

MESOLITHIC TO NEOLITHIC COASTAL ENVIRONMENTAL CHANGE c. 6500-3500 cal BC

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An interim report is presented on research on the ecology of coastal environments and the interplay between natural disturbance factors and human agency in the period c. 6500-3500 cal BC. Fieldwork has involved investigation of the stratigraphic context of submerged forests at Goldcliff East and Redwick. They have been extensively sampled for dendrochronology, pollen and plant macrofossil analysis. Fieldwork has led to the discovery of a new Mesolithic site at Goldcliff East and to the finding of human and animal footprint-tracks nearby.

INTRODUCTION (MB)

This is the first interim report covering the initial 6 months of the period from July 2001 to June 2004 of a new three year research project which is funded by the Natural Environment Research Council (Grant NER/A/S/2000/00490). The project investigators are M. Bell, J.R.L. Allen, S. P. Dark and S.W. Manning working with N. Nayling and S. Buckley. Collaboration and associated research is by C. Bronk Ramsey (Oxford), B. Kromer (Heidelberg), D. Smith (Birmingham) and S. Haslett (Bath Spa). Linked to this project to varying degrees is the research of four PhD students (Scott Timpany, Rachel Scales, Alex Brown and Emma Paddock) who provide a brief outline of their research topics in an Appendix.

The project aims to investigate the processes and consequences of coastal environmental change from 6500-3500 cal BC. A previous survey of submerged intertidal peats throughout England and Wales (Bell 1997) demonstrated the high potential of these contexts for work on later Mesolithic and Neolithic environments. This project will consider the evidence for Mesolithic to initial Neolithic environmental change associated with human

agency in a lowland coastal study area. Previous investigations of Mesolithic environmental impacts have focused on upland and moorland areas (Simmons 1996) with the major exception of a recent study of Star Carr (Mellars and Dark 1998). Evidence for burning will be evaluated alongside the spectrum of other disturbance factors including storms, floods and faunal agents which may have also contributed to the creation of a mosaic of plant communities (Brown 1997) especially in the dynamic context of the coastal zone. Our work will employ multiple sources of palaeoenvironmental evidence (particularly pollen, plant macrofossils and dendrochronology). These sources of evidence and precise timescales of coastal environmental change, which we hope to obtain from a combination of dendrochronology and high precision radiocarbon dating, will contribute to establishing the extent to which disturbance is event related, the return period of events, whether disturbances are coeval between sites and the implications which these changes may have had for human activity.

The initial focus of this project is on two stretches of intertidal zone: the embayment at Goldcliff East and at Redwick. Both areas have been the subject of extensive previous research by members of this team. However, as in the Severn Estuary more generally, prehistoric research has so far been mainly focused on the middle Bronze Age to Iron Age period, c. 1500-0 cal BC, when there is abundant evidence for waterlogged wood structures on the surface of the intertidal peats on the Welsh side of the estuary, both at Goldcliff, Redwick (Bell, this volume) and elsewhere.

The limited excavation of a Mesolithic site on the west side of Goldcliff island (Figure 1, overleaf) was carried out between 1992-1994 (Bell *et al* 2000). However, the diversity and number of later prehistoric sites in the Goldcliff

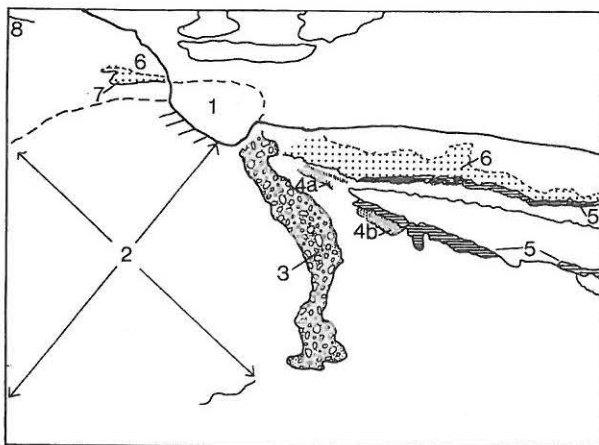


Figure 1: Air photograph of the intertidal area at Goldcliff with an interpretative sketch showing the main features visible. (1) Present and (2) former extent of Goldcliff bedrock island; (3) last Interglacial beach; (4) Mesolithic old land surface (4a) peat covered; (5) laminated silts; (6) upper peat shelf; (7) Mesolithic site excavated 1992-4; (8) Iron Age site excavated 1990-1994. (Crown Copyright Royal Commission on Ancient and Historic Monuments of Wales).

area under investigation at that time, made it impossible to devote anything like the attention and resources which that site deserved. Well preserved Mesolithic sites with animal bone and environmental potential in adjacent wetland are an extreme rarity in a British lowland context. At the time no peats contemporary with the main period of Mesolithic activity had been identified. A radiocarbon date subsequently obtained

demonstrated that the basal peat east of Goldcliff island was contemporary with the Mesolithic occupation. The environmental evidence from this peat will be examined as part of this project.

Investigation of the stratigraphic sequence 4 km to the east at Redwick also led to the identification of a basal submerged forest, peats and clays of similar date. The Goldcliff and

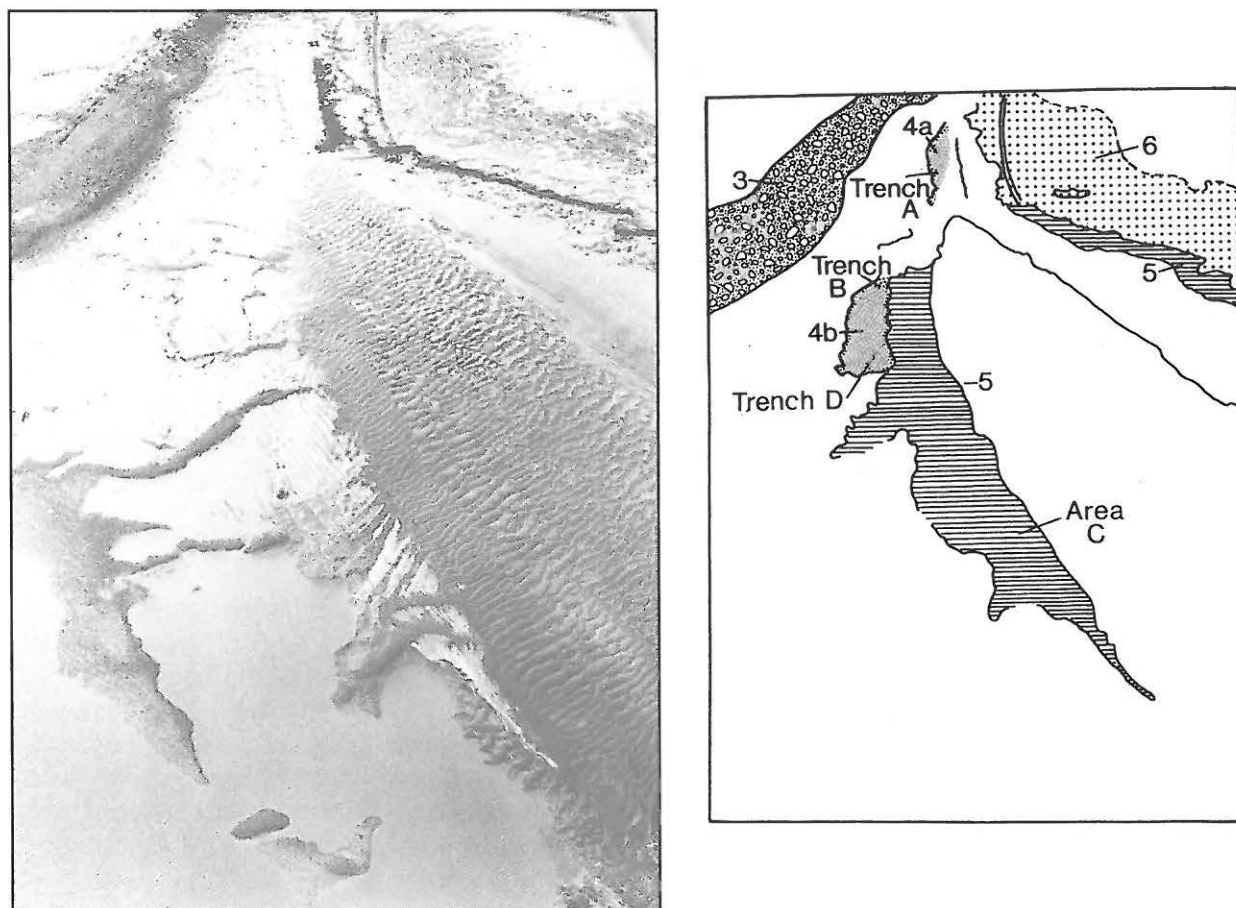


Figure 2: Air photograph of the intertidal area at Goldcliff East with an interpretative sketch showing the locations of Trenches A-D investigated in 2001 and the main stratigraphic units. (3) last interglacial beach; (4) Mesolithic old landsurface, (4a) minerogenic (4b) peat covered; (5) laminated silts; (6) upper peat shelf. (Crown Copyright Royal Commission on Ancient and Historic Monuments of Wales).

Redwick projects, together with sedimentary and foraminiferal research on the sequence between Redwick and Magor Pill by Allen and Haslett (2002), demonstrated the considerable potential which existed for further research in this area over the time frame of the present project. Later, depending on the results in that area, and the opportunities which present themselves elsewhere, our project may range more widely within the Severn Estuary.

STRATIGRAPHIC CONTEXT (JRLA)

Although work has so far been undertaken at only two sites - Redwick and Goldcliff East - substantial stratigraphic variation is evident both within and between the Holocene deposits that are

present, in keeping with what is known from the Gwent Levels generally (Allen 2001).

One area is the embayment immediately to the east of Goldcliff, the medieval remnant of a once more-extensive bedrock island that ranged for several hundred metres to the southeast (Allen 2000). Here the base of the Holocene sequence rises up west-south-westward on to the island and is formed by a palaeosol developed in clayey-stony head overlying Ipswichian raised-beach deposits (Figures 1 and 2). A thin basal peat resting on the head is overlapped by several metres of silt before a thick peat is encountered (Smith and Morgan 1989 fig. 1C). This bed, including a woodland phase and dating from between 5950 \pm 80 BP (Car-659) and 3130 \pm 70 BP

(Car-644), is lithostratigraphically equivalent to the sequence between the base of the third and top of the fourth peats at Redwick (see below). Probably as a response to differential compaction above a rising pre-Holocene surface (Allen 1999), the base of the peat in the Smith and Morgan (1989) transect gradually ascends west-south-westward by almost one metre over a distance of just 300 m. The intervening silt seen at Redwick is represented at Goldcliff East by a bed just a few decimetres thick which wedges out about 600 m from the island. A thin peat occurs a few decimetres above the main bed, but it can be seen only in the angle between the island and the seawall. As at Redwick, the seawall conceals thick silts that lie between the top of the main peat and the embanked land surface.

A rather different sequence is seen at Redwick just 4 km to the east (Allen and Bell 1999, fig. 1A; Allen and Haslett 2002, figs 2, 3). The Holocene deposits rest on a clayey-sandy-pebbly head, which seems to overlie a local deposit of clean, gravelly sand of Pleistocene age. The pebble suite, plausibly of Welsh origin, is dominated by a variety of sandstones and vein quartz, igneous rocks being limited chiefly to porphyritic lavas of intermediate-basic composition, a range of tuffs and some very rare basic intrusives. The oak trees that flourished more than 8000 years ago on the surface of the head eventually become buried beneath Holocene estuarine deposits with a total present thickness of about 10 m. Representing highest intertidal to terrestrial organic marshes, at least five peat beds of variable thickness and facies development are intercalated among the predominant silts, which can be assigned on the basis of their foraminifera chiefly to salt marshes. The most substantial of the peats are the third and fourth beds, separated by silts that reach up to 1.8-1.9 m thick and represent, with an hiatus, an interval of several hundred years. The third peat began to form 5670 \pm 90 BP (Beta-128779); the fourth and thicker bed, which includes fen carr and raised bog, continued to accumulate up to c. 1690 BC. The Bronze Age settlement at Redwick (Bell, this volume) is situated on the surface of this peat. The fifth and uppermost peat is only a few cm thick and developed about 1150 BC. A few metres of silt occur between it and the present, embanked (Roman/medieval) land surface.

SUBMERGED FOREST SURVEY (SB)

The survey carried out during this season was the first systematic investigation of the submerged forests at Goldcliff East and at Redwick (see below). The results provide the spatial framework for this study, for which summary data and maps are presented here.

During low tide both intertidal areas were methodically walked in order to determine the limits of the submerged forest in each respective area, and identify which trees could be safely reached and sampled, weather and tides permitting. The field procedures used were to clean, plan and photograph all *in-situ* trees, where possible, and recover samples from exposed wood for identification and dendrochronological dating. Trees were identified in the field either as oak or non-oak species, and allocated a tree number and labelled for later reference. Stratigraphic recording was undertaken at representative locales in both areas and samples obtained for inter-related pollen, charcoal, plant macrofossil, foraminifera and beetle analyses. Comparative tree data (eg dimensions, morphology, orientation) were also compiled, and tree locations marked using a GARMIN GPS 12XL. In conjunction with the above, a more detailed EDM ground survey was accomplished for each site, with assistance by Heike Neumann.

At Goldcliff East submerged trees are found on the seaward edge of the main peat shelf (47 trees) and on a lower peat exposure (18 trees) at c. -3.7 m OD (Figures 2 and 3). In total, 39 trunks and 18 stumps were sampled at the former, and 12 trunks and 6 stumps at the latter. On the eastern side of the island 65 trees were surveyed, 12 stumps and 53 trunks. To the west, a further 3 oak trunks were recorded and sampled from contexts associated with a previously excavated Mesolithic site (see below). Over half (66%) of the trees identified are oak (*Quercus* spp.). Measurements also reveal that many of the submerged trees are of a similar size; in particular, exposed trunks were approximately 3 m in length and a significant proportion were estimated at between c. 100-500 mm in diameter. In total, 40 oaks were sampled for dendrochronology, a further 21 samples were taken from non-oaks for possible dating, and smaller pieces of wood were

Goldcliff East, 2001

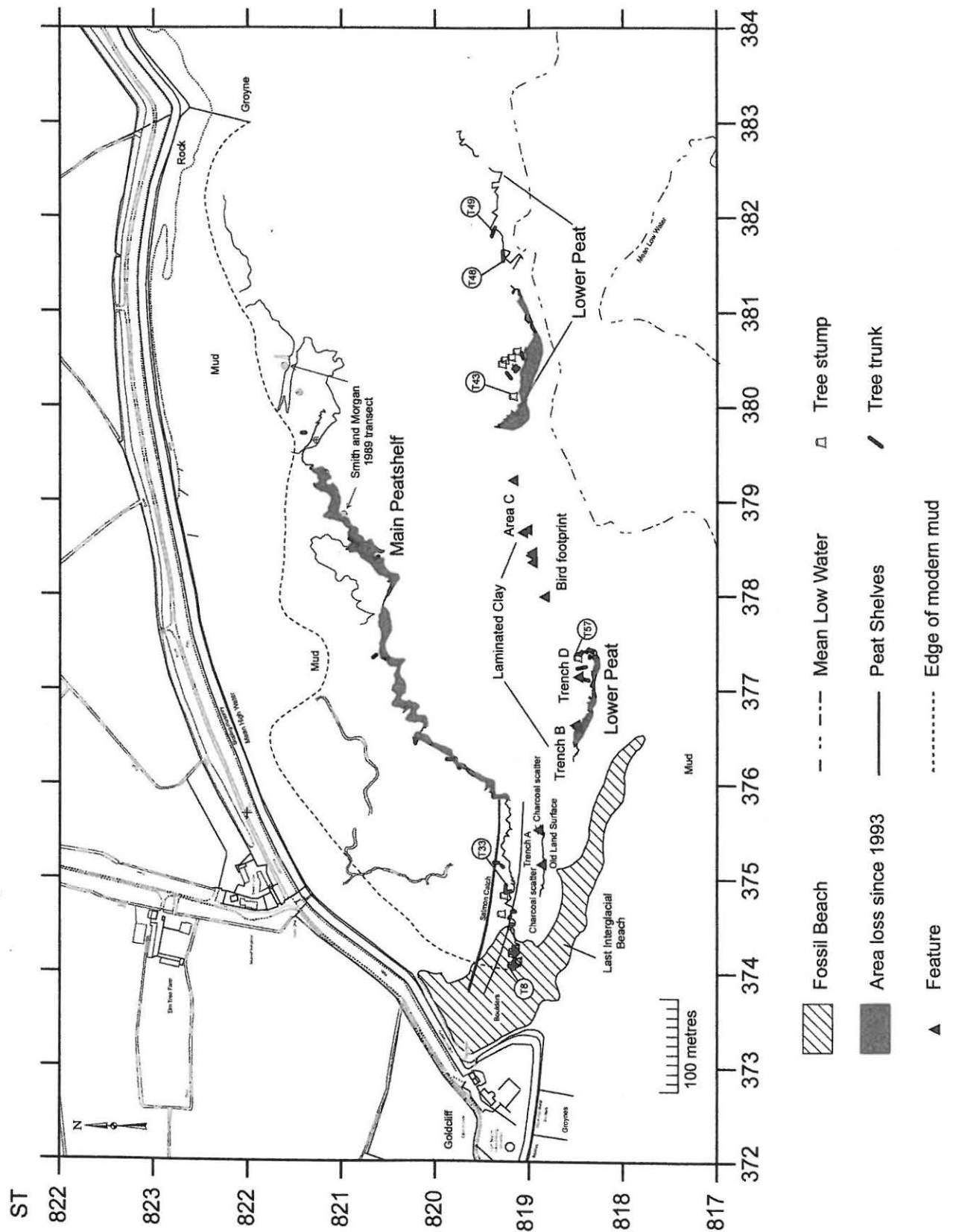


Figure 3: The intertidal area at Goldcliff showing the distribution of submerged forest trees sampled and excavation trenches excavated in 2001. Survey by H. Neumann and S. Buckley; Map base: © Crown Copyright Ordnance Survey. An EDINA Digimap / JISC supplied service.

taken for identification purposes only. A number of trees which were noted in deeper parts of the channel remain to be sampled at a time when tidal conditions are suitable (Nigel Nayling pers. comm.).

The area most intensively surveyed was along the main peat shelf over a length of c. 650 m. Here, a total of 33 trees and parts of trees were sampled near recent salmon putcher traps (Green 1992). Stratigraphic recording was undertaken immediately adjacent to eight oak trunks from this area during an earlier pilot survey, showing that these trees lie within a woody peat which directly overlies blue clay. Subsequently, a test pit was opened next to oak trunk T8 to a depth of c. 1.2 m, and sampled with the aim of providing information on the plant macrofossils and beetles associated with this woodland. Interestingly, c. 78 m east of this site a sizeable non-oak trunk T33, 7 m in length, was identified. Tree-ring analysis and identification of this tree has still to be completed, but should prove to be insightful in terms of understanding the nature of the submerged forest in this area.

To the east of the main peat shelf, c. 170-600 m from the fishtraps, some 12 oak trunks and 6 stumps are located on two stretches of basal *Phragmites* peat approximately 250 m apart (Figure 3). This Mesolithic context is described in more detail below; however, it is particularly noteworthy that evidence of charring on two oaks T43 and T48 was found from this area, perhaps indicating anthropogenic interference at that time.

Resurvey in 2001 of peat shelves first surveyed in 1993 (Fig 3; Bell 1993) indicates that over that 8 year period the upper peat has retreated c. 9 m and the basal peat 4.7 m near Trench B and D and 9.4 m east of Area C. Thus the new archaeological evidence reported below in this area is undergoing rather dramatic erosion.

INVESTIGATION OF MESOLITHIC CONTEXTS AT GOLDCLIFF EAST (MB)

The Mesolithic site on the west edge of the former bedrock island at Goldcliff (Figure 1), excavated between 1992 and 1994, represents a dryland occupation on an old land surface developed on Pleistocene head at between -0.2 to +0.6 m OD (Bell *et al* 2000). The main occupation is dated between 5800-5200 cal BC. The site lay somewhat above the contemporary watertable, pollen was not preserved in the old land surface, and only the more resistant seeds were present. The earliest peat identified west of the island started to form, presumably as a result of rising watertables, c. 200 years later than the occupation of the site. Thus the very full pollen, macrofossil and beetle record obtained from west of Goldcliff island begins a couple of centuries later than the Mesolithic occupation.

In 1993-4 a survey was carried out of the embayment east of Goldcliff island (Bell 1993, figure 32). This did not produce evidence of later prehistoric archaeology on the peat surfaces, which had been so abundant to the west of the island. It did, however, lead to the identification of a lower peat at c. -3.7 m OD at the base of which charcoal fragments and one or two worked flints were found.

During 2001 the area to the east of Goldcliff island was examined in much greater detail during an investigation of the Holocene stratigraphy and submerged forest trees. The contexts investigated are shown in Figures 1-4. A sloping surface was identified dipping away from the former island formed by a sandy and pebbly deposit of beach gravel, sand and head, derived, in part, from the last interglacial fossil beach identified by Allen (2000) around the island margins (Figure 1). About 180 m east of the seawall removal of 5-10 cm of recent mud from this surface using a slurry scraper revealed an exposure of sandy head, or reworked beach deposit, overlain by 0.15 m of sandy humic sediment containing abundant charcoal, flints and bone which is interpreted as an early Holocene old land surface. It was sealed by grey clay representing the incursion of estuarine sediments on the island edge. A 10 m length of this old land surface exposure was cleaned and

limited excavation was carried out (Trench A) demonstrating abundant charcoal and the presence of worked flints and bone. The density of artifacts and the stratigraphic context of this part of the site is comparable to the previously investigated Mesolithic site on the west side of the former Goldcliff island.

To the east this early Holocene surface is interrupted by a shallow active channel carrying water which pours continuously at low tide from a waterfall discharging from a pond on the upper peat surface. This could point to the existence of a spring in this area which, if it flowed in the same location in the Mesolithic, might have proved particularly attractive to people and animals.

East of this channel, c. 80 m from Trench A, the top of the old land surface is a thin *Phragmites* peat which outcrops for about 100 m to the east (Figures 2 and 3). Charcoal, bone fragments and flint flakes were present along this outcrop both in the peat and at its base. Trench B, 1 m by 6 m, was laid out across the densest concentration of finds. The base of this trench was sandy gravel with pebbles probably derived

from the last interglacial beach. This was overlain by a sandy clay subsoil with some charcoal, on the surface of which was 60 mm of reed peat with abundant charcoal, overlain by silts which form the base of a distinctively laminated silt sequence which is exposed by scouring of the channel and rises to the north. Cleaning of mud from the trench surface and its excavation revealed an area c. 0.8 m in diameter with much charcoal, calcined bone and other bone on the reed peat surface. This may represent the remains of a hearth, but if so it was not contained or marked in any way (eg by stones). Similar concentrations of charcoal and burnt artifacts were found on the Mesolithic land surface to the west of the former island (Bell *et al* 2000, fig 4.5-5). Cleaning of the peat surface showed that the site had been affected by irregular shallow linear gullies created by the scouring action of recent tidal waters which are very evident in the overlying silts (Figure 2). The peat surface was also marked by small oval depressions of diameter c. 80 mm, one or two of which had resisted erosion sufficiently to retain the distinctive form of ungulate footprint-tracks of red deer size.

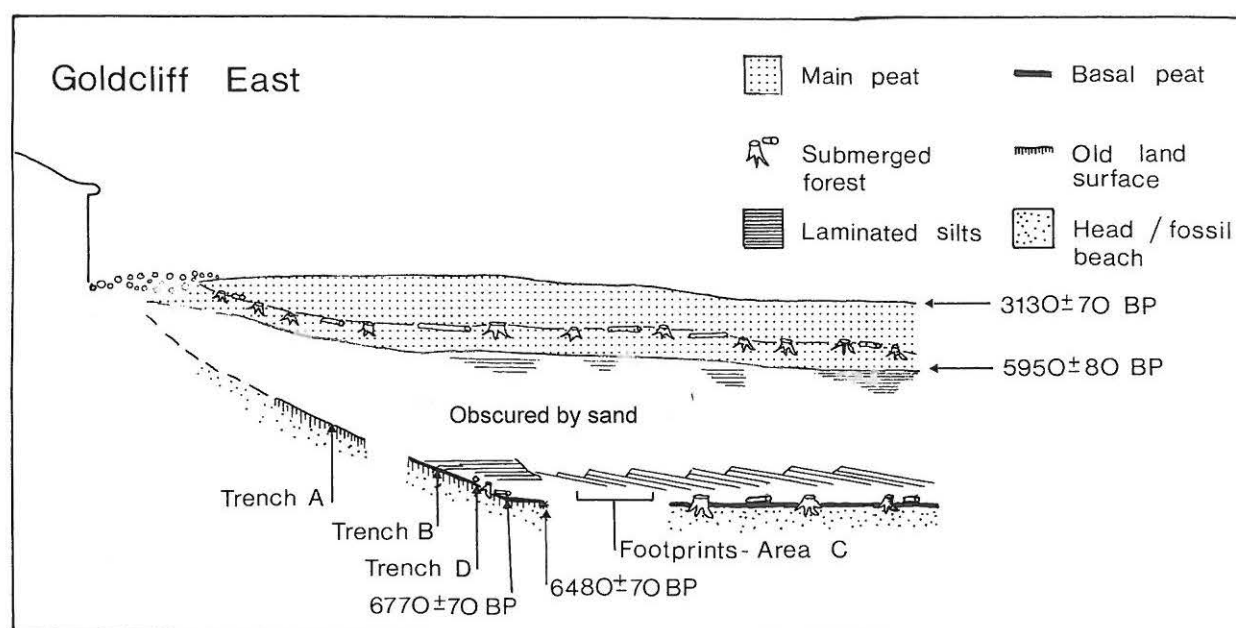


Figure 4: Goldcliff East. Sketch section of the stratigraphic sequence at Goldcliff East showing the relationship between the main deposits examined in 2001.



Figure 5: Goldcliff East: Tree stump 57 on the basal peat shelf (Photo. Edward Sacre).

About 50 m further east the peat was associated with 4 small oak trunks and one prominent stump (Figure 5); at this point the peat surface is -3.7 m OD. A small pit (Trench D) 0.7 m² was opened up on this surface. This revealed a comparable stratigraphy to that of Trench B. Here the peat was 0.11 m thick and once again contained charcoal. Within the upper 60 mm of peat were multiple fine lenses of clay representing at least 8 distinct inundations of minerogenic sediment onto the accumulating organic surface. One of the oak trunks in this area has been dated 6770 ± 70 BP (Beta-60761; 5720 – 5615 cal BC; Allen 2000, fig 2.1). Charcoal from the old land surface beneath the peat at -3.9 m OD has been dated 6480 ± 70 BP (Car-1502; 5510 – 5360 cal BC). For comparison of the calibrated ranges of these and the other radiocarbon dates see Figure 17. Both dates are closely comparable to the dates obtained from the excavated Mesolithic site to the west of Goldcliff island (Bell *et al* 2000, figure 14.3). Sufficient stratigraphic investigation has not yet been carried out to establish whether, as at Redwick (see below), the submerged forest somewhat predates the basal peat. Of particular significance, however, is the fact that charcoal, flints and bone are present within the peat in Trench B. We have therefore a waterlogged old land surface within an area of Mesolithic settlement on the island edge. This will provide the opportunity to investigate the environmental relationships of Mesolithic activity and in particular to establish whether the abundant charcoal which is present round the island edge

relates to any detectable, and possibly human induced, vegetational changes.

To the east the basal peat shelf is buried by modern tidal sand dunes but there is an exposure 260 m from the previously described peat exposure where there is a series of more substantial oak trunks associated with the peat (Figure 3). In this area 5 stumps and 8 trunks have so far been sampled for dendrochronology. At the base of this peat exposure in the underlying sandy soil there are many charcoal fragments and two worked flints. Clearly Mesolithic activity associated with this early Holocene land surface extends *c.* 700 m east of the present edge of Goldcliff island. Within about 200 m of the most easterly lithic finds Derek Upton picked up an unstratified Mesolithic axe/adze (Barton 2000; fig 4.7, 3.96).

Human and animal footprint-tracks

The basal peat was overlain by grey silts that exhibit pronounced laminations, bands of silt being separated by partings of fine sand. This is the lower Wentlooge Formation (Allen and Rae 1987). A direct contact between these laminated silts and the basal peat was exposed in Trench B. For at least 200 m to the east of this trench there were good exposures of the laminated silts in August to October 2001. The outcrop of these silts is shown from the air on Figure 2. Their surface is marked by pronounced linear striations which are erosion features resulting from tidal scour. The outcrops of laminated bands are less distinctly visible at *c.* 70 degrees to the linear striations. About 120 m east of Trench B, where erosion had exposed the surface of individual lamination beds, it was observed that they were covered with tracks of humans, deer and birds. This is designated Area C where an area 12 m by 5 m was planned (Figure 6, opposite). That record was complemented by actual size tracings on polythene sheeting of 6 areas of the main footprint-tracks totalling 11.6 m².

The formation processes of footprint-tracks in Severn Estuary sediments, and the terminology appropriate to their description, have been reviewed by Allen (1997) and Allen *et al* (in prep) Also of particular relevance to the present discovery is an earlier study of Mesolithic

Goldcliff East 2001: Mesolithic Human Footprints and Animal Tracks

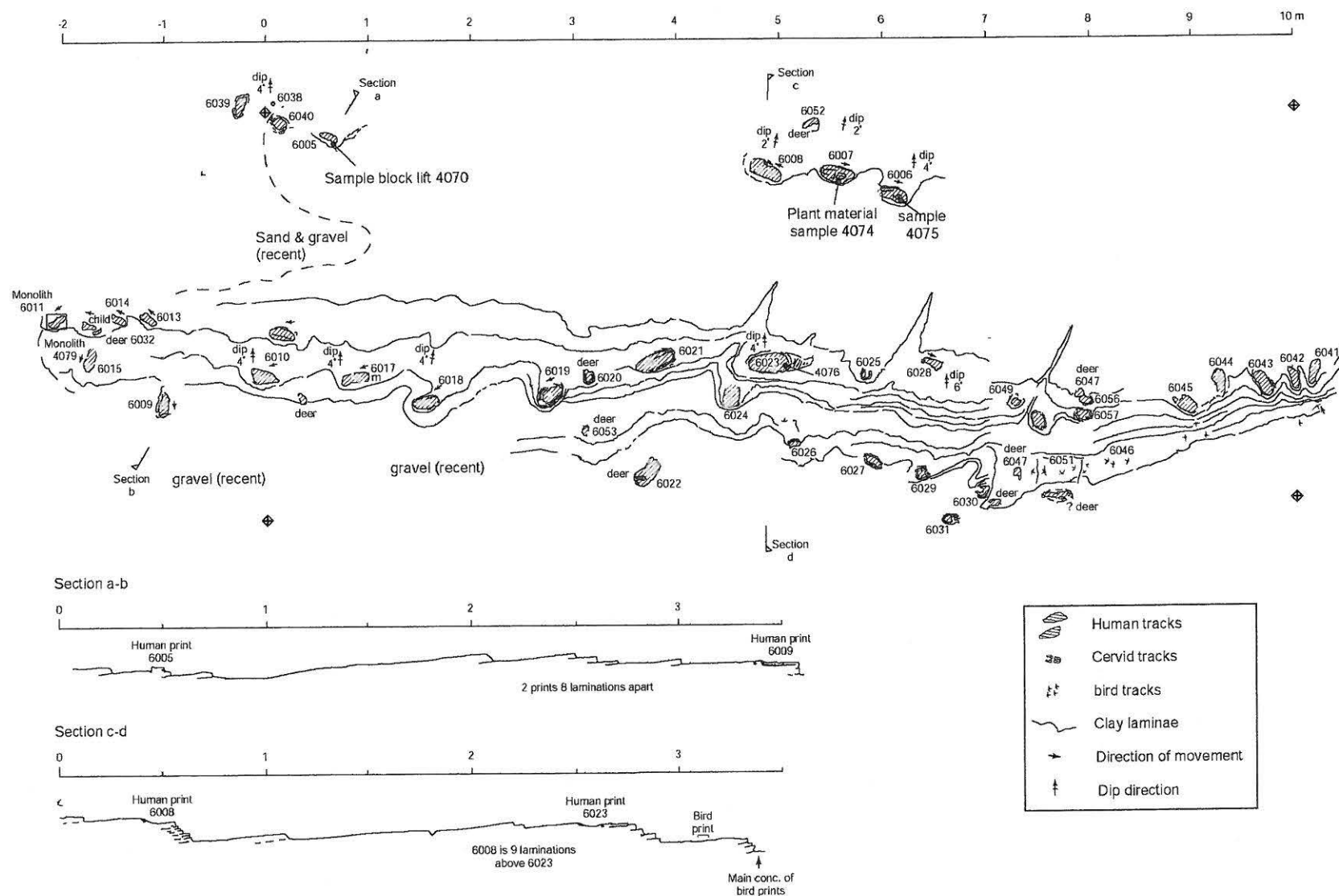


Figure 6: Goldcliff East, Area C: laminated silt banding on which are human and animal footprint-tracks.



Figure 7: Goldcliff East, Area C: Probable child's footprint-track 6012, Trail A, scale 10 cm (Photo. Edward Sacre).

Type	Number	
Human adult (barefoot)	18	<p>footprints in the same lower Wentlooge sedimentary unit at Uskmouth and Magor (Aldhouse-Green <i>et al</i> 1992). In this preliminary paper the term footprint-track is used as a collective term for the group of traces made by the passage of a foot. This includes the footprint <i>sensu stricto</i> (impression of the sole of the foot), the undertraces (eg microfolds in deformed sediment), and the overtraces (sedimentary infill of a footprint), (Allen 1997, fig 1). We use the term footprint-track in preference to track or trackway, terms used by natural historians and palaeontologists, which could be misleading in a wetland archaeological context where constructed trackways of wood can be found.</p>
Human adult (? possibly shod)	6	
Human child (barefoot)	5	
Human (uncertain)	6	
Red Deer (adult)	17	
? Red Deer (juvenile)	1	
Bird	13	
Total	61	

Table 1: Footprint-tracks recorded at Goldcliff East, Area C in 2001.

The Goldcliff human and animal footprints-tracks, of which 61 have so far been recorded (Table 1), were in moderate to poor condition. Most had clearly been exposed for at least months



Figure 8: Goldcliff East, Area C. Human footprint-track group left to right 6006, 6007 (Trail C) and 6008 with deer print 6052. Scale 0.5 m (Photo. Edward Sacre).

and their form had become eroded and angles rounded. In some cases sediment compacted by feet stood on a slightly raised pedestal of silt (Figures 7, opposite and 8, above). The condition of prints sometimes made it difficult to establish whether they marked the footprint itself, the undertraces, or overtraces. This uncertainty in a number of cases inevitably has implications for the precision of measurements made on footprint-track sizes reported below. In the future it is anticipated that greater precision in terms of descriptive nomenclature and measurement can be achieved by peeling away laminations, revealing new uneroded footprint-tracks which are expected to have a more clearly defined form. Even without excavation, we are confident that these footprint-tracks are Mesolithic, and not those of more recent visitors to the foreshore. This rests on evidence reviewed below for the date of the silts on which they were found, coupled with the deformation of the silt/fine sand laminations

which shows that they were made in soft sediments before these beds became compressed, dewatered, semi-consolidated, and thus resistant to such ready deformation. Three footprint-tracks (6005; 6011; 6012) which were considered especially vulnerable to erosion were block lifted for examination in the laboratory.

The footprint-tracks are in sediments in which laminations are grouped within very marked banding of average thickness perhaps 10 mm. The footprint-tracks occur on the bedding planes with stepped edges representing the outcrops of individual bands. The bedding planes dipped to the east at between 2 and 4 degrees (Figure 6). Allen (1990) and Allen and Haslett (2002) have made the interesting suggestion that the banding within parts of the lower Wentlooge formation may represent annual deposition on the saltmarsh. Further investigation of that possibility is proposed. If some specific tidal period (eg



Figure 9: Goldcliff East, Area C: eroded human left footprint-track 6017. Scale 10 cm (Photo. Edward Sacre).

annual) can be assigned to the bands, then it will be possible to be specific about the chronological interval between individual walks. What can be said at present is that the prints shown in Figure 6 cover about 16 main bands. The walk represented by human footprint-track 6005 is separated by 8 bands from the earliest walk represented by footprint-track 6009. The walk represented by human footprint-track 6008 is separated by 9 bands from the walk represented by human footprint-track 6023. The lowest 6 bands, of which only narrow areas of bed surface were exposed, have not so far produced any human prints, only those of red deer and birds.

In some cases the base of a human footprint-track (eg 6006; 6007) was covered with a layer of finely divided plant material which, under the microscope, consisted of tiny seeds. It seems probable that either the human foot had trodden on a surface with a thin coating of seeds, or that seeds have been washed into the base of the hollow subsequently before burial by the overtrace sediment. Either way, they may provide material which can be radiocarbon dated. The

silts, both within and around the footprint-tracks, are marked by circular iron stained tubes which are thought to mark reeds or other vegetation growing on the accumulating surface. The nature of these laminated sediments suggests mid to high saltmarsh. The environment will be further investigated using pollen, plant macrofossils and foraminifera.

Among the mass of prints some distinct trails (lines of footprints-tracks representing an individual's walk) can be identified within single laminar beds (Figure 6). Trail A comprises four footprint-tracks (6011-6014) of a child walking to the north and turning west with a pace length of 307 mm, one of these prints is shown in Figure 7. Trail B comprises two footprint-tracks (6034-5, north of area shown on Figure 6) of an adult with a pace length of 630 mm. Trail C comprises two footprint-tracks (6006-6007; Figure 8) of an adult walking south, with a pace length of 585 mm. Nearby is a print of very similar size, but apparently heading in the opposite direction, perhaps the same individual's return on the same walk.

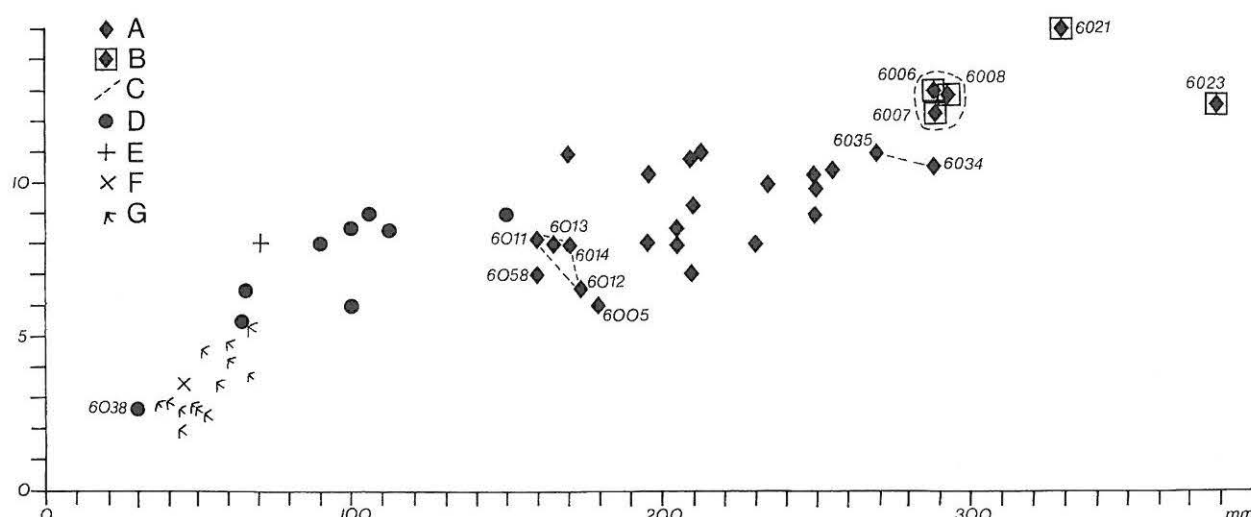


Figure 10: Goldcliff East: The dimensions of human and animal footprint-tracks. A: Human; B: Human, possibly shod; C: tracks of one individual; D: red deer; E: average modern dimensions of red deer (after Lawrence and Brown 1967); F: average modern dimensions of roe deer (after Lawrence and Brown 1967); G: bird prints.

Most of the human footprint-tracks were clearly those of unshod feet. Even some poorly preserved examples had traces of a toe or two and in places the contours of the foot were preserved (eg Figure 9, opposite). Six examples (Trail C; 6006-6008 (Figure 8) and 6021; 6023-4) were of more elongated proportions, and had a distinctly oval dished form with a smooth base, with even curves in both dimensions as opposed to a contoured base. In three of these cases there were finely divided plant macrofossils on the curved base. Two possibilities suggest themselves for future investigation by careful dissection. The first is whether such forms represent residual undertraces of eroded footprints. The second is that these individuals had footwear, perhaps a form of oval clog.

Figure 10 plots the dimensions of measurable footprint-tracks recorded so far in Area C. Broken lines join the prints which are interpreted as part of the same trails. Difficulties of establishing at which level one is observing a footprint-track (ie overtrace, footprint, undertrace) and thus of measuring footprint size have been noted at the beginning of this section. Such factors are illustrated by the graphed distances between prints interpreted as those of the same individual. These distances indicate that the measurements are likely to be no more accurate

than 10-20 mm. These appropriate margins of error have to be born in mind in evaluating the results presented below, for instance the age ranges of individuals should be considered as $\pm 1-2$ years. Figure 10 shows that the human footprint-tracks are of diverse sizes. Some indication of the relationship between foot length and age has been obtained from a survey of average foot growth rates carried out in 1990 by Clarks (pers. comm. 1.2.02). It should be noted, however, that both growth rates and foot size may well have differed as a result of genetic and behavioural differences between Mesolithic and modern populations.

Prints forming Trail A fall in the size range of modern children aged 4-5 (English child's shoe size 10). Using an estimate of the relationship between foot length and stature of 15.5% (Day 1992, 36) this individual was 1.1 m tall. There is a group of footprint-tracks of length 195-210 mm which are within the size range of modern children aged 7-9 (adult shoe size 1-2). Using the above estimates for stature this gives individuals 1.26-1.35 m tall. Prints between 230-250 mm are within the size range of modern youths aged 11-14 and women (adult shoe size 5-7). The stature of this group was between 1.48 and 1.61 m. It is likely that the narrower prints in this group are adult women. The footprint tracks over 250 mm

are equivalent to modern adult males aged over 14. Trail B was made by a male (modern shoe size 11) stature 1.8 m. Trail C may also be a large adult male, although it has been suggested that this individual may have been shod. Prints 6021 and 6023 are much longer than normal male foot size and it has also been suggested from the form of these prints that they too may have been shod.

The small sample available so far is a varied one in terms of age composition, 16 out of 27 measurable prints are those of individuals aged under about 14. The prints from Uskmouth also included adults, children, males and females (Aldhouse-Green *et al* 1992). Later prehistoric human tracks in Liverpool Bay are similarly diverse in terms of human population composition (Huddart *et al* 1999, 567). Activities in the coastal fringe clearly involved the participation of a wide age spectrum of the community, not just a sub-set comprising, for instance, a hunting band of adult males.

Of the animal footprint-tracks in Area C the main group are of red deer size and morphology, apparently a little larger than the average size of modern red deer footprints (Figure 10), which is consistent with the deer bone evidence from earlier Holocene contexts (Noddle 1982). One print (6038) is notably smaller, closer to fallow deer size; it is not well preserved but its curved outlines, larger imprint and the absence of sharp angles suggest it is a juvenile red deer. Birds are also represented; most have the morphology of gull tracks and are the size of the smaller gulls, the black headed and common gulls (Bang *et al* 1990, 72).

Allen (1997, 503) previously noted ill-preserved human footprint-tracks with those of deer at Goldcliff in the same laminated silt unit about 250 m west of Area C. During 2001 three adult human footprint-tracks (6033; 6055; 6054) were also found 43 m west of the main Area C group and another group of 4 footprint-tracks was observed and photographed, in a low cliff of laminated sediments about 60 m to the east of Area C (Figure 3). Others have been observed in outcrops of the laminated silts just below the upper peat shelf (Figure 1). It is evident from

these various finds that footprint-tracks are extensive within the Goldcliff East embayment. There is considerable scope for more detailed study which will be achieved through the current research of Rachel Scales (below).

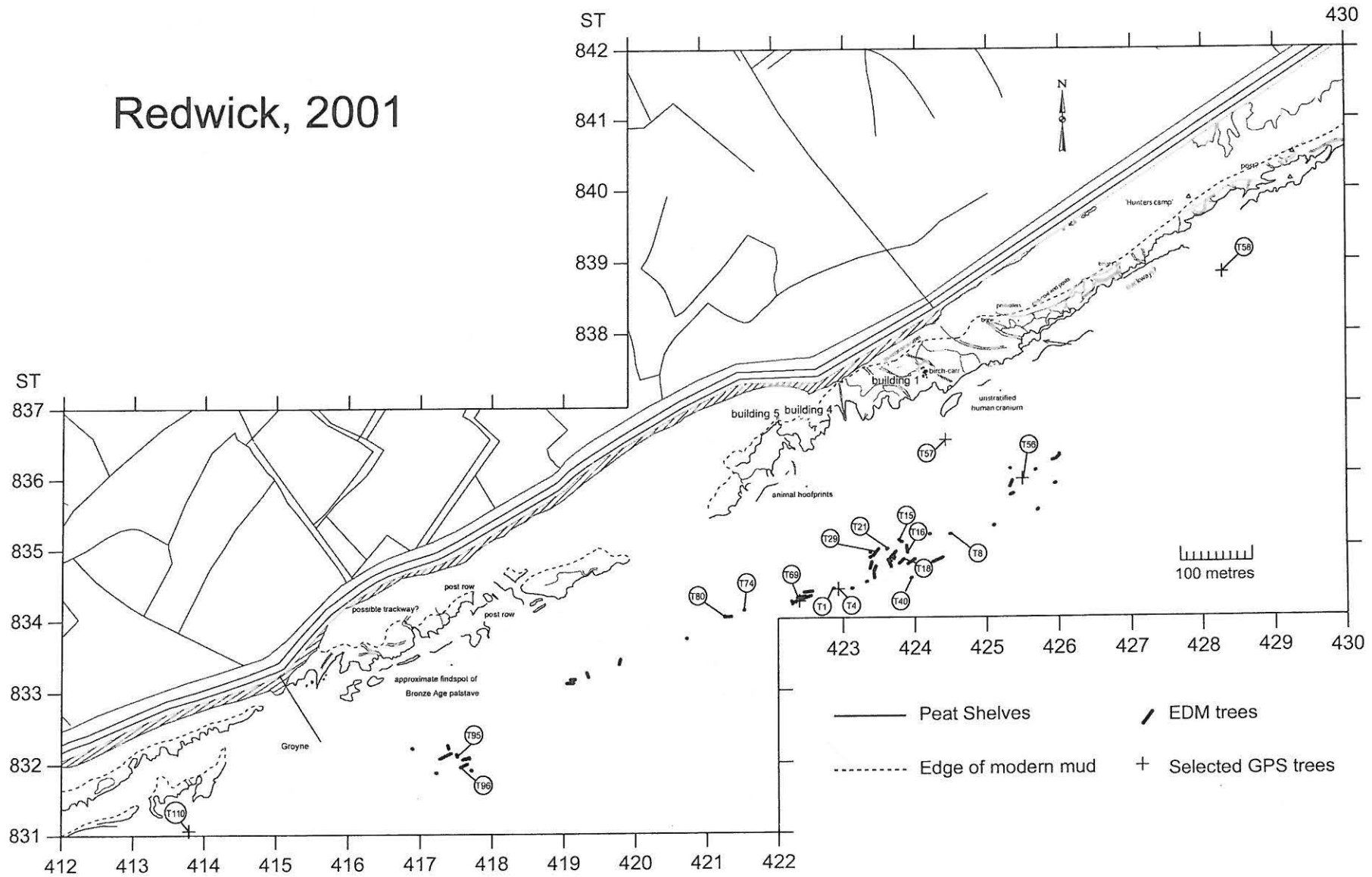
The date of these footprint-tracks has not yet been directly determined from the finely divided plant material which lines the base of some. However, a reasonable indication of their date may be obtained from that of the beds with which these silts are in contact. They overlie the basal peat (investigated in Trenches B and D) where an oak tree date of 6770 \pm 70 BP (Beta-60761, 5720-5615 cal BC) has been obtained (Allen 2000, fig. 2.1; for comparison of calibrated date ranges see Figure 17). They underlie the main upper peat investigated at Goldcliff East by Smith and Morgan (1989) the inception of which is dated 5950 \pm 80 BP (CAR-659; 4930-4730 cal BC). Stratigraphically they are much closer to the earlier date than the later. Thus they are likely to be broadly contemporary with the main period of Mesolithic activity identified at the excavated site on the west edge of Goldcliff island which is dated between c. 5200-5750 cal BC (Bell *et al* 2000, fig. 4.13). They are also likely to be broadly contemporary with the previously identified Mesolithic footprint-tracks from Uskmouth (4.15 km west of the present find) which are sealed by peats dated 6250 \pm 80 BP (OxA-2627; 5300-5080 cal BC; Aldhouse-Green *et al* 1992) and probably a little earlier than those at Magor (5.7 km east below peat dated 5720 \pm 80 BP (OxA-2626; 4670-4470 cal BC; Aldhouse-Green *et al* 1992). Human footprint-tracks have also been spotted, but not recorded, 5 km to the east at Redwick (Bell *et al* 2000, Map 21) where they underlie a peat which, elsewhere in the Redwick area, is dated 5670 \pm 90 BP (Beta-128779; 4640-4400 cal BC; Allen and Bell 1999).

SURVEY AT REDWICK (SB)

Investigation in this area focused on a submerged oak forest which is well exposed for at least 1.7 km along the lower foreshore (Figure 11). It lies approximately 180 m south of the main peat shelf

Figure 11 (opposite): The intertidal area at Redwick showing the distribution of submerged forest trees sampled in 1999-2001 and excavation trenches excavated in 2001. Survey by H. Neumann and S. Buckley; Map base: © Crown Copyright Ordnance Survey. An EDINA Digimap/JISC supplied service.

Redwick, 2001



Redwick 2001: Oak stump R01-T40

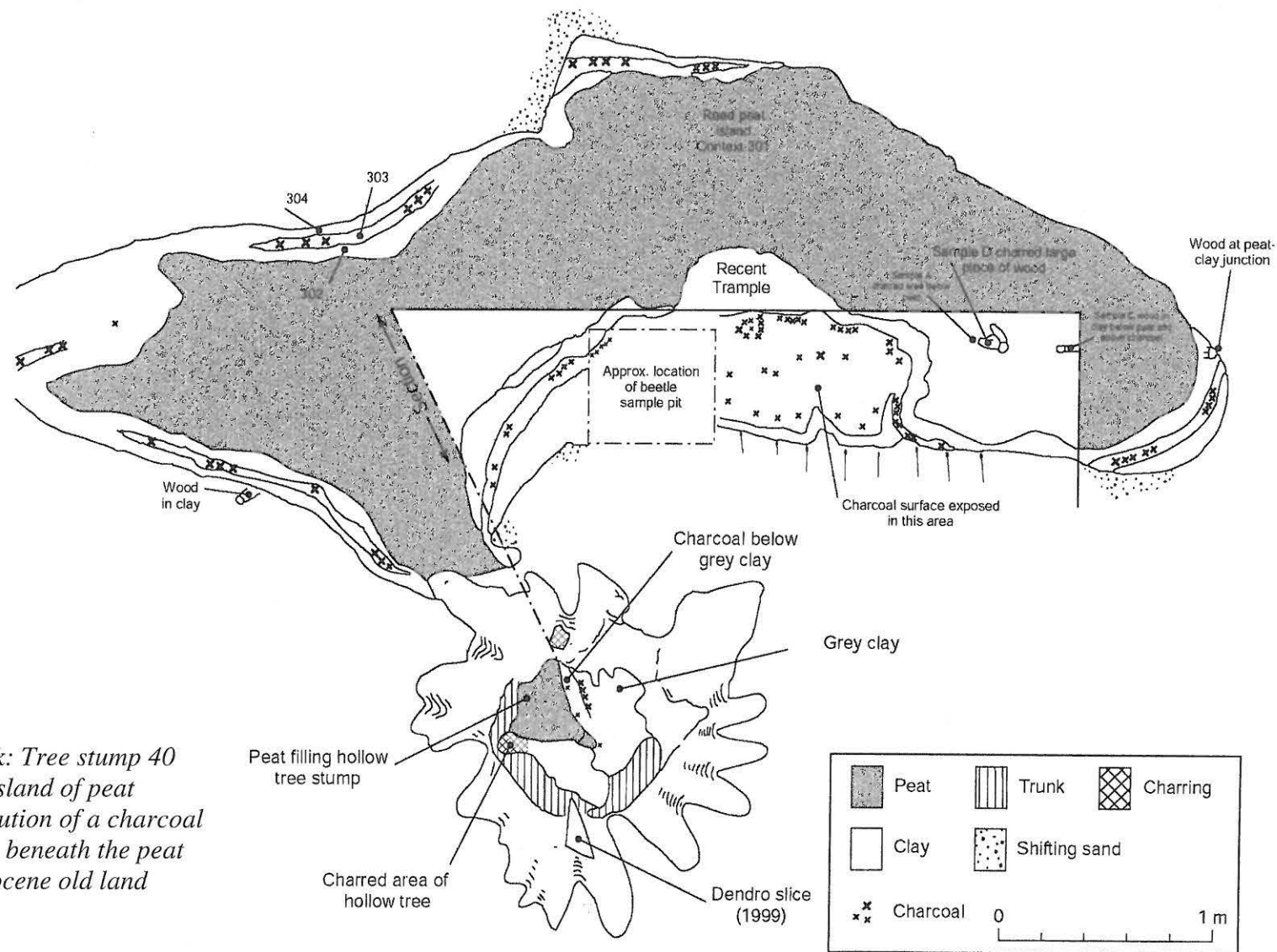


Figure 12: Redwick: Tree stump 40 and the adjoining island of peat showing the distribution of a charcoal horizon within clay beneath the peat and above the Holocene old land surface.

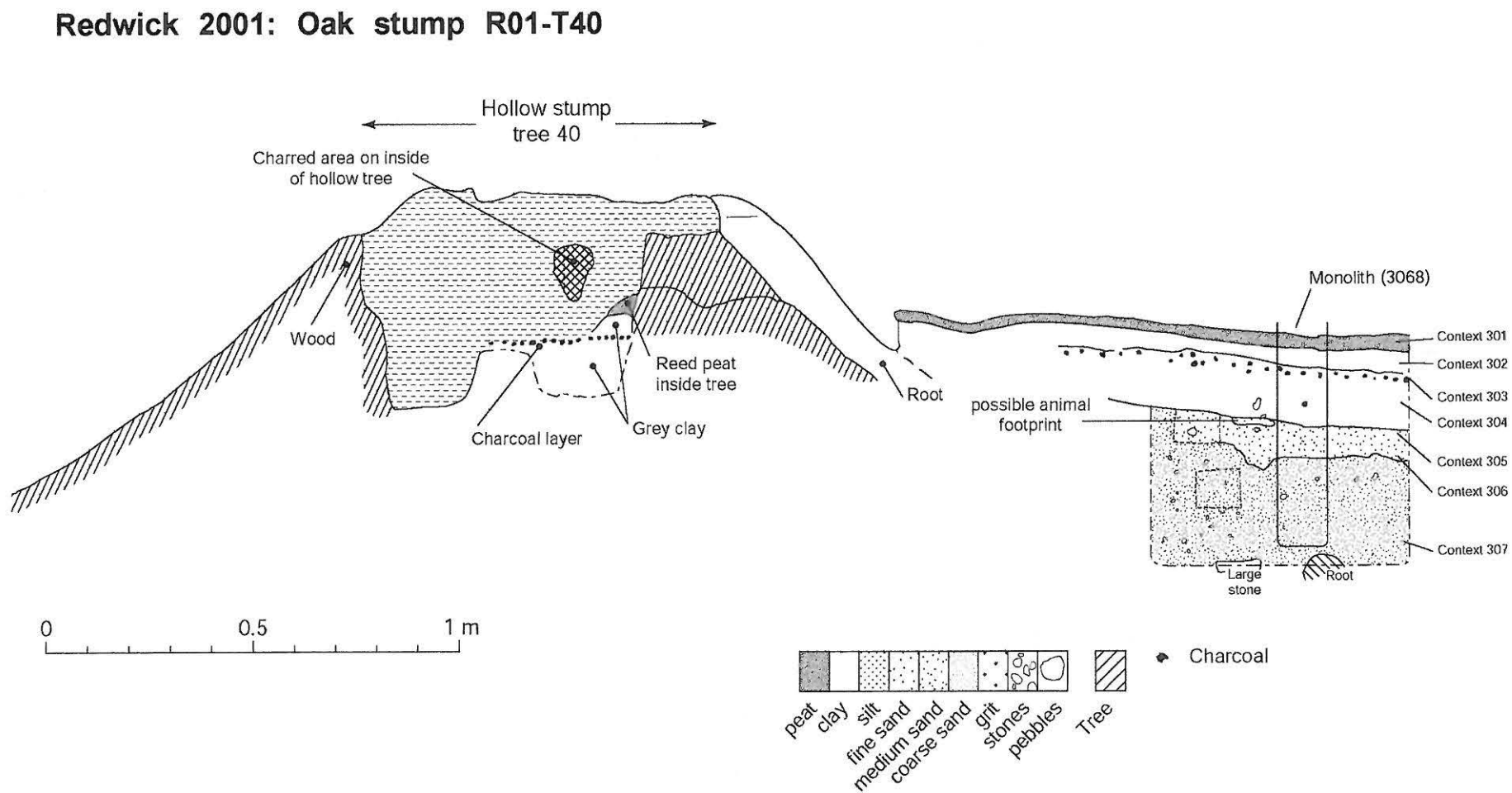


Figure 13: Redwick: The stratigraphy associated with Tree stump 40.

and at its widest point is about 120 m. Earlier survey work had identified some 30 submerged trees within the lower channel (Bell and Neumann 1999); attention this season therefore was focused upon extending this initial survey.

A total of 111 trees were recorded and sampled, comprising 57 stumps and 54 trunks. The average exposed trunk length was c. 4.5 m, and again the majority of trees were estimated at between c. 100-500 mm in diameter, a significant proportion were approximately 500-1000 mm, and a few even larger. This forest is thought to have grown on the pre-inundation old land-surface. So far the youngest surviving rings of one oak from this forest, just to the west of a substantial palaeochannel with Romano-British artifacts, have been radiocarbon dated at 7330 ± 70 BP (Beta-134639; 6270-6090 cal BC; Allen and Bell 1999).

Samples relating to the submerged forest investigations were removed from several localities. Two bulk samples from the lower peat were examined adjacent to stumps T01 and T04 for plant macrofossils and beetles, whilst analysis of the sedimentary sequence on the lower foreshore was confined to oak trunk T18 and stump T40. A profile through the surface peat, estuarine silts, old land surface and head was exposed (see for example, Figure 13) and sampled for pollen, plant macrofossil and sedimentological analyses using 10 x 10 x 50 cm monolith tins, and additional samples were recovered for beetle analysis. The stratigraphies from trenches T18 and T40 were further examined to see how much spatial variation there was in a distinct layer of charcoal identified in the area. Both trees showed evidence of burning which was also apparent on other trees locally, and c. 165 m from T18 on T57 and c. 235 m to the west, on T74 and T80. Details of their location are presented in Figure 11, and the main features recognised from the trench at T40 follow.

PRELIMINARY EXCAVATION RESULTS AT REDWICK (MB)

Redwick Trench T40

This trench is on the southern edge of the submerged forest outcrop. It lies seaward of a prominent channel which at low tide carries continuous drainage from the intertidal area.

South of this channel is a very extensive spread of sub-marine sand dunes. Between the channel and the dunes two fragments of the submerged forest are exposed. One (T77) is the most substantial oak trunk in the forest of which a photograph has previously been published (Bell 2000, fig 3). The other 40 m to its west is the large stump of Tree 40, the trunk of which would have been c 1.2 m in diameter; it has substantial flanking buttresses which characterise trees growing in wet conditions. The centre of the tree was rotted hollow. Preliminary survey during dendrochronological sampling had shown that the stump was associated with a charcoal scatter. Beside this stump a small diamond-shaped island of peat 5 m by 1.5 m has resisted erosion (Figure 12). A small trench 3 m by 1 m on this island investigated the stratigraphic context of the stump. The area where the full sequence could be exposed was limited to 0.6 m² with only the upper 3 layers being investigated in the whole trench. The extent of excavation was limited by the short time of exposure, even at spring tides, and the constant flow of water in the immediately adjacent channel.

The small area excavated revealed the following sequence (Figure 13, opposite): the basal deposit was sandy and pebbly head (307) with tree roots; this was overlain by a slightly organic sandy clay with some gravel (306), and at the surface of this layer was a very thin organic clay band (305) which is interpreted as the top of the old landsurface on which the oaks grew. Careful cleaning of a small area of this surface revealed three imperfect ungulate animal footprint-tracks, two were of red deer size and one was larger, possibly a juvenile aurochsen. This surface was sealed by a layer of clay (304), then by a distinct band of charcoal which included some large pieces (303). The charcoal scatter is exposed at the same stratigraphic horizon around the margins of the peat island (Fig. 12). Above the charcoal was a layer of clay (302) containing occasional wood fragments. The thin reed peat (301) had developed on this surface and contained no wood or charcoal. Examination of the interior of the hollow trunk showed two areas of the interior were charred. Within the hollow trunk was a stratigraphy identical to the upper part in the adjoining trench: clay was overlain by a distinct charcoal layer, clay and the reed peat. Pending the



Figure 14: Redwick: Tree 36 exposed in excavated trench, the tree is rooted in a soil developed on sandy head, the stump is part buried in estuarine clay on which later reed peat has developed (Photo. Edward Sacre).

programme of analytical investigation it appears that an oak growing on a sandy old land surface suffered heart rot. Minerogenic high saltmarsh clays covered the old landsurface. At that point the tree seems to have been burnt and a distinct layer of charcoal accumulated, both within the hollow trunk and in its surroundings. Renewed clay deposition was followed by the development of the reed peat.

Redwick Trench RO18

50 m away on the north side of the active drainage channel Trench RO18 4 m by 1 m, was laid out across half of a large oak stump Tree 36 (Figure 14) and an adjacent prostrate trunk. This revealed a similar sequence of layers. The prostrate trunk rested not on the old land surface but within the minerogenic clay. At a horizon corresponding to the surface on which it rested there were decayed

oak fragments and pieces of branch. The trunk had clearly rotted and undergone erosion on the saltmarsh surface. Fragments of charcoal were found on the same surface. The reed peat covered part of the surface of the prostrate trunk confirming that peat formation postdated the submerged forest. There was a charcoal fragment within the peat. In one small area peaty clay was present over the peat and at the junction between the two was one ungulate footprint of deer size and half an impression of another print.

This exercise demonstrates the importance of looking in detail at the stratigraphic context of submerged forests, notwithstanding the difficulties created by the conditions and the brief period for which they are exposed. In this instance the relationship between the life, decay and burning of the trees and the initial stages of estuarine sedimentation and peat development was significantly more complex than expected and

envisaged in many similar situations. Marine sedimentation, fire, however caused, and the activities of ungulates can be demonstrated as an integral part of the ecology during this phase but as yet there is no direct artifactual evidence of human activity at Redwick in this horizon.

DENDROCHRONOLOGY (NN)

Sampling for dendrochronology (Figure 15) has concentrated on three main areas: tree stumps and fallen boles overlain by basal Mesolithic peats at Redwick; trees in a similar stratigraphic position on the lower foreshore, east of Goldcliff island; and selected trees of probable late Mesolithic to Neolithic date in the upper peat east of Goldcliff.

A total of 111 trees, all apparently oak (*Quercus* spp.) have been sampled at Redwick along a 1.7 km length of the lower foreshore (Figure 11) where a somewhat deeper channel carrying water from Cold Harbour/Magor Pill discourages the accumulation of sand which obscures the Holocene deposits elsewhere. The condition of these trees, probably a reflection of their growth on, and subsequent encapsulation in, minerogenic sediment, prior to peat formation, is less than perfect with sapwood and bark only very rarely surviving. Examination of full cross-section samples from fallen trunks suggests that the heartwood/sapwood boundary will often only survive on the more protected underside. This has implications for future sampling strategies and limits the dating precision possible with this material. Some 3.4 km downstream, 18 oak trees



Figure 15: Goldcliff East: Nigel Nayling chain sawing an oak trunk in the basal peat (Photo. Edward Sacre).

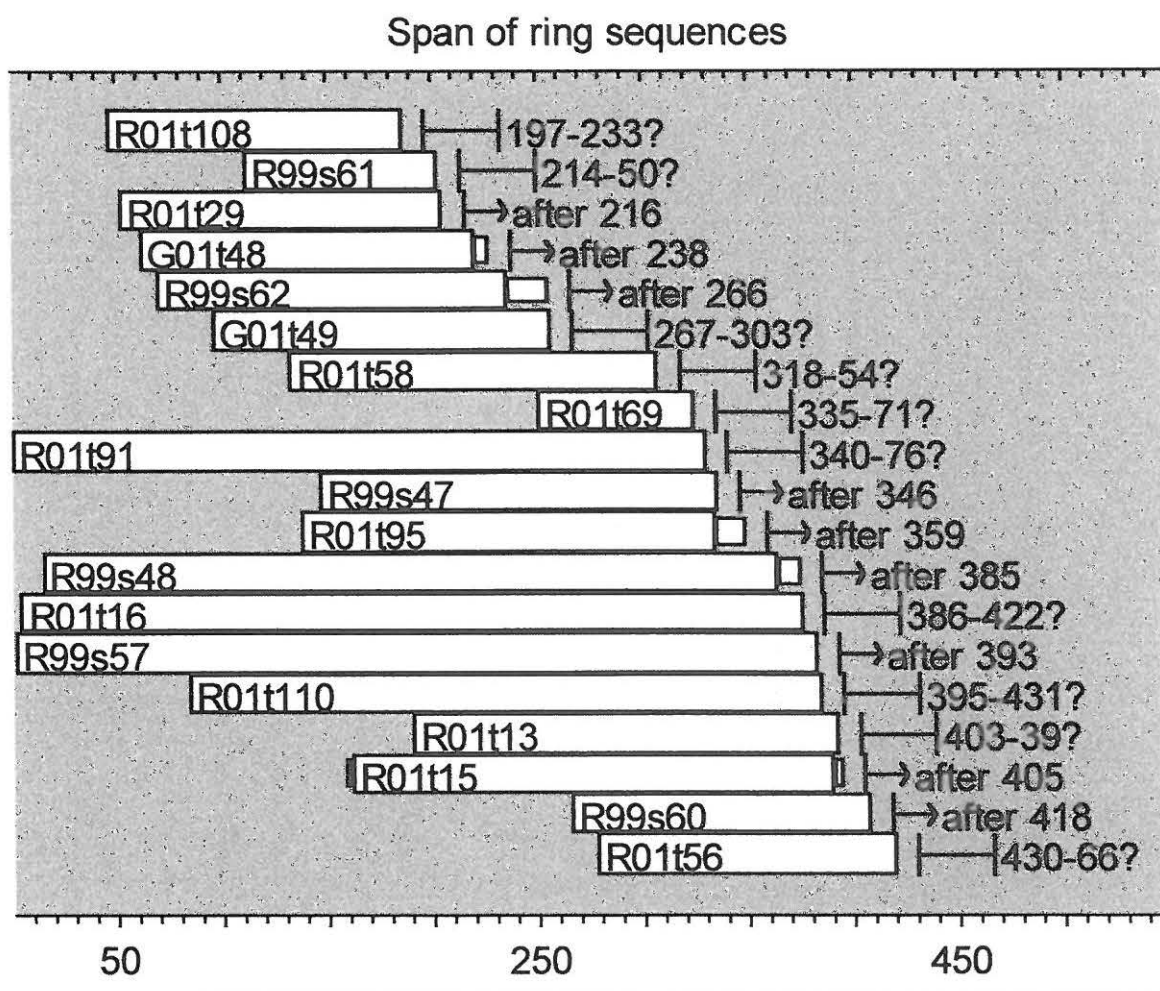


Figure 16: The relative dates of the Mesolithic tree-ring sequences from oak trees growing at Redwick (R99 and R01) and Goldcliff (G01). Where the presence of the heartwood/sapwood boundary is suspected, an estimate of the relative years when the individual trees died is given as a date range. Figure by Nigel Nayling.

have been sampled on the lower foreshore to the east of Goldcliff island (Figure 3). Their condition is similar to those recorded at Redwick, and limited observations suggest that further, broadly contemporary, exposures exist between the two areas.

Along the edge of the upper peat shelf at Goldcliff, some 32 oak trees have been sampled (Figure 3). The majority of these appear to have been growing on, and become buried in, peat. As a result, their condition is superior to those encountered in Mesolithic contexts, with sapwood and bark surviving on the majority of the samples taken.

Analysis of the samples taken in 2001, and samples from Redwick taken in 1999 as part of a pilot study, is far from complete. However, interim results from the study of the Mesolithic material are illuminating.

Figure 16 indicates the relative date spans of 19 successfully cross-dated sequences from Mesolithic trees at Redwick (R99 and R01) and Goldcliff (G01). These interim results indicate that oak trees formed a major element in a forest which extended over many kilometres and lived over a period of at least 450 years. The oak trees at both sites are contemporary. Many of the trees survived to considerable maturity with tree ages in excess of 300 years. The exact relative date of

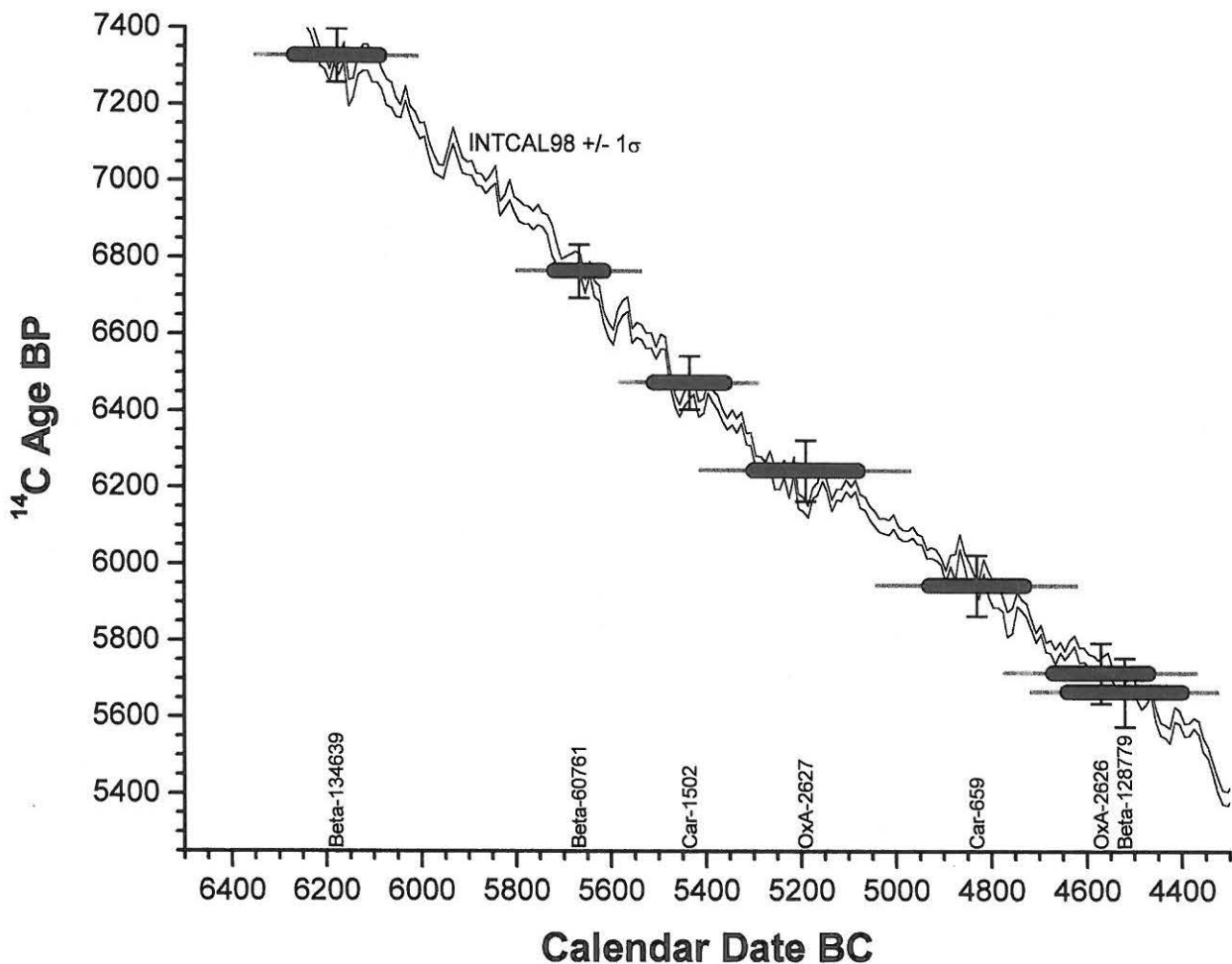


Figure 17: Calibrated age ranges for the radiocarbon data referred to in the text. Quoted radiocarbon (^{14}C) ages shown on the Y axis. Calibrated calendar age ranges shown on the X axis: thick black bars show the 1σ range and the thinner gray bar the 2σ range. The calibrated ranges do not show internal sub-ranges, but give the range from oldest to youngest calendar ages within the total 1σ and 2σ calibrated ranges. Calibration data from the OxCal calibration programme (Ramsey 1995, version 3.5 with resolution set at 2 years and round ranges set as on) employing the INTCAL98 calibration dataset (Stuiver et al 1998). Diagram by Sturt Manning.

tree deaths cannot be determined, as the sapwood and bark do not survive. Where survival of the heartwood/sapwood boundary is suspected, then an estimated date range for death can be given. The results so far suggest that the trees did not all die at the same time as the result of a sudden, catastrophic event such as permanent, rapid immersion in saltwater.

As more results are forthcoming, and these are integrated with spatial information and data

from other studies, we can hope to develop a uniquely detailed understanding of the life and death of an oak dominated forest which covered extensive areas now forming the Severn Estuary. More extensive sampling, at sites throughout the estuary, should tell us just how widespread this forest cover was and provide insights into its eventual demise.

CONCLUSIONS AND FUTURE PROSPECTS

The discovery of a Mesolithic site on the east side of Goldcliff island within a thin peat deposit represents an important development for this project's objective in establishing the relationship between human activity and coastal change in our study area. Human and animal footprints close to the Mesolithic site and a few animal footprints associated with the Mesolithic submerged forest at Redwick provide the opportunity to consider the effect of faunal agents on coastal plant communities. We hope to do further work on the new Mesolithic site at Goldcliff East and, together with the footprints, this will develop our understanding of the nature of Mesolithic coastal activity in this area. The erosion rates of the peat shelves has been quantified as between 0.5 and 1 m per year highlighting the need for appropriate archaeological investigation of this threatened site. Charcoal is widespread on the Mesolithic old land surface at Goldcliff East, and at Redwick there is also abundant charcoal associated with the basal submerged forest, although here no evidence has yet been found for a Mesolithic occupation site. Future pollen and macrofossil investigation will aim to establish to what extent, if any, fire affected coastal vegetation communities. Our investigation of the stratigraphic relationships of the submerged forest trees have begun to identify the complex relationship between tree life, rotting, sedimentation, burning, death, collapse and burial, the detail of which has not been evident from previous studies of submerged forests, but it is essential to understanding their place in dynamic evolving coastal vegetation communities. One result of this is that most of the sapwood and outer rings of the trees examined in the basal Mesolithic submerged forest have rotted. This may limit the opportunity of precise dendrochronological dates for the death of trees in the basal submerged forest even if it eventually proves possible to cross-match the site sequences with absolutely dated sequences elsewhere. However, there is better preservation of sapwood in parts of the submerged forest in the upper peat at Goldcliff East and some of these trees are thought to lie within the latter part of the project time frame, although so far these horizons have only been investigated to a limited extent. Despite many promising early discoveries and results this project is at an early

stage, little laboratory work has yet been done and the results reported above should be regarded as provisional pending further critical enquiry.

ACKNOWLEDGEMENTS

We are grateful to the Natural Environmental Research Council for funding this project. Additional funding for aspects related to footprint recording was provided by the National Museums and Galleries of Wales. We are most grateful to the other members of the project team listed in the introduction for the contribution they have made to project design and development. Their contributions will be more fully covered in future papers. Equipment and support was provided by the Departments of Archaeology at the University of Reading and the University of Wales, Lampeter, from which institutions the team was mostly drawn. This research has built on the pioneering intertidal discoveries of Derek Upton who has assisted us in the field for a decade. Particular thanks are due to Dr Heike Neumann for her help with the EDM survey and work on Figures 3 and 11 and Eddie Sacre who is the project photographer. We are grateful to the Royal Commission on the Ancient and Historic Monuments of Wales and Toby Driver of the Commission staff for air photography.

The field team comprised the authors assisted by the following who are thanked most warmly for their hard work and exceptional dedication under difficult working conditions: Roderick Bale; Susan Beckett; Jemma Bezant; Kim Borrowman; Susan Davis; Denise Druce; Nicky Evans; Alex Feltham; Shaun McConnachie; Steve Jones; Sean Keating; Tom Lyons; Emma Paddock; Charlotte Pearson; Neil Robinson; Scott Timpany; Karen Wicks; Virgil Yendall. Finds processing and administrative support was provided by Jennifer Foster, Pam Sacre and Eleanor and Sarah Bell. The local community at Goldcliff and Witson again allowed us to use their Community Hall as a base and we are especially grateful to Mrs Jill Jones for making this possible. We are grateful to Clarks who provided information on their 1990 survey of the relationship between foot size and age.

APPENDIX - STUDENT RESEARCH LINKED TO THE PROJECT

Scott Timpany: Submerged forests and coastal change in the Severn Estuary

This NERC funded postgraduate research project in the Archaeology Department, Reading University, is linked to the wider NERC project outlined above and supervised by Dr M. Bell and Dr P. Dark. The initial focus of research is on the ecology of the submerged forests at Redwick and Goldcliff on the Welsh side of the Severn Estuary. Although the project will initially focus on those forests dating to the Mesolithic and Neolithic periods, the study is also expected to extend to examples in these areas, and elsewhere in the Severn Estuary, which date to the Bronze Age and Iron Age. This will provide an opportunity to compare woodlands from a range of wetland contexts and periods. Woodland composition and the resources offered by woodland and other plant communities are to be examined. A range of proxy sources will be used including plant macrofossils, wood identification and tree ring studies together with some pollen and non-pollen microfossil analysis. These sources of evidence will be used to disentangle the effects of disturbance factors including: sea-level change, storm events, anthropogenic burning, wind throw, wildfire and faunal activities in an attempt to evaluate the range of factors influencing the character and demise of these coastal woodlands.

Rachel Scales: People-animal relationships in the Severn Estuary wetlands and surroundings

This postgraduate research in the Archaeology Department at Reading University is funded by NERC and supervised by Dr M. Bell and Professor J.R.L. Allen. The research chiefly explores people-animal relationships and animal husbandry in a coastal context through the study of animal bone assemblages and fossilised mammalian tracks. I hope to develop the potential of prehistoric animal tracks as a form of evidence for human activity and animal husbandry. Animal bone assemblages will be examined and compared with the animal track data sets to investigate the relationships between dryland and wetland sites, the levels of human activity and husbandry around

them and the relative importance of both wild and domestic animals. Foraminifera assemblages will also be studied in order to identify the levels of salt marsh associated with grazing and track formation. The principal area of study for this research will be the Severn Estuary, but it will be placed in a wider context, to see if what we are finding is specifically characteristic of the Severn Estuary, whether the economy/husbandry varies from site to site within the Severn environment and if there are similar patterns being recognised in other prehistoric contexts across Britain and Europe.

Emma Paddock: The Palaeoentomology of the Holocene Saltmarshes and Coastal Woodlands of the Severn Estuary – The Development, Exploitation and Decline of a Human Resource

Currently, palaeoentomological analysis of the intercalated peats, which directly border the Severn Estuary, is limited to the work of David Smith, Peter Osborne and Jayne Barrett at the Goldcliff multiperiod site (Smith *et al* 1997, 2000). This study offers a unique opportunity not only to build on this extensive work but also to undertake further site-specific study in the Estuary at Redwick and Goldcliff East on the Caldicot Levels together with Gravel Banks and potentially Oldbury on Severn on the Avon Levels. The ultimate aim is to produce an estuary-wide analysis exploring the relationship between human activity and the coastal zone in the Severn Estuary – many of the samples to be analysed are directly adjacent to areas of human activity and settlement at Redwick and Goldcliff East. Knowledge of the human exploitation of coastal woodlands and the coastal zone during the mid Holocene is limited, as is the inter-relationship between these biomes, human activity and palaeoentomological faunas. Finally, site-specific study will allow correlation and the degree of variability in estuary wide insect faunas to be studied.

Preliminary Findings:

Initial analysis of two peat bands at Redwick, overwhelmingly indicate damp, marshy habitats representing two, incomplete haloseres. The first suite of samples derived from a root buttress

associated with a band of peat from the submerged Mesolithic forest produced an assemblage indicative of high saltmarsh to terrestrial freshwater reed swamp. The second suite, derived from the main peat shelf at Redwick, illustrates the second part of this transition from freshwater reed swamp to alder carr. It is likely that the changing beetle assemblages were initially a result of relative sea level rise, which brought about the vigorous changes to the biomes of the Severn Estuary. Subsequently, as the rise in relative sea levels ceased and succession began, the changes were driven by the typical progressive changes of vegetative succession.

Similar wetland environments are represented at Gravel Banks in samples obtained from an early Mesolithic reed peat that appears to represent a relatively stable environment, which experienced limited change throughout its early development. Marine influence appears very much to gently ebb and flow throughout the profile, though never affecting the assemblage in a particularly profound or cataclysmic way.

Further extensive sampling of both the basal peat and the main peat shelf at Redwick was undertaken during the summer of 2001, including a complete section through the main peat shelf. A similar sampling strategy was also implemented at Goldcliff East where a complete section was also recovered from the main peat shelf. It is anticipated that further sampling of Mesolithic peats at Goldcliff East will be undertaken during the summer of 2002 along with further sampling of a basal peat at Gravel Banks and the further exploration of the potential of Oldbury on Severn.

Alex Brown: *The Mesolithic–Neolithic transition, a wetland-dryland perspective*

This postgraduate research is funded by a University Studentship in the Archaeology Department at the University of Reading and is supervised by Dr M. Bell. It will focus on aspects of the Mesolithic–Neolithic transition in western England and southern Wales with the aim of examining human–environment relationships and mobility through a programme of integrated earth-science and archaeological field and laboratory work, including pollen, fieldwalking and geoprovenancing. It is hoped that the research will

provide new insights into how communities were using wetland and adjoining dryland environments. This will complement the NERC project outlined above by providing a wider context for human activity in the periods in question. It may also help to establish whether and in what ways human wetland activities were linked to wider cycles of environmental relationships including dryland, and conceivably upland, exploitation.

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