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677

DENDROCHRONOLOGY OF THE NORTH FERRIBY BOATS

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Abstract

Tree-ring analysis of all the surviving oak timbers from the three Bronze Age boats found at North Ferriby in Humberside indicates that boats 1 and 2 are probably contemporary, but that boat 3 may be either slightly earlier or later in date. No absolute dating has yet been obtained.

Estimates are given of the size and age of tree used for the boats, and timber conversion methods are discussed. The results are particularly encouraging since the conserved timbers were very difficult to prepare for ring measurement.

(This report replaces Ancient Monuments Laboratory report no 2722.)

Dendrochronology of the North Ferriby boats

Introduction

The original study of the oak timbers from the three Bronze Age boats from North Ferriby in Humberside was carried out in 1978. At that time, there were no dated European tree-ring chronologies covering the Bronze Age period so the absolute dating of the three boats was out of the question. However it was hoped that the tree-ring study would provide relative dating. Radiocarbon analyses had already indicated that the three boats were Bronze Age in date, and that they may have been contemporary (McGrail & Switsur 1975). One of the aims of the study was to confirm or reject this hypothesis. A secondary aim was to extract information about the timbers and their annual rings. This application of tree-ring work which can elucidate some of the problems involved in the selection and conversion of archaeological timbers, has been little used in Britain, but its importance is gradually becoming recognised. It corresponds with the increasing interest of the boat archaeologist in the type of timber, and the carpentry techniques, used in boat construction (McGrail 1976, 1982). Tree-ring analysis of timbers from the Brigg 'raft' illustrates this use of dendrochronology both for relative dating, and as a source of information about the oak timbers themselves (Hillam 1981).

Seven samples were examined at the Sheffield Dendrochronology Laboratory in 1978: one from boat 1 (S3012), two from boat 2 (S3010, S3011) and four from boat 3 (S3073-76). In 1985, an additional sample from boat 1 (S7687) became available for study. By this time long tree-ring chronologies had been completed in both Ireland and Germany (Pilcher et al 1984). It was decided therefore to re-evaluate the 1978 data in the light of this evidence, as well as examining the new sample from boat 1.

The samples

Boats 1 and 2 were excavated at North Ferriby in 1946. They were conserved intact, although only after spending some time out of doors awaiting the availability of storage tanks, and are now in the National Maritime Museum at Greenwich. The third boat was later discovered nearby; it was removed in sections, and taken to Hull Museum. The full history of the boats' excavation and preservation is described else where (Wright 1976). The conservation methods varied, but must be considered since they were important factors in the preparation of the tree-ring samples. Boats 1 and 2 were soaked in glycerol for two years, and boat 2 was then coated with a protective layer of epoxy resin. Boat 3 underwent extensive treatment with PEG 4000.

For the 1978 study, samples were sawn from boats 1 and 2 by staff of the Archaeological Research Centre at the National Maritime Museum, a process made difficult by the glycerol and resin. A section was taken from the keel plank of boat 1, at a distance of 450mm from the bow end (Fig 1). Boat 2 was sampled on both sides of the scarf, including part of a cleat in each case: S3010 came from the north element of the keel plank, and S3011 from the south element (Fig 2). Four sections of boat 3, already sawn into pieces during excavation, were loaned by Hull Museum. Three were from the bottom plank (S3073-75; Hull Museum numbers: P19, P13, P10 respectively), and one from the sidestrake (S3076; Hull Museum number S6 or S7. The National Maritime Museum numbers will be used throughout this report.).

In 1984, during further work on the Ferriby boats, the remains of boat 1 were re-identified, and a second sample was taken from the keel plank at the stern end (Fig 1). This provided a second plank for analysis, and completed the sampling of all the surviving elements of the three Ferriby boats for tree-ring analysis (Fig 1-3).

Sample preparation and ring measurement

The cross-sections were cleaned before measurement in order to identify the boundaries of the annual rings which in oak are well defined. The samples from boats 1 and 2 were cleaned by paring the cross-sections with a sharp Stanley knife, although the glycerol-resin mixture made the task a long and arduous one. The three bottom plank sections from boat 3 were surfaced with a stiff nail brush since the wax was too thick for a knife. The brush produced a clean, if uneven, surface on which the ring boundaries were reasonably well-defined. The sidestrake sample had been sawn in two at Hull to make handling easier, and to provide an even surface. It proved difficult to prepare: the use of knife, brush and plane made no impression on the surface because of the heavy impregnation of wax. Only by soaking the cross-section in hot water was enough wax removed so that the wood structure could be seen. None of the prepared surfaces were as clear as is usual from waterlogged timbers which have not been conserved and, in the case of the side strake, impregnation with PEG had made accurate ring measurement almost impossible.

Where practical, the samples were measured on a travelling stage which was linked by a linear transducer to a display panel on which the ring widths were displayed in units of 0.1mm. The sample is viewed through a low-power binocular microscope, and moved from one ring boundary to the next. The ring widths were recorded by hand after each ring had been traversed. This apparatus has now been replaced by a travelling stage linked to an Apple microcomputer, which has made measurement more speedy and more reliable since the ring width data are automatically input into the computer (Hillam 1985 Fig 1). Two radii from S7687 were measured on this equipment. The resulting ring widths, which are given in units of 0.02mm, were converted by the computer to units of 0.1mm to make them compatible with the other Ferriby ring sequences.

The sections of boat 3 bottom plank were too bulky for use on a travelling stage. They were measured using a hand lens fitted with a 0.1mm scale. This is a method which gives adequate results, although it is tedious and tiring to use. It is very useful for bulky samples, or those that must be measured in situ.

Wherever possible, two radii per sample were measured to check the accuracy of the ring record. This is not usually necessary with oak timbers, but was done here because of the difficulties encountered during sample preparation. Measurement of two radii per sample also ensured that the maximum number of rings were recorded on each sample (Fig 4).

On completion of the practical work, the samples were returned intact to their respective museums. They suffered no damage, other than the removal of a sliver of wood when the end surfaces were cleaned. With boats 1 and 2, it should be possible to incorporate the samples in their original positions, if the boats are needed for display. It is hoped that tree-ring studies such as this will encourage other archaeologists to sample important timbers - preferably before the conservation process is started - and thereby profit from the information which dendrochronology can provide (Morgan et al 1981).

Tree-ring dating

Two radii were measured on samples S3011, S3012 and S7687. (Figs 4, 6). The three pieces of plank from boat 3 had only one radius each, whilst S3010 had many cracks around the cleat which made measurement difficult. The rings of the sidestrake were very contorted, making their resolution practically impossible. An attempt at measurement was made but absolute reliance cannot be placed on the results (although the outer part of the ring sequence does appear to match those from the boat 3 plank pieces).

The ring widths were plotted on transparent semi-logarithmic recorder paper. If two radii were measured, their ring widths were first averaged. The ring plots, known as tree-ring curves, were compared visually by sliding one graph over another and searching for similarities between the two graphs. They were also compared using a computer program developed at Belfast (Baillie & Pilcher 1973). This calculates the degree of correlation between two curves for each position of overlap. The correlation is expressed as the Students *t* statistic. A value of 3.5 or higher indicates a match, provided that the visual match is acceptable.

The two curves from boat 2 matched almost perfectly (*t* = 11.1), suggesting that they were two halves of the same tree, that is, two halves of the one trunk were converted into the two parts of the keel plank. This suggestion is reinforced by the fact that the two timbers looked very similar in size as well as ring pattern. S3010 had more rings than S3011 (Fig 4; Table 1) bacause of the unusual way in which it was cut (see below). A mean curve of 227 years was produced for boat 2. (The ring width data for all three boats is appended to this report.)

The two boat 1 curves were also very similar (t = 13.6), more similar in fact than the two radii from one of them (S7687) which only gave a t-value of 7.8. It seems reasonable to assume therefore that the two keel planks from this boat were also cut from one tree. The ring sequences produced a boat 1 mean curve of 140 years (Fig 4).

The plan of boat 3 (Fig 3) had already indicated that the pieces of bottom plank were probably from the same tree, and this was confirmed by the ring patterns. A mean curve of 105 years was constructed. When it was compared with the sidestrake sequence, the two appeared synchronous (Fig 5), although the agreement was not very high (t = 3.4). This low value is probably due to the measurement difficulties outlined above, so the sidestrake data were not included with the plank mean. The size of the timbers, and the quality of the tree-ring match, indicate that the plank and the sidestrake were cut from different trees, although they were probably felled at the same time.

Computer comparisons of the data from each boat gave a t-value of 4.4 for the match between boats 1 and 2. None of the timbers had sapwood, the distinctive outer part of an oak tree which is often removed during conversion because of its lower strength and its susceptibility to fungal and insect attack. The outer heartwood rings on boats 1 and 2 however differed by only 6 years (Fig 4), indicating that the edges of the planks were probably cut close to the heartwood-sapwood boundary. It seems likely therefore that boats 1 and 2 were constructed at similar times. Certainly the timbers for the two boats may have been felled about the same time.

There was no similarity between these two matching sequences and those from boat 3. This suggests that boat 3 was not contemporary with boats 1 and 2, although it is possible that its timber grew under completely different conditions to that used for boats 1 and 2. This can be tested by dating the three ring sequences either by dendrochronology or by radiocarbon.

The three mean curves were compared by computer with chronologies from Germany and Ireland (Pilcher et al 1984), and with floating chronologies from the Somerset Levels (Morgan 1976, 1978) and Thorne Waste (Morgan unpubl), but no conclusive results were found. Several t-values between 3 and 5 were obtained, but none that were consistent and were acceptable visually. It is not sufficient for Ferriby to match with Germany, for example. It must also match with a second chronology, which in turn must match Germany at a consistent position. This is known as replication, and is vital if reliable tree-ring results are to be obtained. As yet no such crossmatching has been found for Ferriby.

The timber

The tree-ring evidence indicates that, of the surviving timbers, boats 1 and 2 are represented by one tree each, whilst two trees were used for boat 3. The length of radius was estimated for the distance from the pith to the outer ring or, in the case of S3073 and S3074, the two timbers with sapwood, to the heartwood -sapwood boundary (Fig 6; Table 2). The results are very approximate since the rings did not conform to true circles, nor was any allowance made for the amount of shrinkage during conservation, but they provide a rough estimate of the minimum size of tree used for the boats. The results confirm that the sidestrake and the bottom plank of boat 3 were cut from different trees. Allowing 100mm for the missing sapwood and bark, the tree used for the plank was at least 820mm in diameter but that used for the sidestrake was smaller, the minimum diameter being 500mm. The diameters of the trees for boats 1 and 2 were at least 480 and 760mm respectively. The pith was off centre in both boat 2 samples: the radius was approximately 300mm at one side and 400mm at the other. The trees used for boats 1 and 2 would have been large but not unusually so for an oak: the diameter of a trunk used in the construction of the Blackfriar's ship was at least 2.3m (Marsden 1977).

The age of the trees is more difficult to calculate because the pith was always absent, and only two samples had sapwood (Table 1). The number of sapwood rings is taken as 10-50 (Hillam et al 1986). A rough estimate can therefore be given for the minimum age of the trees (Table 2), but they could be considerably older. The minimum ages varied from 120 years for the boat 3 plank to 260 for boat 2.

The trees therefore varied in both size and age. They were slow-grown, with average ring widths between 1 and 2mm. Both these factors suggest they grew in woodland with some crowding from other trees. Much of the land would still be covered with woodland, of which oak was the dominant species, making it relatively easy for the Bronze Age 'boat builders' to select a group of suitable trees close to the place of construction. This proximity was necessary because of the problems involved in transporting large sections of timber. Experimental work in the Somerset Levels has shown that the transport of timber, along with felling, was the most time-consuming part of trackway construction (Coles & Orme 1984).

Although the tree diameters for the bases of boats 2 and 3 are similar, that of boat 1, which is thought to be contemporary with boat 2, is smaller. Probably the trees were selected for convenience rather than for a particular dimension. The height of the tree may have been more limiting since this would dictate the maximum length of the planks. The amount of usable wood may have been no more than about 8m long (eg Rackham 1976).

Without bark or bark edge, the season of felling cannot be determined, but winter is regarded as the traditional time (McGrail 1976). After felling, the trunk was split into two, and a plank hewn from each half tangentially. This type of cutting technique allows the plank with its row of cleats to be shaped from one piece of wood, but it has many disadvantages (McKee 1976). The finished plank is not very stable, having a tendancy to warp and crack. Much timber is wasted, although it is possible to produce very wide planks, far wider than if the timber was split radially. The actual conversion from halved trunk to tangential plank with cleat is difficult, and may have required the work of a skilled craftsman. Some details of the tools used were deduced from the axe and adze marks found on the timbers; these are described fully elsewhere (Wright 1976).

The most efficient way of producing a plank with cleat is illustrated in Fig 7a. The wood for the Ferriby type of boat was usually converted in this way; another example is the Brigg 'raft' (Hillam 1981). It makes maximum use of the trunk with the minimum amount of effort. However, an exception is found in S3010 from boat 2. Here the cleat is nearest to the centre of the tree (Fig 7b). The conversion of this plank would require more labour, and the amount of timber wasted would be greater. In addition the resulting plank would not be as wide as it would using the traditonal method. Finally, if the wood was allowed to dry out, S3010 would warp away from the cleat whilst S3011, for example, would bend towards the cleat. The stresses involved in the former are greater, and probably explain why the cracks around the cleat of S3010 developed. The conversion and production of the north keel plank from boat 2 is both inefficient and unusual: was it intentional, or was it a mistake, perhaps by an apprentice 'boat builder'?

Seasoning time must have been at a minimum, otherwise the timber would have become distorted. It would also have been difficult to work if it was not green and, since boats are usually kept in a wet environment, seasoning would have been pointless.

Conclusion

Analysis of the surviving elements of the three Ferriby boats indicates that boats 1 and 2 were probably contemporary. Further radiocarbon results are needed to indicate whether boat 3 was earlier or later in date than boats 1 and 2. Since available radiocarbon results, used with two standard deviations, indicate that all three boats could be contemporary, boat 3 may not be very different in date. If absolute tree-ring dates cannot be obtained, it may be worthwhile taking samples for high-precision radiocarbon dating, if sufficient material can be found.

No absolute tree-ring dating has yet been found. For the historic period, there are many dated reference chronologies, and dating is usually possible provided a site chronology can first be produced: that is, chronologies made from several trees are usually datable, but individual timbers are not necessarily so (Hillam 1986). By comparison, there are very few chronologies for the Bronze Age and so far only one prehistoric site (Hillam 1976) from the British Isles has been absolutely dated by tree-rings. The Ferriby sequences are made up from two trees (boats 1 and 2) and one tree (boat 3). It may be that the curves will prove difficult to date even when more reference chronologies become available.

In the meantime, analysis of the timbers has provided some information on the use of timber in the Bronze Age, particularly on the selection and conversion of timber. From the tree-ring point of view, the study has shown that conserved timbers can be used successfully for dendrochronology (and still be retained intact for display if necessary), although more accurate measurements can be obtained if waterlogged timbers are examined before the conservation process begins.

Acknowledgements

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Table 1: Details of the tree-ring samples. Sample numbers in brackets are those given at Hull Museum.

boat	sample no	total no of rings	sapwood rings	average ring width (mm)
1	S3012	133	-	1.01
1	S7687	126	-	1.08
2	S3010	227	-	1.32
2	S3011	171	-	1.37
3	S3075 (P10)	84	-	1.90
3	S3074 (P13)	101	15	1.76
3	S3073 (P19)	92	15	1.69
3	S3076 (S6 or 7)	141?	-	1.07?

Table 2: Summary of the Ferriby timbers. Minimum tree size and age are very approximate. 100mm allowance is made for missing sapwood and bark; minimum number of sapwood rings is taken as 10. All measurements are in millimetres.

boat	sample	radius less sapwood		minimum diameter	minimum age
1	S3012	250+	same tree	480	160
	S7687	190-230+			
2	S3010	320-400+	same tree	760	260
	S3011	300-400+			
3	S3075	360+	same tree	820	120
	S3074	360+			
	S3073	-			
	S3076	200+		500	170

Legends to figs

Fig 1: Boat 1 showing positions of the tree-ring samples (after Wright 1976).

Fig 2: Boat 2 with position of samples (after Wright 1976).

Fig 3: Boat 3 with position of samples (after Wright 1976).

Fig 4: Bar diagram with relative positions of the ring sequences from boats 1 and 2. Two radii were measured on all samples except S3010. Timbers were felled after year 237 on the arbitrary scale.

Fig 5: Bar diagram showing relative positions of the boat 3 ring sequences. Sapwood rings represented by hatching; sapwood estimate taken as 10-50 rings. Timbers felled between years 169 and 203 on the arbitrary scale; scale is independent of the one given in Fig 4.

Fig 6: Relationship of the surviving Ferriby timbers to their parent tree trunks. Sketches are not to scale; estimates of radius length (mm) are very approximate. Radii measured are marked 1 or 2 as appropriate. Note the orientation of S3010.

Fig 7: Ways of converting timber into a plank with cleat. a) traditional method; b) as shown by sample S3010 from Ferriby boat 2. Arrows indicate the potential direction of warping.

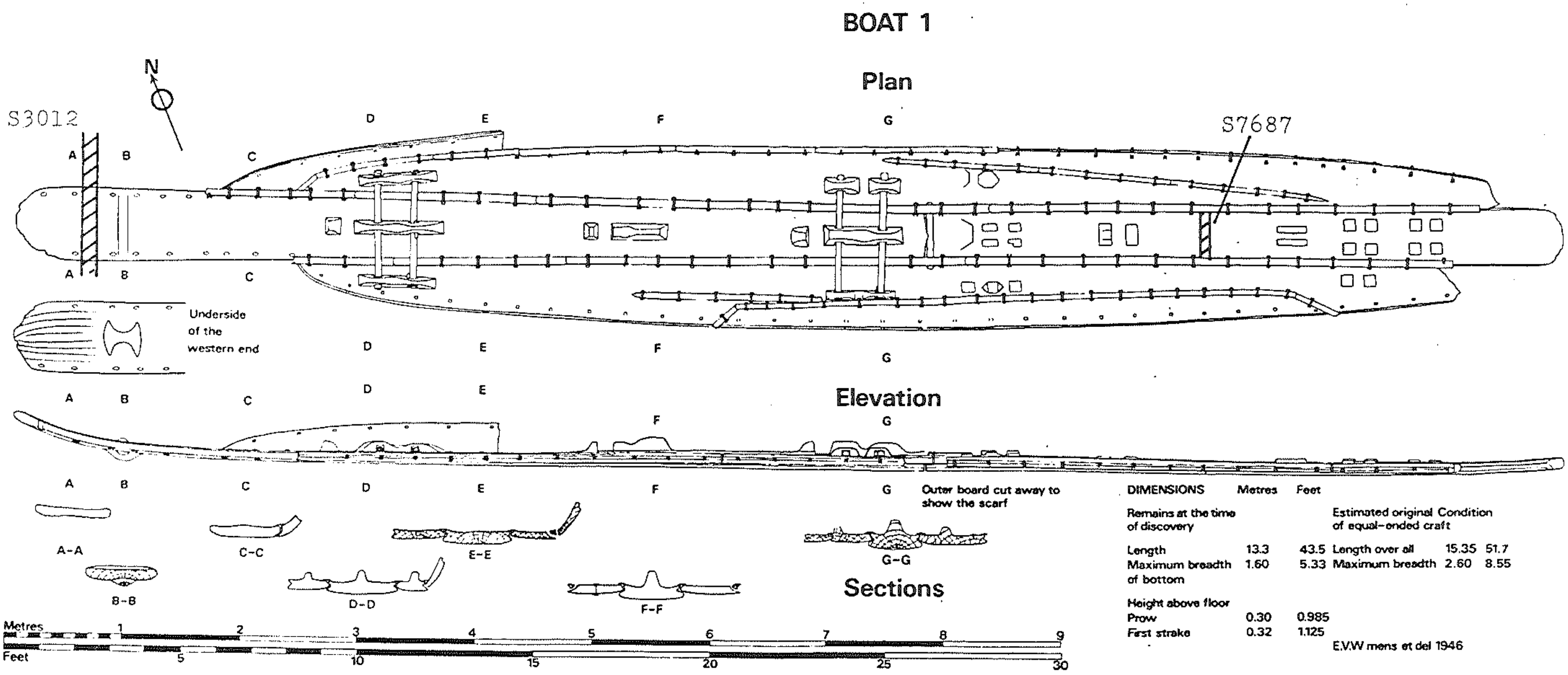

BOAT 1
Plan
S3012
N
S7687
A B C D E F G
Underside
of the
western end
Elevation
Outer board cut away to show the scarf
A-A
B-B
C-C
D-D
E-E
F-F
G-G
Sections
Metres 1 2 3 4 5 6 7 8 9
Feet 5 10 15 20 25 30
DIMENSIONS Metres Feet
Remains at the time of discovery
Length 13.3 43.5
Maximum breadth of bottom 1.60 5.33
Height above floor
Prow 0.30 0.985
First strake 0.32 1.125
Estimated original Condition of equal-ended craft
Length over all 15.35 51.7
Maximum breadth 2.60 8.55
E.V.W mens et del 1946

Fig 1

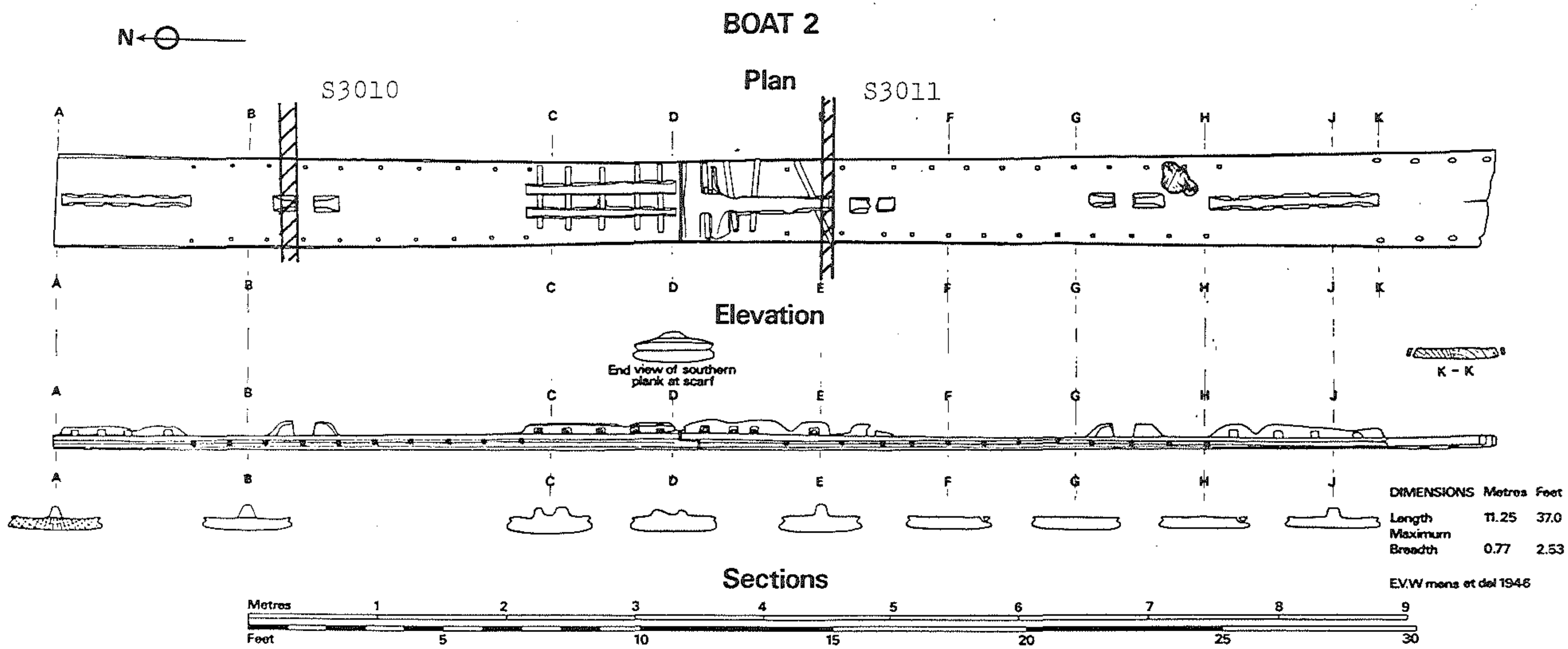

BOAT 2
N
Plan
S3010
S3011
A
B
C
D
E
F
G
H
J
K
Elevation
End view of southern plank at scarf
K - K
Sections
DIMENSIONS Metres Feet
Length 11.25 37.0
Maximum Breadth 0.77 2.53
E.V.W mens et del 1946
Metres 1 2 3 4 5 6 7 8 9
Feet 5 10 15 20 25 30

Fig 2

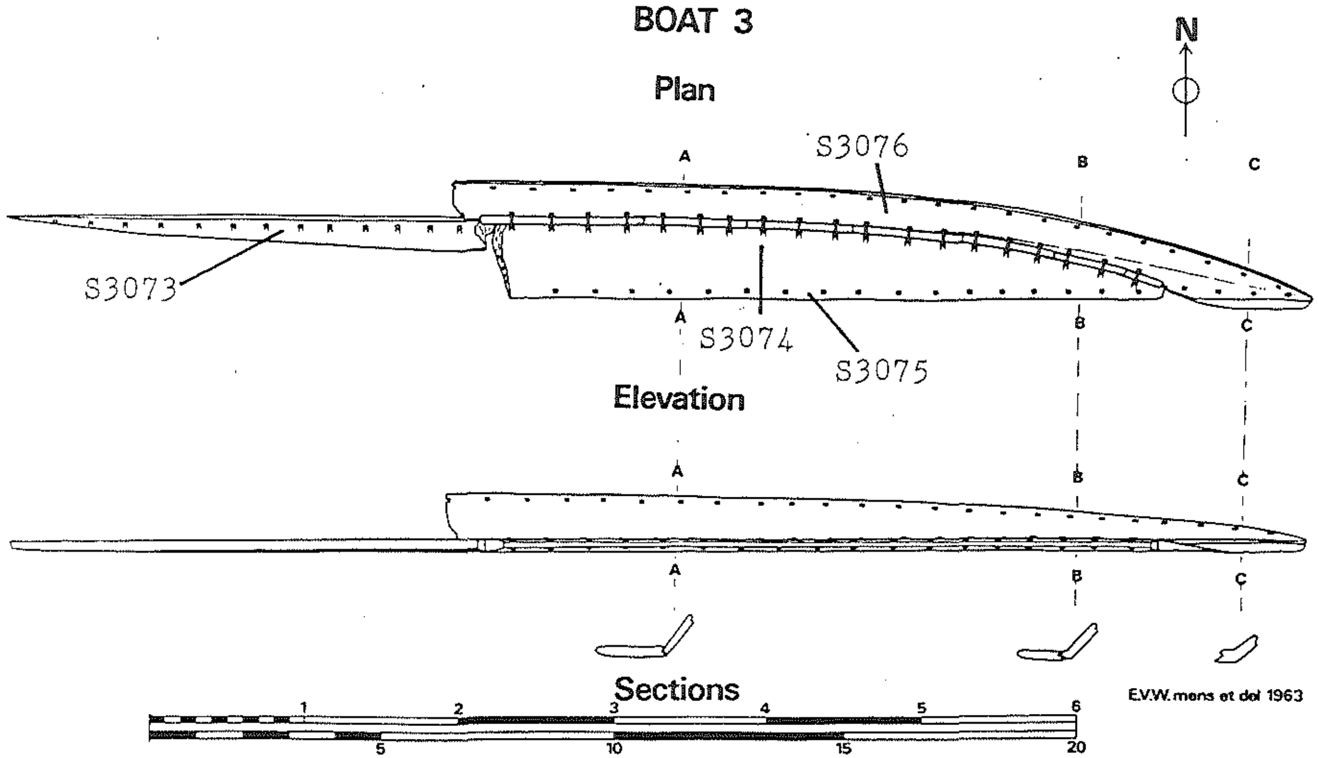

BOAT 3
Plan
N
A
B
C
S3076
S3073
S3074
S3075
Elevation
Sections
1
2
3
4
5
6
5
10
15
20
E.V.W.mens et del 1963

Fig 3

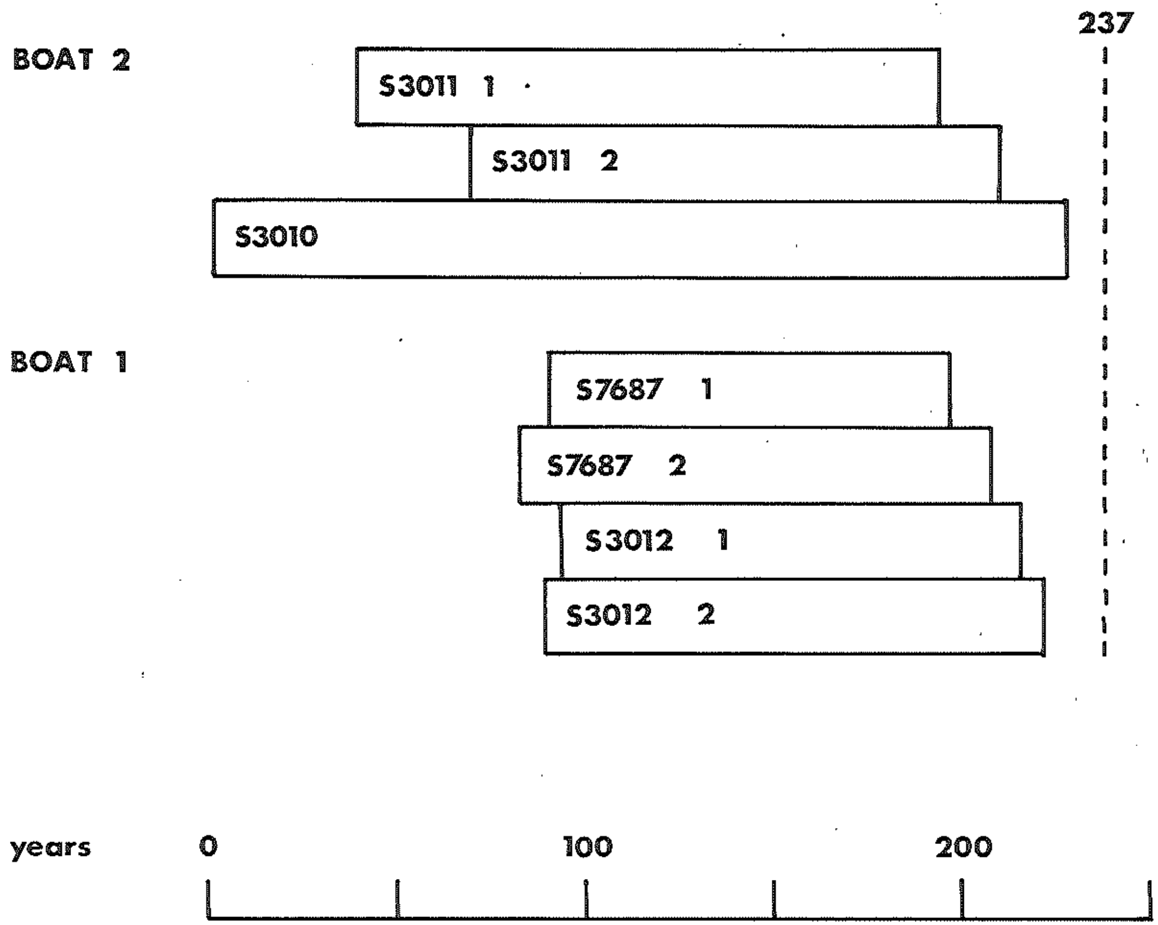

237
BOAT 2
S3011 1
S3011 2
S3010
BOAT 1
S7687 1
S7687 2
S3012 1
S3012 2
years
0
100
200

Fig 4

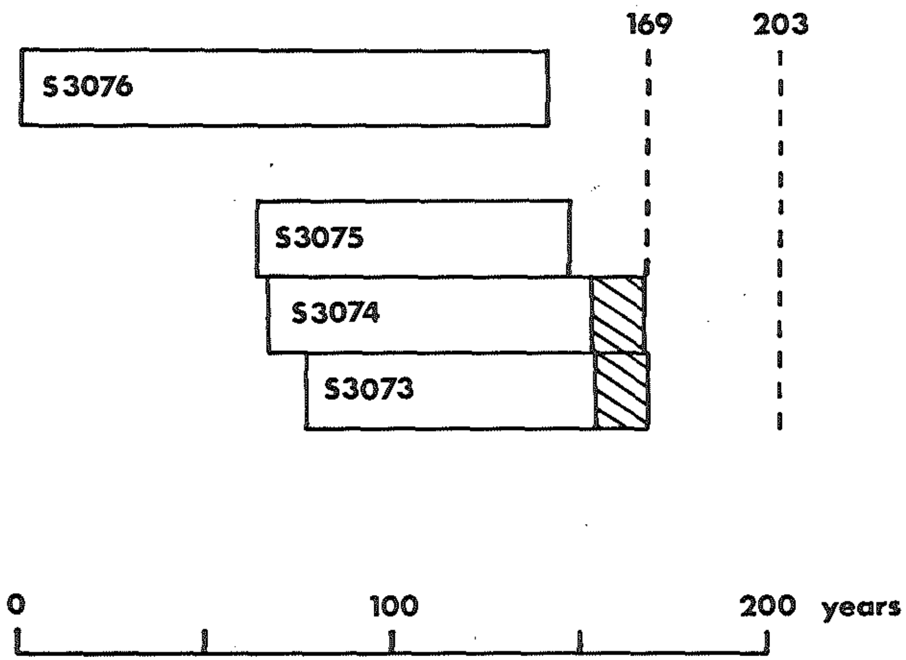
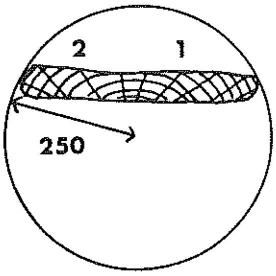
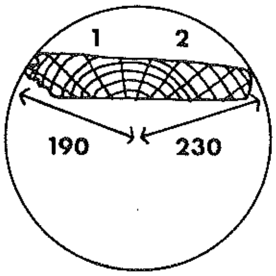


Fig 5

BOAT 1

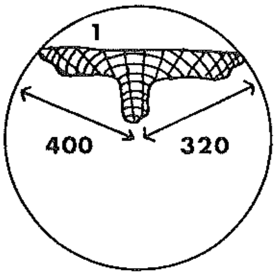


3012

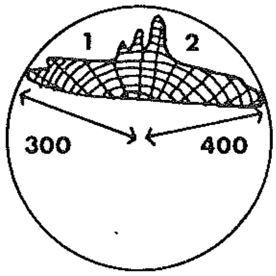


7687

BOAT 2

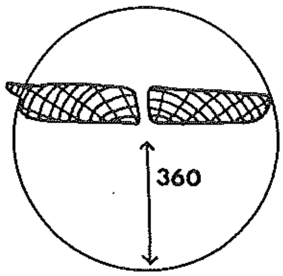


3010

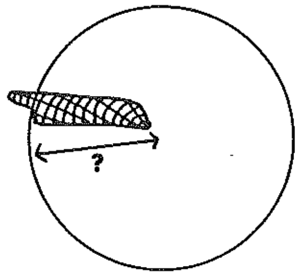


3011

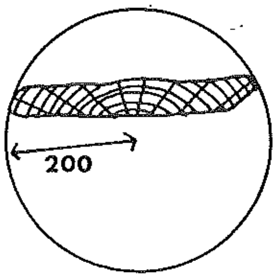
BOAT 3



3074 3075



3073



3076

Fig 6

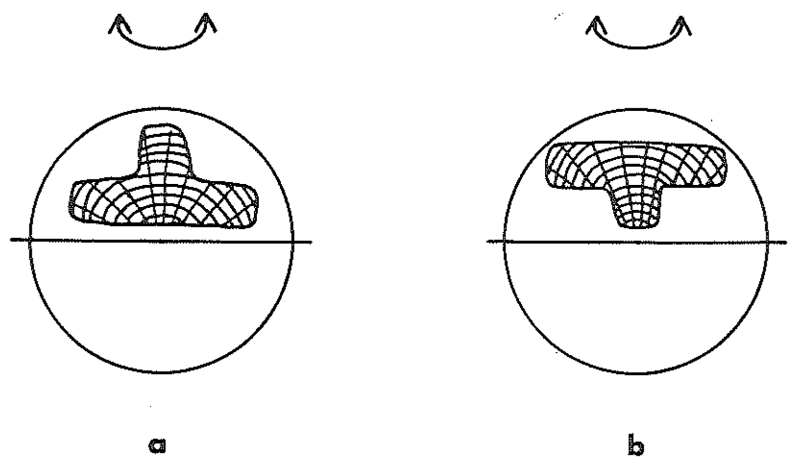


Fig 7

Dendrochronology of the North Ferriby boats

Appendix: the ring width data

List of ring widths in units of 0.1mm for the mean curves from boats 1 and 2, and the boat 3 plank mean. The first two lines identify the sequence; third line - number of rings measured; fourth and subsequent lines - ring widths, ten to a line. Further details of each sequence are given in the comment at the end of each list. Ferriby 1/2 is the mean curve produced by averaging the widths of the matching sequences from boats 1 and 2.

FERRIBY 1
FERRIBY1 MEAN
140

1 -	10	8	3	8	4	6	6	14	11	7
11 -	11	6	4	5	7	7	10	13	8	9
21 -	4	6	14	10	9	7	5	6	8	4
31 -	4	6	7	7	7	5	7	4	8	10
41 -	10	10	8	14	12	7	13	14	16	13
51 -	17	9	8	9	11	9	6	5	7	6
61 -	5	7	8	5	4	7	10	7	6	8
71 -	6	6	5	4	7	8	6	7	9	11
81 -	10	14	14	18	27	21	17	17	17	16
91 -	13	15	21	17	15	14	20	15	19	23
101 -	19	18	15	11	14	14	10	9	13	12
111 -	16	18	13	12	11	14	14	14	12	10
121 -	9	12	13	10	13	14	7	6	7	4
131 -	6	11	14	10	7	12	8	10	11	8

COMMENT - MEAN OF S3012 & S7687

FERRIBY
FERRIBY2 MEAN
227

1	-	15	19	23	16	19	25	17	21	19	12
11	-	18	14	9	15	20	18	17	10	11	16
21	-	14	17	15	10	14	18	12	8	12	9
31	-	6	9	6	9	14	17	25	22	17	13
41	-	17	12	16	14	13	12	10	15	9	8
51	-	12	9	15	16	13	15	13	8	7	10
61	-	16	14	14	17	15	8	10	13	11	14
71	-	16	17	11	9	12	13	11	16	11	14
81	-	12	17	13	14	9	9	10	9	14	12
91	-	12	13	11	9	14	14	14	13	14	12
101	-	12	8	10	15	17	15	16	14	12	11
111	-	9	13	11	14	15	18	10	15	16	17
121	-	13	12	11	14	17	12	11	16	13	11
131	-	14	17	13	11	18	13	19	15	18	16
141	-	12	17	18	16	18	10	15	22	17	12
151	-	14	11	15	12	10	13	12	11	15	12
161	-	14	14	20	15	18	20	18	16	14	20
171	-	16	21	15	23	13	14	19	23	15	14
181	-	13	11	10	14	11	14	12	13	15	12
191	-	12	14	20	14	15	11	11	11	14	17
201	-	12	9	14	11	12	8	10	8	7	6
211	-	5	9	10	9	6	9	7	11	6	4
221	-	5	4	5	7	7	8	12			

COMMENT - MEAN OF S3010 & S3011

FERRIBY
FERRIBY3
105

1	-	11	11	15	17	13	18	19	23	22	16
11	-	15	18	22	19	22	23	16	19	23	15
21	-	16	15	21	23	16	24	24	23	22	21
31	-	21	23	19	18	25	17	23	17	14	19
41	-	15	14	13	20	18	21	18	16	13	13
51	-	12	13	11	13	13	16	22	11	13	11
61	-	14	12	23	21	17	18	20	18	19	20
71	-	17	14	10	15	20	18	16	20	25	20
81	-	15	14	19	21	23	14	16	22	17	12
91	-	11	12	20	23	21	22	16	20	25	20
101	-	18	21	22	26	21					

COMMENT - PLANK MEAN (S3073 S3074 S3075)

FERRIBY
FERRIBY1/2
227

1	-	15	19	23	16	19	25	17	21	19	12
11	-	18	14	9	15	20	18	17	10	11	16
21	-	14	17	15	10	14	18	12	8	12	9
31	-	6	9	6	9	14	17	25	22	17	13
41	-	17	12	16	14	13	12	10	15	9	8
51	-	12	9	15	16	13	15	13	8	7	10
61	-	16	14	14	17	15	8	10	13	11	14
71	-	16	17	11	9	12	13	11	16	11	14
81	-	12	13	10	8	8	6	8	7	14	11
91	-	9	12	8	6	9	10	10	11	13	10
101	-	10	6	8	14	13	12	11	9	9	9
111	-	6	8	8.	10	11	12	7	11	10	12
121	-	11	11	10	11	15	12	9	14	13	13
131	-	13	17	11	9	13	12	14	10	11	11
141	-	9	11	12	12	11	7	11	16	12	9
151	-	11	8	10	8	7	10	10	8	11	10
161	-	12	12	17	13	18	23	19	16	15	18
171	-	16	17	15	22	15	14	16	21	15	16
181	-	18	15	14	14	11	14	13	11	12	12
191	-	12	15	19	13	13	11	12	12	14	14
201	-	11	9	13	12	11	10	12	7	6	6
211	-	4	7	10	11	8	8	9	9	8	7
221	-	6	4	5	7	7	8	12			

COMMENT - MEAN OF SEQUENCES FROM BOATS 1 & 2