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Sea View, Mersea Island, Essex

Radiocarbon dating of waterlogged timbers

Peter Marshall, Oliver Hutchinson, Danielle Newman, Zoë Hazell, Sanne Palstra and Irka Hajdas

Scientific Dating

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Summary

Radiocarbon dating of two linear features recorded by CITiZAN at Sea View, Mersea Island, Essex has demonstrated that they were constructed from timbers felled in the late seventh–eight centuries cal AD.

Contributors

Peter Marshall, Oliver Hutchinson, Danielle Newman, Zoë Hazell, Sanne Palstra and Irka Hajdas

Acknowledgements

The survey of Sea View would not have been possible without the generosity, dedication, knowledge, and enthusiasm of the Mersea Island CITiZAN volunteer team — Mark and Jane Dixon, James Pullen, John Pullen-Appleby, Carol Wyatt, Alan Williams and Geoff Lunn. We would also like to thank Robert Howard (Nottingham Tree-ring Dating Laboratory) for sub-sampling the timbers for radiocarbon dating.

Valuable comments and insightful feedback on a draft of this report was provided by Marcus Jecock (Historic England) whose expertise and support were invaluable in shaping CITiZAN.

Front cover photo

The front cover photo shows the view inland towards Sea View from the wooden features exposed at low tide on the morning of the 21st February 2022 (photograph taken by Peter Marshall © Historic England).

Archive location

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Historic environment record

Essex HER, Historic Environment Specialist Team, Place Services, County Hall, Chelmsford, Essex, CM1 1QH

Date of survey and research

The CITiZAN volunteer team on Mersea Island first identified the Sea View feature in 2019 and following an initial walkover conducted in the early winter of 2019 it was surveyed over two low tides on the 22nd July 2020 by CITiZAN archaeologists Oliver Hutchinson and Danielle Newman. Samples for radiocarbon dating were collected on the 21st February 2022, with identification and radiocarbon dating undertaken in 2022. The report was compiled in 2024.

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Introduction

Mersea Island, Essex is located at the mouth of the Blackwater and Colne estuaries (Fig. 1) 12 miles south of Colchester. Sea View, TM 02631 12256, is accessed via a public beach, a five-minute walk from the nearby public car park.

The feature at Sea View is likely to have first been observed in 1999 (Colchester MCC5216) when five photographs of a timber alignment were taken in the vicinity of the surveyed remains described in this report. No notes or precise location data appear to have been gathered in 1999. Given the scale of the feature described here, however, it is likely that it represented its initial exposure.

The Coastal and Intertidal Zone Archaeological Network (CITiZAN) were alerted to timbers visible at Sea View by volunteer James Pullen in the late summer of 2019. He described groups of linear timbers running perpendicular to the present shoreline with a complex arrangement of smaller stakes and uprights towards the low water line. In October 2019 CITiZAN undertook a survey of the visible timbers (Fig. 2).

The principle remains observed fall into three categories (Figs 2–4)

1. two linear timber features (Group 1; Features 1 and 2; Figs 3–5);
2. two short alignments of posts running perpendicular to Features 1 and 2 (Group 2; Fig. 2);
3. two sections of exposed wattle or brushwood (Feature 3; Figs 3 and 6).

A full description of the Sea View timber features, details of the survey methodology and a discussion of what they may have been used for can be found in Hutchinson (2022).

It should be noted that access to the entirety of this feature is possible only at the lowest tides. The northern sector of the site (immediately north of the naturally occurring oyster bed (Fig. 2) is exposed relatively regularly. However, the southern section requires the lowest of tides to access fully. Even then, there is limited scope to undertake detailed survey given the scant time afforded by the rising tide. On these tides it is possible to observe the continuation of Feature 1 below the water line for some 20m before the depth of the water halts progress on foot. The feature was observed to continue beyond this point yet further to an unknown extent.

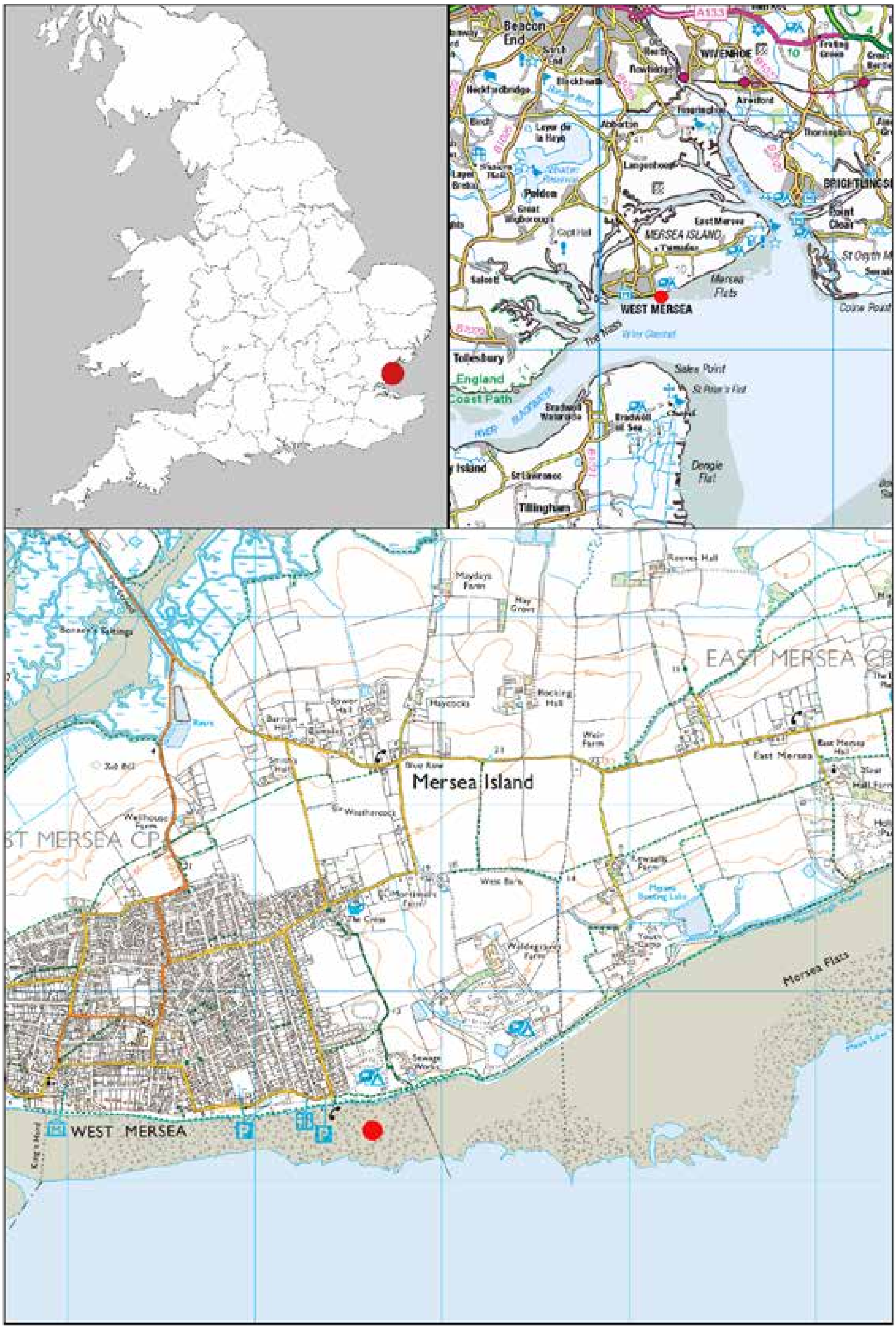

Figure 1: Maps to show the location of Sea View, Mersea Island, Essex, England, marked in red. Scale: top right 1:211,654, bottom 1:26,457

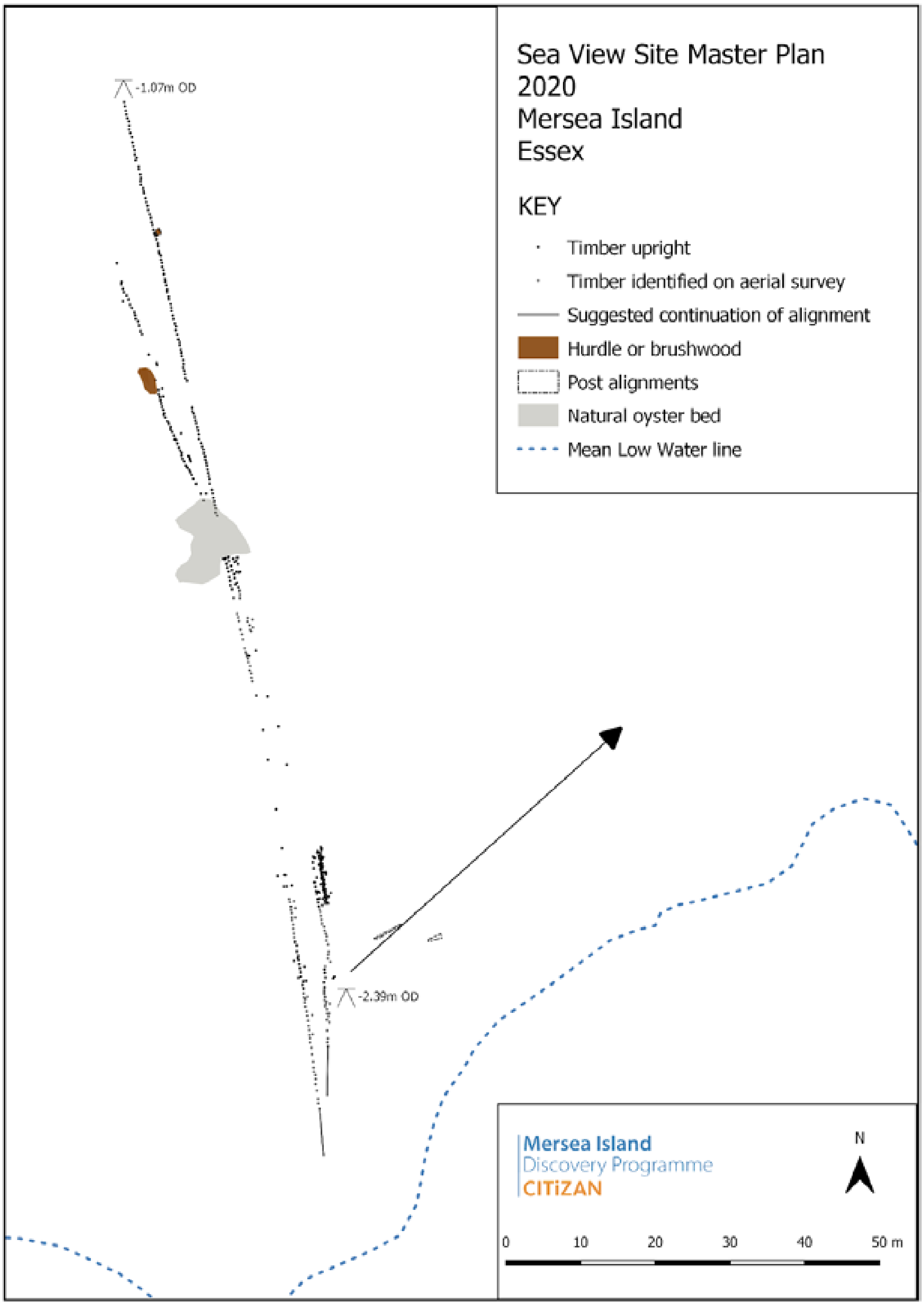

Figure 2: Sea View site plan (© O Hutchinson).

Figure 3: Feature 1 looking south with Feature 3 (hurdle panel) in the foreground. The natural oyster bed that obscures the centre of the alignment can be seen towards the upper portion of the image (© O Hutchinson).

Figure 4: The northern end of Feature 1, looking southeast, from which sample 1 was taken. Cleaning back of surface sediments revealed a possible trench or channel into which the upright piles were located. Tape scale is 1m (© O Hutchinson).

Figure 5: Feature 2 highlighted in red. Image looking south (© O Hutchinson).

Figure 6: Feature 3 - a section of wattle hurdle work (© O Hutchinson).

Group 1: Feature 1

Feature 1 is a row of timber piles running 138m north–south, perpendicular to the modern shoreline (Fig. 3). A natural oyster bed obscures a *c*. 5m section in roughly the centre of the alignment where Features 1 and 2 intersect. It is assumed that Feature 1 continues on a relatively precise N–S alignment given the similarity in timber size, spacing and alignment both to the north and south of the oyster bed. This continuation can be seen in (Fig. 3). The piles are regularly spaced averaging 500mm apart and set vertically with a considerable and consistent degree of precision. The survey observed 100 vertical upright timber piles in the round. The piles average 160mm in diameter when measured at the base where the presence of bark indicates their original size as trunks. They stand between 20–600mm proud of the foreshore with the more exposed (and therefore taller) piles found towards the northern section of the alignment. The tops of the exposed piles are heavily eroded, often to a point made up of just heartwood. From tip to foreshore the timber is friable and honeycombed where erosive tidal forces and marine worms have combined forces to breakdown the ancient wood.

At the northern end of the alignment where the feature 1 sample was taken, simple clearing back of loose surface sediments and oysters indicated that the piles were set into a blue grey, possibly marine deposit running parallel to a yellow/brown deposit (Fig. 4). It was unclear how far along the alignment this trench or channel extends, and if it is natural or backfilled.

In the southern portion of the feature several piles of similar dimensions are set in pairs at mixed intervals, perhaps repairs or unique structural elements. Six timbers, again of similar dimensions, were observed (but sadly not recorded due to time constraints) set *c.*1m westwards and angled at *c.* 70° towards Feature 1. Roughly projected, the intersection of these timbers with the main vertical alignment would occur at *c.* 2.2m, providing a rough estimate for the functioning height of the structure.

Group 1: Feature 2

Group 1: Feature 2

A second row of smaller piles (Fig. 5) and stakes extending 124m northwest–southeast form Feature 2. They average 100mm diameter and no bark was present on any timbers in this row. All appear to have been set vertically but with less precision than those in Feature 1. Based on the size and alignment of timbers, it is assumed that Feature 2 continues to the east of Feature 1 south of the intersection. It begins to curve westward at the southern limit of the alignment, towards Feature 1. It is proposed that Features 1 and 2 intersect again at some point to the south of the surveyed remains (Fig. 2). Seven more uprights of similar dimensions, in close alignment with Feature 2, were observed underwater southwards of the low water line extending *c*. 6m. Given their position, it is highly unlikely they will ever be completely exposed, the only practical way to survey them being from a boat or in a swimsuit. They appeared in a good state of preservation, perhaps only recently exposed with little erosion evident. Bark appeared to be present on several of the uprights above the mudline.

Towards the southern end of Feature 2 five rows of smaller uprights were observed (note the cluster of points in Fig. 2). Time did not permit a detailed survey of these timbers, and many were added to the site plan using aerial imagery. They were found to be in rows of progressively smaller dimensions, with the largest row adjacent to the larger timbers of the main alignment. Regularly set and spaced at a *c.* 60° angle pointing away from the main uprights, the cluster likely extended further south (some tips of stakes were noted but not investigated).

Sampling

Single posts from the two linear timber features (Feature 1; Fig. 7 and Feature 2; Fig. 8; Table 1) that comprised Group 1 were sampled for radiocarbon dating on the 21st February 2022 by Oliver Hutchinson, Danielle Newman and Peter Marshall. The two sampled posts appeared to be representative examples of those within the two features as there was a very clear uniformity to the dimensions of the timbers utilised in their construction. Given the time-constraints of working in the intertidal zone only two posts could be sampled within the tidal window.

Figure 7: Post sampled for radiocarbon dating from Feature 1 (© Historic England).

Figure 8: Post sampled for radiocarbon dating from Feature 2 (© Historic England).

Wood identification

Wood identifications were carried out on both timbers sampled for radiocarbon dating by Zoë Hazell (Table 1). Thin sections were taken by hand using a double-edged razor blade, from the three planes of wood required for secure identifications: the transverse section (TS), radial longitudinal section (RLS) and the transverse longitudinal section (TLS). These were then examined under high power magnification (×100–400) using a Leica DM2500. Identifications were made using a combination of the texts and keys by Schweingruber (1982) and Gale and Cutler (2000). The identifications were made to genus level, as is standard practice based on the microscopic anatomical features of wood.

Two wood types were identified (Table 1), both of which are hardwoods: *Betula* sp. (birch) and *Alnus* sp. (alder). In Britain, there are three native *Betula* tree species (Stace 2010): *B. pubescens* (downy birch), *B. pendula* (silver birch) and *B. nana* (dwarf birch), although the latter is found on "upland moors and bogs on peat" of northern Britain (Stace 2010, 294). The only native alder is *Alnus glutinosa* (common alder) (Stace 2010).

Radiocarbon dating sampling

Due to the lack of distinctive rings in both timbers it was not possible to obtain samples that could be used in a radiocarbon wiggle-match and thus radiocarbon measurements were obtained on material from “inner” and “outer” rings. Dissection was undertaken by Robert Howard (Nottingham Tree-ring Dating Laboratory).

Radiocarbon dating

Radiocarbon dating is based on the radioactive decay of ^{14}C, which trees absorb from the atmosphere during photosynthesis and store in their growth-rings. The radiocarbon from each year is stored in a separate annual ring. Once a ring has formed, no more ^{14}C is added to it, and so the proportion of ^{14}C versus other carbon isotopes reduces in the ring through time as the radiocarbon decays. Radiocarbon ages, like those in Table 1, measure the proportion of ^{14}C in a sample and are expressed in radiocarbon years BP (before present, ‘present’ being a constant, conventional date of AD 1950).

Table 1: Sea View radiocarbon and associated stable isotope measurements

Laboratory Number	**Sample number & material**	**Radiocarbon Age (BP)**	**$\delta^{13}C_{IRMS}$ (‰)**	**$\delta^{13}C_{AMS}$ (‰)**
ETH-123016	1.1 Waterlogged wood, *Betula* sp. (Z Hazell), inner rings, from Feature 1	1332±19		−23.5
GrM-29795	1.2. Waterlogged wood, *Betula* sp. (Z Hazell), outer rings, from Feature 1	1270±21	−27.9±0.15	
ETH-123017	2.1 Waterlogged wood, *Alnus* sp. (Z Hazell), inner rings, from Feature 2	1346±19		−24.5
GrM-29796	2.2 Waterlogged wood, *Alnus* sp. (Z Hazell), outer rings, from Feature 2	1297±21	−28.0±0.15	

Radiocarbon dating was undertaken at the Centre for Isotope Research, University of Groningen, the Netherlands and the Laboratory of Ion Beam Physics, ETH Zürich, Switzerland in 2022. At ETH Zürich cellulose was extracted from each ring using the base-acid-base-acid-bleaching (BABAB) method described by Němec et al. (2010), combusted and graphitised as outlined in Wacker et al. (2010a), and dated by Accelerator Mass Spectrometry (Synal et al. 2007; Wacker et al. 2010b).

At the Centre for Isotope Research the samples were pretreated using an acid-base-acid protocol (4% HCl, 1% NaOH, <1% HCl) followed by bleaching (Dee et al. 2020, 67–8) and combusted in an elemental analyser (IsotopeCube NCS), coupled to an Isotope Ratio Mass Spectrometer (Isoprime 100). The resultant CO_2 was graphitised by hydrogen reduction in the presence of an iron catalyst. The graphite was then pressed into aluminium cathodes and dated by AMS (Synal et al 2007; Salehpour et al 2016).

Data reduction was undertaken at both laboratories as described by Wacker et al. (2010c). Both facilities maintain continual programmes of quality assurance procedures, in addition to participation in international inter-comparison exercises (Scott et al. 2017). Details of quality assurance data and error calculation at Groningen are provided by Aerts-Bijma et al. (2021), and similar details for ETH are provided in Sookdeo et al. (2020).

Details of the radiocarbon ages and associated stable isotopic measurements are provided in Table 1. The radiocarbon results are conventional radiocarbon ages (Stuiver and Polach 1977), corrected for fractionation using $\delta^{13}C$ values measured by AMS. At the University of Groningen $\delta^{13}C$ values were also measured by Isotope Ratio Mass Spectrometry. These values more accurately reflect the natural isotopic composition of the sampled wood.

Radiocarbon ages are not the same as calendar dates because the concentration of ^{14}C in the atmosphere has fluctuated over time. A radiocarbon measurement has thus to be calibrated against an independent scale to arrive at the corresponding calendar date. That independent scale is the IntCal20 calibration curve (Reimer et al. 2020). For the period covered by this study, this is constructed from radiocarbon measurements on tree-ring samples dated absolutely by dendrochronology. The probability distributions of the calibrated radiocarbon dates are derived from the probability method (Stuiver and Reimer 1993).

Chronological modelling

The chronological modelling described below has been undertaken using OxCal 4.4 (Bronk Ramsey 1995; 2009), and the internationally agreed calibration curve for terrestrial samples from the northern hemisphere (IntCal20; Reimer et al. 2020). The model is defined by the OxCal CQL2 keywords and by the brackets on the left-hand side of Figure 9 (the full code is given in Appendix 1). In the diagram, calibrated radiocarbon dates are shown in outline and the posterior density estimates produced by the chronological modelling are shown in solid black. The Highest Posterior Density intervals which describe the posterior distributions are given in italics.

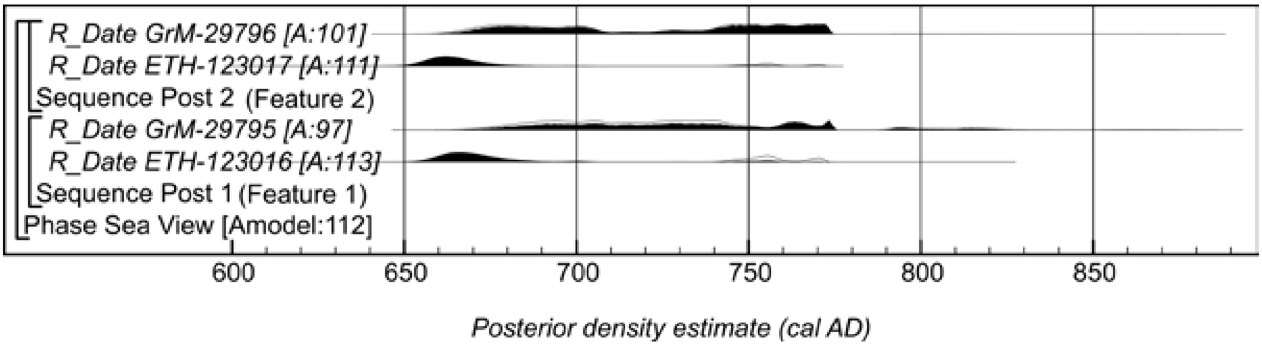

Figure 9: Probability distributions of dates from Sea View.
Post 1 is part of Feature 1 and Post 2 is part of Feature 2. Each distribution represents the relative probability that an event occurs at a particular time. For each of the dates two distributions have been plotted: one in outline, which is the result of simple radiocarbon calibration, and a solid one, based on the chronological model used. The large square brackets down the left-hand side along with the OxCal keywords define the overall model exactly (© Historic England).

Due to the lack of distinctive rings in both sampled timbers wiggle-matching (Galimberti et al. 2004) of their calibrated radiocarbon dates to the shape of the radiocarbon calibration curve could not be undertaken as we do not know the number of years between them. We have therefore used the OxCal `Sequence` command that simply defines an order for events (i.e. the calibrated radiocarbon dates); inner rings < outer rings. The model shown in Figure 9 has good overall agreement (Amodel: 112) with all the individual dates having good individual agreement (A: > 60.0). The A statistic shows how closely an individual calibrated radiocarbon date agrees its position in the sequence (most values in a model should be equal to or greater than 60). The Amodel statistic is calculated for the model from the individual indices of agreement and provides a measure of the consistency between the prior information and radiocarbon dates (Bronk Ramsey 2009, 357). The model index of agreement has a threshold value 60 and models with lower values need to be critically re-examined.

The model suggests that the outer rings of the sampled timber from Feature 1 formed in *cal AD 670–780* (*91% probability*; *GrM-29795*; Fig. 9) or *cal AD 790–825* (*4% probability*), probably in *cal AD 685–745* (*55% probability*) or *cal AD 755–775* (*13% probability*) and from Feature 2 formed in *cal AD 665–710* (*40% probability*; *GrM-29796*; Fig. 9) or *cal AD 720–775* (*55% probability*), probably in *cal AD 670–705* (*24% probability*) or *cal AD 740–775* (*44% probability*).

A model (Fig. 10) that incorporates the field observation that the less precise Feature 2 is earlier than the structurally more significant and precise Feature 1, representing a later repair or reuse following the original alignment (Hutchinson 2022, §Discussion) has good overall agreement (Amodel: 97) and suggest the structures were constructed in the late seventh–eight centuries cal AD.

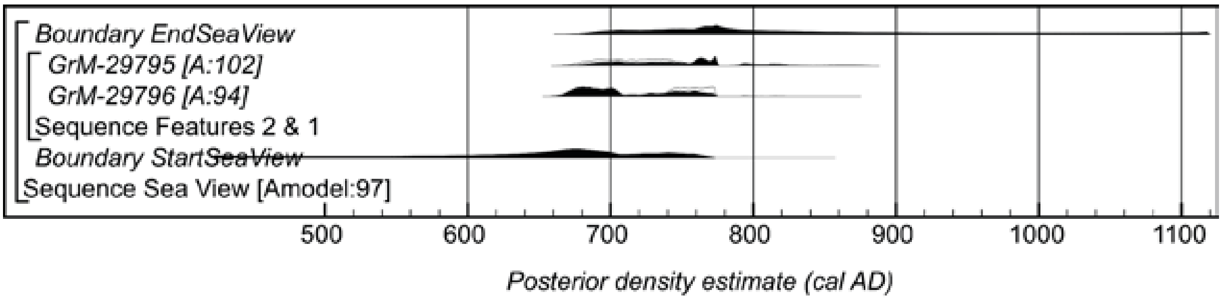

Figure 10: Probability distributions of dates from Sea View.
The format is identical to Figure 9 (© Historic England).

Discussion

The dating evidence indicates the Sea View feature was constructed and maintained throughout the mid-Saxon period. This makes it contemporary with several other large-scale timber structures in the Blackwater estuary, identified as intertidal fish traps and similarly dated to the mid-Saxon period (Heppel 2005; Figs 11–12). Similarities in size and form to other fish traps mean it is possible that Sea View was constructed with a similar purpose and function. If so, only a portion of the original structure is visible, as it would likely not function effectively in the observed configuration, at least not as we understand them to operate. For an intertidal fish trap to work well, it requires two alignments set in a V shape to kettle retreating shoals into a trap end, in this case the southern end of the structure, which would sit just above the mean low water line. The curious cluster of rows of progressively smaller stakes may have been a series of pegs and stakes securely attached a net within the main structure to the ground. But the continuation of the feature southwards below the water line suggests that the trap (or cod) end of the structure was situated elsewhere. The proposed alignment bearing north-west (Fig. 2) is based on a small number of timbers similar to Feature 2 observed in a rough alignment but that disappear under a raised oyster reef. If a second leading arm exists below the reef, it may support this notion to the trap end having been situated near the cluster of ground pegs and stakes.

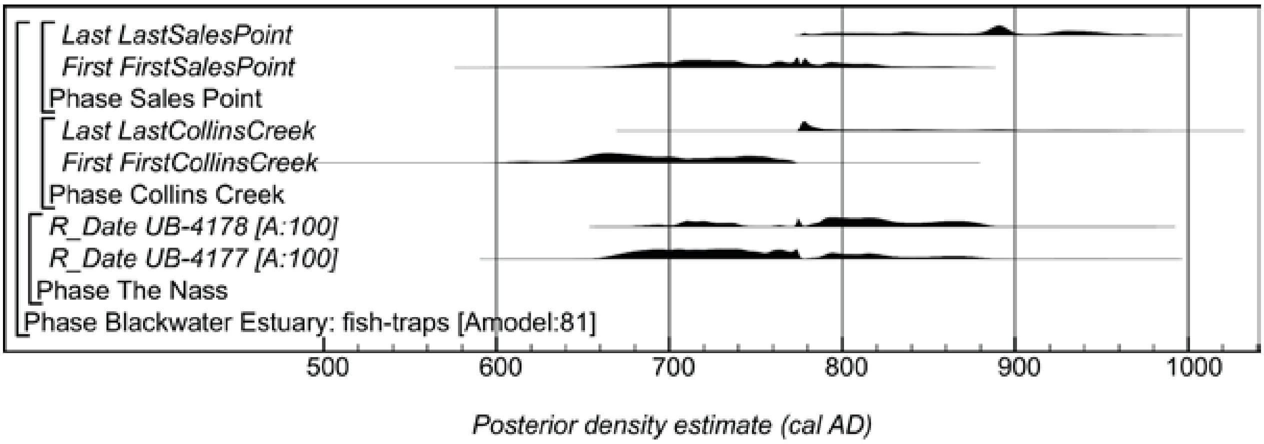

Figure 11: Probability distributions of dates for the construction of fish-traps in the Blackwater Estuary derived from the model described in Appendix 2 (Fig. 14) (© Historic England).

Two other fish-traps have been identified on Mersea's southern shores (Heppell 2005). One is *c.* 1km to the west, the other *c.* 1.5km to the east (Fig. 12). They follow the typical V-shape design. Across the estuary at Sales Point lies a larger rectangular structure that may bear the most similarity to Sea View if it were designed to be a fish trap.

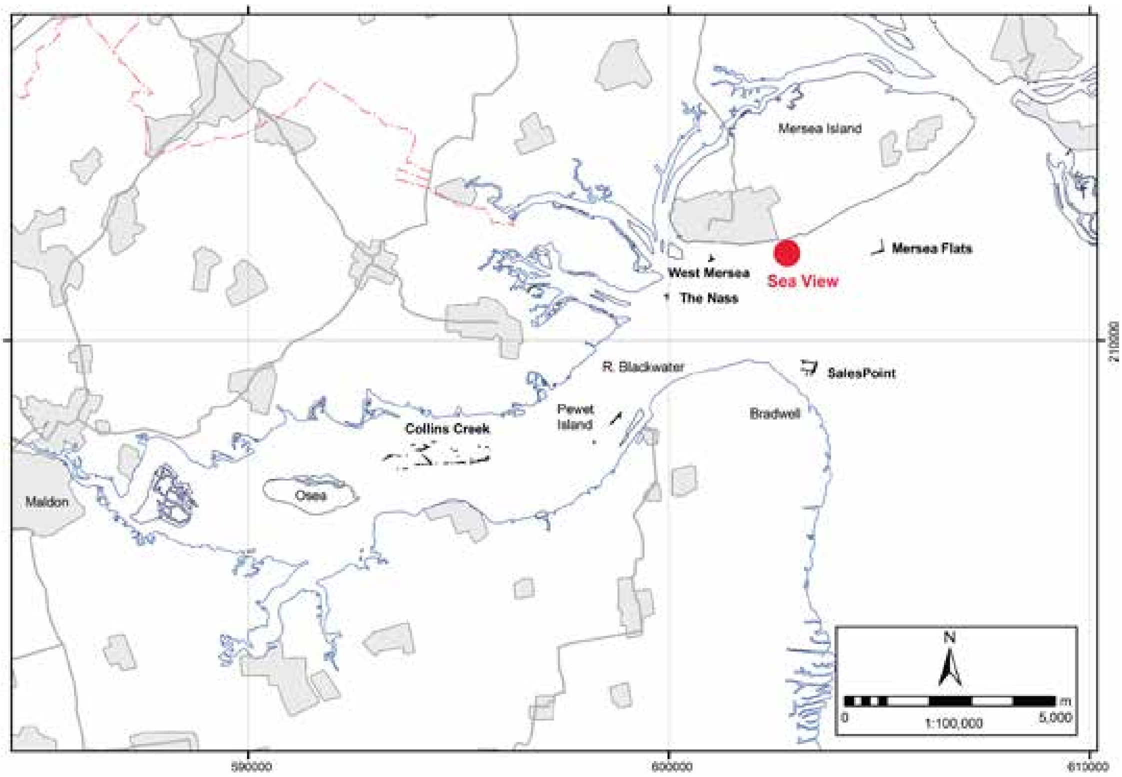

Figure 12: Location of known fish traps in the Blackwater Estuary (adapted from Heppel 2005) (© Historic England).

The later repair or enhancement of the alignment (Feature 1) suggests a structure of significant value for the local community. It was engineered far more precisely and with considerable investment in resource. A small archaeological intervention at the northern end of Feature 1 found that the pile was driven over 1m into the sediment, a long, neatly worked point over 0.75m long surely aiding its builders to force it through the sediments. Couple this observation with that at the southern end of the feature (where upright and bracing timber met at a height of roughly 2.2m) and the structure comprises over 100 birch trunks of 3m+ in height—a considerable investment of woodland resources.

An alternative function for Sea View may have been a type of revetment to protect a valuable section of marshland from erosion, possibly to support transit across the marshland to the low-water line and a crossing point over the river. The north–south alignment puts it at odds with the direction of ebbing and flowing tides (shown by the orientation of contemporary fish traps on Mersea) being too perpendicular to the shoreline. Rather, it may have been intentionally aligned to a route across the island of Mersea and the original, and contemporary (Hillam 1980; Fig. 13), Strood crossing on the northern shore, and on towards Bradwell on the southern shores of the Blackwater.

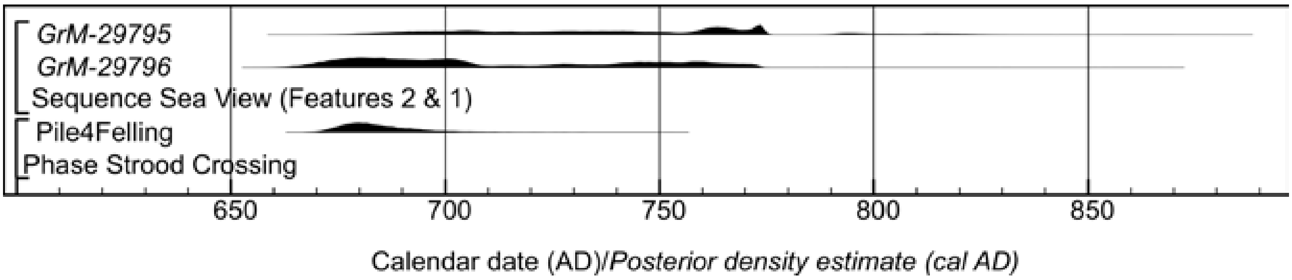

Figure 13: Probability distributions of dates for the construction of Sea View (Features 1 and 2) and the Strood Crossing (© Historic England).

References

Aerts-Bijma, A. T., Paul, D., Dee, M. W., Palstra, S. W. L., and Meijer, H. A. J. 2021 'An independent assessment of uncertainty for radiocarbon analysis with the new generation high-yield accelerator mass spectrometers', *Radiocarbon,* 63(1), 1–22: https://doi.org/10.1017/RDC.2020.101

Bronk Ramsey, C. 1995 'Radiocarbon calibration and analysis of stratigraphy: the OxCal program', *Radiocarbon,* 37(2), 425–30: https://doi.org/10.1017/S0033822200030903

Bronk Ramsey, C. 2009 'Bayesian analysis of radiocarbon dates', *Radiocarbon,* 51(1), 337–60: https://doi.org/10.1017/S0033822200033865

Dee, M. W., Palstra, S. W. L., Aerts-Bijma, A. T., Bleeker, M. O., De Bruijn, S., Ghebru, F., Jansen, H. G., Kuitems, M., Paul, D., Richie, R. R., Spriensma, J. J., Scifo, A., Van Zonneveld, D., Verstappen-Dumoulin, B. M. a. A., Wietzes-Land, P., and Meijer, H. A. J. 2020 'Radiocarbon dating at Groningen: New and updated chemical pretreatment procedures', *Radiocarbon,* 62(1), 63–74: https://doi.org/10.1017/RDC.2019.101

Gale, R., and Cutler, D. 2000 *Plants in Archaeology: Identification manual of artefacts of plant origin from Europe and the Mediterranean*, (Otley: Westbury Academic & Scientific Publishing).

Galimberti, M., Ramsey, C. B., and Manning, S. W. 2004 'Wiggle-match dating of tree-ring sequences', *Radiocarbon,* 46(2), 917–24: https://doi.org/10.1017/S0033822200035967

Heppell, E. M. 2005 ‘Cudmore Grove Country Park, Essex: excavation and survey assessment and updated project design’, (Unpublished report, Essex County Council).

Hillam, J. 1980 ‘The dating of the Mersea Strood Timbers’, Historic England AML Report 3261: https://historicengland.org.uk/research/results/reports/3261

Hutchinson, O. 2022 ‘A Large Mid-Saxon Timber Structure in the Intertidal Zone Sea View, Mersea Island, Essex’ (unpublished report, Coastal and Intertidal Zone Archaeological Network).

Němec, M., Wacker, L., Hajdas, I., and Gäggeler, H. 2010 'Alternative methods for cellulose preparation for AMS measurement', *Radiocarbon,* 52, 1358–70: https://doi.org/10.1017/S0033822200046440

Reimer, P. J., Austin, W. E. N., Bard, E., Bayliss, A., Blackwell, P. G., Bronk Ramsey, C., Butzin, M., Cheng, H., Edwards, R. L., Friedrich, M., Grootes, P. M., Guilderson, T. P., Hajdas, I., Heaton, T. J., Hogg, A. G., Hughen, K. A., Kromer, B., Manning, S. W., Muscheler, R., Palmer, J. G., Pearson, C., Van Der Plicht, J., Reimer, R. W., Richards, D. A., Scott, E. M., Southon, J. R., Turney, C. S. M., Wacker, L., Adolphi, F., Büntgen, U., Capano, M., Fahrni, S. M., Fogtmann-Schulz, A., Friedrich, R., Köhler, P., Kudsk, S., Miyake, F., Olsen, J., Reinig, F., Sakamoto, M., Sookdeo, A., and Talamo, S. 2020 'The IntCal20 northern hemisphere radiocarbon age calibration curve (0–55 cal kBP)', *Radiocarbon,* 64(2), 725–57: https://doi.org/10.1017/RDC.2020.41

Salehpour, M., Håkansson, K., Possnert, G., Wacker, L., and Synal, H.-A. 2016 'Performance report for the low energy compact accelerator mass spectrometer at Uppsala University', *Nuclear Instruments and Methods in Physics Research B,* 371, 360−4: https://doi.org/10.1016/j.nimb.2015.10.034

Scott, E. M., Naysmith, P., and Cook, G. T. 2017 'Should Archaeologists Care about 14C Intercomparisons? Why? A Summary Report on SIRI', *Radiocarbon,* 59(5), 1589–96: https://doi.org/10.1017/RDC.2017.12

Schweingruber, F,. 1982 *Microscopic Wood Anatomy: structural variability of stems and twigs in recent and subfossil woods from central Europe*, (Birmensdorf).

Sookdeo, A., Kromer, B., Büntgen, U., Friedrich, M., Friedrich, R., Helle, G., Pauly, M., Nievergelt, D., Reinig, F., Treydte, K., Synal, H.-A., and Wacker, L. 2020 'Quality Dating: A well-defined protocol implemented at ETH for high-precision ^{14}C dates tested on Late Glacial wood', *Radiocarbon,* 62(4), 891–9: https://doi.org/10.1017/RDC.2019.132

Stace, C. 2010 *New Flora of the British Isles,* 3rd edition, 3rd printing (Cambridge: Cambridge University Press).

Stuiver, M., and Polach, H. A. 1977 'Discussion reporting of ^{14}C data', *Radiocarbon,* 19(3), 355-63: https://doi.org/10.1017/S0033822200003672

Stuiver, M., and Reimer, P. J. 1993 'Extended ^{14}C data base and revised CALIB 3.0 ^{14}C calibration program', *Radiocarbon,* 35(1), 215–30: https://doi.org/10.1017/S0033822200013904

Synal, H.-A., Stocker, M., and Suter, M. 2007 'MICADAS: A new compact radiocarbon AMS system ', *Nuclear Instruments and Methods in Physics Research B,* 259, 7–13: https://doi.org/10.1016/j.nimb.2007.01.138

Wacker, L., Bonani, G., Friedrich, M., Hajdas, I., Kromer, B., Němec, M., Ruff, M., Suter, M., Synal, H. A., and Vockenhuber, C. 2010a 'MICADAS: Routine and high-precision radiocarbon dating', *Radiocarbon*, 52(2), 252–62: https://doi.org/10.1017/S0033822200045288

Wacker, L., Němec, M., and Bourquin, J. 2010b 'A revolutionary graphitisation system: Fully automated, compact and simple', *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms*, 268(7–8), 931–4: https://doi.org/10.1016/j.nimb.2009.10.067

Wacker, L., Christl, M., and Synal, H. A. 2010c 'Bats: A new tool for AMS data reduction', *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms*, 268(7–8), 976–9: https://doi.org/10.1016/j.nimb.2009.10.078

Appendix 1: CQL2 code for Sea View (Fig. 9) chronological model

```
Options()
{
 Resolution=1;
 kIterations=20000;
};
Plot()
{
 Phase("Sea View")
 {
  Sequence("Post 1 (Feature 1)")
  {
   R_Date("ETH-123016", 1332, 19);
   R_Date("GrM-29795", 1270, 21);
  };
  Sequence("Post 2 (Feature 2)")
  {
   R_Date("ETH-123017", 1346, 19);
   R_Date("GrM-29796", 1297, 21);
  };
 };
};
```

Appendix 2: Blackwater estuary fishing structures: radiocarbon dating and chronological modelling

Introduction

Eleven radiocarbon measurements are available (Table 2) on samples associated from inter-tidal fishing structures in the Blackwater estuary (Collins Creek, n=5, Sales Point, n=4; and The Nass n=2) obtained as part of survey work undertaken in the 1990s (Hall and Clark 2000; Strachan 1998).

Table 2: Blackwater estuary (The Nass, Collins Creek and Sales Point) fishing structures, radiocarbon and associated stable isotope measurements

Laboratory Number	Sample details	Radiocarbon Age (BP)	$\delta^{13}C_{IRMS}$ (‰)
The Nass			
UB-4177	Waterlogged wood, *Corylus* sp., from TL 99942 11015 (Strachan 1998, table 3)	1268±39	-
UB-4178	Waterlogged wood, *Quercus* sp., from TL 99892 11047 (Strachan 1998, table 3)	1227±24	-
Collins Creek			
UB-4139	Waterlogged wood, *Quercus* sp., from TL 95465 07144 (Strachan 1998, table 2), S1 (Hall and Clark 2000, fig 2)	1300±45	−22.1±0.2
UB-4140	Waterlogged wood, *Corylus* sp., from TL 95434 07107 (Strachan 1998, table 2), S2 (Hall and Clark 2000, fig 2)	1286±45	−30.3±0.2
UB-4141	Waterlogged wood, *Quercus* sp., from TL 95472 07171 (Strachan 1998, table 2), S3 (Hall and Clark 2000, fig 2)	1262±45	−26.7±0.2
UB-3485	Waterlogged wood, unidentified, from SA (Hall and Clark 2000, fig 2)	1364+48	−25.3±0.2
UB-3486	Waterlogged wood, unidentified, from SB (Hall and Clark 2000, fig 2)	1140±33	−24.9±0.2
Sales Point			
UB-4113	Waterlogged wood, *Alnus* sp., from TM 03195 09527 (Strachan 1998, table 4)	1144±16	-
UB-4114	Waterlogged wood, *Alnus* sp., from TM 03462 09460 (Strachan 1998, table 4)	1214±16	-
UB-4115	Waterlogged wood, *Alnus* sp., from TM 03536 09458 (Strachan 1998, table 4)	1251±21	-

UB-4116	Waterlogged wood, *Alnus* sp., from TM 03354 09375 (Strachan 1998, table 4)	1277±43	-

The samples

The waterlogged wood samples all derive from what appear to be “individual” structures (Hall and Clark 2000; Strachan 1998) and given the requirements for obtaining a radiocarbon date in the 1990s (>200g wet wood) probably comprise complete cross-sections of timbers of *c.* 15–15 rings (see Groves 2000, table 1), thus any age-at-death offset (Bayliss and Marshall 2022, §3.2.3) will be minimal.

Radiocarbon dating

The 11 waterlogged wood samples were processed and dated by liquid scintillation spectrometry at the Queen’s University, Belfast as outlined in Bayliss et al. (2013; 2015)

Chronological modelling

The chronological modelling presented below has been undertaken using OxCal 4.4 (Bronk Ramsey 2009), and the internationally agreed calibration curve for the northern hemisphere (IntCal20; Reimer et al. 2020).

The model is defined by the OxCal CQL2 keywords and by the brackets on the left-hand side of Figure 14 (the full code is given in Appendix 3). On the figure, calibrated radiocarbon dates are shown in outline, and the posterior density estimates produced by the chronological modelling are shown in solid black. The other distributions correspond to aspects of the model. For example, the distribution *LastCollinsCreek* (Fig. 14) is the posterior density estimate for the date of the last dated event from fishing structures at Collins Creek. In the text highest posterior density intervals, which describe the posterior distributions, are given in italics.

The model shown in Figure 14 has good overall agreement (Amodel: 81) and estimates derived from it for the dates of fishing structures at Collins Creek, Sales Point and The Nass are given in Table 3.

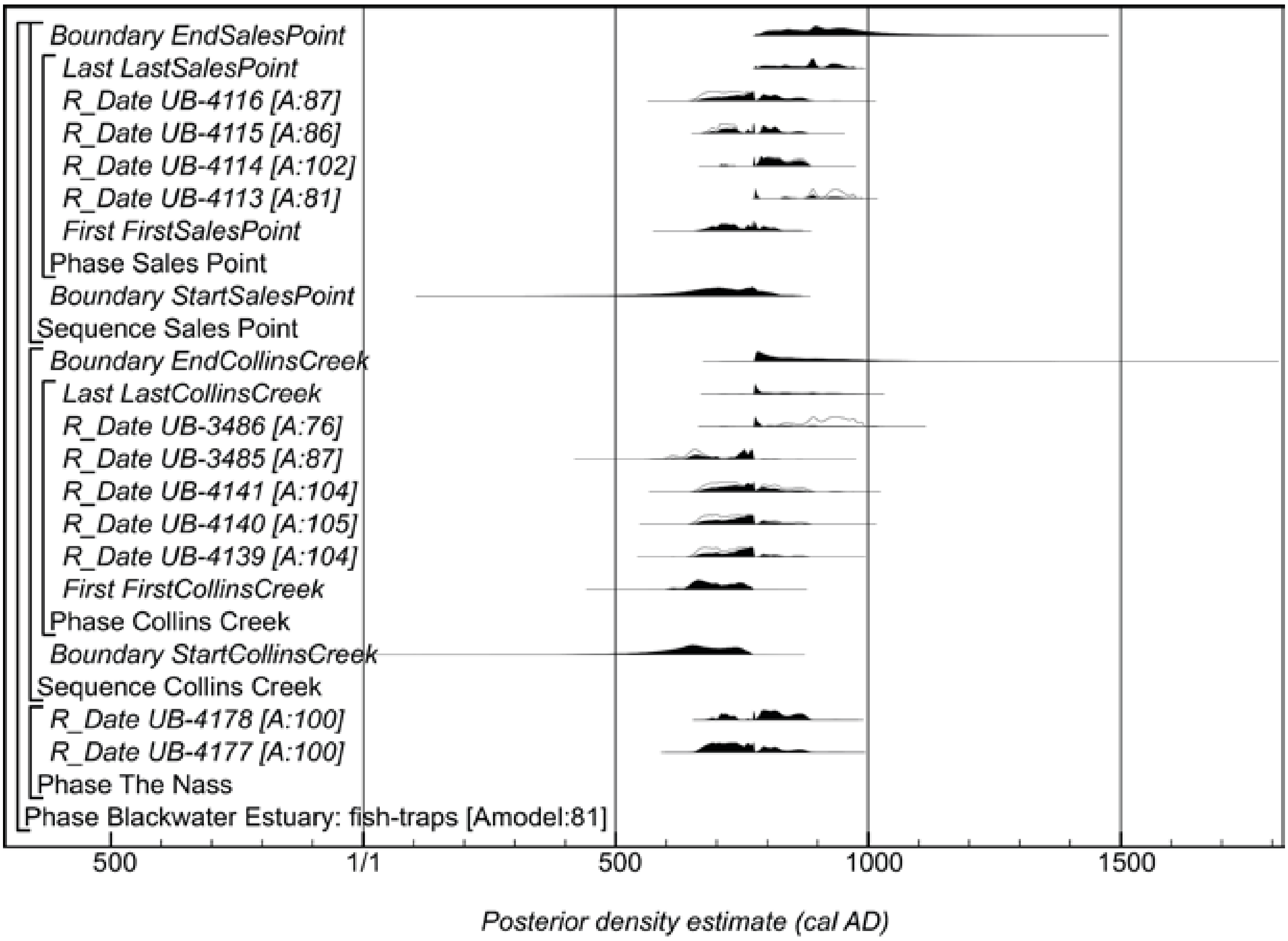

Figure 14: Probability distributions of dates from Blackwater Estuary fish-traps: The Naas, Collins Creek and Sales Point. The format is identical to Figure 8 (© Historic England).

Table 3: Highest Posterior Density intervals from key parameters for Blackwater estuary fishing structures

Parameter name	**Parameter description**	***Posterior Density Estimate (95% probability unless otherwise stated) cal AD***
The Nass		
UB-4177	`R_Date` estimating the date of construction of the fishing structure at TL 99942 11015	*660–835 (90%) or 845–880 (5%)*
UB-4178	`R_Date` estimating the date of construction of the fishing structure at TL 99892 11047	*685–745 (20%) or 770–885 (75%)*
Collins Creek		
FirstCollinsCreek	`First` parameter estimating the first dated event in the Collins Creek fishing structures	*635–775*

Parameter name	**Parameter description**	***Posterior Density Estimate (95% probability unless otherwise stated) cal AD***
UB-4139	`R_Date` estimating the date of construction of the fishing structure S1 at TL 95465 07144	*655–825*
UB-4140	`R_Date` estimating the date of construction of the fishing structure S2 at TL 95434 07107	*655–835*
UB-4141	`R_Date` estimating the date of construction of the fishing structure S3 at TL 95472 07171	*665–840 (92%) or 850–875 (3%)*
UB-3485	`R_Date` estimating the date of construction of the fishing structure SA	*605–625 (2%) or 635–775 (93%)*
UB-3486	`R_Date` estimating the date of construction of the fishing structure SB	*770–975*
LastCollinsCreek	`Last` parameter estimating the last dated event in the Collins Creek fishing structures	*770–975*
Sales Point		
FirstSalesPoint	`First` parameter estimating the first dated event in the Sales Point fishing structures	*665–830*
UB-4113	`R_Date` estimating the date of construction of the fishing structure at TM 03195 09527	*775–790 (24%) or 825–860 (13%) or 875–975 (53%)*
UB-4114	`R_Date` estimating the date of construction of the fishing structure at TM 03462 09460	*770–885*
UB-4115	`R_Date` estimating the date of construction of the fishing structure at TM 03536 09458	*680–840 (88%) or 850–880 (7%)*
UB-4116	`R_Date` estimating the date of construction of the fishing structure at TM 03354 09375	*670–880*
LastSalesPoint	`Last` parameter estimating the last dated event in the Sales Point fishing structures	*775–975*

References

Bayliss, A., and Marshall, P. 2022 *Radiocarbon Dating and Chronological Modelling: Guidelines and Best Practice* (Swindon: Historic England)

Bayliss, A., Bronk Ramsey, C., Cook, G., McCormac, F. G., Otlet, R., and Walker, A. J. 2013 *Radiocarbon dates from samples funded by English Heritage between 1988 and 1993* (Swindon: English Heritage)

Bayliss, A., Bronk Ramsey, C., Cook, G., McCormac, F. G. and Marshall, P. 2015 *Radiocarbon Dates: from samples funded by English Heritage between 1993 and 1998* (Swindon: Historic England)

Bronk Ramsey, C. 2009 'Bayesian analysis of radiocarbon dates', *Radiocarbon,* 51, 337–60: https://doi.org/10.1017/S0033822200033865

Groves, C. 2000 'Identification and tree-ring analysis of wood from Collins Creek – a pilot study' (144–5) in Hall. R. L., and Clarke, C. P. 2000 'A Saxon inter-tidal timber fish weir at Collins Creek in the Blackwater estuary', *Essex Archaeology and History*, 31, 125–46

Hall. R. L., and Clarke, C. P. 2000 'A Saxon inter-tidal timber fish weir at Collins Creek in the Blackwater estuary', *Essex Archaeology and History*, 31, 125–46

Reimer, P. J., Austin, W. E. N., Bard, E., Bayliss, A., Blackwell, P. G., Bronk Ramsey, C., Butzin, M., Cheng, H., Edwards, R. L., Friedrich, M., Grootes, P. M., Guilderson, T. P., Hajdas, I., Heaton, T. J., Hogg, A. G., Hughen, K. A., Kromer, B., Manning, S. W., Muscheler, R., Palmer, J. G., Pearson, C., Van Der Plicht, J., Reimer, R. W., Richards, D. A., Scott, E. M., Southon, J. R., Turney, C. S. M., Wacker, L., Adolphi, F., Büntgen, U., Capano, M., Fahrni, S. M., Fogtmann-Schulz, A., Friedrich, R., Köhler, P., Kudsk, S., Miyake, F., Olsen, J., Reinig, F., Sakamoto, M., Sookdeo, A., and Talamo, S. 2020 'The IntCal20 northern hemisphere radiocarbon age calibration curve (0–55 cal kBP)', *Radiocarbon,* 64(2), 725–57: https://doi.org/10.1017/RDC.2020.41

Strachan, D. 1998 'Inter-tidal stationary fishing structures in Essex: some C14 dates', *Essex Archaeology and History*, 29, 274–82

Appendix 3: CQL2 code for Blackwater estuary (Fig. 14) chronological model

```
Options()
 {
  Resolution=1;
  kIterations=20000;
 };
 Plot()
 {
  Phase("Blackwater Estuary: fish-traps")
  {
   Phase("The Nass")
   {
    R_Date("UB-4177", 1268, 39);
    R_Date("UB-4178", 1227, 24);
   };
   Sequence("Collins Creek")
   {
    Boundary("StartCollinsCreek");
    Phase("Collins Creek")
    {
     First("FirstCollinsCreek");
     R_Date("UB-4139", 1300, 45);
     R_Date("UB-4140", 1286, 45);
     R_Date("UB-4141", 1262, 45);
     R_Date("UB-3485", 1364, 48);
     R_Date("UB-3486", 1140, 33);
     Last("LastCollinsCreek");
    };
    Boundary("EndCollinsCreek");
   };
   Sequence("Sales Point")
   {
    Boundary("StartSalesPoint");
    Phase("Sales Point")
    {
     First("FirstSalesPoint");
     R_Date("UB-4113", 1144, 16);
     R_Date("UB-4114", 1214, 16);
     R_Date("UB-4115", 1251, 21);
```

```
    R_Date("UB-4116", 1277, 43);
    Last("LastSalesPoint");
   };
   Boundary("EndSalesPoint");
  };
 };
};
```

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