. If sand is present at a grid point the Edelman auger will be used to cut through the sand into any surviving deposits beneath. If the sand's thickness is minimal, it should be possible to clear the sand and take an accurate height reading of the buried layer using the GPS. If it is thick, or the water table is high at a particular grid point, it may be necessary to measure the auger itself from the point on the shaft in line with the surface of the sand to the top of the peat within the auger chamber. This will be noted for the grid point ID and later will be subtracted from the corresponding surface peat data. The thickness of the peat layer and depth of deposits to bedrock will also be measured at a number of points.

Alternatively, a total station and staff may be used. This will require the total station to be tied into an exact position on the grid, either by leaving a fixed point to return to with GPS at a later date, or by triangulating the position using back sights from absolute positions such as the corners of buildings or other permanent structures. The grid will need to be set up either using tapes and the 7.7m diagonal method and then each points position measured using the total station or by using the total station itself to measure out positions. To do this the total station will need to be set up on a baseline from which to measure grid points from. Both methods will take a lot longer than using GPS and so will require more beach time, which will need to be factored in with tide times in order to take as much advantage of the receding tide as possible.

All data will be compiled into a GIS database, mapping both current and past landscapes in three dimensions.

Aerial Photography:

Aerial shots of the sites will be taken using a Phantom 2 remote operated drone with GoPro camera attached. It is hoped that these can be taken during fieldwork in order to acquire an accurate picture of the extent of deposits within the survey area at the time of survey.

Palaeoenvironmental sampling:

It is hoped that both topographic and palaeoenvironmental surveys can be conducted in a co-ordinated programme so as to gather the most accurate snapshot as possible from the evidence to hand. Height data will be particularly sensitive as erosion between topographic survey and sample collection may change the topographic character of the site and so samples taken may not reflect the original survey.

Sampling methods will depend on the conditions faced on the day. Gouge and power augers will **not** be used due to inaccuracies when sourcing radiocarbon dates from samples, first highlighted by Ratcliffe and Straker (1996). Instead it is proposed that a Russian corer will be used in order to obtain an uncontaminated and intact sample. A secondary option may be to dig a slot through deposits and take a monolith from the section created. Use of this option will depend on the thickness of deposits – too deep and the digging of a trench may be presented with difficulties due to the height of the water table, or in pure safety terms due to instability of the section. Suitability will be assessed on a sample by sample basis.

A4.4 Proposed Fieldwork Dates:

It is proposed that fieldwork will take place between 18th-23rd February 2015 and 19th-23rd March 2015. These dates have been chosen for their extreme low tides. 2015 will host the lowest tides until 2026 and so it is important to take advantage of these. By choosing the lowest tides, the time window for investigation is extended allowing for a more comprehensive survey, which should negate mistakes in terms of positioning or missing evidence. This also supports the "snapshot" ideal; obtaining as much accurate information about a site at one particular point in time, in order to create a control from which to conduct any future comparisons. On a more basic level, the lower tides allow for a larger area to be surveyed, meaning the optimum amount of evidence can be analysed. This will be particularly important when taking the samples themselves, as it is expected that deposits further into the intertidal zone have been subject to better preservation due to lack of exposure to drying conditions and perhaps greater protection from overlying sediments. This will have to be verified during fieldwork.

A4.5 Access:

All sites will be accessed via public access points.

A4.6 Health and Safety:

The intertidal zone is a high risk study area. The conditions are constantly changing and there are many dangers to those undertaking fieldwork. A risk assessment will been created highlighted all possible risks.

Tide times will be monitored daily along with weather conditions. All team members will be made aware of the predicted time of turn of tide and a latest time to turn back up the beach. No investigation will be undertaken past the lowest tideline. This would require resources unobtainable by the project at this time and would have far more safety implications due to the dangerous sea conditions within the Bristol Channel. In place of such investigations, results from projects such as the West Coast Palaeolandscapes Project, which used equipment such as side scan sonar to attempt to image the floor of the channel (Fitch et al. 2011).

Lone working will be avoided where possible. Most fieldwork tasks will require at least 2 people to complete, and the more workers involved, the more efficient data collection should be. All fieldwork will be conducted within daylight hours.

All fieldworkers will carry a mobile phone and each team a two-way radio. Regular contact will be maintained and all workers should be in sight of their colleagues. All workers will wear high visibility clothing where possible. Emergency service numbers will be held by all participants and emergency scenarios agreed on.

Towards the lower tide levels it will be important to assess underfoot conditions. Where water and sand or basal sediments mix there may be a risk of quicksand forming. Underfoot conditions will be assessed cautiously and areas deemed dangerous will be avoided. This will be especially important towards the turn and on the incoming of the tide. An exit strategy will always be kept in mind.

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Appendix 5: Fieldwork Risk Assessment

Project

The Changing Tides Project: Fieldwork for PhD Research

Name of Assessor	Date of original Asessment	Date of Update(s)
R. PHILP	10 FEBRUARY 2015	**11 MAY 2015**

Brief description of the activity and its location

The project requires fieldwork to be undertaken in the intertidal zone at Port Eynon and Broughton Bay on the Gower Peninsula. The project includes staff, postgraduate students, undergraduate students and volunteers from Cardiff University as well as external individuals. Tasks include equipment set up, topographic survey, augering, and recording in a tidal environment. Tasks will be undertaken over the course of the year, specificially during low spring tide events to ensure safety and maximum survey time. Travel to and from site will be from Cardiff by car on a daily basis. No overnight accomodation is required.

Activity	Description of Hazard	Overall Risk[1]	Likelihood[2]	Severity[3]	Control measures
GENERAL					• Staff & students to receive this RA & to be given site specific briefing.
1. TRANSPORT TO AND FROM SITE	1.1 Vehicle/pedestrian accidents, etc.	5	1	5	• Assessed/experienced drivers only.
	1.2 Collision with other vehicle on public highway.	5	1	5	• Drivers briefed to take care.
	1.3 Injury from unsecured equipment, tools and other objects in the event of a sudden halt	5	1	5	• All tools and equipment objects to be fastened down or and securely separated from personnel.
3. PEDESTRIAN MOVEMENT AROUND SITE	3.1 Trip, slip and fall	4	1	4	• All staff/students to wear appropriate footwear on site at all times and use caution. • High visibility vests to be worn as required • Care to taken when moving around site • Hazards to be identified
	3.2 Intertidal conditions underfoot: quicksand/soft sediments.	5	2	4	• Tidal conditions constantly monitored. • All staff/students to be briefed on tidal conditions and times and to take extra care towards the low tide mark. • All staff/students to be briefed on what to do if trapped in quicksand. • Visual contact to be maintained at all times. • Lone working avoided • All fieldwork conducted within daylight hours.
4. FIELDWORK ACTIVITES	4.1 Sharp/heavy tools	6	2	3	• Staff/students trained to use tools safely; (e.g. spade, auger, monolith tins, mallet) • Tools maintained regularly.
	4.2 Lifting strain	3	1	3	• Staff/students trained in lifting techniques. • Equipment shared out between all able team members for carrying onto site. • Auger to be controlled by two team members when extracting from the sediment.
5. HANDLING ARCHAEOLOGICAL MATERAL	5.1 Handling archaeological materials such as bone and pottery.	3	1	1	• Cover cuts • Wash hands after activity • Antibacterial cleaner to be available
	5.2 Damage by sharp archaeological objects.	3	1	1	• Handle carefully, • Allow to be used only in controlled manner.

[1] Risk = Likelihood x Severity. A score of 0-5 = low (no further action needed), 6-15 = medium (appropriate additional control measures to be implemented), 16-25 = high (implement appropriate control measures as a high priority)
[2] Likelihood rated from 1 (very unlikely) to 5 (almost certain)
[3] Severity rated from 1 (no injury or illness) to 5 (fatality, disabling injury)

Activity	Description of Hazard	Overall Risk[4]	Likelihood[5]	Severity[6]	Control measures
6. WEATHER	6.1 Sunburn / heat stroke	4	4	1	• Staff/students instructed to take extra care in sunny conditions (use sunblock, keep skin covered, wear hat, drink water); • Morning and afternoon 'tea' breaks; • Shade available for cover.
	6.2 Wet/Cold weather – Exposure/hypothermia	4	4	1	• Staff/students to provide & wear waterproofs and extra layers. • Cover available on/near site. • Hot drinks flasks to be kept to hand.
7. TIDE	7.1 Cut off by the tide	6	2	4	• Tide times to be monitored. • Attention to be paid to the state of the tide, particularly once it has turned. • Enough team members present to carry equipment away from encroaching tide and assist anyone in need.
8. BEHAVIOUR	8.1 Conflict	3	1	3	• Staff/students to be polite at all times • Staff/students to avoid all potential conflicts

[4] Risk = Likelihood x Severity. A score of 0-5 = low (no further action needed), 6-15 = medium (appropriate additional control measures to be implemented), 16-25 = high (implement appropriate control measures as a high priority)
[5] Likelihood rated from 1 (very unlikely) to 5 (almost certain)
[6] Severity rated from 1 (no injury or illness) to 5 (fatality, disabling injury)

Appendix 6: Foot length and height source data

		Foot length cm			
Number	**Height cm**	**Male**	**Female**	**Children**	**Age**
1	155	29.5			
2	160	26			
3	161.00	25.00			
4	161.00	26.00			
5	163.00	26.00			
6	163	23			
7	168.0	27.0			
8	169.0	26.0			
9	169.0	26.0			
10	170	25			
11	170.0	25.0			
12	170.0	25.3			
13	170.0	25.3			
14	170	26			
15	170	27.5			
16	171.5	26.0			
17	172.5	25.0			
18	173	23			
19	173.0	25.0			
20	173.0	25.0			
21	173	72			
22	173	27.5			
23	173	26.5			
24	174	24			
25	174.00	24.00			
26	174.0	25.0			
27	175.0	26.0			
28	175	26			
29	175.0	26.0			
30	175.00	26.00			
31	175.00	26.00			
32	175.0	27.0			
33	175.0	28.0			
34	175	28			
35	175	27			
36	175	27.5			
38	175	29.5			
39	176.0	26.0			

		Foot length cm			
Number	Height cm	Male	Female	Children	Age
40	177.0	26.0			
41	177.0	27.0			
42	177	27			
43	178.0	23.0			
44	178.00	24.00			
45	178.0	25.0			
46	178.0	26.0			
47	178.0	26.0			
48	178.0	26.0			
49	178.0	26.0			
50	178	27			
51	178.0	29.0			
52	178.0	29.0			
53	178	26.5			
54	178	27.5			
55	178.50	26.00			
56	179.0	25.0			
57	179.0	26.0			
58	179.0	27.0			
59	179.0	29.0			
60	180.00	25.00			
61	180	25.5			
62	180.0	26.0			
63	180.00	26.00			
64	180.0	27.0			
65	180.0	27.0			
66	180.0	27.0			
67	180.00	27.00			
68	180.0	27.4			
69	180.0	27.4			
70	180	30			
71	180.50	28.00			
72	181.0	27.0			
73	182	23			
74	182.00	25.50			
75	182.0	26.0			
76	182.0	26.2			
77	182.0	26.2			
78	182	28			
79	183.0	26.0			
80	183.0	26.0			
81	183.0	26.0			

		Foot length cm			
Number	Height cm	Male	Female	Children	Age
82	183.0	26.0			
83	183.00	26.00			
84	183.00	26.00			
85	183.0	28.0			
86	183.0	28.0			
87	183.00	28.00			
88	183.00	30.50			
89	183	29			
90	183	28			
91	184.0	26.0			
92	184.0	27.0			
93	184.0	27.5			
94	185.0	24.0			
95	185	25			
96	185.0	26.0			
97	185.0	27.0			
98	185.0	28.0			
99	185	29.5			
100	185	28			
101	186.0	27.0			
102	186.0	27.0			
103	187.0	27.0			
104	187.0	27.0			
105	187	27			
106	187.0	27.5			
107	188.0	26.0			
108	188.0	26.0			
109	188.0	28.0			
110	188.0	28.0			
111	188.0	29.5			
112	188	29			
113	188	28			
114	188	27.5			
115	188	28.5			
116	188	30.5			
117	189	27			
118	189.0	30.0			
119	189.5	30.5			
120	190	28			
121	190	28			
122	190.00	28.00			
123	191	28.5			

		Foot length cm			
Number	**Height cm**	**Male**	**Female**	**Children**	**Age**
124	192.5	29.2			
125	193	28			
126	199	31			
127	201.00	30.00			
128	203.00	30.00			
129	174.00	25.00			
130	177.00	28.50			
131	178.00	28.00			
132	180.00	26.00			
133	190.00	28.00			
134	193.00	29.00			
1	149.00		21.00		
2	150		21		
3	150.0		22.0		
4	150.5		22.0		
5	151.00		24.00		
6	152.0		21.1		
7	152.0		21.1		
8	152.0		22.0		
9	152.0		22.0		
10	152.4		21.6		
11	153		21		
12	154		21		
13	154.0		21.4		
14	154.0		21.4		
15	155		23.5		
16	155.00		27.00		
17	155		24		
18	156.00		23.50		
19	157		20		
20	157.0		22.0		
21	157.0		23.0		
22	157.0		24.0		
23	157.0		24.1		
24	157.00		26.00		
25	157.5		23.5		
26	157.5		23		
27	157.5		24.5		
28	157.5		23.5		
29	158.00		22.00		
30	158.00		22.00		
31	158		23		

		Foot length cm			
Number	Height cm	Male	Female	Children	Age
32	158.5		23.8		
33	159.0		16.4		
34	159.0		16.4		
35	159.00		23.00		
36	159.00		23.00		
37	159.0		24.0		
38	159.0		24.0		
39	160		21		
40	160.0		22.0		
41	160.00		22.50		
42	160.0		23.0		
43	160.0		23.0		
44	160.0		24.0		
45	160.0		24.0		
46	160.00		24.00		
47	160		24		
48	160		25		
49	160		24.5		
50	161.0		21.0		
51	161.0		23.3		
52	161.0		23.3		
53	161		25		
54	162.00		22.00		
55	162.0		23.0		
56	162.0		23.0		
57	162		24		
58	162.5		24.0		
59	163		21		
60	163.0		21.0		
61	163.0		22.0		
62	163.0		22.0		
63	163.0		22.4		
64	163.0		22.4		
65	163.0		25.0		
66	163		24		
67	163		24.5		
68	163		26		
69	164.0		22.5		
70	164		24		
71	164.0		25.0		
72	164.5		24.0		
73	164.5		24.5		

		Foot length cm			
Number	Height cm	Male	Female	Children	Age
74	165.00		22.50		
75	165.0		24.0		
76	165.0		24.0		
77	165.0		24.0		
78	165.0		24.0		
79	165.0		24.0		
80	165.0		24.0		
81	165.0		24.5		
82	165.0		24.5		
83	165.0		27.0		
84	165		25.5		
85	165		23		
86	165		24		
87	165		24.5		
88	165		24		
89	165		24		
90	165		25.5		
91	166.0		23.0		
92	166		23.5		
93	166.0		24.0		
94	166.0		24.0		
95	166.0		24.0		
96	166.0		25.0		
97	166		24.5		
98	167		22.0		
99	167.0		24.0		
100	167.0		24.0		
101	167.0		24.0		
102	167.00		24.00		
103	167.00		25.50		
104	167.0		26.0		
105	167.5		25.1		
106	168.0		22.0		
107	168.0		22.0		
108	168		23		
109	168.0		23.0		
110	168.0		23.0		
111	168		24		
112	168.0		24.0		
113	168.0		24.0		
114	168.0		24.0		
115	168.0		24.0		

		Foot length cm			
Number	**Height cm**	**Male**	**Female**	**Children**	**Age**
116	168.0		24.0		
117	168.0		24.0		
118	168.0		24.5		
119	168.0		24.5		
120	168.0		24.5		
121	168.0		25.0		
122	168.0		26.0		
123	168.0		26.0		
124	168.0		26.0		
125	168		24.5		
126	168		26		
127	168		23.5		
128	169.00		23.00		
129	169		24		
130	169.0		24.0		
131	169.0		24.0		
132	169.00		25.00		
133	169		25		
134	170.00		20.00		
135	170.00		22.00		
136	170		23		
137	170.00		23.00		
138	170.0		27.0		
139	170.0		27.0		
140	170.0		27.0		
141	170		24		
142	170		24		
143	171		24		
144	171.0		25.0		
145	171.0		25.0		
146	172.00		22.00		
147	172.0		24.0		
148	172.0		24.5		
149	172.0		24.5		
150	172.00		25.00		
151	172		25.4		
152	173.0		24.0		
153	173.0		25.0		
154	173.0		25.0		
155	173.0		25.0		
156	173.0		26.0		
157	173		24.5		

		Foot length cm			
Number	Height cm	Male	Female	Children	Age
158	173		26		
159	173		24.5		
160	173		24.5		
161	174.0		24.0		
162	174.0		24.0		
163	174		26		
164	174.0		28.5		
165	175		24		
166	175.0		25.0		
167	176.0		26.0		
168	177.0		24.0		
169	177.0		25.0		
170	177.0		25.0		
171	178.0		25.4		
172	178		26.5		
173	178		26		
174	179.00		24.50		
175	179.0		25.6		
176	179.0		25.6		
177	179.0		27.0		
178	180.0		25.0		
179	180.0		25.0		
180	180.0		25.0		
181	180.0		26.0		
182	181.00		24.00		
183	183		27		
184	152		22		
185	152		23		
186	158		23		
187	162		24		
188	162		24		
189	166		24		
190	166		24		
191	175.0		26		
192	175		26.5		
193	176		26.5		
194	177		26		
1	86			14	3
2	102			14.5	3
3	102			16	
4	110			15	
5	110			15	5

		Foot length cm			
Number	Height cm	Male	Female	Children	Age
6	110			16.5	4
7	122			19	6
8	126			18	
9	126			19	8
10	126			19	8
11	127			20	8
12	128			20	7
13	130			22	8
14	134			20	
15	136			21	8
16	137			20	9
17	137			22	8
18	138			22	10
19	140			21	10
20	144			21	8
21	149			22	9
22	150			22	
23	150			23	10
24	150			24	8
25	155			24	11
26	160			26	12

Appendix 7: Pollen Processing

Pollen processing conducted following standard methods as stated by (Erdtman 1960) *and* (Moore et al. 1991)*.*

PPE:

High-necked lab coat

Vinyl gloves

Rubber gloves

Rubber boots

PVC apron

Protective gauntlets

Protective face shield

HF antidote cream

Equipment List:

Large glass beakers

50ml centrifuge tubes

Test tube stand

Plastic beakers of various sizes

Vortex mixer

Plastic stirring rods

Centrifuge

150µ polyester mesh

Paper clips

1ml disposable pipettes

Plastic funnels

2ml micro-centrifuge tubes

Micro-centrifuge

Exotic Marker:

Lycopodium Tablets

Chemical List (in order of use):

Sodium Carbonate (Na_2CO_3)

Hydrochloric Acid (HCl) 10%

Hydrofluoric Acid (HF) 40%

Distilled water

Sodium Hydroxide (NaOH) 10%

Glacial Acetic Acid (CH_3COOH)

Acetic Anhydride (Ac_2O)

Sulphuric Acid (H_2SO_4)

Absolute Ethanol (C_2H_6O)

Glycerine

Stage 1: Sample Preparation

- Place a beaker containing 200ml of water onto the hotplate to bring to boil.
- Weigh an empty beaker and centrifuge tube, then tare the scales and remove the centrifuge tube.
- Place each centrifuge tube containing a sample into the beaker and record the weight *(8 per batch)*.
- Add one lycopodium tablet to each tube.

Stage 2: Hydrochloric Acid (HCl) Treatment

To dissolve carbonates.

- Fill fume cupboard trough with water and add two scoops of sodium carbonate to the water *(to neutralise decanted chemicals).*
- Rubber gloves must be worn whenever chemicals are being handled.
- Place centrifuge tubes in stand within the fume cupboard and remove lids.
- Add 5ml of distilled water *(to dissolve the lycopodium tablet).*
- Add 10ml of HCl to each sample. Do this carefully initially, to allow for more violent reactions.
- Use a vortex mixer to mix sample into a solution. If this fails to break sample pellet down, use a plastic stirring rod to aid mixing *(be sure to wash stirring rod between each sample)*.
- Place centrifuge tubes, with lids loosened, in a Bain Marie to boil for 15 minutes.
- Once boiled, remove from Bain Marie and tighten lids.
- Place tubes into centrifuge, taking care to balance the machine.
- Centrifuge for 5 minutes at 3000rpm (*speed 7*).
- Decant liquid into fume cupboard trough, taking care to retain the sample pellet.

Stage 3: Hydrofluoric Acid (HF) Treatment

To remove silicates.

This stage should not be conducted without supervision from a trained individual. Make sure all risk assessments have been read and signed, and appropriate training undertaken before using HF. No glass equipment should be used with HF.

HF antidote gel (calcium gluconate) should be kept on hand in the lab and at home in case of contact with skin. If contact made rinse for at least 5 minutes under cold running water, apply antidote cream and transfer casualty to hospital.

- Add more sodium carbonate to the water trough.
- Put on PPE: rubber boots, PVC apron, arm gauntlets, vinyl and rubber gloves and face shield.
- Add 1ml of HCl to each sample.
- Top up each tube to the 15ml line with HF.

- Using a plastic stirring rod, mix each sample, rinsing the rod between each one *(Do not use vortex mixer with HF).*
- Place tubes in a Bain Marie to boil for 20 minutes.
- Remove from Bain Marie and centrifuge for 5 minutes.
- Very carefully decant liquid into water trough *(If water continues to fizz add more sodium carbonate).*
- Add 10ml of HCl to each sample and then top up with very hot distilled water to ¾ full.
- Mix, centrifuge for 5 minutes and decant.
- Fill once again to the ¾ mark with very hot distilled water.
- Mix, centrifuge for 5 minutes and decant.

Stage 4: Sodium Hydroxide (NaOH) Treatment

To raise the pH to alkaline in order to allow humic acids to be put into solution.

- Add 10ml NaOH to each sample.
- Mix using a vortex mixer and place in a Bain Marie for 10-15 minutes *(if a particularly peaty sample aim for the latter).*
- Centrifuge for 5 minutes and decant.
- Fill tube to ¾ full with distilled water.
- Mix, centrifuge for 5 minutes and decant.
- Repeat process until sample is clear.

Break

Stage 5: Acetolysis Treatment

To remove cellulose.

- Add 10ml of glacial acetic acid to each sample.
- Mix using a vortex mixer, centrifuge for 5 minutes and decant.
- Make up the acetolysis solution *(9 parts acetic anhydride to 1 part sulphuric acid)*. For a batch of 8 samples place 54ml of acetic anhydride into a measuring cylinder and 6ml of sulphuric acid into another *(all equipment must be dry to avoid unwanted violent reaction)*. Slowly add the sulphuric acid in small amounts, while mixing with a stirring rod *(this process causes an exothermic reaction and can be explosive, so must be done very carefully)*.
- Add 7ml of the acetolysis solution to each sample.
- Mix using a vortex mixer and place in a Bain Marie for 7 minutes.
- Centrifuge for 5 minutes and decant.
- Add 10ml of glacial acetic acid to each sample.
- Mix using a vortex mixer, centrifuge for 5 minutes and decant.
- Add 10ml of absolute ethanol to each sample.
- Mix using a vortex mixer, centrifuge for 5 minutes and decant.

Stage 6: Sieving

To remove any further unwanted coarse particulates.

- Fold a 15x15cm square of 150µm mesh into quarters and secure three of those corners together with a paperclip.
- Place mesh into a funnel over a beaker.
- Pour sample into mesh and use ethanol to rinse through *(be sure to rinse all residue from the tube)*.
- Gently swirl beaker and then allow to rest for a few seconds to allow any remaining sediment to settle.
- Pour sample back into test tube gently, but firmly; leaving the sediment in the beaker.
- Centrifuge for 5 minutes and decant.
- Pipette remaining sample into micro centrifuge test tube *(a very small amount of ethanol may be required in order to collect entire sample. If it is not possible to collect entire sample, keep the pipette in the corresponding tube and repeat process after centrifuge stage)*.
- Micro centrifuge the samples at 3000rpm for 2 minutes.
- Pour off ethanol and place tube upside down on a piece of hand towel to allow any excess liquid to drain.
- Add a few drops of glycerine *(approximately the same volume as the sample itself)* to each of the samples.

Stage 7: Slide Preparation

- Using a cocktail stick, mix the sample and glycerine until well combined *(mixture should be relatively clear; add more glycerine if necessary – it is sometimes worth doing this in a new test tube)*.
- Place a very small amount of mixture at the centre of the slide *(one drop from the end of the cocktail stick)*.
- Carefully place the coverslip over the sample and use a cocktail stick to ease out any air bubbles.
- Using nail varnish, seal the edges of the cover slip.
- Label slide with sample number.

Appendix 8: PE1 Assessment

In order to assess the viability of the study and test the methodologies outlined above, it was decided to conduct a preliminary assessment on one of the sample cores obtained. Following advice from a professional palynologist it was decided to assess the top and bottom of each sedimentary layer and count 100 pollen grains per sample (Richer pers. comm. 2016). This is standard procedure in the commercial sector in order to quickly ascertain the usefulness of a sample. The results outlined below give a low resolution interpretation of the deposits at the point of sample, which will allow a general overview of the changes in the environment that have occurred. A full analysis of these deposits (500 grains per slide) from a greater concentration of subsamples will now be conducted on all cores in order to give high resolution environmental data across both study sites. The discussion at the end of this report therefore represents a preliminary overview of the data so far and is subject to change.

A8.1 Site:

Column PE1 (see Figure 106) was taken using a combination of a monolith tin (top 25cm) and a Russian Auger. The column records to a depth of 64.5cm below the surface. Surface height was recorded using a survey grade Trimble RTK GPS system. The sequence consists of at least six peat layers interspersed with organic clay and sand layers, indicating a fluctuating environment. It was not possible to sample to the base of the sequence due to tidal restrictions.

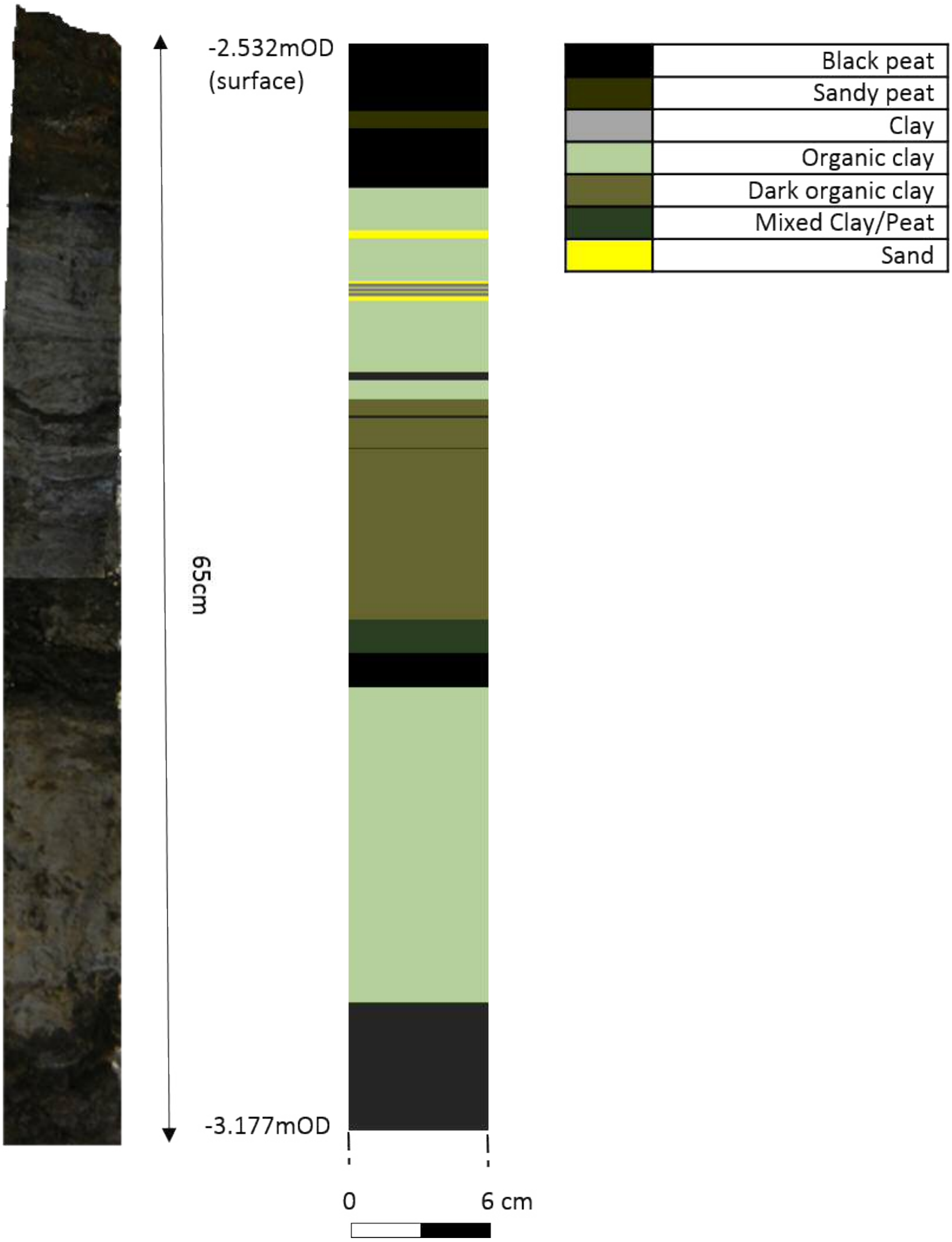

Figure 106: Diagram of PE1 alongside composite photograph of column sample

A8.2 Phases:

The pollen diagram in Figure 107 was plotted using the TILIA and TILIA*GRAPH programmes (Grimm 2015). Zoning was accomplished through the use of the CONISS (Constrained Incremental Sum of Squares) function within the TILIA software package. Zone descriptions can be found in Figure 107.

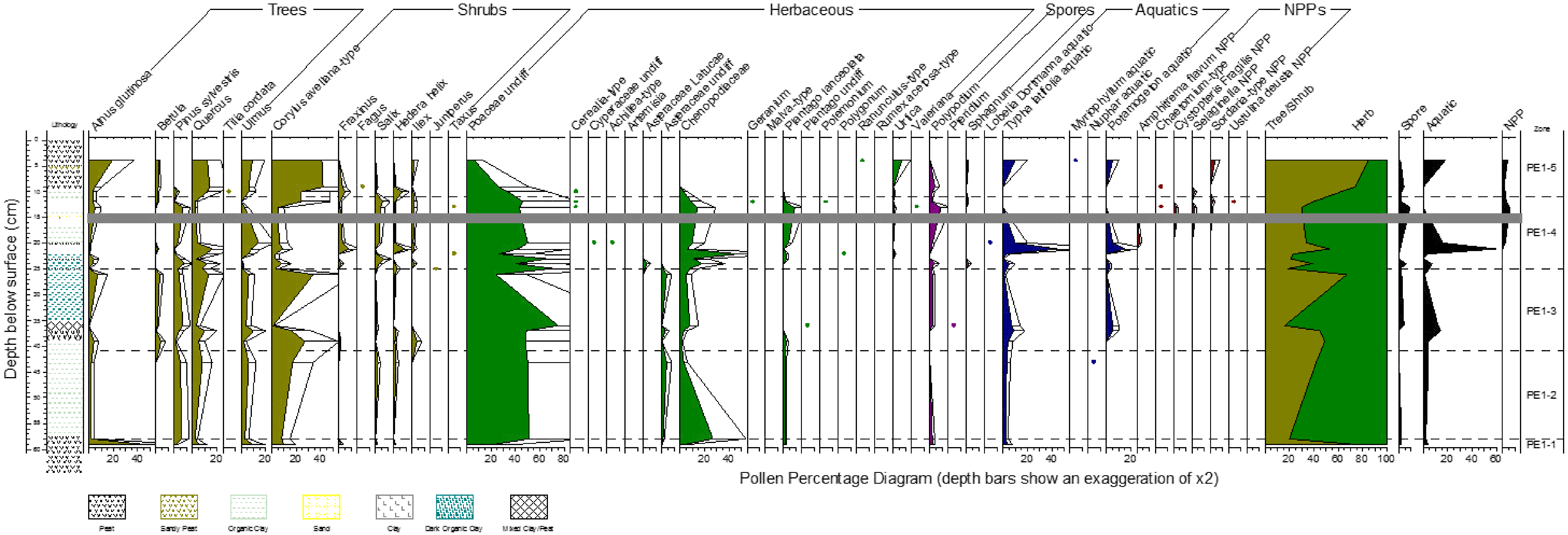

Figure 107: Pollen percentage diagram from PE1

Table 38: Pollen phases from PE1

Phase	Description	Interpretation
PE1-1	The column does not extend completely to the base of the sequence and as such this phase represents the latest stage of the lowest recorded peat layer. Here we see a sharp decrease in *Alnus* along with smaller decreases in *Quercus*, *Ulmus* and *Corylus*. There is a very slight rise in *Pinus*, though this still only represents a very small amount of the pollen and is highly transportable, so could have been blown or washed in from further afield.	The decrease in most tree/shrub pollen is accompanied by a sharp rise in *Poaceae* and *Chenopodiaceae*, suggesting the development of a more open landscape. The presence of Chenopodiaceae may indicate the formation of salt marsh conditions.
PE1-2	High levels of *Poaceae* are maintained throughout this phase. After the peak in *Chenopodiaceae* identified towards the end of PE1-1, levels decrease in conjunction with a rise in *Quercus* and *Corylus* and small spikes in *Ulmus, Salix* and *Hedera Helix* along with *Asteraceae. Alnus* levels appear to remain constant during this phase, as do levels of aquatic pollen *Typha Latifolia*.	Phase 2 displays a period of relatively slow change with high herbaceous percentages suggesting a continuation of the open landscape. The reduction in *Chenopodiaceae* may indicate the movement of the above mentioned salt marsh further away from the point of sample, which consequently might indicate a sea level regression. Steady levels of *Typha Latifolia* might suggest development of more brackish conditions. N.B. It must be noted that very few samples have been taken within this layer resulting in very low resolution. Ordinarily this would not constitute to a phase, but it has been included due to its clear difference in character with the preceding and succeeding phases. This is an area of the column that requires further subsampling in order to aid more in depth analysis.
PE1-3	*Poaceae* is the dominant taxa in this phase, reaching a peak as the sediments change from a mixed clay/peat to a dark organic clay. This corresponds with a small peak in *Chenopodiaceae.* Prior to this peak there is a small rise in aquatics *Typha latifolia* and *Potamogeton.* As the mixed layer accumulates, herbaceous species decline, corresponding with a substantial increase in *Corylus* and smaller increases in arboreal pollen such as *Alnus* and *Quercus.* At the boundary between phases 3 and 4 there is another spike in *Poaceae* corresponding with dips in most arboreal and shrub taxa.	The high concentration of *Poaceae* suggests an open environment with a possible salt marsh influence evident from relatively high levels of *Chenopodiaceae* after the initial peak at the beginning of the phase. Deciduous woodland appears to flank this environment, becoming more dominant towards the top of the mixed peat/clay layer. N.B. This phase is again low in data resolution. Further subsamples from this section of the column will be investigated as part of the full analysis of the sample.
PE1-4	At the beginning of the phase there are a number of spikes and dips over a relatively small depth in the sequence. These changes correspond to thin layers of overlying clay and peat. Peaks in the herbaceous taxa; *Poaceae* correspond as might be expected with dips in arboreal and shrub taxa such as *Alnus, Quercus* and *Corylus* and vice versa. Interestingly, a peak in *Chenopodiaceae* appears to coincide with peaks in the aquatic taxa including *Typha latifolia* and *Potamogeton.* Each of these counts are the highest within the entire column, suggesting this is the point where they are at their greatest influence. Towards the centre of this phase, between 14.8 and 16.2cm below the ground surface, seven thin layers of sand and clay occur, in which no pollen survives. After this phase we see another small spike in the herbaceous taxa and fall in arboreal and shrubs. This is also the point that NPPs begin to be identified, including *Cystopteris Fragilis, Selaginella* and *Sordaria*-type, albeit in very small quantities. These taxa are all found within an organic clay.	Possibility of episodes of rising and falling sea levels. Relatively open environment, with herbaceous taxa dominating throughout despite peaks and troughs. This suggests movement between saltmarsh and reed swamp in an area skirted by deciduous woodland. The small quantities of NPPs may indicate the presence of animal faeces, which could suggest livestock if associated with other anthropogenic factors.
PE1-5	*Poaceae* and *Chenopodiaceae* levels decline, while *Alnus* and aquatic taxa such as *Typha latifolia* increase sharply. *Quercus, Ulmus,* and *Corylus* also increase substantially at the beginning of the phase, but levels appear to stabilise after the initial rise. A small selection of NPPs including *Sordaria*-type are also present. These changes coincide with a change in sediment from organic clay to peat.	The decrease in herbaceous taxa suggests the landscape is once again becoming more enclosed and the appearance of aquatics dominated by *Typha latifolia* suggests a reed swamp type environment. The spike in *Alnus* might also suggest Alder Carr. Presence of NPPs such as *Sordaria*-type can indicate animal faecal remains, which could suggest the occurrence of livestock in the area. Likely that salt marsh in nearby, but receding, due to declining *Chenopodiaceae.*

A8.3 Discussion:

During the peat phases we see spikes in arboreal taxa and shrubs, in particular *Alnus glutinosa*, *Quercus*, *Ulmus* and *Corylus avellana-type* along with aquatic plants such as *Typha latifolia* and *Potamogeton.* Levels of herbaceous taxa, for example *Poaceae*, are generally lower or receding within these phases, suggesting the environment is more enclosed and wet. The species recorded would suggest a mixture of alder carr and deciduous woodland, along with the presence of reed beds. The footprints were made within this type of landscape, perhaps in the shallows at the wetland edge.

In between the peat accumulation phases, organic clay deposits have formed. These tell a different story to the peat, containing much higher levels of herbaceous species and lower levels of arboreal taxa and shrubs. This would suggest a much more open environment. The main species constituents within these levels are *Poaceae* and *Chenopodiaceae*. The presence of the latter is indicative of the formation of salt marsh conditions and could suggest a period of sea level rise. Interestingly peaks in *Chenopodiaceae* appear to be followed by peaks in *Typha latifolia* and *Potamogeton*, suggesting periods of sea level regression allowed the re-establishment of freshwater conditions.

Early indications seem to suggest that although comparisons can be drawn between this site and the two case studies in terms of certain layers, the full sequence recorded at Port Eynon does not appear to be replicated at either of the other sites.

Sea Level Change:

It is an undeniable fact that this site has been affected by sea level change. The past landscape now sits within both submarine and intertidal environments. However the pollen and sedimentary evidence appear to show that the changes in sea level were not just one linear rise, but part of a series of rises and consequent regressions. The physical column itself hinted at such a sequence, with depositions of peat interspersed with clays.

The apparent establishment of salt marsh at a number of points within this column indicates that sea levels rose to such a point that this area became intertidal. This does not mean the site was directly coastal at the point of deposition, but it indicates that the coast had moved inland and was closer than it had been when freshwater or woodland deposits were being laid down. Likewise, where we see movement from salt marsh back to freshwater or woodland deposits, it suggests that sea levels had regressed, taking the salt marsh communities with them, the coastline now further away. The fluctuation in pollen levels happen over relatively small depths of sediment and could suggest these changes in environment happened fairly rapidly. Perhaps even with human timescales.

A further feature to note within the sequence is the occurrence of a succession of seven thin layers of sand and clayey silts between 14.8 and 16.2cm below the ground surface. No pollen was present within this section of the sequence and it is suggested that these layers may be indicative of a number of short-lived and possibly violent events, such as storm surges. This could explain the sand layers, as it is likely they represent sand carried from the coastal edge. Again it could be suggested that these occurred within human timescales.

Archaeological significance:

Though small in number the NPPs such as *Sordaria* present in the upper layers of the column indicate the possible presence of animal dung. This supports evidence from the very top of the sequence, where footprints belonging to possibly domesticated animals have been found alongside human footprints. The presence of these particular NPPs below the surface might suggest the presence of animals was not a new occurrence on the site. Possible cereal pollen have been identified, again towards the top of the sequence, but only in very small amounts (1 or 2 grains in places), which can merely suggest a presence. It must also be remembered, as mentioned earlier in this chapter, that these grains could also be attributed to the coastal grass species *Glyceria* and so confident identification cannot be made in this case.

In terms of the human and animal footprints, based on the current evidence available, it appears that they were made within a reed swamp environment, within reasonably close proximity to both salt marsh and an *Alnus* and *Corylus* dominated woodland. See Footprints chapter for more in depth analysis.

In relation to sea level change, as mentioned above, many of the environmental changes could have occurred within human timescales. The presence of human footprints in a deposit that appears to have represented a transitional waterlogged phase is interesting, as it demonstrates the fact that the prehistoric inhabitants of this landscape were utilising a varied selection of environments and were not avoiding transitional areas.

Appendix 9: Subsample positions for pollen analysis

A9.1 Broughton Bay

cm	0	Br 1		cm	0	Br2		cm	0	Br3	
	1				1		<17>		1		<7>
	2				2				2		<8>
	3		<56>		3				3		
	4				4				4		
	5				5				5		
	6				6				6		
	7				7				7		
	8				8				8		<9>
	9				9				9		<10>
	10				10				10		
	11				11				11		
	12				12				12		
	13				13				13		
	14		<57>		14				14		
	15		<58>		15				15		<11>
	16				16				16		<12>
	17				17				17		
	18				18				18		
	19				19				19		
	20				20				20		
	21				21				21		
	22				22				22		<13>
	23				23				23		<14>
	24				24				24		
	25				25				25		<15>
	26				26		<18>				
	27		<59>		27		<19>				
					28						
					29						
					30		<20>				
					31		<21>				
					32						
					33						
					34						
					35						
					36						
					37						
					38						
					39						
					40		<22>				

cm	0	Br4		cm	0	Br5	
	1				1		<47>
	2		<60>		2		<48>
	3				3		
	4				4		
	5				5		
	6		<61>		6		
	7		<62>		7		
	8				8		<49>
	9				9		<50>
	10				10		
	11				11		
	12				12		
	13				13		
	14				14		
	15				15		
	16				16		
	17				17		
	18				18		
	19				19		
	20				20		
	21				21		
	22				22		
	23				23		
	24				24		
	25		<63>		25		<51>
					26		<52>
					27		
					28		
					29		
					30		
					31		
					32		
					33		
					34		
					35		
					36		
					37		
					38		
					39		
					40		
					41		
					42		
					43		
					44		<54>

A9.2 Port Eynon

cm	0	PE1		cm	0	PE2		cm	0	PE3	
	1				1				1		
	2		<64>		2				2		
	3				3				3		
	4		<23>		4				4		
	5				5				5		
	6		<65>		6				6		
	7				7		<1>		7		
	8				8				8		
	9		<24>		9				9		<43>
	10		<25>		10		<73>		10		
	11				11				11		
	12		<26>		12				12		
	13		<27>		13				13		<79>
	14				14		<74>		14		
	15		<28>		15				15		
	16				16				16		
	17		<29>		17				17		<80>
	18		<66>		18		<75>		18		
	19				19				19		
	20		<30>		20				20		
	21		<31>		21				21		<81>
	22		<32>		22				22		
	23		<33>		23		<2>		23		
	24		<34>		24				24		
	25		<35>		25				25		<44>
	26		<36>		26		<3>		26		<45>
	27				27				27		
	28		<67>		28		<4>		28		
	29				29				29		
	30				30		<5>		30		
	31		<68>		31				31		<82>
	32				32				32		
	33		<69>		33		<76>		33		
	34				34				34		
	35				35				35		
	36		<37>		36		<77>		36		<83>
	37		<38>		37				37		
	38				38				38		
	39		<39>		39				39		
	40				40		<78>		40		
	41				41				41		<84>
	42		<40>		42				42		
	43				43		<6>		43		
	44				44				44		
	45				45				45		
	46		<70>						46		<46>
	47										
	48										
	49										
	50										
	51		<71>								
	52										
	53										
	54										
	55		<72>								
	56										
	57										
	58		<41>								
	59										
	60		<42>								

Appendix 10: Footprint Data

A10.1 3 years old

Probability Density Curve		
Foot size	**Raw counts**	**Prob Dens.**
13	0	0
14	1	0.5
15	1	0.5
16	0	0
Total	2	

Table 39: Probability Density Data for 3-year-old participants

STANDARD DEVIATION	
STDEV	0.353553391
AVERAGE	14.25
+STDEV	14.60
-STDEV	13.90
+2STDEV	14.96
-2STDEV	13.54

Table 40: Standard Deviation Calculations (3yo)

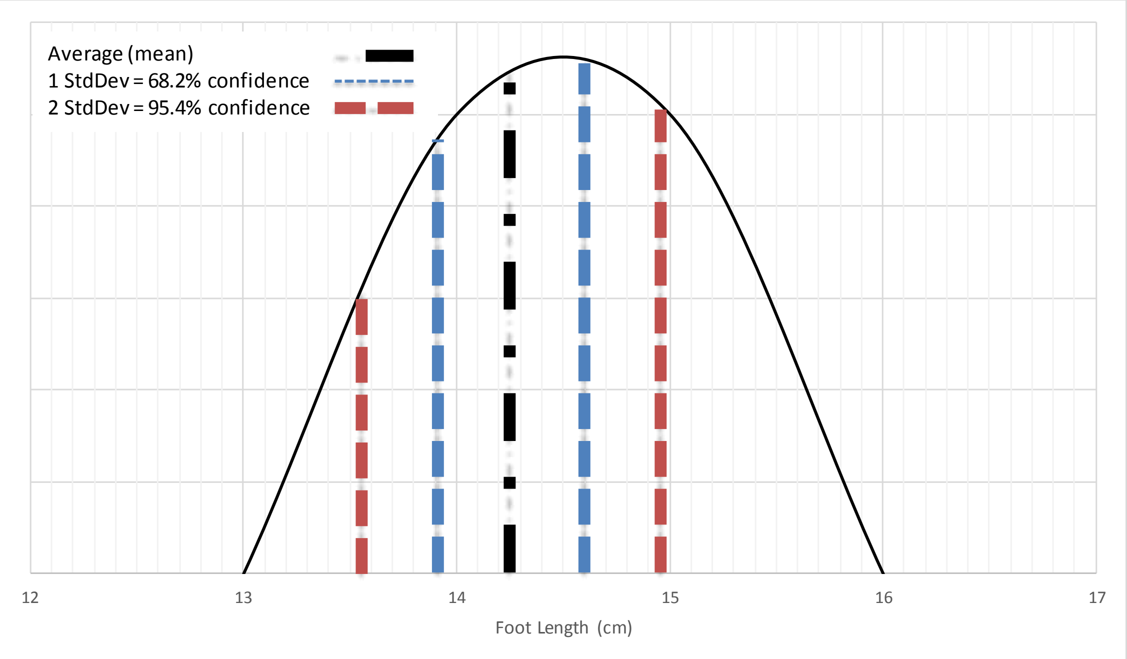

Figure 108: Graph showing probability density curve and confidence parameters calculated by standard deviation to 2-sigma for 3-year-old participants.

A10.2 4-6 years old

Probability Density Curve		
Foot size	**Raw counts**	**Prob Dens.**
14	0	0
15	1	0.25
16	1	0.25
17	1	0.25
18	0	0
19	1	0.25
20	0	0
Total	4	

Table 41: Probability Density Data for 4-6-year-old participants

STANDARD DEVIATION	
STDEV	1.701714821
AVERAGE	16.63
+STDEV	18.33
-STDEV	14.92
+2STDEV	20.03
-2STDEV	13.22

Table 42: Standard Deviation Calculations (4-6yo)

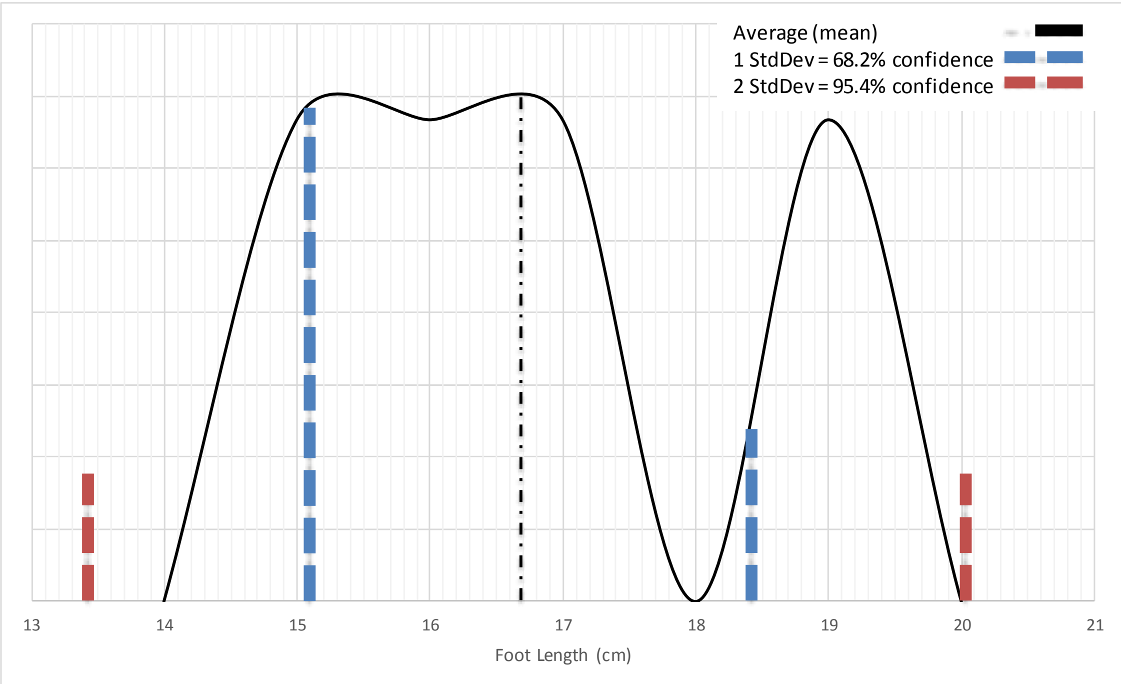

Figure 109: Graph showing probability density curve and confidence parameters calculated by standard deviation to 2-sigma for 4-6 year old participants

A10.3 7-10 years old

Probability Density Curve		
Foot size	**Raw counts**	**Prob Dens.**
18	0	0
19	3	0.157894737
20	4	0.210526316
21	4	0.210526316
22	5	0.263157895
23	1	0.052631579
24	2	0.105263158
25	0	0
Total	19	

Table 43: Probability Density Data for 7-10-year-old participants

STANDARD DEVIATION	
STDEV	1.537066394
AVERAGE	21.16
+STDEV	22.69
-STDEV	19.62
+2STDEV	24.23
-2STDEV	18.08

Table 44: Standard Deviation Calculations (7-10yo)

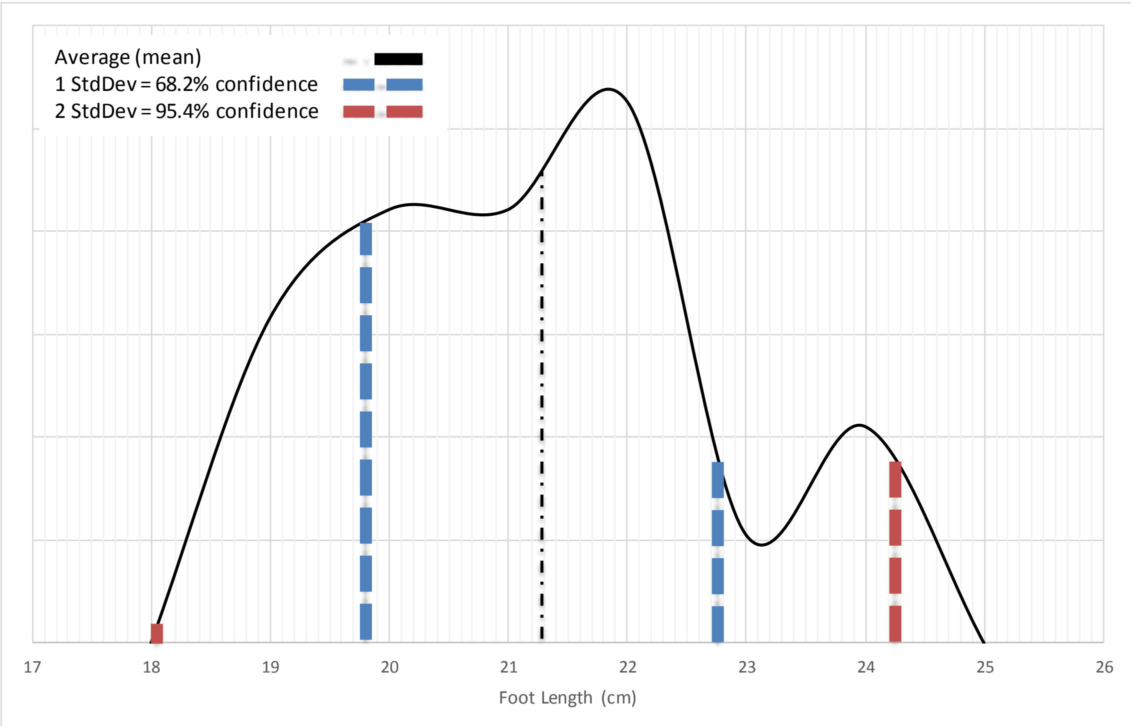

Figure 110: Graph showing probability density curve and confidence parameters calculated by standard deviation to 2-sigma for 7-10 year old participants

A10.4 11-12 years old

Probability Density Curve		
Foot size	**Raw counts**	**Prob Dens.**
19	0	0
20	1	0.0625
21	2	0.125
22	1	0.0625
23	3	0.1875
24	3	0.1875
25	4	0.25
26	2	0.125
27	0	0
Total	16	

Table 45: Probability Density Data for 11-12-year-old participants

STANDARD DEVIATION	
STDEV	1.811709598
AVERAGE	23.47
+STDEV	25.28
-STDEV	21.66
+2STDEV	27.09
-2STDEV	19.85

Table 46: Standard Deviation Calculations (11-12yo)

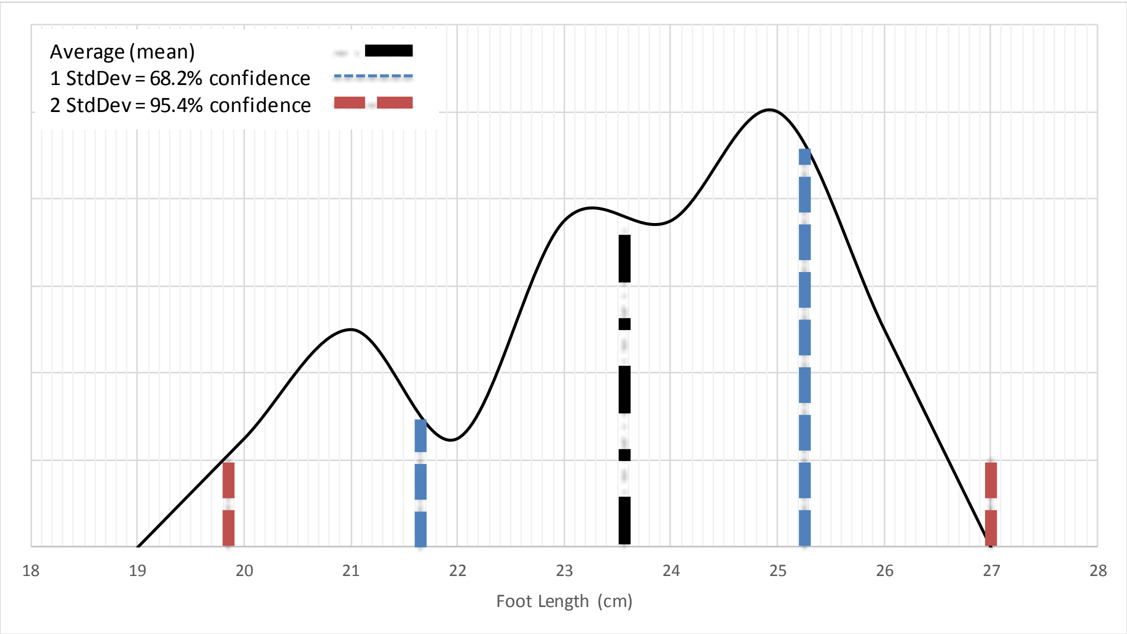

Figure 111: Graph showing probability density curve and confidence parameters calculated by standard deviation to 2-sigma for 11-12 year old participants

A10.5 Adult Female

Probability Density Curve		
Foot size	**Raw counts**	**Prob Dens.**
15	0	0
16	2	0.006472492
17	0	0
18	1	0.003236246
19	1	0.003236246
20	4	0.012944984
21	17	0.055016181
22	41	0.132686084
23	49	0.158576052
24	89	0.28802589
25	63	0.203883495
26	29	0.093851133
27	11	0.035598706
28	1	0.003236246
29	1	0.003236246
30	0	0
Total	309	

Table 47: Probability density data for adult female participants

STANDARD DEVIATION	
STDEV	1.667582609
AVERAGE	23.73
+STDEV	25.40
-STDEV	22.06
+2STDEV	27.06
-2STDEV	20.39

Table 48: Standard Deviation Calculations (AF)

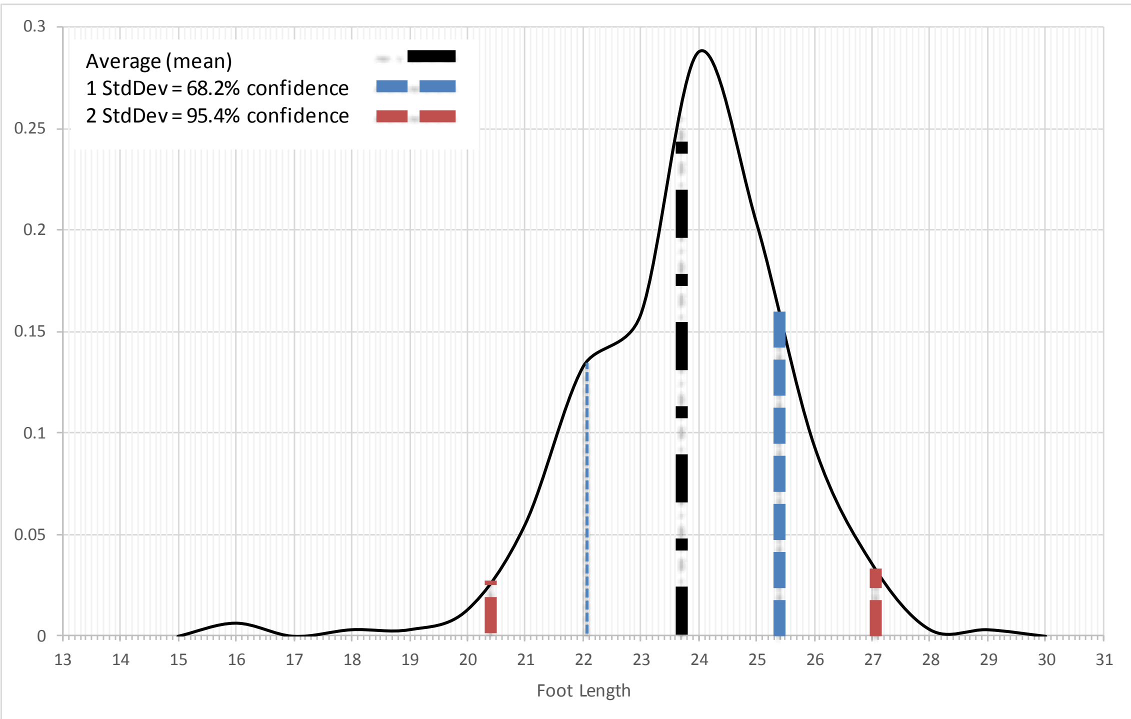

Figure 112: Graph showing probability density curve and confidence parameters calculated by standard deviation to 2-sigma for adult female participants

A10.6 Adult Male

Probability Density Curve		
Foot size	**Raw counts**	**Prob Dens.**
21	0	0
22	1	0.004385965
23	7	0.030701754
24	10	0.043859649
25	31	0.135964912
26	65	0.285087719
27	41	0.179824561
28	45	0.197368421
29	13	0.057017544
30	11	0.048245614
31	4	0.01754386
32	0	0
Total	228	

Table 49: Probability density data for adult male participants

STANDARD DEVIATION	
STDEV	3.4178763
AVERAGE	26.84
+STDEV	30.26
-STDEV	23.42
+2STDEV	33.68
-2STDEV	20.01

Table 50: Standard Deviation Calculations (AM)

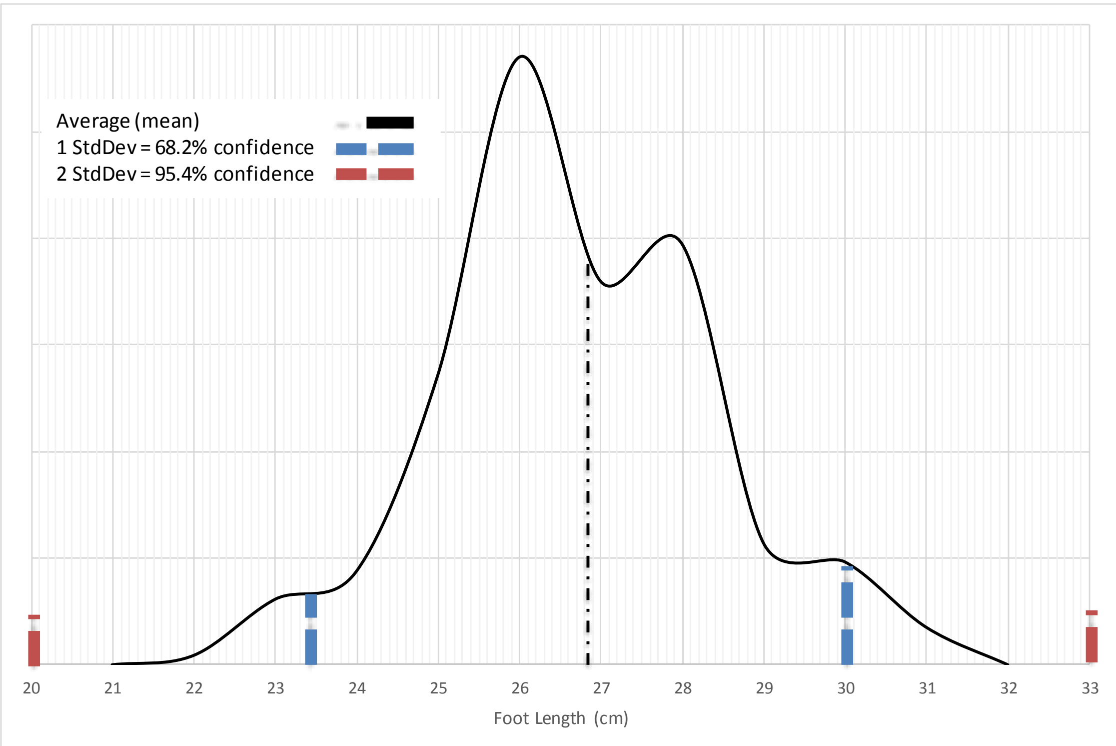

Figure 113: Graph showing probability density curve and confidence parameters calculated by standard deviation to 2-sigma for adult male participants

Appendix 11: Source data for environmental comparisons diagram

This comparison uses date phases extracted from the investigations at Goldcliff as a starting point, as this was the site with the most in depth research.

Phase	Goldcliff 1 (Smith and Morgan 1989)	Goldcliff 2 (Smith and Morgan 1989)	Uskmouth (Aldhouse-Green et al 1992)	Goldcliff (Caseldine in Bell 2000)	Goldcliff East Site D (Dark in Bell 2007)	Goldcliff East Site B (Dark in Bell 2007)	Goldcliff East Site J (Dark in Bell 2007)	Upper submerged forest Goldcliff (Timpany in Bell 2007)	Kenfig (Bennet et al 2010)	Lydstep (Murphy et al 2014).	Port Eynon	Broughton
7002±35 BP						Reed swamp formation. Wider environment of hazel woodland. Human indicators.						
7000BP		Marine influence and evidence for variety of environments including fenland, reedswamp and riverine.										
6871±33BP							Leading up to this date decline in hazel woodland and rise in saltmarsh. Marine inundation at increased frequency.					
6870BP to 6750BP -	Reedswamp with nearby marine influence.											

Phase	Goldcliff 1 (Smith and Morgan 1989)	Goldcliff 2 (Smith and Morgan 1989)	Uskmouth (Aldhouse-Green et al 1992)	Goldcliff (Caseldine in Bell 2000)	Goldcliff East Site D (Dark in Bell 2007)	Goldcliff East Site B (Dark in Bell 2007)	Goldcliff East Site J (Dark in Bell 2007)	Upper submerged forest Goldcliff (Timpany in Bell 2007)	Kenfig (Bennet et al 2010)	Lydstep (Murphy et al 2014).	Port Eynon	Broughton
6750-6025 BP	Alder dominant in background. Evidence for sporadic marine transgression and reedswamp.											
6726±33BP					Saltmarsh encroachment - marine transgression							
6600- 6165BP	6470BP Occasional marine incursion	Alder carr develops	Reedswamp and saltmarsh 6250-6260 BP Direct marine influence - saltmarsh Moving towards sedge fenland.		6500BP marine inundation, salt marsh followed by reedswamp						6415 -6180 BP Fluctuating marine influence interspersed with reed swamp development.	

Phase	Goldcliff 1 (Smith and Morgan 1989)	Goldcliff 2 (Smith and Morgan 1989)	Uskmouth (Aldhouse-Green et al 1992)	Goldcliff (Caseldine in Bell 2000)	Goldcliff East Site D (Dark in Bell 2007)	Goldcliff East Site B (Dark in Bell 2007)	Goldcliff East Site J (Dark in Bell 2007)	Upper submerged forest Goldcliff (Timpany in Bell 2007)	Kenfig (Bennet et al 2010)	Lydstep (Murphy et al 2014).	Port Eynon	Broughton
6165-5745BP	6130BP Decline in alder carr after marine incursion ends. Return to freshwater fenland. 6025-5730BP -Sedge fenland, decline in alder. Nearby marine influence	Marin influence moving towards freshwater fenland and then development of ombrotrophic bog	Reedswamp with nearby marine presence	6000BP Sedge fenland communities with nearby marine influence.	Reedswamp							
5730±BP to 5650 BP								Saltmarsh reedswamp phase				
5650-5061 BP								Birch/willow followed by alder carr woodland		Alder carr and sedge fenland	Alder carr and sedge fenland	
5695-5190BP	Development of ombrotrophic bog			Sporadic Marine influence followed by development of ombrotrophic bog.				5213±23BP Development of sedge fenland with some ombrotrophic bog				5196±34 maintained sedge fenland and alder carr.

Phase	Goldcliff 1 (Smith and Morgan 1989)	Goldcliff 2 (Smith and Morgan 1989)	Uskmouth (Aldhouse-Green et al 1992)	Goldcliff (Caseldine in Bell 2000)	Goldcliff East Site D (Dark in Bell 2007)	Goldcliff East Site B (Dark in Bell 2007)	Goldcliff East Site J (Dark in Bell 2007)	Upper submerged forest Goldcliff (Timpany in Bell 2007)	Kenfig (Bennet et al 2010)	Lydstep (Murphy et al 2014).	Port Eynon	Broughton
5650-5061 BP								Birch/willow followed by alder carr woodland		Alder carr and sedge fenland	Alder carr and sedge fenland	

Appendix 12: Media Interest

A12.1 Press Release

Rare prehistoric footprints redefined as 7,000 years old

28 February 2017

In a massive time-shift, new analysis conducted by a Cardiff University researcher pushes our understanding of a set of rare human footprints on the Welsh coast back by 3,000 years.

Discovered in 2014, the ancient footprints of both children and adults at Port Eynon on the Gower peninsular were initially thought to date to the Bronze Age.

However, new Radiocarbon dating by Archaeology PhD student Rhiannon Philp, now places the fragile footprints still further back to the Mesolithic period, a time when humans were predominantly hunting and gathering.

'Frozen' footprints

Rhiannon, a student in the University's School of History, Archaeology and Religion, said: "These 'frozen' footprints made in freshwater marshland give us a fleeting glance of a group of adults and children travelling together seven millennia ago.

"But the picture is even more precise. Wild animal tracks suggest deer and wild boar moving in the same direction. What we might be witnessing 7,000 years later is a snapshot moment of a

Mesolithic hunting party tracking their prey through an open, boggy landscape now lost to the waves."

Post Ice Age human footprints are rare in the UK, with only nine recorded intertidal sites, the majority of which are in Wales.

Rhiannon's research is helping to contextualise and rebuild a landscape now lost to rising sea levels and increase understanding of the people who lived within it.

"Given the fragility of these examples and climate change now and then, it is incredibly important to obtain as much information as possible whenever the opportunity arises," added Rhiannon.

The analysis was funded by the Cambrian Archaeological Society and the Gower Society. Further research is now underway to better understand the ancient environment and the demographics of the people whose traces are now glimpsed only at low tide.

A12.2 List of Media Coverage

- "Coast: The Great Guide: 2. Southern Wales" aired 28th September 2016, BBC 2.
- Independent i, 01/03/2017, p6
- Metro 01/03/2017, p9;
- Western Mail, 01/03/2017, p3
- Daily Mail online: http://www.dailymail.co.uk/sciencetech/article-4267378/Footprints-reveal-Mesolithic-hunters-tracked-prey.html
- AOL: https://www.aol.co.uk/news/2017/02/28/footprints-date-back-7-000-years-and-could-show-hunting-party/
- South Wales Evening Post: http://www.southwales-eveningpost.co.uk/gower/story-30168470-detail/story.html
- Wales Online: http://www.walesonline.co.uk/news/wales-news/ancient-human-footprints-discovered-welsh-12667046
- BBC: http://www.bbc.co.uk/news/uk-wales-south-west-wales-39117097
- Express and Star: http://www.expressandstar.com/news/uk-news/2017/02/28/footprints-date-back-7000-years-and-could-show-hunting-party/
- Talk Radio: http://talkradio.co.uk/news/ancient-footprints-discovered-wales-found-be-7000-years-old-17022810634
- Belfast Telegraph: http://www.belfasttelegraph.co.uk/news/uk/footprints-date-back-7000-years-and-could-show-hunting-party-35489498.html
- BT: http://home.bt.com/news/uk-news/footprints-date-back-7000-years-and-could-show-hunting-party-11364160269300
- Shropshire Star: http://www.shropshirestar.com/news/uk-news/2017/02/28/footprints-date-back-7000-years-and-could-show-hunting-party/
- BBC Wales Today news segment aired 05/03/2017
- Current Archaeology 326: "Gower footprints lead further back in time" April 2017

Appendix 13: Outreach and Engagement - The Footprints in Time Project

A13.1 Project Summary

Rising sea levels and climate change are no new thing. 10,000 years ago coast of South Wales was beginning to sink beneath the waves. Forests gave way to marshland and eventually became the beaches we know today.

In the past few years, remnants of these ancient landscapes have been revealing themselves more regularly due to an increase in stormy weather. Our own symptoms of climate change are revealing how ancient inhabitants of South Wales dealt with their changing environment.

What did these people have to deal with? How did it affect them? Can this inform on our own experiences of climate change?

In a series of workshops, participants will discover how ancient footprints preserved on the shore today can shed light on the lives of people who lived there and how we can link our own lives to theirs.

Participants will:

- Contribute to exciting current research by taking part in our "Where's Wally" inspired pollen hunt and discover how the environment was changing for Wales' ancient inhabitants thousands of years ago.
- Debate the link between climate change and sustainable energy.
- Discover how new technology is harnessing the power of the sea.
- Get creative with stop animation to show what climate change means to them.

This project is designed and delivered by representatives from Cardiff University School of History, Archaeology and Religion in conjunction with Tidal Lagoon Power Ltd.

A13.2 Project Report

Project Aims:

Aims	*Our Approach*
Climate change: Raise awareness of historic and current climate change and human responses to this.	We built expertise from archaeological and current climate change researchers into our workshops.
Global citizenship; raise awareness about local politics and planning decisions.	We involved TLP Ltd and utilised the My2050 website to engage participants in the idea of local and national policy.
Introduce and share knowledge: Involve schools in new and innovative research projects.	The project was based on new research being undertaken by PhD student and project lead, Rhiannon Philp.
Raising educational aspirations; encouraging students to consider STEM subjects and careers.	We highlighted non-traditional STEM areas and as an all-female team, hope to have inspired female participants to consider STEM careers.
Enhanced Engagement: Provide training, skills and experience in outreach and engagement development and delivery for post graduate students from the School of History, Archaeology and Religion.	Project lead, Rhiannon Philp is a current PhD student. She developed project management and delivery skills in order to successfully deliver this project on time and to budget.
Development of resources to explore climate change.	Our workshops are now ready to be utilised at further events and our 3D printed pollen will become an important resource for teaching participants about environmental change.

Contributors:

Footprints in Time was a collaboration between Cardiff University Archaeology department (led by PhD student Rhiannon Philp and academic staff member Jacqui Mulville) and Tidal Lagoon Power Ltd (via Joanna Lane). Cardiff University Bioimaging Unit and Bioscience's 3D printing lab were also involved in the development of our 3D pollen resources.

Participants:

Step Up Plus Summer School:

This summer school was part of the Cardiff University Step-Up programme, which aims to raise aspirations and attainment in secondary school pupils, focussing on Communities First areas. We provided a 2.5 hour session for a group of sixth form students.

Fitzalan High School:

Fitzalan were our main partner school and were involved from the very start of the project. The school is situated in Cardiff and has a catchment which includes Communities First areas. SHARE already have a strong relationship with this school, as they are heavily involved in our SHARE with Schools and CAER Heritage projects. We delivered a three hour session to a group of 16 Key Stage 3 pupils

Longsands Academy:

Prior to the official project delivery, we were given the opportunity to engage with Longsands Academy in Cambridgeshire through links held by a project team member. Though this school does not fall into the remit of the Cardiff City Region Exchange Project, it was decided that this would be a good opportunity to test out elements of the workshops that were in development. We delivered early versions of the pollen identification and footprint measuring activities, which seemed to go down very well and other than small logistical elements, very few changes needed to be implemented during the official pilot. Feedback from the school can be seen in the feedback section of this report.

At the start of this project we proposed that we would also work with ***Ysgol*** *Gyfun Gymraeg Plasmawr. Unfortunately we were unable to make this happen for the pilot, but we are hoping to engage with this school in the future.*

Workshops:

The project took the form of three consecutive workshops, designed to be deliverable as one event, but with the flexibility to work as individual workshops in their own right. Aspects of these workshops were also trialled separately at school visits, outreach events and festivals around the country as part of Cardiff's highly successful engagement project: *Guerilla Archaeology*.

Workshop 1: *Footprints to the Past*	Introduced participants to the idea of drowned landscapes and archaeological evidence in the intertidal zone, focussing on the Port Eynon footprints. Participants contributed their own height and foot length to a dataset that has been gathered from a wide range of sources through outreach events, Cardiff Archaeology students and school groups. They then used this data to try to interpret selected prints from the Port Eynon assemblage, including whether they were adult or child, male or female and their age.
Workshop 2: *Where's Polly?*	Asked participants to work out the type of environment the footprints were made in. Identification methods were introduced using our prototype 3D printed pollen grains, which allowed participants to handle and rotate a number of species that they were trying to identify. This led to a better understanding of the identifiable attributes. The group was split in three and provided with three separate pollen assemblages. Using custom made ID guides and species information 'Top Trumps' style cards, participants identified and counted their pollen and then picked one of four different environments that they felt best fit their assemblage.
Workshop 3: Future Footprints	Participants were introduced to the idea of resource exploitation in the Severn Estuary and how our "footprints" have changed from prehistory through to the present day. Utilising the *My2050* website (http://my2050.decc.gov.uk/), a group debate was then initiated on how best to reduce our carbon footprint, with the aim of hitting the CO^2 emissions target of 20% of 1990 levels.

The session was concluded by asking participants to create a stop motion animation about something they had learnt during the day's activities. This utilised *Stop Motion Studio*, a free and easy to use app on iPads.

Results:

Participants appeared to engage fully in each aspect of the sessions and asked intelligent and intuitive questions throughout. They were able to interpret the prehistoric footprint data using their own measurements and showed impressive ability in the identification activity. Participants were also very engaged in trying to come up with a solution to reducing our carbon footprint, with some taking this further into the animation challenge at the end of the sessions. Some fantastic animations were created, examples of which will be sent through with this report. Themes ranged from the history of the Severn Estuary, to future power solutions with others focussing on the footprints themselves. Participants showed an understanding for the different periods in the estuary's history and how technology and activities had changed. We felt the animation activity provided a fantastic opportunity for the participants to show what they had learnt in a visual and innovative way and we will be using this activity in future engagement workshops.

Outcomes:

- The animations created by the Step Up Plus group were included in the graduation ceremony for the programme and the schools have also taken copies for their own use. The videos will be showcased on the SHARE social media outlets in the near future.
- Our session with Fitzalan High School has featured heavily in a video commissioned by Cardiff University engagement, which will be used to showcase engagement projects across the university.
- We were invited to the National Eisteddfod where we delivered activities based on the workshops developed in this project. Here, we were also asked to meet with the Secretary of State for Wales, Alun Cairns.
- We have developed new and exciting partnerships, both with Tidal Lagoon Power Ltd. and more recently with Cardiff University Bioimaging Unit. It is hoped that we can continue to work with both parties on future endeavours.
- The resources we have created have already been utilised by Guerilla Archaeology at a number of events and festivals across the country. These have included the CADW open day at Bryn Celli Ddu on Anglesey and Green Man Festival. Our presence at these events has also led to a number of enquiries for other events, including most recently, the

British Science Festival. The 3D printed pollen grains have been particularly successful, causing something of a social media storm, provoking international interest.

- The project was also picked up on by the University communications team, who ran a press release in July: http://www.cardiff.ac.uk/news/view/400169-footprints-in-time.

Feedback:

Yvonne Roberts-Ablett, Fitzalan High School:	*Step Up Plus Scheme:*	*Elizabeth Whitehead, Longsands Academy*:
"Thank you so much for today they had a brilliant time and we thought that all the workshops were spot on! Great spread of literacy and numeracy skills and really useful and practical ideas. The pupils were all chatting on their way back and found it so interesting – you've ignited a new spark into our issues with studying Latin!"	Participants were asked to rate their academic sessions numerically, 1 being high and 5 being low. Our session scored highly with 1.33 placing it 4^{th} out of 20 academic sessions run that day.	"The session was incredibly well run and really inspired our students. Many of them didn't realise quite what was involved with archaeology and thoroughly enjoyed seeing new aspects of it. They really got stuck in with the work on pollen grains and enjoyed learning more about how to determine different past landscapes. As a school we valued the opportunity provided greatly and feel that there should be more opportunities like this available."

Reflection:

We have learnt a number of important lessons through undertaking this project:

Working with schools	Co-ordinating with the school timetables proved difficult at times. We found the best time of year for extracurricular activities was the end of the summer term, but that flexibility was needed with events often being booked in very short notice. Overall, we developed strong links with our partner schools and look forward to working with them again in the future.
Timings	These differed depending on the participants' abilities and events on the day. We lost nearly an hour on one of our sessions due to a late arrival and had to adjust our workshops to fit the new timescale. Despite these factors, all aspects of the proposed workshops were completed and we felt participants showed good understanding of the issues addressed.
Working with external partners	Overall this was very successful, but compromises did need to be made on both sides in order to mesh together the past, present and future themes. Good communication was required in order to maintain a coherent narrative. This included regular email contact as well as face to face meetings.

Rhiannon Philp, Project Lead: "I thoroughly enjoyed being involved with this project. It was fantastic to be able to talk to participants about my research and see them engage with, in some cases, quite difficult concepts. I am very proud of the resources we have developed and feel the animations created by our participants show great overall understanding of the themes that were being dealt with."

Jacqui Mulville, Project Support: "We succeeded in drawing together a wide range of themes and activities, including aspects, such as the 3D printed resources and the use of stop animation, which seemed farfetched in the beginning. We created a social media storm with our 3D pollen and received wide acknowledgment of our good work by school groups. It was brilliant to watch all the ideas come together."

Joanna Lane, Project Partner (with Tidal Lagoon Power Ltd.): "Tidal Lagoon Power (TLP) is delighted with the outcomes of the Footprints in the Past project. Working with archaeologists in the School of History, Archaeology and Religion (SHARE) via University's City Region Exchange pilot engagement programme has enabled us to collaborate on an ambitious and exciting pilot project. The outputs include a range of activities and resources based on current research in the University as well as key questions about climate change, local developments in renewable energy and the local environment. TLP has benefited from the School's excellent relationship with schools in the region and the pilot has led to a number of invitation to deliver further outreach. TLP recognises the wealth of experience and expertise of the School's staff and students involved with SHARE with Schools and Guerrilla Archaeology and we hope to continue to collaborate with these initiatives."

Future:

TLP has expressed an interest to continue to collaborate with the University on outreach in the future, as well as partnerships in research and learning. We will be exploring further funding options to develop this project and hope to deliver these activities at a range of events across the region as part of our wider outreach and community engagement. As mentioned above, we have already started to receive requests for future outreach events. Aspects of the workshops will be taken up by SHARE with Schools and delivered as part of their school visits in the coming academic year. Guerilla Archaeology will continue to utilise the resources developed for its own events. We are also continuing our relationship with Cardiff Bioimaging Unit and will be looking to develop an online database to host the 3D pollen grain models to make them accessible to other interested parties, so that they might print their own version.

Appendix 14: Pollen Count Data

A14.1 Broughton Bay

Table 51: Br1 Pollen Count Data

Pollen	Br1			Depth (cm)	3	14	15	27
Code	Name	Element	Units	Group				
#Samp.Analyst	Rhiannon Philp							
Lyc.tab:quantity added:number	Lycopodium tablets	quantity added	number	CONC	1	1	1	1
Lyc.tab:concentration:number/tablet	Lycopodium tablets	concentration	number/tablet	CONC	9666	9666	9666	9666
Lyc.spik:counted:number	Lycopodium counted	counted	number	CONC	4	5	1	2
samp.quant:mass:g	Sample quantity	mass	g	CONC	2.12	2.01	2.46	1.77
Aln	Alnus glutinosa	pollen	NISP	Tree/Shrub	94	226	180	113
Bet	Betula	pollen	NISP	Tree/Shrub		2		2
Carp	Carpinus	pollen	NISP	Tree/Shrub				
Cast	Castanea	pollen	NISP	Tree/Shrub				
Larix	Larix	pollen	NISP	Tree/Shrub				
PinSyl	Pinus sylvestris	pollen	NISP	Tree/Shrub		2	1	3
Querc	Quercus	pollen	NISP	Tree/Shrub	47	39	30	33
TilaCor	Tilia cordata	pollen	NISP	Tree/Shrub				1
Ulmus	Ulmus	pollen	NISP	Tree/Shrub	12	11	3	10
Cory	Corylus avellana-type	pollen	NISP	Tree/Shrub	31	37	30	21
Frax	Fraxinus	pollen	NISP	Tree/Shrub	3			1
Fag	Fagus	pollen	NISP	Tree/Shrub				
Sal	Salix	pollen	NISP	Tree/Shrub	26		2	
Heder	Hedera helix	pollen	NISP	Tree/Shrub	1	2		1
Ilex	Ilex	pollen	NISP	Tree/Shrub	19	1		
Jun	Juniperus	pollen	NISP	Tree/Shrub	8	7	5	4
LigVul	Ligustrum vulgaris	pollen	NISP	Tree/Shrub				
Pop	Populus	pollen	NISP	Tree/Shrub				
Taxus	Taxus	pollen	NISP	Tree/Shrub				
Poa	Poaceae undiff	pollen	NISP	HERB	176	120	191	211
Carex	Carex	pollen	NISP	HERB		1	5	
Cereali	Cerealia-type	pollen	NISP	HERB				
Cyp	Cyperaceae undiff	pollen	NISP	HERB	6	11	31	74
AchillAnth	Achillea Anthemis	pollen	NISP	HERB				
Achill	Achillea-type	pollen	NISP	HERB				
Agrostemma	Agrostemma	pollen	NISP	HERB				
Apia	Apiaceae	pollen	NISP	HERB	3	1		
Arm	Armeria type	pollen	NISP	HERB				
Art	Artemisia	pollen	NISP	HERB				
AstAmb	Asteraceae ambrosia	pollen	NISP	HERB		1		
AstAst	Asteraceae Asteroideae	pollen	NISP	HERB	1		1	
Ast-Lac	Asteraceae Latucae	pollen	NISP	HERB				

Pollen	Br1			Depth (cm)	3	14	15	27
Code	Name	Element	Units	Group				
AstTrip	Asteraceae Tripolium	pollen	NISP	HERB		2		
Ast	Asteraceae undiff	pollen	NISP	HERB				
Brass	Brassicaceae	pollen	NISP	HERB				
Cent	Centaurea	pollen	NISP	HERB		1		
Cheno	Chenopodioideae	pollen	NISP	HERB	1	3		
Daphne	Daphne	pollen	NISP	HERB				
Erica	Ericaceae undiff	pollen	NISP	HERB				
Fili	Filipendula	pollen	NISP	HERB				
Gal	Gallium	pollen	NISP	HERB	1		1	
Ger	Geranium	pollen	NISP	HERB				
HellVir	Helleborus viridius	pollen	NISP	HERB				
Knaut	Knautia	pollen	NISP	HERB		2	1	
Lin	Linaceae	pollen	NISP	HERB				
LinCat	Linum catharicum	pollen	NISP	HERB				
Malv	Malva-type	pollen	NISP	HERB				
Mimo	Mimosaceae	pollen	NISP	HERB	1			
ParPal	Parnassia palustris	pollen	NISP	HERB				
PlanLa	Plantago lanceolata	pollen	NISP	HERB	5	1	13	7
PlanMaj	Plantago major	pollen	NISP	HERB	2	9	5	7
PlanMar	Plantago maritimus	pollen	NISP	HERB				
Plant	Plantago undiff	pollen	NISP	HERB				
Pole	Polemonium	pollen	NISP	HERB				
Polyg	Polygonum	pollen	NISP	HERB				
PrimVulg	Primula vulgaris	pollen	NISP	HERB				
Ranun	Ranunculus-type	pollen	NISP	HERB	2	7	3	
SambNig	Sambucus nigra	pollen	NISP	HERB	5	5		
Sax	Saxifragaceae undiff	pollen	NISP	HERB	2			
Rumex	Rumex	pollen	NISP	HERB				
RumAce	Rumex acetosa-type	pollen	NISP	HERB				
Urtica	Urtica	pollen	NISP	HERB	53	9	1	3
Urt	Urticularia	pollen	NISP	HERB				
Val	Valeriana	pollen	NISP	HERB				
ValD	Valeriana dioca	pollen	NISP	HERB				
ViberLan	Viburnum lantana	pollen	NISP	HERB				
AdiCapVen	Adiantum capilleris veneris	pollen	NISP	HERB				
BlechSpic	Blechrum spicant	spore	NISP	SPORE	2			
Dryopteris	Dryopteris	spore	NISP	SPORE		1		
Ophio	Ophioglossum	spore	NISP	SPORE				
Poly	Polypodium	spore	NISP	SPORE	80	34	49	79
Pteridium	Pteridium	spore	NISP	SPORE				
Sphag	Sphagnum	spore	NISP	SPORE	3			1
ThelPal	Thelypteris palustris	spore	NISP	SPORE				
ButUmb	Butomus umbellatus	aquatic	NISP	AQUATIC				
Calitriche	Calitriche	aquatic	NISP	AQUATIC				

Pollen	Br1			Depth (cm)	3	14	15	27
Code	Name	Element	Units	Group				
Elodea	Elodea	aquatic	NISP	AQUATIC				
Lemna	Lemna	aquatic	NISP	AQUATIC	2	1	2	2
LobDort	Lobelia Dortmanna	aquatic	NISP	AQUATIC				
TyphaLat	Typha latifolia	aquatic	NISP	AQUATIC	3			7
Myrio	Myriophyllum	aquatic	NISP	AQUATIC		7		1
Nuph	Nuphar	aquatic	NISP	AQUATIC				
Nymph	Nymphaea alba type	aquatic	NISP	AQUATIC				
Pot	Potamogeton	aquatic	NISP	AQUATIC	1	52	37	2
Ruppia	Ruppia	aquatic	NISP	AQUATIC				
Trig	Triglochin	aquatic	NISP	AQUATIC				
TyphaAng	Typha angustifolia	aquatic	NISP	AQUATIC				
TyphaDom	Typha domingensis	aquatic	NISP	AQUATIC				
AmpFlav	Amphitrema flavum	NPP	NISP	NPP				
Bysso	Byssothecium Type 16	NPP	NISP	NPP				
Cerco	Cercophora	NPP	NISP	NPP				16
Chaet	Chaetomium-type							
Chonio	Choniochaeta	NPP	NISP	NPP	13	17	8	2
CysFrag	Cystopteris Fragilis	NPP	NISP	NPP				
DiporRhiz	Diporotheca rhizophila	NPP	NISP	NPP		1		3
Gel	Gelasinospora	NPP	NISP	NPP		2		
Meliola	Meliola ellisii	NPP	NISP	NPP				
Persicio	Persiciospora	NPP	NISP	NPP		2		
Pod	Podospora	NPP	NISP	NPP	2	1	6	
ScopBar	Scopinella barbata	NPP	NISP	NPP				
Sel	Selaginella	NPP	NISP	NPP				
Sordaria	Sordaria-type	NPP	NISP	NPP	6	5	11	5
Sporo	Sporimiella	NPP	NISP	NPP		1		
Tetraploa	Tetraploa	NPP	NISP	NPP				1
UstDeu	Ustulina deusta	NPP	NISP	NPP	40	18	52	17
Valsaria	Valsaria cf. variospora	NPP	NISP	NPP	2	13	10	12
Indet	Indeterminate	Indeterminate	NISP	INDET	11	21	7	6
Charcoal	Microcharcoal ≥25µm	NPP	NISP	CHAR	59	21	9	9
SUM(Group)			percent	None	0	0	0	0
SUM(CONC)	Concentrations		percent	None	9673.12	9674.01	9670.46	9670.77
SUM(Tree/Shrub)	Tree/Shrubs		percent	TLP	241	327	251	189
SUM(HERB)	Herbs		percent	TLP	258	173	252	302
SUM(SPORE)	Spores		percent	TLP+S	85	35	49	80
SUM(AQUATIC)	Aquatics		percent	TLP+A	6	60	39	12
SUM(NPP)	Non Pollen Palynmorphs		percent	None	63	60	87	56
SUM(INDET)	Indeterminable		percent	None	11	21	7	6
SUM(CHAR)	Microcharcoal >25microns		percent	None	59	21	9	9
SSUM(TLP)	Total Land Pollen			Tree/Shrub;HERB	499	500	503	491
SSUM(TLP+A)	Total Land Pollen + Aquatics			Tree/Shrub;HERB;AQUATIC	505	560	542	503
SSUM(TLP+S)	Total Land Pollen + Spores			Tree/Shrub;HERB;SPORE	584	535	552	571

Table 52: Br2 Pollen Counts

Pollen		Br2		Depth (cm)	26	27	30	31	40
Code	**Name**	**Element**	**Units**	**Group**					
#Samp.Analyst	Rhiannon Philp								
Lyc.tab:quantity added:number	Lycopodium tablets	quantity added	number	CONC	1	1	1	1	1
Lyc.tab:concentration:number/tablet	Lycopodium tablets	concentration	number/tablet	CONC	9666	9666	9666	9666	9666
Lyc.spik:counted:number	Lycopodium counted	counted	number	CONC	2	3	13	8	2
samp.quant:mass:g	Sample quantity	mass	g	CONC	1.88	2.05	2.71	3.1	2.88
Aln	Alnus glutinosa	pollen	NISP	Tree/Shrub	204	173	39	39	96
Bet	Betula	pollen	NISP	Tree/Shrub	2	3		2	3
PinSyl	Pinus sylvestris	pollen	NISP	Tree/Shrub	1		3		1
Querc	Quercus	pollen	NISP	Tree/Shrub	55	59	63	109	33
TilaCor	Tilia cordata	pollen	NISP	Tree/Shrub		1	1		
Ulmus	Ulmus	pollen	NISP	Tree/Shrub	1	3	1	4	7
Cory	Corylus avellana-type	pollen	NISP	Tree/Shrub	58	103	70	44	26
Frax	Fraxinus	pollen	NISP	Tree/Shrub	2	3		1	
Sal	Salix	pollen	NISP	Tree/Shrub	5	19		3	2
Heder	Hedera helix	pollen	NISP	Tree/Shrub	6	7		1	
Ilex	Ilex	pollen	NISP	Tree/Shrub	4	13			
Jun	Juniperus	pollen	NISP	Tree/Shrub	3				
Poa	Poaceae undiff	pollen	NISP	HERB	80	66	215	221	65
Carex	Carex	pollen	NISP	HERB			1	4	1
Cyp	Cyperaceae undiff	pollen	NISP	HERB	56	24	14	2	30
Apia	Apiaceae	pollen	NISP	HERB			2		3
Art	Artemisia	pollen	NISP	HERB	2				
ArtMar	Artemisia maritima	pollen	NISP	HERB				1	
AstAst	Asteraceae Asteroideae	pollen	NISP	HERB	1				
Ast-Lac	Asteraceae Latucae	pollen	NISP	HERB			1		
AstTrip	Asteraceae Tripolium	pollen	NISP	HERB			1		
Cheno	Chenopodioideae	pollen	NISP	HERB		5	71	54	117
Cirs	Cirsium	pollen	NISP	HERB			1		
Fili	Filipendula	pollen	NISP	HERB	2		1	1	
Gal	Gallium	pollen	NISP	HERB	1	1			
PlanLa	Plantago lanceolata	pollen	NISP	HERB	8	1	2	2	4
PlanMaj	Plantago major	pollen	NISP	HERB	2	2		3	14
PlanMar	Plantago maritimus	pollen	NISP	HERB	1				
Ranun	Ranunculus-type	pollen	NISP	HERB	5	5	9	5	4
SambNig	Sambucus nigra	pollen	NISP	HERB		6	6	7	
SolaNig	Solanum nigrum	pollen	NISP	HERB		1			
Urtica	Urtica	pollen	NISP	HERB		6			1
Val	Valeriana	pollen	NISP	HERB					1
Dryopteris	Dryopteris	spore	NISP	SPORE			1		
Poly	Polypodium	spore	NISP	SPORE	11	4	4	11	5

Pollen		Br2		Depth (cm)	26	27	30	31	40
Code	**Name**	**Element**	**Units**	**Group**					
Sphag	Sphagnum	spore	NISP	SPORE					2
Lemna	Lemna	aquatic	NISP	AQUATIC	5	40	1	1	4
TyphaLat	Typha latifolia	aquatic	NISP	AQUATIC		16	1	4	3
Pot	Potamogeton	aquatic	NISP	AQUATIC	4				
Gel	Gelasinospora	NPP	NISP	NPP	19	1	2		
Meliola	Meliola ellisii	NPP	NISP	NPP	3				
Sordaria	Sordaria-type	NPP	NISP	NPP	80	103			
UstDeu	Ustulina deusta	NPP	NISP	NPP	7	6			
Indet	Indeterminate	Indeterminate	NISP	INDET	5	5	2	4	12
Charcoal	Microcharcoal ≥25µm	NPP	NISP	CHAR		1		4	
SUM(Group)			percent	None	0	0	0	0	0
SUM(CONC)	Concentrations		percent	None	9670.88	9672.05	9682.71	9678.1	9671.88
SUM(Tree/Shrub)	Tree/Shrubs		percent	TLP	341	384	177	203	168
SUM(HERB)	Herbs		percent	TLP	158	117	324	300	240
SUM(SPORE)	Spores		percent	TLP+S	11	4	5	11	7
SUM(AQUATIC)	Aquatics		percent	TLP+A	9	56	2	5	7
SUM(NPP)	Non Pollen Palynmorphs		percent	None	109	110	2	0	0
SUM(INDET)	Indeterminable		percent	None	5	5	2	4	12
SUM(CHAR)	Microcharcoal >25microns		percent	None	0	1	0	4	0
SSUM(TLP)	Total Land Pollen			Tree/Shrub;HERB	499	501	501	503	408
SSUM(TLP+S)	Total Land Pollen + Spores			Tree/Shrub;HERB;SPORE	510	505	506	514	415
SSUM(TLP+A)	Total Land Pollen + Aquatics			Tree/Shrub;HERB;AQUATIC	508	557	503	508	415

Table 53: Br3 Pollen Counts

Pollen		Br3		Depth (cm)	1	2	8	9	15	16	22	23	25
Code	**Name**	**Element**	**Units**	**Group**									
#Samp.Analyst	Rhiannon Philp												
Lyc.tab:quantity added:number	Lycopodium tablets	quantity added	number	CONC	1	1	1	1	1	1	1	1	1
Lyc.tab:concentration:number/tablet	Lycopodium tablets	concentration	number/tablet	CONC	9666	9666	9666	9666	9666	9666	9666	9666	9666
Lyc.spik:counted:number	Lycopodium counted	counted	number	CONC	7	18	5	9	4	2			1
samp.quant:mass:g	Sample quantity	mass	g	CONC	2.15	2.52	2.85	3.1	2.95	3.3	2.65	2.54	2.66
Aln	Alnus glutinosa	pollen	NISP	Tree/Shrub	51	71	67	65	134	145	193	226	255
Bet	Betula	pollen	NISP	Tree/Shrub	1	1	2	4				1	1
PinSyl	Pinus sylvestris	pollen	NISP	Tree/Shrub	3			1	1				
Querc	Quercus	pollen	NISP	Tree/Shrub	73	81	61	90	31	33	22	23	18
TilaCor	Tilia cordata	pollen	NISP	Tree/Shrub		1							
Ulmus	Ulmus	pollen	NISP	Tree/Shrub	4	3	1	8		3	8	3	2
Cory	Corylus avellana-type	pollen	NISP	Tree/Shrub	51	59	45	49	69	75	49	48	63
Frax	Fraxinus	pollen	NISP	Tree/Shrub	1	5	2		3	2	2		
Sal	Salix	pollen	NISP	Tree/Shrub	1		7	2	2		1	5	4
Heder	Hedera helix	pollen	NISP	Tree/Shrub	2	1	1	3	2	2	1		2

Pollen	Br3			Depth (cm)	1	2	8	9	15	16	22	23	25
Code	Name	Element	Units	Group									
Ilex	Ilex	pollen	NISP	Tree/Shrub	1	2		3		2	1	1	
Jun	Juniperus	pollen	NISP	Tree/Shrub		3	1	3	2				
Poa	Poaceae undiff	pollen	NISP	HERB	182	147	139	158	179	181	157	130	113
Carex	Carex	pollen	NISP	HERB			1						
Cereali	Cerealia-type	pollen	NISP	HERB				1					
Cyp	Cyperaceae undiff	pollen	NISP	HERB	35	16	15	13	8	9	37	38	33
AchillAnth	Achillea Anthemis	pollen	NISP	HERB		1	3	4		2			
Apia	Apiaceae	pollen	NISP	HERB	1	5	1	1		1	1	1	1
Ast-Lac	Asteraceae Latucae	pollen	NISP	HERB	1	1	2	1		1	1		
AstrDan	Astragulus danicus	pollen	NISP	HERB						2	1	1	2
Cheno	Chenopodioideae	pollen	NISP	HERB	36	48	33	36	47	23	10	7	3
Fili	Filipendula	pollen	NISP	HERB				2					
FumaThym	Fumana thymifolia	pollen	NISP	HERB		1			2				
Gal	Gallium	pollen	NISP	HERB	40	15	38	12					
HydroVul	Hydrocotle vulgaris	pollen	NISP	HERB				3	1				
Knaut	Knautia	pollen	NISP	HERB								1	
PlanLa	Plantago lanceolata	pollen	NISP	HERB	2	19	29	16	6	12	9	7	4
PlanMaj	Plantago major	pollen	NISP	HERB	11	5	34	20	6	1	1		
PlanMar	Plantago maritimus	pollen	NISP	HERB							5	4	1
Ranun	Ranunculus-type	pollen	NISP	HERB	3	12	13	6		2			1
SilDio	Silene dioica	pollen	NISP	HERB								2	
Rumex	Rumex	pollen	NISP	HERB				1					
RumAce	Rumex acetosa-type	pollen	NISP	HERB		4	1	2		3		1	
RumAcetosel	Rumex acetosella	pollen	NISP	HERB		1							
Urtica	Urtica	pollen	NISP	HERB	1		4		4	1	1		
Val	Valeriana	pollen	NISP	HERB			1		1			3	
Dryopteris	Dryopteris	spore	NISP	SPORE		6	2		2	1	3	2	1
Poly	Polypodium	spore	NISP	SPORE	10	11	2	4	3	6	4	4	7
Sphag	Sphagnum	spore	NISP	SPORE	1	5	1	4	6	6	1	1	
Lemna	Lemna	aquatic	NISP	AQUATIC		7	9	4	10	7	13	25	30
TyphaLat	Typha latifolia	aquatic	NISP	AQUATIC	1	4		3	1		1	1	2
Nymph	Nymphaea alba type	aquatic	NISP	AQUATIC				1					
Pot	Potamogeton	aquatic	NISP	AQUATIC	3	10	11	24	1		4		2
Trig	Triglochin	aquatic	NISP	AQUATIC							3	2	
Botryo	Botryococcus	NPP	NISP	NPP							2		
Cerco	Cercophora	NPP	NISP	NPP				3					
Chaet	Chaetomium-type					1							
Chonio	Choniochaeta	NPP	NISP	NPP	1	3							
Coleo	Coleochaete	NPP	NISP	NPP				1					
Gel	Gelasinospora	NPP	NISP	NPP	6								
Pedi	Pediastrum	NPP	NISP	NPP								1	
Peris	Perisseiasphaeridium cf.	NPP	NISP	NPP					1				
Pod	Podospora	NPP	NISP	NPP	65								
Sordaria	Sordaria-type	NPP	NISP	NPP	1	4	2						

Pollen	Br3			Depth (cm)	1	2	8	9	15	16	22	23	25
Code	Name	Element	Units	Group									
Spyro	Spyrogyra	NPP	NISP	NPP	1						3		
UstDeu	Ustulina deusta	NPP	NISP	NPP	3								
Indet	Indeterminate	Indeterminat e	NISP	INDET	12	12	5	9	6	3	20	14	
Charcoal	Microcharcoal ≥25µm	NPP	NISP	CHAR	10	63	22	25	4				
SUM(Group)			percent	None	0	0	0	0	0	0	0	0	0
SUM(CONC)	Concentrations		percent	None	9676.1 5	9687.5 2	9674.8 5	9679. 1	9673.9 5	9672. 3	9669.6 5	9669.5 4	9670.6 6
SUM(Tree/Shrub)	Tree/Shrubs		percent	TLP	188	227	187	228	244	262	277	307	345
SUM(HERB)	Herbs		percent	TLP	312	275	314	276	254	238	223	195	158
SUM(SPORE)	Spores		percent	TLP+S	11	22	5	8	11	13	8	7	8
SUM(AQUATIC)	Aquatics		percent	TLP+A	4	21	20	32	12	7	21	28	34
SUM(NPP)	Non Pollen Palynmorphs		percent	None	77	7	2	4	1	0	5	1	0
SUM(INDET)	Indeterminable		percent	None	12	12	5	9	6	3	20	14	0
SUM(CHAR)	Microcharcoal >25microns		percent	None	10	63	22	25	4	0	0	0	0
SSUM(TLP)	Total Land Pollen			Tree/Shrub;HERB	500	502	501	504	498	500	500	502	503
SSUM(TLP+A)	Total Land Pollen + Aquatics			Tree/Shrub;HERB;AQUAT IC	504	523	521	536	510	507	521	530	537
SSUM(TLP+S)	Total Land Pollen + Spores			Tree/Shrub;HERB;SPORE	511	524	506	512	509	513	508	509	511

Table 54: Br4 Pollen Counts

Pollen	Br4			Depth (cm)	2	6	7	25
Code	Name	Element	Units	Group				
#Samp.Analyst	Rhiannon Philp							
Lyc.tab:quantity added:number	Lycopodium tablets	quantity added	number	CONC	1	1	1	1
Lyc.tab:concentration:number/tablet	Lycopodium tablets	concentration	number/tablet	CONC	9666	9666	9666	9666
Lyc.spik:counted:number	Lycopodium counted	counted	number	CONC	4	25	21	8
samp.quant:mass:g	Sample quantity	mass	g	CONC	2.97	2.43	2.99	2.13
Aln	Alnus glutinosa	pollen	NISP	Tree/Shrub	26	10	17	23
Bet	Betula	pollen	NISP	Tree/Shrub		3	1	51
Carp	Carpinus	pollen	NISP	Tree/Shrub		3		
PinSyl	Pinus sylvestris	pollen	NISP	Tree/Shrub		2		1
Querc	Quercus	pollen	NISP	Tree/Shrub	7	13	13	21
Ulmus	Ulmus	pollen	NISP	Tree/Shrub	3	11	3	3
Cory	Corylus avellana-type	pollen	NISP	Tree/Shrub	267	23	25	217
Frax	Fraxinus	pollen	NISP	Tree/Shrub			2	4
Sal	Salix	pollen	NISP	Tree/Shrub	1	3		17
Ilex	Ilex	pollen	NISP	Tree/Shrub				6
Poa	Poaceae undiff	pollen	NISP	HERB	128	259	210	38
Carex	Carex	pollen	NISP	HERB	27	16		1
Cereali	Cerealia-type	pollen	NISP	HERB	1			
Cyp	Cyperaceae undiff	pollen	NISP	HERB	8	132	222	103

Pollen	Br4			Depth (cm)	2	6	7	25
Code	Name	Element	Units	Group				
Apia	Apiaceae	pollen	NISP	HERB		4	1	
Ast-Lac	Asteraceae Latucae	pollen	NISP	HERB		1		
AstTrip	Asteraceae Tripolium	pollen	NISP	HERB		1		
Camp	Campanula	pollen	NISP	HERB	1			
Cheno	Chenopodioideae	pollen	NISP	HERB		1		1
Gal	Gallium	pollen	NISP	HERB		1		
PlanLa	Plantago lanceolata	pollen	NISP	HERB	13	6	6	9
PlanMaj	Plantago major	pollen	NISP	HERB	7	2		1
Ranun	Ranunculus-type	pollen	NISP	HERB	3	2		
SambNig	Sambucus nigra	pollen	NISP	HERB	7		1	5
Sax	Saxifragaceae undiff	pollen	NISP	HERB				1
Urtica	Urtica	pollen	NISP	HERB	1	11		
Dryopteris	Dryopteris	spore	NISP	SPORE			5	2
Osmu	Osmunda	spore	NISP	SPORE			5	
Poly	Polypodium	spore	NISP	SPORE		340	79	13
PterAqui	Pteridium aquilinum	spore	NISP	SPORE	8	16		
Sphag	Sphagnum	spore	NISP	SPORE	1	8	12	4
ThelPal	Thelypteris palustris	spore	NISP	SPORE		1		
Lemna	Lemna	aquatic	NISP	AQUATIC				1
TyphaLat	Typha latifolia	aquatic	NISP	AQUATIC		2		1
Nymph	Nymphaea alba type	aquatic	NISP	AQUATIC	2	4	3	
Pot	Potamogeton	aquatic	NISP	AQUATIC		1	1	8
Sagi	Sagittaria	aquatic	NISP	AQUATIC				1
Cerco	Cercophora	NPP	NISP	NPP				1
Chaet	Chaetomium-type						2	
Chonio	Choniochaeta	NPP	NISP	NPP	4	16	12	
Delit	Delitschia	NPP	NISP	NPP			3	
Sordaria	Sordaria-type	NPP	NISP	NPP		2	8	
Sporo	Sporimiella	NPP	NISP	NPP			17	
Type 83	Type 83	NPP	NISP	NPP			12	
UstDeu	Ustulina deusta	NPP	NISP	NPP	3			5
Valsaria	Valsaria cf. variospora	NPP	NISP	NPP	2	8	8	2
Indet	Indeterminate	Indeterminate	NISP	INDET	1	7	19	25
Charcoal	Microcharcoal ≥25µm	NPP	NISP	CHAR	2	1		
SUM(Group)			percent	None	0	0	0	0
SUM(CONC)	Concentrations		percent	None	9673.97	9694.43	9690.99	9677.1
SUM(Tree/Shrub)	Tree/Shrubs		percent	TLP	304	68	61	343
SUM(HERB)	Herbs		percent	TLP	196	436	440	159
SUM(SPORE)	Spores		percent	TLP+S	9	365	101	19
SUM(AQUATIC)	Aquatics		percent	TLP+A	2	7	4	11
SUM(NPP)	Non Pollen Palynmorphs		percent	None	9	26	60	8
SUM(INDET)	Indeterminable		percent	None	1	7	19	25
SUM(CHAR)	Microcharcoal >25microns		percent	None	2	1	0	0
SSUM(TLP)	Total Land Pollen			Tree/Shrub;HERB	500	504	501	502

Pollen	Br4			Depth (cm)	2	6	7	25
Code	Name	Element	Units	Group				
SSUM(TLP+A)	Total Land Pollen + Aquatics			Tree/Shrub;HERB;AQUATIC	502	511	505	513
SSUM(TLP+S)	Total Land Pollen + Spores			Tree/Shrub;HERB;SPORE	509	869	602	521

Table 55: Br5 Pollen Counts

Pollen	Br5			Depth (cm)	1	2	8	9	25	26	36	37	44
Code	Name	Element	Units	Group									
#Samp.Analyst	Rhiannon Philp												
Lyc.tab:quantity added:number	Lycopodium tablets	quantity added	number	CONC	1	1	1	1	1	1	1	1	1
Lyc.tab:concentration:number/tablet	Lycopodium tablets	concentration	number/tablet	CONC	9666	9666	9666	9666	9666	9666	9666	9666	9666
Lyc.spik:counted:number	Lycopodium counted	counted	number	CONC	18	22	4	7	28	10	4	5	11
samp.quant:mass:g	Sample quantity	mass	g	CONC	2.11	1.84	2.15	2.49	2	2.18	2.61	1.7	1.49
Aln	Alnus glutinosa	pollen	NISP	Tree/Shrub	10	5	9	7	9	41	123	44	46
Bet	Betula	pollen	NISP	Tree/Shrub	7	3	4		2	3	2	8	
Cast	Castanea	pollen	NISP	Tree/Shrub	4	7	1		2			2	
PinSyl	Pinus sylvestris	pollen	NISP	Tree/Shrub	1				1	1			
Querc	Quercus	pollen	NISP	Tree/Shrub	36	15	19	13	16	33	19	32	20
TilaCor	Tilia cordata	pollen	NISP	Tree/Shrub			1						
Ulmus	Ulmus	pollen	NISP	Tree/Shrub	9	8	1		3	4	2	4	
Cory	Corylus avellana-type	pollen	NISP	Tree/Shrub	11	11	37	62		74	45	63	80
Frax	Fraxinus	pollen	NISP	Tree/Shrub	1	1	2	1	4	5	2	1	
Sal	Salix	pollen	NISP	Tree/Shrub	1		1	2	1	14	13	19	10
Heder	Hedera helix	pollen	NISP	Tree/Shrub	9	3	1	1			1		1
Ilex	Ilex	pollen	NISP	Tree/Shrub			2	4		8	1	1	1
Jun	Juniperus	pollen	NISP	Tree/Shrub				1	1	1			
Pop	Populus	pollen	NISP	Tree/Shrub	1								
Poa	Poaceae undiff	pollen	NISP	HERB	217	219	236	235	105	146	108	176	174
Carex	Carex	pollen	NISP	HERB	12		6	5	3	3	4		6
Cereali	Cerealia-type	pollen	NISP	HERB				2					
Cyp	Cyperaceae undiff	pollen	NISP	HERB	93	142	109	95	269	113	144	110	136
AchillAnth	Achillea Anthemis	pollen	NISP	HERB			1	2					
Agrostemma	Agrostemma	pollen	NISP	HERB					4				
AndroMax	Androsace maxima	pollen	NISP	HERB	3			1					
Apia	Apiaceae	pollen	NISP	HERB	3	2	1	2	10	6	4	3	2
Ast-Lac	Asteraceae Latucae	pollen	NISP	HERB	5	6	4	10	2	1			
Astr	Astragalus-type	pollen	NISP	HERB	1								
AstrDan	Astragulus danicus	pollen	NISP	HERB			2	1		1			
Caryophyll	Caryophyllaceae	pollen	NISP	HERB		10							
Cent	Centaurea	pollen	NISP	HERB									1
Cheno	Chenopodioideae	pollen	NISP	HERB	9				2	1	2	2	2
Falo	Falopia convolvulus	pollen	NISP	HERB		3							
Fili	Filipendula	pollen	NISP	HERB	2						2		

Pollen	Br5			Depth (cm)	1	2	8	9	25	26	36	37	44
Code	**Name**	**Element**	**Units**	**Group**									
Gal	Gallium	pollen	NISP	HERB	4	6	10	10		5	1	1	
HippoRham	Hippophae rhamnoides	pollen	NISP	HERB					1				
HydroVul	Hydrocotle vulgaris	pollen	NISP	HERB	7	20	7	6	11	5	2	1	
Knaut	Knautia	pollen	NISP	HERB					1				
Lotus	Lotus	pollen	NISP	HERB		2							
LythSali	Lythrum salicaria	pollen	NISP	HERB									1
PlanLa	Plantago lanceolata	pollen	NISP	HERB	19	5	29	17	18	21	8	16	12
PlanMaj	Plantago major	pollen	NISP	HERB	4	10	7	7	5	4		2	2
Pole	Polemonium	pollen	NISP	HERB		13							
Polyg	Polygonum	pollen	NISP	HERB				2					
Pote	Potentilla-type	pollen	NISP	HERB	1								
PrimVulg	Primula vulgaris	pollen	NISP	HERB	5								
PrunVulg	Prunella vulgaris	pollen	NISP	HERB		2		1					
Ranun	Ranunculus-type	pollen	NISP	HERB	20	5	5	2	3	4	4	1	1
RosArv	Rosa arvensis	pollen	NISP	HERB		1							
SambNig	Sambucus nigra	pollen	NISP	HERB	2					8	8	12	5
Scab	Scabiosa	pollen	NISP	HERB				2					
SmyrOlus	Smyrnium olusatrum	pollen	NISP	HERB								1	
SolaDulc	Solanum dulcamara	pollen	NISP	HERB					1	3			
SymphOff	Symphytum officianale	pollen	NISP	HERB									1
Rumex	Rumex	pollen	NISP	HERB		1	1						
RumAce	Rumex acetosa-type	pollen	NISP	HERB	3	4		5	3		4	2	
RumAcetosel	Rumex acetosella	pollen	NISP	HERB			2	5			1		
Urtica	Urtica	pollen	NISP	HERB	2	1	2	1				1	
Val	Valeriana	pollen	NISP	HERB	1		1						1
BlechSpic	Blechrum spicant	spore	NISP	SPORE						4			
Osmu	Osmunda	spore	NISP	SPORE		2							
Poly	Polypodium	spore	NISP	SPORE	13	49	10	12	173	19	54	39	41
Sphag	Sphagnum	spore	NISP	SPORE	7	9	4	5	2	16	6	8	14
Lemna	Lemna	aquatic	NISP	AQUATIC	19	14	24	37			10	1	6
TyphaLat	Typha latifolia	aquatic	NISP	AQUATIC	2				6		1	3	2
Nuph	Nuphar	aquatic	NISP	AQUATIC	1								
Nymph	Nymphaea alba type	aquatic	NISP	AQUATIC						1			
Pot	Potamogeton	aquatic	NISP	AQUATIC	3	12	8	6	6	8	2	4	2
Botryo	Botryococcus	NPP	NISP	NPP							28	5	3
Chaet	Chaetomium-type										3	1	3
Chonio	Choniochaeta	NPP	NISP	NPP					3				1
Gel	Gelasinospora	NPP	NISP	NPP							1		
Meliola	Meliola ellisii	NPP	NISP	NPP			2						
Peris	Perisseiasphaeridium cf.	NPP	NISP	NPP			13						
Persicio	Persiciospora	NPP	NISP	NPP	6	325		6					
Pod	Podospora	NPP	NISP	NPP			3		3			4	
Sordaria	Sordaria-type	NPP	NISP	NPP	10	18	3	9	2		1	1	6
Sporo	Sporimiella	NPP	NISP	NPP	2			4					4

Pollen	Br5			Depth (cm)	1	2	8	9	25	26	36	37	44
Code	Name	Element	Units	Group									
Tetraploa	Tetraploa	NPP	NISP	NPP			2	2			1		
Type 83	Type 83	NPP	NISP	NPP						1			
UstDeu	Ustulina deusta	NPP	NISP	NPP			23	10			12	6	7
Valsaria	Valsaria cf. variospora	NPP	NISP	NPP	1	6		3	2		7	3	2
Indet	Indeterminate	Indeterminate	NISP	INDET	7	14	8	8	12	32	11	11	18
Charcoal	Microcharcoal ≥25µm	NPP	NISP	CHAR	10		7	16	1		7	5	8
SUM(Group)			percent	None	0	0	0	0	0	0	0	0	0
SUM(CONC)	Concentrations		percent	None	9687.1 1	9690.8 4	9673.1 5	9676. 5	969 7	9679.1 8	9673.6 1	9673. 7	9679.4 9
SUM(Tree/Shrub)	Tree/Shrubs		percent	TLP	90	53	78	91	39	184	208	174	158
SUM(HERB)	Herbs		percent	TLP	413	452	423	411	438	321	292	328	344
SUM(SPORE)	Spores		percent	TLP+S	20	60	14	17	175	39	60	47	55
SUM(AQUATIC)	Aquatics		percent	TLP+A	25	26	32	43	12	9	13	8	10
SUM(NPP)	Non Pollen Palynomorphs		percent	None	19	349	46	34	10	1	50	19	23
SUM(INDET)	Indeterminable		percent	None	7	14	8	8	12	32	11	11	18
SUM(CHAR)	Microcharcoal >25 microns		percent	None	10	0	7	16	1	0	7	5	8
SSUM(TLP)	Total Land Pollen			Tree/Shrub;HERB	503	505	501	502	477	505	500	502	502
SSUM(TLP+A)	Total Land Pollen + Aquatics			Tree/Shrub;HERB;AQUATI C	528	531	533	545	489	514	513	510	512
SSUM(TLP+S)	Total Land Pollen + Spores			Tree/Shrub;HERB;SPORE	523	565	515	519	652	544	560	549	557

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Table 56: PE1 Pollen Counts

Pollen	PE1			Depth (cm)	2	4	6	9	10	12	13	15	17	19	20	21	22	23	24	25	26	28	31	33	36	37	39	43	47	51	55	58	59
Code	Name	Element	Units	Group																													
Code	Name	Element	Units	Group																													
#Chron1	Sample age (Bayesian)		yr AD/BC																														
#Samp.Analyst	Rhiannon Philp																																
Lyc.tab:quantity added:number	Lycopodium tablets	quantity added	number	CONC	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Lyc.tab:concentration:number/tablet	Lycopodium tablets	concentration	number/tablet	CONC	96 66	96 66	96 66	96 66	96 66	96 66	96 66	96 66	96 66	96 66	96 66	96 66	96 66	96 66	96 66	96 66	96 66	96 66	96 66	96 66	96 66	96 66	96 66	96 66	96 66	96 66	96 66	96 66	96 66
Lyc.spik:counted:number	Lycopodium counted	counted	number	CONC	2	33	11	25	37	33	18			30	15	51	26	24	76	19	14	15	13	26	38	24	21	4	41	24	19	21	8

Pollen	PE1			Depth (cm)	2	4	6	9	10	12	13	15	17	19	20	21	22	23	24	25	26	28	31	33	36	37	39	43	47	51	55	58	59
Code	**Name**	**Element**	**Units**	**Group**																													
samp.quant:mass:g	Sample quantity	mass	g	CONC	2.09	1.57	2.62	1.58	2.57	3.25	3.69	3.36	2.63	3.46	3.98	1.71	2.52	2.83	1.96	2.82	2.48	2.56	2.4	3.07	2.4	1.98	1.36	2.4	2.75	3.57	3.32	3.4	1.82
Aln	Alnus glutinosa	pollen	NISP	Tree/Shrub	60	114	70	67	22	22	8			18	4	32	7	10	8	3	35	28	22	13	25	2	14	8	13	23	19	6	173
Bet	Betula	pollen	NISP	Tree/Shrub	4	10	3	13	7	8	1			7		4	2	1	6	3	9	9	4	1	1	1	3	14	8		1	2	1
Carp	Carpinus	pollen	NISP	Tree/Shrub										1								5											
PinSyl	Pinus sylvestris	pollen	NISP	Tree/Shrub	1	3	6	2	14	4	13			13	9	4	6	8	16	22	11	4	13	17	20	25	10	3	22	19	24	23	2
Querc	Quercus	pollen	NISP	Tree/Shrub	40	65	14	74	37	41	11			61	12	66	37	19	45	53	73	65	68	52	54	24	81	34	75	55	47	26	43
TilaCor	Tilia cordata	pollen	NISP	Tree/Shrub		2		2	4	1				1		1		1	1	1	1			1	1				1				
Ulmus	Ulmus	pollen	NISP	Tree/Shrub	10	12	7	18	23	15	5			23	15	18	14	1	9	10	10	13	14		3	13	15	11	11	13	3	9	21
Cory	Corylus avellana-type	pollen	NISP	Tree/Shrub	89	167	55	171	94	83	10			99	12	35	29	12	26	38	162		116	10	58	7	47	132	60	45	45	37	33
Frax	Fraxinus	pollen	NISP	Tree/Shrub	2	1	1	8	10	11	1			2	3	12			5		2	8	2	2	5		3	4	6	8	7	1	3
Fag	Fagus	pollen	NISP	Tree/Shrub		1		1																									
Sal	Salix	pollen	NISP	Tree/Shrub	4	7	1	3	2	10	5				9	20	3	14	9	6	9	2			1	4	10	3	5	4	3	7	4
Heder	Hedera helix	pollen	NISP	Tree/Shrub	2			7	17	3	1			6	1	11	1	2	2	6	7	5	3	1	10		8	2	2		2	5	3
Ilex	Ilex	pollen	NISP	Tree/Shrub		6		2	1	3	3			3	2	4		2	6	2		5	1	1	3		7	6		1	1		2
Jun	Juniperus	pollen	NISP	Tree/Shrub				2							1	1			3	1		3	1		2					5	4		
LigVul	Ligustrum vulgaris	pollen	NISP	Tree/Shrub						1																							
Pop	Populus	pollen	NISP	Tree/Shrub							1																						
Taxus	Taxus	pollen	NISP	Tree/Shrub							1						1																
Poa	Poaceae undiff	pollen	NISP	HERB	216	53	51	124	211	220	87			82	111	212	174	247	206	285	123	157	199	342	244	366	258	265	268	260	295	267	193
Carex	Carex	pollen	NISP	HERB	5		1				9			18	3	13	1		12	5	3	8	3	7		4	7	4		10	2		
Cereali	Cerealia-type	pollen	NISP	HERB	3			2	7	12	1			12	5	13	1	8	34	7	7	7	8	3	5	10	14	1	6	11	3	2	1
Cyp	Cyperaceae undiff	pollen	NISP	HERB	53	14	2	6	7	15					4	3	2	1	2	4	4	2				2	1			2	5		8
Achill	Achillea-type	pollen	NISP	HERB											4	2					1				1	2	1						

Pollen	PE1			Depth (cm)	2	4	6	9	10	12	13	15	17	19	20	21	22	23	24	25	26	28	31	33	36	37	39	43	47	51	55	58	59
Code	**Name**	**Element**	**Units**	**Group**																													
Apia	Apiaceae	pollen	NISP	HERB	2				1		2			1		1	1	1	2			2	1				1				1	1	
Arm	Armeria type	pollen	NISP	HERB							2																						
Art	Artemisia	pollen	NISP	HERB																			1										
AstAst	Asteraceae Asteroideae	pollen	NISP	HERB						1						1			1						3						3		
Ast-Lac	Asteraceae Latucae	pollen	NISP	HERB						2	4				3				3	1		1		1							1	1	
Ast	Asteraceae undiff	pollen	NISP	HERB							1									1	4						3		4			1	
Brass	Brassicaceae	pollen	NISP	HERB																							1						
Cheno	Chenopodioideae	pollen	NISP	HERB	1				22	21	18			24	29	26	211	50	88	31	30	32	37	34	26	22	8	1	16	3	13	100	1
Erica	Ericaceae undiff	pollen	NISP	HERB		1				2	1					1	1	6	6	6	7	8				12						4	3
Fili	Filipendula	pollen	NISP	HERB					1																								
Gal	Gallium	pollen	NISP	HERB												1																	
Ger	Geranium	pollen	NISP	HERB						1																							
HellVir	Helleborus viridius	pollen	NISP	HERB			1																										
Lin	Linaceae	pollen	NISP	HERB										1								1											
LinCat	Linum catharicum	pollen	NISP	HERB																1													
Malv	Malva-type	pollen	NISP	HERB																													
PlanLa	Plantago lanceolata	pollen	NISP	HERB	2	2	2	1	3	5	16			2	9	3	4	9	3	2	1		2	7	5	3	1	5	1	4	1	3	3
PlanMaj	Plantago major	pollen	NISP	HERB		2	2	1	4	2	1			2	2	4		2	4			1			1		1	1	1			1	9
PlanMar	Plantago maritimus	pollen	NISP	HERB		1		1	4	6																							
Plant	Plantago undiff	pollen	NISP	HERB																						1							
Pole	Polemonium	pollen	NISP	HERB						1																							
Polyg	Polygonum	pollen	NISP	HERB						2							1																

Pollen	**PE1**			**Depth (cm)**	2	4	6	9	10	12	13	15	17	19	20	21	22	23	24	25	26	28	31	33	36	37	39	43	47	51	55	58	59
Code	**Name**	**Element**	**Units**	**Group**																													
Ranun	Ranunculus-type	pollen	NISP	HERB	5	3	1	1	6	9	1			15	2	2			4	4	6	6	3	3	17	2	2	3	2	11	9	5	1
SambNig	Sambucus nigra	pollen	NISP	HERB																					4								
Sax	Saxifragaceae undiff	pollen	NISP	HERB	2		2							8		16	1	1				1	5	3	11				1	24	8	1	
Rumex	Rumex	pollen	NISP	HERB																											1		
RumAce	Rumex acetosa-type	pollen	NISP	HERB							1				1																		
Urtica	Urtica	pollen	NISP	HERB		11			1		2				1		1													2			
Urt	Urticularia	pollen	NISP	HERB				1	2																								
Val	Valeriana	pollen	NISP	HERB					5		1																						
ValD	Valeriana dioca	pollen	NISP	HERB				1																									
Poly	Polypodium	spore	NISP	SPORE	4	1		3	10	2	3			8	3	10	3	12	13	6	1	3	9	7	13	14	9		6	10	16	12	8
Pteridium	Pteridium	spore	NISP	SPORE																						2							
Sphag	Sphagnum	spore	NISP	SPORE	1	1		1	3	5	1			1	1	1	4	1	2	1		1	1	1		3		1	1	2	2	1	2
ThelPal	Thelypteris palustris	spore	NISP	SPORE							1																						
ButUmb	Butomus umbellatus	aquatic	NISP	AQUATIC						1																							
Lemna	Lemna	aquatic	NISP	AQUATIC						5	9			2	5		1	2	6	1	2	1	1	4	7	1	1		6	5	2	1	
LobDort	Lobelia Dortmanna	aquatic	NISP	AQUATIC											1																		
TyphaLat	Typha latifolia	aquatic	NISP	AQUATIC	5	10		1		6	3			6	16	32	7	15	7	20	18	7		1	2	16	21	6	5	2	3	5	14
Myrio	Myriophyllum	aquatic	NISP	AQUATIC		4		1																									
Nuph	Nuphar	aquatic	NISP	AQUATIC					5	5	2			4	4	5	1	2	1	2	4	1	2	7	16	3	1		2	5	6		
Nymph	Nymphaea alba type	aquatic	NISP	AQUATIC	13	4	6		2	2								1						1	2								8
Pot	Potamogeton	aquatic	NISP	AQUATIC	2	13	6	2	2	2	2			2	25	201	6	4	30	19	7	3	2	2	5	14	71	15	2	2	2	1	8
Trig	Triglochin	aquatic	NISP	AQUATIC														2	3	1	1			1						1			

Pollen	PE1			Depth (cm)	2	4	6	9	10	12	13	15	17	19	20	21	22	23	24	25	26	28	31	33	36	37	39	43	47	51	55	58	59
Code	**Name**	**Element**	**Units**	**Group**																													
TyphaAng	Typha angustifolia	aquatic	NISP	AQUATIC										8		15	13	30	13	36	8			9		12	4	3					
TyphaDom	Typha domingensis	aquatic	NISP	AQUATIC							1																						
AmpFlav	Amphitrema flavum	NPP	NISP	NPP											2																		
Chaet	Chaetomium-type							1			1																						
CysFrag	Cystopteris Fragilis	NPP	NISP	NPP							2																						
Gel	Gelasinospora	NPP	NISP	NPP																2													
Pod	Podospora	NPP	NISP	NPP	1	1		4	3	1	1				1	3	1	15	4	5	1	1	3	6	2	4	1		13	59	3	3	5
ScopBar	Scopinella barbata	NPP	NISP	NPP																			8					75					
Sel	Selaginella	NPP	NISP	NPP					2		2																						
Sordaria	Sordaria-type	NPP	NISP	NPP	1	7	4	9	4	18	8			8	13	15	2	7	4	4	7	8	1	1	25	4	13	5	20	40	2	13	22
UstDeu	Ustulina deusta	NPP	NISP	NPP						1																							
Indet	Indeterminate	Indeterminate	NISP	INDET	10	13	3	2	28	12	25			4	14	36	21	25	27	11	13	7	3	1		11	22	5	15	5	15	15	6
Charcoal	Microcharcoal ≥25µm	NPP	NISP	CHAR	3	208	6	11	44	38	14			27	10	22	17	25	41	20	8	30	31	59	55	29	7		120	133	133	100	8
SUM(Group)			percent	None	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SUM(CONC)	Concentrations		percent	None	9671.09	9701.57	9680.62	9693.6	9706.57	9703.25	9688.69	9670.36	9669.63	9700.46	9685.98	9719.71	9695.52	9693.83	9744.96	9688.82	9683.48	9684.56	9682.4	9696.07	9707.4	9692.98	9689.36	9673.4	9710.75	9694.57	9689.32	9691.4	9676.82
SUM(Tree/Shrub)	Tree/Shrubs		percent	TLP	212	388	157	370	231	202	60	0	0	234	68	208	100	70	136	145	319	147	244	98	183	76	198	217	203	173	156	116	285
SUM(HERB)	Herbs		percent	TLP	289	87	62	138	274	299	147	0	0	165	174	298	398	325	365	347	186	226	259	400	317	424	298	280	299	327	342	386	219
SUM(SPORE)	Spores		percent	TLP+S	5	2	0	4	13	7	5	0	0	9	4	11	7	13	15	7	1	4	10	8	13	19	9	1	7	12	18	13	10
SUM(AQUATIC)	Aquatics		percent	TLP+A	20	31	12	4	9	21	17	0	0	22	51	253	28	56	60	79	40	12	5	25	32	46	98	24	15	15	13	7	30
SUM(NPP)	Non Pollen Palynomorphs		percent	None	2	8	4	13	9	20	13	0	0	8	16	18	3	22	8	11	8	9	12	7	27	8	14	80	33	99	5	16	27

Pollen	PE1			Depth (cm)	2	4	6	9	10	12	13	15	17	19	20	21	22	23	24	25	26	28	31	33	36	37	39	43	47	51	55	58	59
Code	Name	Element	Units	Group																													
SUM(INDET)	Indeterminable		percent	None	10	13	3	2	28	12	25	0	0	4	14	36	21	25	27	11	13	7	3	1	0	11	22	5	15	5	15	15	6
SUM(CHAR)	Microcharcoal >25microns		percent	None	3	208	6	11	44	38	14	0	0	27	10	22	17	25	41	20	8	30	31	59	55	29	7	0	120	133	133	100	8
SSUM(TLP)	Total Land Pollen			Tree/Shrub;HERB	501	475	219	508	505	501	207	0	0	399	242	506	498	395	501	492	505	373	503	498	500	500	496	497	502	500	498	502	504
SSUM(TLP+A)	Total Land Pollen + Aquatics			Tree/Shrub;HERB;AQUATIC	521	506	231	512	514	522	224	0	0	421	293	759	526	451	561	571	545	385	508	523	532	546	594	521	517	515	511	509	534
SSUM(TLP+S)	Total Land Pollen + Spores			Tree/Shrub;HERB;SPORE	506	477	219	512	518	508	212	0	0	408	246	517	505	408	516	499	506	377	513	506	513	519	505	498	509	512	516	515	514

Table 57: PE2 Pollen Counts

Pollen	PE2			Depth (cm)	7	11	15	19	23	26	28	30	33	36	40	43
Code	Name	Element	Units	Group												
Code	Name	Element	Units	Group												
#Chron1	Sample age (Bayesian)		yr AD/BC			.										
#Samp.Analyst	Rhiannon Philp															
Lyc.tab:quantity added:number	Lycopodium tablets	quantity added	number	CONC	1	1	1	1	1	1	1	1	1	1	1	1
Lyc.tab:concentration:number/tablet	Lycopodium tablets	concentration	number/tablet	CONC	9666	9666	9666	9666	9666	9666	9666	9666	9666	9666	9666	9666
Lyc.spik:counted:number	Lycopodium counted	counted	number	CONC	22	18	6	5	3	9	5	3	12	4	5	6
samp.quant:mass:g	Sample quantity	mass	g	CONC	1.55	1.89	3.4	2.71	1.65	1.3	1.52	1.61	2.4	2.14	2.78	2.4
Aln	Alnus glutinosa	pollen	NISP	Tree/Shrub	39	28	80	71	29	112	113	121	89	209	30	90
Bet	Betula	pollen	NISP	Tree/Shrub	4		4			6	2	3	2	3	1	
Cast	Castanea	pollen	NISP	Tree/Shrub						1						
Larix	Larix	pollen	NISP	Tree/Shrub	11					2						
PinSyl	Pinus sylvestris	pollen	NISP	Tree/Shrub	3	1	1	1	3	2		1	1		2	
Querc	Quercus	pollen	NISP	Tree/Shrub	40	46	18	34	18	30	50	25	35	19	4	5
TilaCor	Tilia cordata	pollen	NISP	Tree/Shrub	1											1
Ulmus	Ulmus	pollen	NISP	Tree/Shrub	40	3	5	17	18	11	25	24	21	19	1	5
Cory	Corylus avellana-type	pollen	NISP	Tree/Shrub	26	6	40	55	17	42	89	58	73	26	17	44
Frax	Fraxinus	pollen	NISP	Tree/Shrub	4	1		1			5		2		1	
Sal	Salix	pollen	NISP	Tree/Shrub	15	1	2	3	1	19		8	4	9	5	10
Heder	Hedera helix	pollen	NISP	Tree/Shrub	2	4			2	4	4	2	1	1		1
Ilex	Ilex	pollen	NISP	Tree/Shrub	3	6	4	5	3	6	5	10	13	5	1	2
Jun	Juniperus	pollen	NISP	Tree/Shrub	8				1		1	3				
Poa	Poaceae undiff	pollen	NISP	HERB	136	227	212	128	54	98	101	147	115	128	390	211
Carex	Carex	pollen	NISP	HERB		6	18	19	7		12		12	12		
Cereali	Cerealia-type	pollen	NISP	HERB	19	10	3	13	4	20	12	15	5	2	4	6

Pollen	PE2			Depth (cm)	7	11	15	19	23	26	28	30	33	36	40	43
Code	Name	Element	Units	Group												
Cyp	Cyperaceae undiff	pollen	NISP	HERB	158	106	76	125	36	34	53	44	111	38	33	52
Achill	Achillea-type	pollen	NISP	HERB			1								3	
Agrostemma	Agrostemma	pollen	NISP	HERB							1					
Apia	Apiaceae	pollen	NISP	HERB				5			2				1	5
AstAst	Asteraceae Asteroideae	pollen	NISP	HERB					2		1					
Ast-Lac	Asteraceae Latucae	pollen	NISP	HERB										1		
Cheno	Chenopodioideae	pollen	NISP	HERB			3	1		1						
Daphne	Daphne	pollen	NISP	HERB						1		3				10
Erica	Ericaceae undiff	pollen	NISP	HERB							1					
Fili	Filipendula	pollen	NISP	HERB												6
ParPal	Parnassia palustris	pollen	NISP	HERB									1			
PlanLa	Plantago lanceolata	pollen	NISP	HERB		15	2	12	25	16	9	14	6	18	3	20
PlanMaj	Plantago major	pollen	NISP	HERB		8	26	16	22	42	6	2	8	3		11
PlanMar	Plantago maritimus	pollen	NISP	HERB		8	1		8	41	2	16			4	19
Plant	Plantago undiff	pollen	NISP	HERB	1				5							
PrimVulg	Primula vulgaris	pollen	NISP	HERB					1							
Ranun	Ranunculus-type	pollen	NISP	HERB	1	15	2			12	7	9	5	7	5	5
Sax	Saxifragaceae undiff	pollen	NISP	HERB		5		1			1					
Rumex	Rumex	pollen	NISP	HERB			2							1		
RumAce	Rumex acetosa-type	pollen	NISP	HERB			1									
Urtica	Urtica	pollen	NISP	HERB	6	2	1							1		1
AdiCapVen	Adiantum capilleris veneris	pollen	NISP	HERB							1					
Dryopteris	Dryopteris	pollen	NISP	SPORE			1		2		11		7			
Ophio	Ophioglossum	pollen	NISP	SPORE						4						
Poly	Polypodium	spore	NISP	SPORE	6	9	17	21	7	21	51	43	11	3	1	8
Sphag	Sphagnum	spore	NISP	SPORE	3			2							2	
ThelPal	Thelypteris palustris	spore	NISP	SPORE			46	37					4			
Calitriche	Calitriche	aquatic	NISP	AQUATIC						6						
Elodea	Elodea	aquatic	NISP	AQUATIC						2						
Lemna	Lemna	aquatic	NISP	AQUATIC				4							3	
TyphaLat	Typha latifolia	aquatic	NISP	AQUATIC	6	28	6	5	27	8	1	4	6	2	7	9
Myrio	Myriophyllum	aquatic	NISP	AQUATIC					3	1	1	3				
Nuph	Nuphar	aquatic	NISP	AQUATIC				2								
Nymph	Nymphaea alba type	aquatic	NISP	AQUATIC		5	8	7	3	4	10	18	9	2	1	1
Pot	Potamogeton	aquatic	NISP	AQUATIC	15	1	11	17	7	11	19	14	8	8	1	3
Ruppia	Ruppia	aquatic	NISP	AQUATIC												18
Trig	Triglochin	aquatic	NISP	AQUATIC		1							2			
TyphaAng	Typha angustifolia	aquatic	NISP	AQUATIC		50										
Bysso	Byssothecium Type 16	NPP	NISP	NPP	1											
Cerco	Cercophora	NPP	NISP	NPP										12	12	
Chaet	Chaetomium-type	NPP	NISP	NPP					35				1			
Chonio	Choniochaeta	NPP	NISP	NPP											4	
DiporRhiz	Diporotheca rhizophila	NPP	NISP	NPP				1							4	

Pollen	PE2			Depth (cm)	7	11	15	19	23	26	28	30	33	36	40	43
Code	**Name**	**Element**	**Units**	**Group**												
Gel	Gelasinospora	NPP	NISP	NPP	13											
Meliola	Meliola ellisii	NPP	NISP	NPP		184	33	14	37	105	13	15	8		10	2
Persicio	Persiciospora	NPP	NISP	NPP			3	1		1						
ScopBar	Scopinella barbata	NPP	NISP	NPP				1								
Sordaria	Sordaria-type	NPP	NISP	NPP	15	100	25	15	25	30	10	13	10	1	25	25
Tetraploa	Tetraploa	NPP	NISP	NPP			28	14	26	15	11	8	14			
UstDeu	Ustulina deusta	NPP	NISP	NPP		141	30	22	87	34	15	13	22	44	72	50
Indet	Indeterminable	Indeterminable	NISP	INDET	55	25	6	6	24	24	12	20	4	5	1	8
Charcoal	Microcharcoal ≥25µm	NPP	NISP	CHAR	4	34	19	4	5	9	25	4	11	5	14	80
SUM(Group)			percent	None	0	0	0	0	0	0	0	0	0	0	0	0
SUM(CONC)			percent	None	9690.55	9686.89	9676.4	9674.7	9671.65	9677.3	9673.52	9671.61	9681.4	9673.14	9674.78	9675.4
SUM(Tree/Shrub)	Tree/Shrubs		percent	TLP	196	96	154	187	92	235	294	255	241	291	62	158
SUM(HERB)	Herbs		percent	TLP	321	402	348	320	164	266	209	250	263	211	443	346
SUM(SPORE)	Spores		percent	TLP+S	9	9	64	60	9	25	62	43	22	3	3	8
SUM(AQUATIC)	Aquatics		percent	TLP+A	21	85	25	35	40	32	31	39	25	12	12	31
SUM(NPP)	Non Pollen Palynmorphs		percent	None	29	467	124	88	211	208	55	54	59	63	141	79
SUM(INDET)	Indeterminable		percent	None	55	25	6	6	24	24	12	20	4	5	1	8
SUM(CHAR)	Microcharcoal >25microns		percent	None	4	34	19	4	5	9	25	4	11	5	14	80
SSUM(TLP)	Total Land Pollen			Tree/Shrub;HERB	517	498	502	507	256	501	503	505	504	502	505	504
SSUM(TLP+A)	Total Land Pollen + Aquatics			Tree/Shrub;HERB;AQUATIC	538	583	527	542	296	533	534	544	529	514	517	535
SSUM(TLP+S)	Total Land Pollen + Spores			Tree/Shrub;HERB;SPORE	526	507	566	567	265	526	565	548	526	505	508	512

Table 58: PE3 Pollen Counts

Pollen	PE3			Depth (cm)	8	12	16	20	24	25	30	35	40	45
Code	**Name**	**Element**	**Units**	**Group**										
Code	Name	Element	Units	Group										
#Chron1	Sample age (Bayesian)		yr AD/BC											
#Samp.Analyst	Rhiannon Philp													
Lyc.tab:quantity added:number	Lycopodium tablets	quantity added	number	CONC	1	1	1	1	1	1	1	1	1	1
Lyc.tab:concentration:number/tablet	Lycopodium tablets	concentration	number/tablet	CONC	9666	9666	9666	9666	9666	9666	9666	9666	9666	9666
Lyc.spik:counted:number	Lycopodium counted	counted	number	CONC	8	6	10	3	20	12	6	4	1	8
samp.quant:mass:g	Sample quantity	mass	g	CONC	2.09	3.03	3.58	3.03	1.91	2.22	3.35	4.21	3.71	2.22
Aln	Alnus glutinosa	pollen	NISP	Tree/Shrub	53	43	18	21	36	21	15	60	46	42
Bet	Betula	pollen	NISP	Tree/Shrub		4		1		1		2	2	4
Cast	Castanea	pollen	NISP	Tree/Shrub				10						
PinSyl	Pinus sylvestris	pollen	NISP	Tree/Shrub		3			2	5	1	4	1	4
Querc	Quercus	pollen	NISP	Tree/Shrub	34	67	66	37	57	42	15	19	33	28

Pollen	PE3			Depth (cm)	8	12	16	20	24	25	30	35	40	45
Code	Name	Element	Units	Group										
TilaCor	Tilia cordata	pollen	NISP	Tree/Shrub					1	1				
Ulmus	Ulmus	pollen	NISP	Tree/Shrub	11	4		2	12		7	31	10	8
Cory	Corylus avellana-type	pollen	NISP	Tree/Shrub	33	17	8	9	18	18	23	61	25	35
Frax	Fraxinus	pollen	NISP	Tree/Shrub			1	3	2					6
Sal	Salix	pollen	NISP	Tree/Shrub	16	10	6		6	1	1	2	6	
Heder	Hedera helix	pollen	NISP	Tree/Shrub	2			1	1				1	1
Ilex	Ilex	pollen	NISP	Tree/Shrub	27	11	19	5	12	6	1	1	1	11
Jun	Juniperus	pollen	NISP	Tree/Shrub								1		1
Poa	Poaceae undiff	pollen	NISP	HERB	166	222	326	333	216	244	316	244	290	130
Carex	Carex	pollen	NISP	HERB	8	2		5	1	12	11	5	5	18
Cyp	Cyperaceae undiff	pollen	NISP	HERB	44	9	21	3	73	78	21	20	42	111
AchillAnth	Achillea Anthemis	pollen	NISP	HERB	13									
Apia	Apiaceae	pollen	NISP	HERB	2		3	2	1					
AstAst	Asteraceae Asteroideae	pollen	NISP	HERB	2	63	1			1	1			
Ast-Lac	Asteraceae Latucae	pollen	NISP	HERB	3		1	1			2			
Cheno	Chenopodioideae	pollen	NISP	HERB	70	2			1			2		
Daphne	Daphne	pollen	NISP	HERB		1								5
Gal	Gallium	pollen	NISP	HERB			2							
Malv	Malva-type	pollen	NISP	HERB	3							1		
PlanLa	Plantago lanceolata	pollen	NISP	HERB	5	14	18	32	58	55	35	21	21	83
PlanMaj	Plantago major	pollen	NISP	HERB	1		5	11	5	13	35	17	12	13
PlanMar	Plantago maritimus	pollen	NISP	HERB			4	1	2	1	3	1	2	1
Pole	Polemonium	pollen	NISP	HERB		1	1				4		1	3
Ranun	Ranunculus-type	pollen	NISP	HERB	5	16	10	4	1	5	7	8	6	
SambNig	Sambucus nigra	pollen	NISP	HERB	1									
Sax	Saxifragaceae undiff	pollen	NISP	HERB				1					1	
Rumex	Rumex	pollen	NISP	HERB	1									
RumAce	Rumex acetosa-type	pollen	NISP	HERB		7					3			
Urtica	Urtica	pollen	NISP	HERB							1	2	2	
Val	Valeriana	pollen	NISP	HERB		5								
ViberLan	Viburnum lantana	pollen	NISP	HERB		2								
Dryopteris	Dryopteris	pollen	NISP	SPORE			2				2			
Poly	Polypodium	spore	NISP	SPORE	7	4	97	6	68	67	4	18	5	7
Sphag	Sphagnum	spore	NISP	SPORE	3	5	26	3	8	2	1	1	4	1
ThelPal	Thelypteris palustris	spore	NISP	SPORE			3					61	44	26
Lemna	Lemna	aquatic	NISP	AQUATIC	2	36	7							
LobDort	Lobelia Dortmanna	aquatic	NISP	AQUATIC										2
TyphaLat	Typha latifolia	aquatic	NISP	AQUATIC	23	2	30	1	11	2	15	3	2	6
Nymph	Nymphaea alba type	aquatic	NISP	AQUATIC		2		7		3	3	4	11	9
Pot	Potamogeton	aquatic	NISP	AQUATIC	5	1		3	6	2	4	3	8	13
Trig	Triglochin	aquatic	NISP	AQUATIC	1				2					
TyphaAng	Typha angustifolia	aquatic	NISP	AQUATIC		2		1			3			
Chonio	Choniochaeta	NPP	NISP	NPP		163	7	4	85	52	11	9	1	2
Meliola	Meliola ellisii	NPP	NISP	NPP		12	1		12	87	1	4		

Pollen	PE3			Depth (cm)	8	12	16	20	24	25	30	35	40	45
Code	Name	Element	Units	Group										
Persicio	Persiciospora	NPP	NISP	NPP	2		11							
Pod	Podospora	NPP	NISP	NPP	9	930			14		2			
Sordaria	Sordaria-type	NPP	NISP	NPP	51	8	13	85	17	9	1	5		1
Sporo	Sporimiella	NPP	NISP	NPP	5			5				1		
Tetraploa	Tetraploa	NPP	NISP	NPP		8	33	6	26	70	3	4	4	4
UstDeu	Ustulina deusta	NPP	NISP	NPP	20	35	124	41	85	124		85	26	37
Valsaria	Valsaria cf. variospora	NPP	NISP	NPP	10	4	5	19	16	70	4	16	2	12
Indet	Indeterminate	Indeterminate	NISP	INDET	21			4		5	14	8	13	6
Charcoal	Microcharcoal ≥25µm	NPP	NISP	CHAR	3	15	3	1		2	9		7	4
SUM(Group)			percent	None	0	0	0	0	0	0	0	0	0	0
SUM(CONC)	Concentrations		percent	None	9677.09	9676.03	9680.58	9673	9688.91	9681.22	9676.35	9675.21	9671.71	9677.22
SUM(Tree/Shrub)	Tree/Shrubs		percent	TLP	176	159	118	89	147	95	63	181	125	140
SUM(HERB)	Herbs		percent	TLP	324	344	392	393	358	409	439	321	382	364
SUM(SPORE)	Spores		percent	TLP+S	10	9	128	9	76	69	7	80	53	34
SUM(AQUATIC)	Aquatics		percent	TLP+A	31	43	37	12	19	7	25	10	21	30
SUM(NPP)	Non Pollen Palynmorphs		percent	None	97	1160	194	160	255	412	22	124	33	56
SUM(INDET)	Indeterminable		percent	None	21	0	0	4	0	5	14	8	13	6
SUM(CHAR)	Microcharcoal >25microns		percent	None	3	15	3	1	0	2	9	0	7	4
SSUM(TLP)	Total Land Pollen			Tree/Shrub;HERB	500	503	510	482	505	504	502	502	507	504
SSUM(TLP+A)	Total Land Pollen + Aquatics			Tree/Shrub;HERB;AQUATIC	531	546	547	494	524	511	527	512	528	534
SSUM(TLP+S)	Total Land Pollen + Spores			Tree/Shrub;HERB;SPORE	510	512	638	491	581	573	509	582	560	538

Table 59: PE4 Pollen Counts

Pollen	PE4			Depth (cm)	10	20	30	40	50
Code	Name	Element	Units	Group					
#Samp.Analyst	Rhiannon Philp								
Lyc.tab:quantity added:number	Lycopodium tablets	quantity added	number	CONC					1
Lyc.tab:concentration:number/tablet	Lycopodium tablets	concentration	number/tablet	CONC					9666
Lyc.spik:counted:number	Lycopodium counted	counted	number	CONC					24
samp.quant:mass:g	Sample quantity	mass	g	CONC					2.52
Aln	Alnus glutinosa	pollen	NISP	Tree/Shrub					47
Bet	Betula	pollen	NISP	Tree/Shrub					20
PinSyl	Pinus sylvestris	pollen	NISP	Tree/Shrub					3
Querc	Quercus	pollen	NISP	Tree/Shrub					49
Ulmus	Ulmus	pollen	NISP	Tree/Shrub					31
Cory	Corylus avellana-type	pollen	NISP	Tree/Shrub					301
Frax	Fraxinus	pollen	NISP	Tree/Shrub					4
Sal	Salix	pollen	NISP	Tree/Shrub					1
Heder	Hedera helix	pollen	NISP	Tree/Shrub					9

Pollen	PE4			Depth (cm)	10	20	30	40	50
Code	**Name**	**Element**	**Units**	**Group**					
Ilex	Ilex	pollen	NISP	Tree/Shrub					5
Jun	Juniperus	pollen	NISP	Tree/Shrub					2
Poa	Poaceae undiff	pollen	NISP	HERB					82
Carex	Carex	pollen	NISP	HERB					14
Cereali	Cerealia-type	pollen	NISP	HERB					2
Cheno	Chenopodioideae	pollen	NISP	HERB					4
Erica	Ericaceae undiff	pollen	NISP	HERB					1
PlanMaj	Plantago major	pollen	NISP	HERB					1
Ranun	Ranunculus-type	pollen	NISP	HERB					3
Urtica	Urtica	pollen	NISP	HERB					2
Poly	Polypodium	spore	NISP	SPORE					1
Sphag	Sphagnum	spore	NISP	SPORE					6
Lemna	Lemna	aquatic	NISP	AQUATIC					2
Nymph	Nymphaea alba type	aquatic	NISP	AQUATIC					2
Pot	Potamogeton	aquatic	NISP	AQUATIC					10
Valsaria	Valsaria cf. variospora	NPP	NISP	NPP					1
Indet	Indeterminate	Indeterminate	NISP	INDET					46
Charcoal	Microcharcoal ≥25µm	NPP	NISP	CHAR					2
SUM(Group)			percent	None	0	0	0	0	0
SUM(CONC)	Concentration		percent	None	0	0	0	0	9693.52
SUM(Tree/Shrub)	Tree/Shrubs		percent	TLP	0	0	0	0	472
SUM(HERB)	Herbs		percent	TLP	0	0	0	0	109
SUM(SPORE)	Spores		percent	TLP+S	0	0	0	0	7
SUM(AQUATIC)	Aquatics		percent	TLP+A	0	0	0	0	14
SUM(NPP)	Non Pollen Palynmorphs		percent	None	0	0	0	0	1
SUM(INDET)	Indeterminable		percent	None	0	0	0	0	46
SUM(CHAR)	Microcharcoal >25microns		percent	None	0	0	0	0	2
SSUM(TLP)	Total Land Pollen			Tree/Shrub;HERB	0	0	0	0	581
SSUM(TLP+A)	Total Land Pollen + Aquatics			Tree/Shrub;HERB;AQUATIC	0	0	0	0	595
SSUM(TLP+S)	Total Land Pollen + Spores			Tree/Shrub;HERB;SPORE	0	0	0	0	588

Appendix 15: Sources of funding

Date	Funder	Amount	Reason
March 2016	Cardiff University City Region Exchange	£4820	Footprints in Time Pilot Engagement Project
November 2016	The Cambrian Archaeological Association	£1000	Towards the six radiocarbon dates obtained in this study
November 2016	The Gower Society	£500	Towards the six radiocarbon dates obtained in this study
December 2016	Cardiff University School of History Archaeology and Religion Postgraduate Fund	£346	Towards the six radiocarbon dates obtained in this study