EVIDENCE FOR HOLOCENE SEA-LEVEL CHANGES AT CALDICOT PILL

by Robert Scaife and Anthony Long

Introduction

Preserved within the unconsolidated sediments at Caldicot Pill is a valuable record of local and regional changes in sea-level and shoreline position dating from the mid-Holocene. This paper examines this record, by comparing radiocarbon dates collected from Caldicot Pill with a previously published sea-level curve for the Bristol Channel (Heyworth and Kidson 1982). The paper concentrates on the sea-level record from between *c.* 6500 and 5000 BP, which is a period of particular importance to both sea-level and archaeological research in the Severn Estuary, and in southern England as a whole.

Following the early-Holocene rapid rise in sea-level recorded throughout sites in southern England, after *c.* 6000 BP the rate of sea-level rise began to slow. In response, coastal wetlands throughout the Severn Estuary (and elsewhere in Southern England) expanded and shorelines advanced. The spatial and temporal details of this change in coastal dynamics varied, largely because superimposed on regional changes in sea-level were many other local factors which influenced shoreline development. Nevertheless, the general expansion of wetland peat communities which took place during this period altered the configuration of the coastline, as well as the nature and distribution of coastal resources available for exploitation by late Mesolithic communities.

Methodology

Regional changes in sea-level recorded at this site reflect the interaction of oceanic (or 'eustatic') and crustal factors. At the peak of the Devensian ice age, eustatic sea-level was *c.* -120 m below its current levels (Fairbanks 1989), with large volumes of ocean water locked on land as ice. However, as the climate warmed, this ice melted and in southern England sea-level rose rapidly until *c.* 6-5000 BP, after which the rate of rise decreased. In Great Britain as a whole, the timing and magnitude of the 'Flandrian transgression' varied considerably due to differential crustal movements. These movements were caused by the re-distribution of mass within the upper mantle which accompanied the unloading of the land by ice and loading of the continental shelf by water. In a recent study of crustal movements in Great Britain, Shennan (1989) concluded that the Bristol Channel was experiencing crustal subsidence at between *c.* -0.2 to -0.5 mm per year. This contrasts with areas to the north, which are crustally stable (e.g. the North Wales coast), or which are experiencing crustal uplift of *c.* +2 mm per year (Scottish sites close to the former centre of ice loading). In southern England the pattern of crustal movements is complicated by the geological subsidence of the Southern North Sea Basin. Consequently, other sites in southern England, such as The Solent, Romney Marsh, and the Thames Estuary, have generally experienced a greater net rise in relative sea-level compared with the Severn Estuary.

The type of stratigraphic sequence recorded at Caldicot Pill and throughout the Severn Estuary is broadly similar to mid-Holocene sequences recorded at many other coastal sites in the UK, consisting of alternating inorganic and organic deposits (Scaife, this volume p. 67). The extent to which the changes between these types of deposit represent distinct oscillations in sea-level is debatable. Kidson and Heyworth (1978), for example, have argued in favour of a smoothly rising sea-level curve for areas in southwest England and west Wales. They state that any oscillations of sea-level are smaller than the other uncertainties associated with the collection and analysis of the original stratigraphic data. In contrast, in northwest England (Tooley 1978), northern France (Ters 1973) and in the Thames Estuary (Devoy 1979), alternating sequences of organic and inorganic sediments have been interpreted as evidence for an oscillating sea-level.

To some extent, these two schools of thought have both been superceded in recent years by methodological developments in Holocene sea-level research. For example, Shennan (1982) has argued strongly against the use of a single line, called a 'sea-level curve', be it oscillating or smoothly rising. In particular, when age and altitude errors are recognised, a 'sea-level band' which envelops the original sea-level index points (and their age and altitude uncertainties) is a more accurate graphical representation of the data. Under this approach, the magnitude of any sea-level oscillation is constrained by the width of the sea-level band. Hence, where there are large uncertainties regarding the accuracy of the data, identifying small amplitude oscillations in sea-level from such information may not be possible.

Heyworth and Kidson (1982) recognised the wide number of variables which can influence the construction of age/altitude graphs, but presented a single line sea-level curve for the Bristol Channel. No further systematic mid-Holocene sea-level studies have since been completed for this region, although extensive investigations of the late-Holocene record of sea-level changes have been undertaken (e.g. Allen 1987b; Allen 1990a; Allen and Rae 1988). At present the age/altitude curve of Heyworth and Kidson (1982) remains the best available estimate of early- and mid-Holocene sea-level changes here. Thus, their curve is used here as a basis for the following analysis.

The reconstruction of past vertical changes in sea-level is dependent on the collection and analysis of sea-level index points. Each index point has five attributes: a location; an age; an altitude; an indicative meaning; and a reference water level. The indicative meaning of an index point describes the altitudinal relationship between the local depositional environment in which the index point accumulated and the reference tide level. The most accurate sea-level index points used for time/altitude studies are transgressive and regressive contacts. These record the transition between fresh, terrestrial and brackish marine environments. The reference tide level for these stratigraphic contacts is generally mean high water of spring tides, while the indicative meaning for such contacts is typically 0.20m (Shennan 1982). When other factors associated with levelling and sediment compaction are taken into account, a transgressive or regressive contact will have a typical altitudinal uncertainty of *c.* ±0.50 m.

Results

The litho- and biostratigraphic data from Caldicot Pill enable the indicative meaning and reference tide level of the dated stratigraphic units to be assessed. The lithostratigraphy and biostratigraphy clearly show that marine conditions existed prior to a phase of reedswamp, freshwater sediment and peat accumulation at Caldicot Pill. This temporary cessation of marine conditions is marked primarily by the basal occurrence of *Phragmites* in the sediment stratigraphy. Progressively more terrestrial and freshwater conditions (at Oscar 3) culminated in oak and hazel woodland, damp alder carr and freshwater pond or slow flowing riverine conditions. The numerous oak root boles and trunks attest to this but their final demise is evidence of a return to marine conditions, perhaps those which pertain today. The upper peat contact in Oscar 3, records a transition from a predominantly fresh/brackish to a brackish/marine depositional environment and is a transgressive contact. This contact has been dated to 6360±70 BP and the reference tide level for the index point is approximately mean high water of spring tides.

The date from the upper level of the exposed peat in context 333-340 cm is 1 cm above the regressive contact recorded at -2.47 m OD. Given that the sample dated is only 1 cm thick, and that high frequencies of saltmarsh pollen types are recorded immediately below the dated level, the indicative meaning and reference tide level of this index point is similar to that from Oscar 3.

Because of spatial variations in the height of mean high water of spring tide, it is common to adjust the observed altitude of an index point to a common datum, usually mean sea-level. This procedure assumes that the difference in height between mean sea-level and mean high water of spring

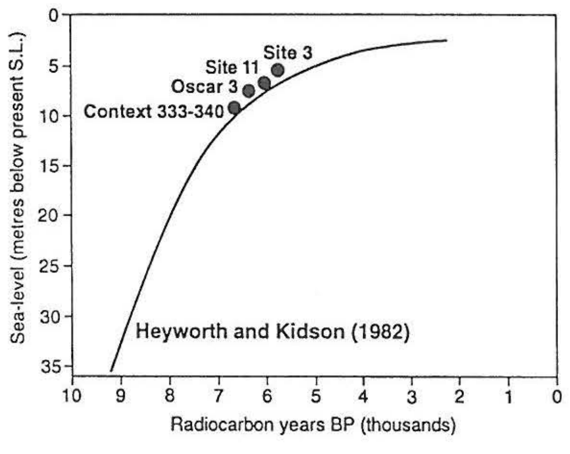

Figure 36. Age/altitude diagram of sea-level change in the Severn Estuary with the Caldicot Pill dates for comparison.

tides has been constant through time. This may not be true, especially in areas such as the Bristol Channel where palaeotidal changes may have occurred. Heyworth and Kidson (1982) adjusted their sea-level curve to mean sea-level for comparison with other sites in Wales and the English Channel. The altitude of the two new index points described from Caldicot Pill above must, therefore, be corrected in the same manner. The current altitude of mean high water of spring tides at Avonmouth is +6.70 m OD and this figure is, therefore, subtracted from the observed altitude of the index points. When compared with the sea-level curve proposed by Heyworth and Kidson (1982), these two index points both plot *c.*1 m above the proposed curve (Figure 36).

Two other radiocarbon dates from site 3 and site 11 can also be cautiously related to the Heyworth and Kidson (1982) curve. At site 3, one of the 18 fallen tree trunks recorded at *c.* +1.3 m OD has been dated to 5760±70 BP (BETA-54827) while at site 11, alder roots at *c.* 0.0 m OD have been dated to 6040±70 BP (BETA-54829). Assessing the indicative meaning and reference tide level for these index points is difficult (see discussion in Heyworth and Kidson 1982). As a first approximation it is assumed that they formed at, or above, mean high water of spring tides. As is to be expected, dates from the tree at site 3, and from the alder roots at site 11, lie approximately 0.2 to 1.5 m above the sea-level curve proposed by Heyworth and Kidson (1982).

Although the altitudes of the Caldicot dates are comparable with the curve proposed by Heyworth and Kidson (1982), the alternations between organic and inorganic sedimentation do not necessarily record distinct oscillations in sea-level. Variation in rates of organic and inorganic sedimentation, as well as the local proximity of tidal conditions due to shoreline change, may induce such

Table 1. Caldicot Pill: Radiocarbon dates and sea-level relationships

	Strati-graphic position	Lab code	Age ^{14}C BP	Altitude (m)	Mean sea-level (m)
Oscar 3	transgressive contact	BETA-79887	6360±70	-0.82	-7.52±0.50
Context 333-340	1 cm above regressive contact	BETA-79886	6660±80	-2.48	-9.18±0.50

Table 2. Severn Estuary and Bristol Channel peat dates

South Wales		
Caldicot Pill		
5760±70 BP	BETA-54827	*Quercus* wood
6040±70 BP	BETA-54829	*Alnus* root
Uskmouth		
5810±80 BP	OxA-2628	Base of lower peat
6140±80 BP	OxA-3307	Base of lower peat
Goldcliff		
5850±80 BP	CAR-658	
North Devon and Somerset		
Minehead		
6730±150 BP	QPQ-1343	
Westward Ho!		
5190±80 BP	HAR-6363	Top of peat
5200±120 BP	HAR-5640	Top of peat
6100±100 BP	HAR-5631	*Quercus* wood
5630±80 BP	HAR-5630	*Salix* root
5740±100 BP	HAR-5641	Base of peat
6586±130 BP	Q-672	Wood on top peat
6680±120 BP	Q-1249	Wood in peat
5004±105 BP	IGS-42	Roots in peat

stratigraphical changes independent of any significant vertical change in sea-level. For example, it is possible that barrier bars may have been formed which caused a reduction of marine influences and localised terrestrial fen and freshwater lagoons. This can be regarded as a marked possibility since sub-sediment contours at Caldicot Pill show the presence of an 'island' feature which may have been responsible for localised point bar formation. If, however, the widespread occurrence of such peat and freshwater sediments along the north and south side of the Bristol Channel and Severn Estuary is considered, it appears more likely that we are dealing here with a regional contract of marine conditions from the area, perhaps in response to the reduction in the rate of sea-level rise recorded at this time. Dates available for intertidal peats and wood from elsewhere in the Severn Estuary which broadly conform with the Caldicot sequence are as in Table 2.

Other factors should also be recognised when interpreting the evidence for sea-level changes recorded at Caldicot Pill. The assumption that radiocarbon dating and accurate surveyed heights of organic deposits provide data on the date of colonisation and destruction of brackish and freshwater mire/peat forming communities may be questioned. For example, Heyworth and Kidson (1982) argue that salt marsh deposits may be unsuitable for determining past sea-levels due to the ability of some halophytic vegetation to grow well above the ground water table through long root systems. Thus, it is clear that *Phragmites*, which is frequently found in such situations, may quickly grow upwards in response to rapidly accumulating sediment whilst still maintaining its roots at a lower ground water level (Heyworth and Kidson 1982, 96). In addition, there are problems associated with errors in accurate surveying of the stratigraphical levels and geological considerations of changes in tidal range and the effects of sediment compaction of peats overlain by mineral overburden and differential rates of sedimentation in differing freshwater and marine environments.

In conclusion, it is clear that at least locally, there had been marine and saltmarsh conditions existing in the Caldicot Pill area by the middle Holocene. This was a response to major post-Devensian (Flandrian Chronozone I) sea-level rise. By the beginning of the mid-Holocene (Flandrian Chronozone II) after sharply rising sea-levels, the rate of sea-level rise fell. Marine conditions were removed from many sites in the Bristol Channel between *c.* 6500 and 5000 BP, with saltmarsh conditions being replaced by reedswamp, localised fen carr woodland with oak, alder and hazel in drier peat forming areas, and local freshwater river or lagoons. The altitudes of the Caldicot Pill index points agree closely with the sea-level curve proposed by Heyworth and Kidson (1982), and appear, therefore, to record processes operating at the scale of at least the Bristol Channel. The regional significance of the sea-level record at Caldicot Pill and in the Bristol Channel as a whole, awaits a larger scale comparison of sea-level data from these and other sites throughout southern England as a whole.

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