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REPORT

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Tree-ring analysis of the Brigg and Ferriby boats: an interim report.

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Until recently dendrochronology was little used as a tool for the dating of boats. The main reason was the dendrochronologist's reluctance to deal with samples of unknown origin. Boats known to be local, such as dugouts or the Brigg or Ferriby boats themselves, should, however, prove no more difficult to date than any other timber from an archaeological site. Tree-ring analysis and the radiocarbon method are often the only techniques applicable to the dating of boats (McGrail, 1978), so that even if they are unprovenanced, dendrochronology may yield valuable information.

The first attempt to utilise tree-rings was around 1940, when an oak post from the Sutton Hoo ship-burial was examined (Godwin,1940). This produced poor results and so far remains undated (Fletcher,1977). In Germany, the Bremen cog was successfully dated, the year of construction being 1380 (Liese & Bauch,1965). Two experiments with Irish boat timbers have also produced dates. The remains of a clinker-built boat from the bed of the River Blackwater, Co. Armagh, were dated to 1693±9 or later (Baillie, 1974), whilst a group of ship's timbers from the Dublin excavations were of Medieval age (Baillie,1978). Analysis of the Graveney boat has provided a tentative date (Fletcher,1977). It is hoped that this report will show that not only is dendrochronology a useful dating technique, but that it can also provide further information of interest to the boat archaeologist.

The Brigg 'raft'

Sections of 10-15 cms. thickness were removed from positions C26, C36 and C46; that is, the sixth cleat of the oak strakes 2,3 and 4. They were labelled S/1168, S/1169 and S/1170 respectively.

A plan of the surviving boat can be seen in the latest excavation report (McGrail,1975). Because of their waterlogged state, the samples were deep-frozen to provide a firmer surface on which to work. They were cleaned with a surform plane, whilst still frozen. This gave a smooth cross-section, on which the individual annual rings were clearly visible.

The measuring equipment at Sheffield is adapted from the Bannister tree-ring measuring apparatus (Bannister,1978). It consists of a low power binocular microscope over a travelling stage which is linked, via a linear transducer, to a digital voltmeter. This registers the width on a screen after each ring has been traversed and is accurate to 0.1 of a millimetre. Three radii of every sample were measured to ensure that the maximum number of rings was recorded. Since one ring is equivalent to one year in an oak tree, the ring-widths for the most number of years were obtained. The results are shown in Figure 1, which also indicates the position of each radius in the original samples. The ring-widths were plotted against age on transparent semi-logarithmic recorder paper and a mean curve constructed for each sample.

Figure 1 near here

Results

Visual comparison of the mean curves showed that they matched extremely well and that C36 and C46 were almost identical. The Belfast computer program (Baillie & Pilcher,1973) was used to confirm the cross-matching. This compares the data of two curves and calculates the value of Student's 't' for each position of overlap. Thus, it gives some idea of the degree of correlation. Any value above 3.5 can be considered as being of possible significance. The results for the Brigg samples are shown below:

sample	C26	C46
C36	10.13	20.80
C46	9.37	

This suggests that C36 and C46 derive from the same tree, probably opposite halves of the trunk. The matches with C26 also give very high 't' values, as would be expected if it was taken from a tree growing close to the C36/C46 tree. No quantitative experimental work has been done on this aspect of dendrochronology. It would be difficult to generalise since the degrees of correlation between radii taken from the same tree varies so much from tree to tree. Any deductions, therefore, must always be rather subjective. It is possible that one tree would have only produced two planks of approximately 8 metres in length, although again there are no forestry tables to substantiate this. Thus, the base of the boat now remaining would have required not less than three trees, emphasing the extreme wastefulness of this type of boat construction. Examination of samples from strakes 1 and 5 would give further information about the number of trees used.

Some inference may perhaps be made as to the origin of the timber. The 'boat builders' must have had access to a stand of oak trees: they needed several trees per boat and the timbers themselves, narrow-ringed and so slow grown (see Table 1 and Appendix), suggest a degree of crowding from other trees. They probably chose the nearest group of oaks - part of a mixed deciduous woodland maybe - to the construction point, since it would be difficult to move such large sections of timber over long distances.

A Brigg mean curve of 148 years was made, although the first 13 years should be viewed with care because the rings of C46 were difficult to resolve at this point, being very narrow and faint (see Figure 1). The presence of sapwood on C26 and C36 helps in calculating the age of the trees. The sapwood rings, which formed the living part of the tree, are recognisable by their colour and structure. The number of rings are, to a certain extent, constant for a mature tree of about 150 years or older. No quantitative work has yet been done on this in England. Irish and German studies suggest that the oak has 32 $\pm$ 9, 20 $\pm$ 6 or 25.0 years of sapwood (Baillie,1974; Hollstein,1965; Huber,1967), although exceptions were by no means rare. From observations of both English and Irish trees, the author would tend to agree with the first value. $\pm$ 9 represents one standard deviation from the mean value. Since sample C46 was cut very close to the pith, the trees must have been at least 160 years old, when felled. It is not possible to state in which season the tree was felled because the sapwood is incomplete. It is generally thought that winter was the preferred time (McGrail,1976).

The radii of the trunks were roughly estimated, the results given in Figure 1 being the distances between the pith and the heartwood-sapwood transition. Great accuracy was not possible because the rings did not conform to the idealised circles shown in the diagram. Nor was the amount of shrinkage taken into account. The radii were similar for each sample. Assuming that C26 and C36/C46 belong to different trees, an average radius for both would be c.25 cms. plus 3 cms. sapwood allowance. This gives a minimum diameter of 52 cms. for the trees.

The 'raft' had been radiocarbon dated to 2543 $\pm$ 100 bp[1] (McGrail & Switsur,1975). Further dates, as yet unpublished, confirm that the felling date for the trees lies between 2700 and 2500 bp (McGrail, personal communication). Very few tree-ring reference curves are available for this period. Brigg was compared to an Iron Age chronology from Central Europe, which is absolutely dated to 717 - 469 BC (Hollstein,1973), but no significant results were found. It is probable that if the Brigg dates were calibrated, they would be slightly older than this. Further comparisons with an

[1] C-14 dates, given as bp, are uncalibrated. BC signifies calender years.

unpublished curve from the north-east of Ireland again produced no convincing results. When more regional chronologies are available for England, then it may be possible to cross-match the Brigg curve and eventually obtain a calender date for the construction of the 'raft'.

The Ferriby boats

The three boats from North Ferriby were excavated many years ago by E.V. Wright. Their history and excavation, with detailed plans, can be found in his guide book (Wright,1976). Ferriby boat 3 is stored in Hull Museum, whilst boats 1 and 2 are kept at the National Maritime Museum with a view to restoration. It was these two, the most complete, that were used for the present study. A section was taken from the keel plank of boat 1, at a distance of 45 cms. from the bow end; this was labelled S/3012. Boat 2 was sampled on each side of the scarf. Both included part of a cleat and were numbered S/3010 and S/3011, the former being from the north element and the latter from the south element of the keel plank.

The boats had been conserved in a dry condition, after soaking in glycerine and, in the case of boat 2, coating with an epoxy resin. This mixture made the task of cleaning the samples for analysis an extremely difficult one, but measurable surfaces were finally produced using a very sharp knife. Two radii were measured for S/3011 and S/3012, but because of the many cracks around the cleat of S/3010, only one radius was attempted here.

Results

The two ring curves from boat 2 matched almost perfectly and gave a 't'-value of 11.12. It is assumed that only one tree was involved, on this evidence and because it seems likely that two halves of one trunk would be used to shape the two parts of the keel plank. The number of rings for each radius, with a rough sketch, is shown in Figure 2. S/3010 had more rings because of the unusual

Figure 2 near here

way in which it was cut. This will be discussed in more detail below. A mean curve of 227 years was produced for boat 2, whilst boat 1 gave a sequence of 133 years. Sapwood was missing from all the samples, as was the pith, making it impossible to age the trees with any accuracy. The boat 1 tree must have been at least 150 years and that of boat 2 at least 250 years old, when felled; but both could well have been considerably older.

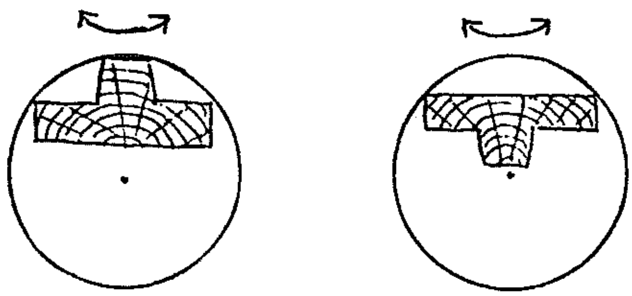
The curves from the two boats were compared by computer. A value of t = 5.25 was obtained at the position shown in Figure 2. Visual comparison confirmed this result. The outside rings of each boat differ by less than ten years. Since the edges of the planks were probably trimmed close to the heartwood-sapwood transition, it seems likely that the boats were constructed at the same time. Only the presence of the complete sapwood could confirm this, but they were certainly contemporary.

Radiocarbon measurements had already given dates of c.3300 bp for boat 1 and c.3500 bp for boat 2 (McGrail & Switsur,1975). Further samples are being processed at the Cambridge radiocarbon laboratory, but the results are as yet unavailable. This left some uncertainty as to whether the boats were of the same age. All that could be said from the radiocarbon evidence was that they <u>could</u> have been contemporary, if the dates were used with two standard deviation limits. However, the new dendrochronology results confirm this conclusively.

The length of the radii were again estimated. Boat 1 had a minimum radius of 25 cms. plus 3cms. allowance for the missing sapwood, giving a diameter of at least 56 cms.. Samples S/3010 and S/3011 show very similar dimensions, reinforcing the assumption that they belong to two halves of the one tree. In both, the pith is off-centre, resulting in a radius of 30-32 cms. at one side and 40 cms. on the other. A minimum diameter would, therefore, have been 76 cms.. This would have been a large tree but not unusually so for an oak. Indeed, the diameter for an oak tree used in the construction of the Blackfriar's ship is at least 2.3 m. (Marsden, 1977).

Examination of the cutting techniques employed in the production of boats 2's timber can provide further information. Sample S/3011 is cut in the normal way (see also the diagram of the Brigg sections). This makes maximum use of the halved tree trunk with the minimum amount of effort. If the wood was allowed to dry out at all, the plank edges would warp upwards towards the cleat as shown in Figure 3 below. The opposite applies to S/3010: it

Figure 3



S/3011 S/3010

would be far harder to work and the amount of timber wasted would be greater. The arrows in Figure 3 show the direction of warping. It will be seen that, if allowed to dry, S/3010 would warp upwards away from the cleat. This may explain why the cracks around the cleat, mentioned earlier, developed. The method of cutting gave rise to stresses in this area which, with the passage of time, produced the cracks. All this suggests that the seasoning time was at a minimum. Moreover, the vast size of the timbers, in both the Brigg and Ferriby boats, make it likely that they would be worked in their fresh condition: they would be too hard, when dry, to shape with ease. The green planks would have been used almost immediately and the boat kept in a moist atmosphere so as to prevent the wood from drying out (McGrail,1976). Why S/3010 was cut in this manner will remain a mystery: was it intentional or was it a mistake?

The dating of the North Ferriby boats in absolute terms is, at the moment, impossible because only floating tree-ring chronologies are available for the date range, 3726 - 3112 bp, which is the span obtained by taking two standard deviation limits on the radiocarbon dates. Covering this period are sequences from Zug-Sumpf in Switzerland (Huber & Merz,1962), the Somerset Levels (Morgan,1976,1978) and the north-east of Ireland (Pilcher et al, 1977). The last would provide the firmest dating as it has been partially calibrated (Pearson et al,1977); but this, as with the two others, would mean cross-matching over a long distance. Computer comparisons produced several 'significant' results of between 3.00 and 4.00, but none that were convincing visually. When attempting to find correlations, for example between Ferriby and Ireland, a single value such as t = 3.7 is insufficient proof of cross-matching. Indeed, over such a distance the real match could be as low as t = 1.00.

As with Brigg, further advances in English dendrochronology will have to be made before the Ferriby boats can be absolutely dated. In conclusion, it can be said that both sites have produced sensitive ring-curves, the values of which are given in the Appendix for use in the future. Once suitable reference chronologies become available, they should be ideal for tree-ring dating. This report, however, points the way to further work. Now that it is known that boats 1 and 2 from Ferriby were contemporary, it would be interesting to discover if this also applies to boat 3.

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Table 1

Details of the six samples examined.

Figure 1

Block diagram of the Brigg timbers showing the relative positions of the samples with their individual radii. The rough sketch of the cross-sections illustrates their position in an idealised tree trunk. Also given is the length of the radii from pith to the heartwood-sapwood transition.

Figure 2

Block diagram for the two Ferriby boats. The cross-sections, in their idealised circles, show the length of radius between pith and heartwood-sapwood transition. The different orientation of the two timbers from boat 2 can be seen.

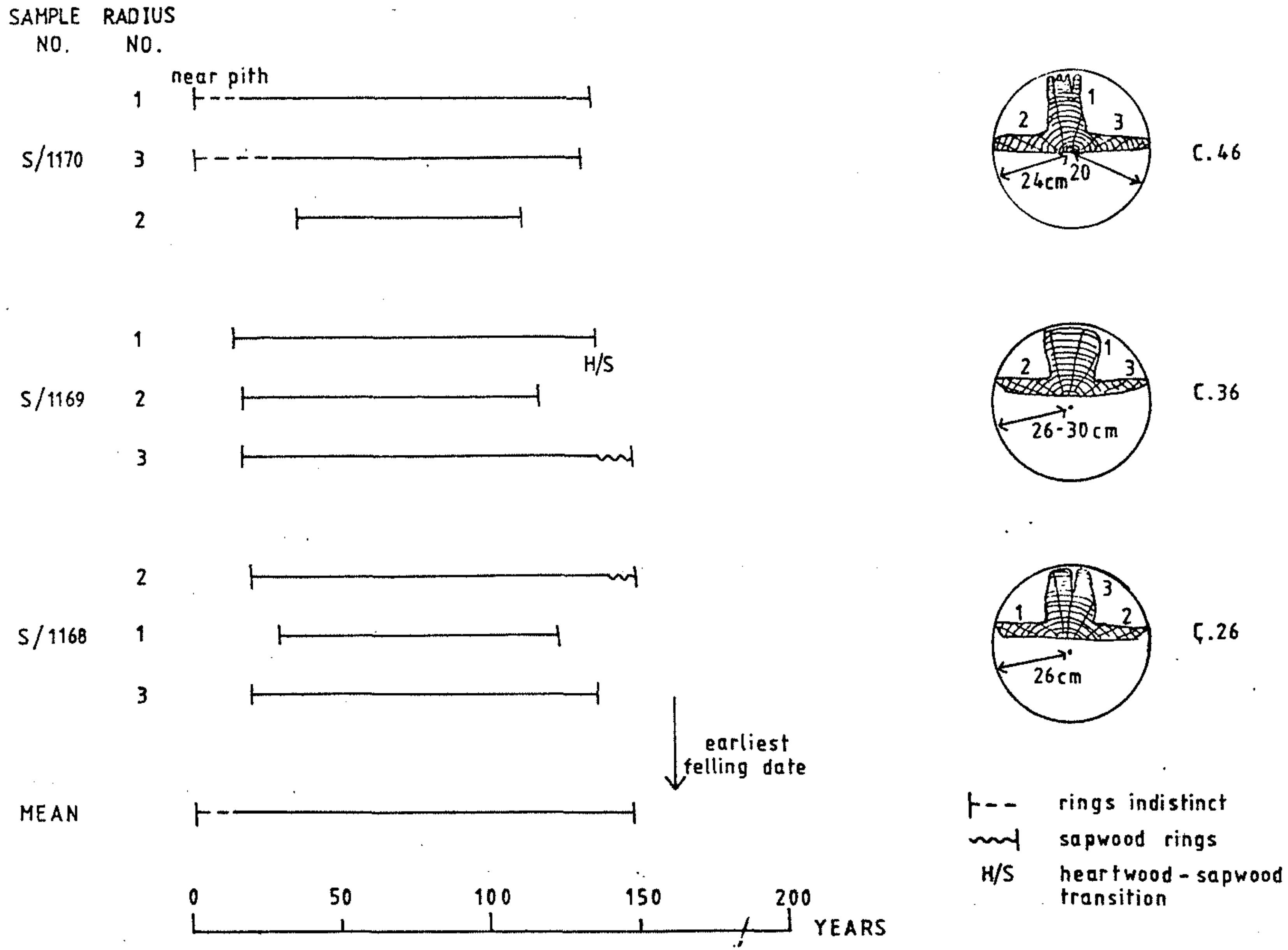
Figure 3

Cross-sections of the Ferriby 2 samples showing the methods of cutting. S/3011 is the more usual form. The arrows indicate the potential direction of warping.

Appendix

The ring widths of the mean curves, in 0.1 mms., are given for Brigg, Ferriby 1 and Ferriby 2.

BRIGG 'RAFT'



SAMPLE NO.
RADIUS NO.
near pith
S/1170
1
3
2
S/1169
1
H/S
2
3
S/1168
2
1
3
MEAN
earliest felling date
0
50
100
150
200
YEARS
2
1
3
24cm
20
C.46
1
2
3
26-30cm
C.36
3
1
2
26cm
C.26
rings indistinct
sapwood rings
H/S heartwood-sapwood transition

FERRIBY

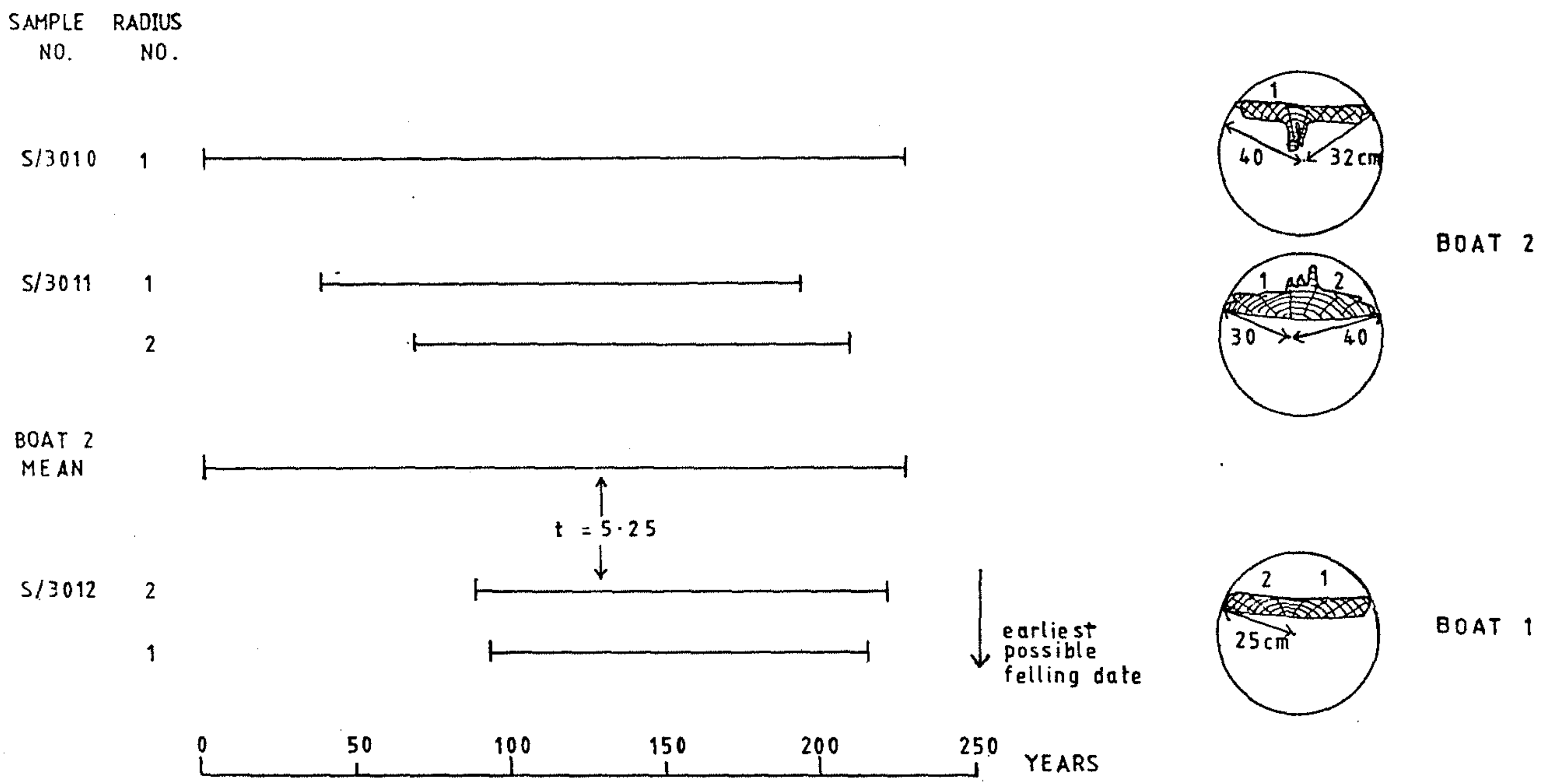


FIGURE 2

Table 1

	Sample number	Number of rings	Sapwood rings	Average ring widths (mm.)
Brigg, C26	S/1168	129	9	1.50
Brigg, C36	S/1169	134	12	1.26
Brigg, C46	S/1170	133	-	1.14
Ferriby II	S/3010	227	-	1.32
Ferriby II	S/3011	171	-	1.37
Ferriby I	S/3012	133	-	1.01

APPENDIX

Brigg mean curve

The mean of S/1168, S/1169 and S/1170. Values X 0.1 mms.

years	0	1	2	3	4	5	6	7	8	9
0		41	27	22	12	16	11	16	11	8
10	14	9	7	3	14	14	20	22	17	12
20	20	19	13	14	18	18	15	16	15	19
30	13	12	12	11	14	9	11	12	12	14
40	15	12	10	9	8	11	12	16	15	16
50	14	20	17	12	11	14	17	12	15	14
60	7	6	6	10	14	13	14	12	7	12
70	11	8	11	14	13	9	11	7	11	16
80	14	14	16	11	15	16	17	13	7	12
90	14	16	13	7	12	10	7	13	12	13
100	10	11	14	13	11	9	8	11	9	12
110	13	11	13	14	18	11	8	11	11	14
120	13	9	19	10	14	13	24	22	18	15
130	18	22	16	10	15	21	20	18	15	14
140	14	15	11	15	10	15	14	9	11	

APPENDIX(continued)

Ferriby II mean curve

The mean of S/3010 and S/3011. Values X 0.1 mms.

years	0	1	2	3	4	5	6	7	8	9
0		15	19	23	16	19	25	17	21	19
10	12	18	14	9	15	20	18	17	10	11
20	16	14	17	15	10	14	18	12	8	12
30	9	6	9	6	9	14	17	25	22	17
40	13	17	12	16	14	13	12	10	15	9
50	8	12	9	15	16	13	15	13	8	7
60	10	16	14	14	17	15	8	10	13	11
70	14	16	17	11	9	12	13	11	16	11
80	14	12	17	13	14	9	9	10	9	14
90	12	12	13	11	9	14	14	14	13	14
100	12	12	8	10	15	17	15	16	14	12
110	11	9	13	11	14	15	18	10	15	16
120	17	13	12	11	14	17	12	11	16	13
130	11	14	17	13	11	18	13	19	13	18
140	16	12	17	18	16	18	10	15	22	17
150	12	14	11	15	12	10	13	12	11	15
160	12	14	14	20	13	18	20	19	16	14
170	20	16	21	15	23	13	14	19	23	15
180	14	13	11	10	14	11	14	12	13	15
190	12	12	14	20	14	15	11	11	11	14
200	17	12	9	14	11	12	8	10	8	7
210	6	5	9	10	9	6	9	7	11	6
220	4	5	4	5	7	7	8	12		

APPENDIX(continued)

Ferriby I

Ring widths (X 0.1 mm) of S/3012

years	0	1	2	3	4	5	6	7	8	9
0		18	15	9	12	6	4	5	5	7
10	10	14	9	9	5	8	16	12	11	9
20	6	7	10	5	5	7	9	10	8	5
30	7	4	8	11	10	8	7	14	10	6
40	12	11	10	9	14	7	7	11	14	11
50	8	6	8	6	4	6	8	5	4	8
60	10	8	6	9	7	6	5	4	6	8
70	6	7	9	12	10	13	14	20	25	20
80	16	17	18	18	14	18	26	18	17	16
90	23	16	21	23	19	18	14	9	13	11
100	8	8	11	10	14	17	13	12	12	14
110	15	15	16	12	10	11	12	8	9	9
120	7	6	7	4	6	11	14	10	7	12
130	8	10	11	8						