Ancient Monuments Laboratory
Report 8/92

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Summary

Dendrochronological analysis of 15 oak samples from New Baxtergate, Grimsby, produced two absolutely dated chronologies covering the periods AD1100-1405 and AD1148-1284. The 306 year chronology matches reference curves from the Baltic region, whilst the 137 year sequence dates with chronologies from the British Isles. The analysis indicated that some of the medieval waterfront timbers were from local woodlands but others originated from the Baltic region.

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Introduction

The proposed redevelopment of the River Head and Freshney Haven area of Grimsby resulted in a series of archaeological excavations being undertaken during 1986-1989 (Figure 1). In the early medieval period Grimsby was a major port and the River Head and Freshney Haven formed the eastern and northern boundaries of the town. Freshney Haven is a man-made feature thought to date to the fourteenth century and constructed to increase the capacity of the port.

The archaeological investigation at New Baxtergate (Trench 1 - N1 1986) revealed the remains of an eighteenth century waterfront structure and an earlier medieval revetment and tile and cobble trackway. The medieval revetment (phase II) consisted of uprights and horizontal planking (Figure 2) which fronted onto the River Head. The overlapping planking or shuttering was thought to consist of a reused section of a clinker built vessel (McGrail pers comm). Additional or secondary planking had been added above the section of the boat timbers to raise the height of the waterfront (Evans pers comm). Other archaeological dating evidence, such as pottery and associated finds suggested that the phase II revetment was of 13th-14th century date. Fourteen timbers from this revetment were sampled for dendrochronological analysis (Table 1). A single timber find from a phase IIIa deposit overlying a waterfront on the River Freshney, in the northern area of Trench 1, was also sampled. It was hoped that the analysis would provide more precise dating evidence for the construction of the phase II revetment and offer additional dating information for phase IIIa.

Method

The samples were prepared by freezing them for a minimum of 48 hours and then cleaning their cross-sectional surface with a surform plane. Any unsuitable samples were rejected before measurement. These are usually samples with unclear ring sequences or samples with less than 50 rings. Ring patterns with fewer than 50 rings are generally unsuitable for absolute dating as they may not be unique (Hillam *et al* 1987). However samples with 30-49 rings and bark or bark edge, which therefore have the potential to provide precise felling dates, may be included for measurement if there are several of them associated with a single structure.

The growth rings of the suitable samples were measured to an accuracy of 0.01mm on a travelling stage, built by the City of London Polytechnic. The travelling stage is connected to an Atari microcomputer. The tree-ring software for the Atari was written and developed by Ian Tyers (pers comm 1990). The ring width sequences were plotted on semi-logarithmic paper to allow visual comparison of the patterns. The process of crossmatching and dating was aided by the use of programs on the Atari microcomputer, although visual matching was still used to check the computer results. The crossdating programs are based on versions of CROS (Baillie & Pilcher 1973, Munro 1984) and measure the amount of correlation between two ring sequences. The Student's *t* test is then used as a significance test on the correlation coefficient. All *t* values quoted in this report are identical to those produced by the original CROS program (Baillie & Pilcher 1973). Generally a *t* value of 3.5 or over represents a match, provided that the visual match is acceptable (Baillie 1982: 82-85).

Dating is achieved by crossmatching the ring sequences from the individual timbers and combining the matching patterns to produce a site master curve.

All previously unmatched sequences from the site are compared with this master curve and if any additional patterns are found to crossmatch these are incorporated to produce a new site master curve. This master curve and all unmatched ring sequences are then tested against reference chronologies to obtain absolute dates. A master curve is used for absolute dating purposes whenever possible as it enhances the common climatic signal and reduces the background noise resulting from the local growth conditions of individual trees.

The results only date the rings present in the timber and therefore do not necessarily represent the felling date. If the bark or bark edge is present on a sample the exact felling year can be determined. In the absence of bark surface the felling date is calculated using the sapwood estimate of 10-55 rings. This is the range of the 95% confidence limits for the number of sapwood rings on British oak (*Quercus* spp) trees over 30 years old (Hillam *et al* 1987). In the total absence of sapwood, the addition of 10 rings (the minimum number of sapwood rings expected) to the date of the last measured heartwood ring produces a probable *terminus post quem* for felling. During timber conversion a large number of outer rings could be removed and as this number of heartwood rings is unknown, the actual felling date could be much later.

A different sapwood estimate must be used for timbers derived from outside the British Isles. This is due to a geographical variation in the number of sapwood rings present which increases from east to west across north-west Europe. The number of sapwood rings in oaks studied from north Poland and south-west Finland indicates that the best estimate of the sapwood range applicable to timbers of Baltic origin is 7-36 (see eg Baillie *et al* 1985; Eckstein *et al* 1986). This range gives the upper and lower extremes of

sapwood numbers so the range of the 95% confidence limits will be narrower but there is currently insufficient published data available with which to calculate these.

Once the felling date range or *terminus post quem* for felling has been calculated, factors such as stockpiling, reuse and seasoning of timber must be considered since they might affect the interpretation of the tree-ring dates. The possibility of a timber structure having undergone repair work should also be taken into account. Thus, whilst the date obtained for the measured tree-ring sequence is precise and has been achieved by a completely independent process, the interpretation of tree-ring dates can be refined by studying other archaeological and documentary evidence.

Results

The number of rings, their orientation and the size of the cross-section of each sample was noted (Table 1). All fifteen timbers were oak and had between 30-207 annual growth rings. Sample 394, an upright, 395, a tieback beam and two planks (368, 376) from the phase II revetment were considered unsuitable for further analysis as they contained less than 50 rings but average ring widths were estimated for these timbers. The remaining eleven samples, including the single sample from phase IIIa, were measured and their average ring widths calculated. The ring width data are stored at the Sheffield Dendrochronology Laboratory. The inner 50 rings of sample 377 were counted rather than measured as they were badly distorted possibly due to the close proximity of a knot.

The ring sequences were compared against each other and eight, including the phase IIIa timber, were found to crossmatch (Figure 3). These were combined to form a 306 year master curve, Grimsbyl (Table 2). Two other timbers also crossmatched each other and were averaged to produce a second site master

curve, Grimsby2, with 137 years (Figure 3; Table 3). The two site master curves were compared with each other and the unmatched ring sequence, but no further reliable matching was found.

Both site master curves and the unmatched individual ring sequence were checked against dated reference chronologies from north-east England and then elsewhere in the British Isles. The reference chronologies used spanned the period AD404 to AD1981. A good match was found for Grimsby2 when it covered the period AD1148-1284 (Table 4). No consistent results were obtained for either the 306 year master curve or the unmatched individual ring sequence. Consequently these were also compared with reference chronologies from the rest of Europe. Consistently high *t* values and good visual matching was obtained for Grimsby1 at AD1100-1405 with chronologies of a Baltic origin (Table 4).

Neither of the two phase II samples of English origin, 369 and 372, had retained any sapwood. The dates of the outermost measured rings are AD1281 and AD1284 respectively. The sapwood estimate applicable to British timbers indicates a *terminus post quem* for felling of AD1291 for 369 and AD1294 for 372 (Table 5). The high *t* value (6.3) and very good visual similarity suggests that the two timbers are probably contemporary.

One (375) of the seven dated phase II samples which crossmatch Baltic reference chronologies had retained four sapwood rings. The application of the sapwood range of 7-36 to this timber indicates that it was probably felled during the period AD1346-1375. Four of the other samples have *termini post quem* for felling ranging from AD1313 (383) to AD1335 (377). Samples 398 and 399, taken from secondary planking in the revetment above the reused boat timber section, appear likely to represent later felling phases. Their

outermost rings date to AD1396 and AD1405 indicating that they were probably felled after AD1403 and AD1412 respectively.

The phase IIIa timber (219) had retained five sapwood rings and its heartwood-sapwood transition dates to AD1333. 219 was therefore probably felled after AD1340 but before AD1370.

The timbers

Thirteen of the fifteen timbers analysed were radially split or sawn planks. The remaining two were whole trunks which had been worked on one or more sides to produce a rectangular shaped timber. The two English planks (369, 372), which have neither sapwood or pith, were at least 150 years old and probably over 0.5m diameter when felled. The Baltic planks, with the possible exception of 1224 and 374, were likely to have been 200+ years when felled with diameters ranging from approximately 0.25m to over 0.5m. The dated planks, both English and Baltic, have average ring widths ranging from 1.0-1.6mm. Slow grown timbers have narrow average ring widths and come from trees which grew under conditions that were limiting, such as dense woodland.

The remaining timbers which have not been dated tend to have average ring widths over 2.0mm, excluding 378, suggesting that they grew in a more open environment where competition was less severe. It is noticeable that 394 (upright) and 395 (tie-back beam) are from smaller younger trees, 46 and 30 years old respectively when felled.

Discussion

The English timbers in the medieval revetment match very well with reference chronologies from northern England, particularly those from Beverley, Hull and York (Table 4). It is as yet not possible to source timber in any detail using dendrochronology but the analysis suggests that the 369 and 372 are

likely to have been derived from local woodland.

The importation of non-native timber is well documented and from the later thirteenth century this trade became increasingly important. The Customs Accounts for all the ports of the east coast of England show large imports of Baltic timber, particularly when trade was under the control of the Hanseatic League (Salzman 1979: 245-7).

The quality of the internal matching between the Baltic timbers found at Grimsby (Table 5) implies that the timber may have been obtained from a broad area of woodland. The Grimsby timbers appear to represent a different woodland source than contemporary timbers of Baltic origin found at Hull (Hillam 1991). These two site chronologies crossmatch with a low t value (Table 4), whereas the Grimsby planks match very well with other reused boat timbers at Gun and Shot Wharf and Symonds Wharf (Tyers 1990). Although these timbers can be identified as being of Baltic origin rather than British or German it is not possible to suggest a more localised origin, but it should be noted that Grimsby1 and some of its individual components do match the Polish chronology (Wazny & Eckstein 1991) extremely well (Table 4; 7).

The problems encountered when sourcing timber derived from British woodlands are enhanced when dealing with foreign imports. Whereas dating is carried out on British timbers using a large regional network of individual site master curves, the dating of foreign imports relies on various composite chronologies representing large regions and on chronologies from other sites in Britain that have had imported timber present. As more chronologies are established from imported timber found in England and a more localised network of chronologies becomes available for areas such as the Baltic region, it is hoped to develop further the tree-ring evidence concerning the original sources of such timber. This may provide a clearer indication of the location

of woodland areas that were providing timber for trade with England.

The tree-ring analysis has identified at least three felling phases for the timber from the medieval revetment (phase II). The English timbers were both probably felled after AD1294, whereas the Baltic timbers indicate felling dates ranging from the fourteenth-fifteenth centuries. Samples 369 and 372, both English timbers, and the Baltic timbers 374, 375, 377, 382 and 383 are reused and thought to represent a single clinker built boat (McGrail & Evans pers comm) implying that they are broadly contemporary. Although a mid fourteenth century felling date has been obtained from timber 375 this cannot be directly related to the construction of the revetment. An allowance must be made for the time lapse between the felling of the timbers, their primary use in a boat and the subsequent dismantling of the boat and reuse of the timbers in the building of the phase II revetment. These seven timbers therefore suggest that the revetment was probably not erected before the latter half of the fourteenth century which is consistent with the 13-14th century date implied by other archaeological dating evidence.

There is no other archaeological evidence to connect the two remaining Baltic planks 398 and 399 with the same clinker built vessel which was utilised to produce the lower part of the waterfront, although there is some indication that 399 may have been reused (Evans pers comm). They were felled after AD1403 and AD1412 respectively and could represent a fifteenth century repair phase or possibly a heightening of the waterfront. However if they were incorporated into the revetment at the same time as the reused boat timbers the earliest construction date for the revetment is pushed into the fifteenth century. It is not possible to determine from the tree-ring analysis which is the more likely of the two suggested interpretations.

The lack of precise dating evidence for the the construction of the revetment is due partly to the amount of reused material present. There is an absence of timbers suitable for dating purposes from the other major structural elements of the waterfront. The only two non-planks sampled were 394 and 395 but neither contained sufficient rings for tree-ring dating (see above). The bark was intact of these timbers and it therefore seems improbable that they were either transported over a long distance or reused. They appear likely to have been obtained from local woodland and felled for primary use in the phase II revetment, whereas the higher quality timber required for the shuttering was mostly derived from the breaking up of a boat.

Timber 219, associated with a phase IIIa deposit, has a felling date range which is very similar to that of 375. It could therefore be contemporary with the reused boat timbers which would suggest the possibility that it may also have been originally associated with the clinker built vessel.

The seven dated planks which are thought to represent a single vessel are a mixture of Baltic and English timber (see above) which implies an English origin for the boat. The articulated section of the hull was used in an inverted position. Planks 369, 372 and 383 were basal strakes and 374, 377 and 382 upper strakes. The *termini post quem* for felling of the six dated strakes range from AD1291 to AD1335. The quality of the match both visually and statistically between 374 and 383 is very good ($t = 7.1$). This implies that these two timbers, an upper and a basal strake, are contemporary. If it is assumed that all six planks are contemporary and associated with the primary construction, the boat could not have been constructed before AD1335. Timber 375, a repair tingle, was felled during AD1346-1375 which indicates that the boat was probably built before *circa* AD1375, although an allowance has to be made for the interval between felling and, if the boat is an English

boat, the importation and subsequent distribution of the timber. Due to the absence of a precise date for the construction of the revetment, and therefore also a date for when the boat timbers were reused, the tree-ring evidence cannot give an accurate indication of the maximum length of time that the boat could have been in existence.

Conclusion

Nine of the timbers from the phase II revetment and the single timber from the phase IIIa deposit were dated resulting in the production of two site master chronologies, one of which matches British sequences and the other matching Baltic chronologies. This adds to the growing body of data from Baltic timbers found in Britain and will be a useful aid for future dating of timbers derived from this source.

The waterfront structure consisted of a mixture of English and Baltic timber. All dated timbers associated with the initial construction of the revetment were reused and thus tree-ring analysis cannot give a precise construction date. However the results indicate that the revetment was unlikely to have been built before the latter half of the fourteenth century. The two planks associated with the section of the revetment above the reused boat timbers both have a *terminus post quem* in the early fifteenth century suggesting that the waterfront may have undergone repairs during this century.

The combination of English and Baltic planking in the hull of the vessel utilised in the revetment suggests that it was an English boat. The tree-ring dates from its timbers indicate that the vessel was probably built during the mid fourteenth century, after AD1335 and before about AD1375.

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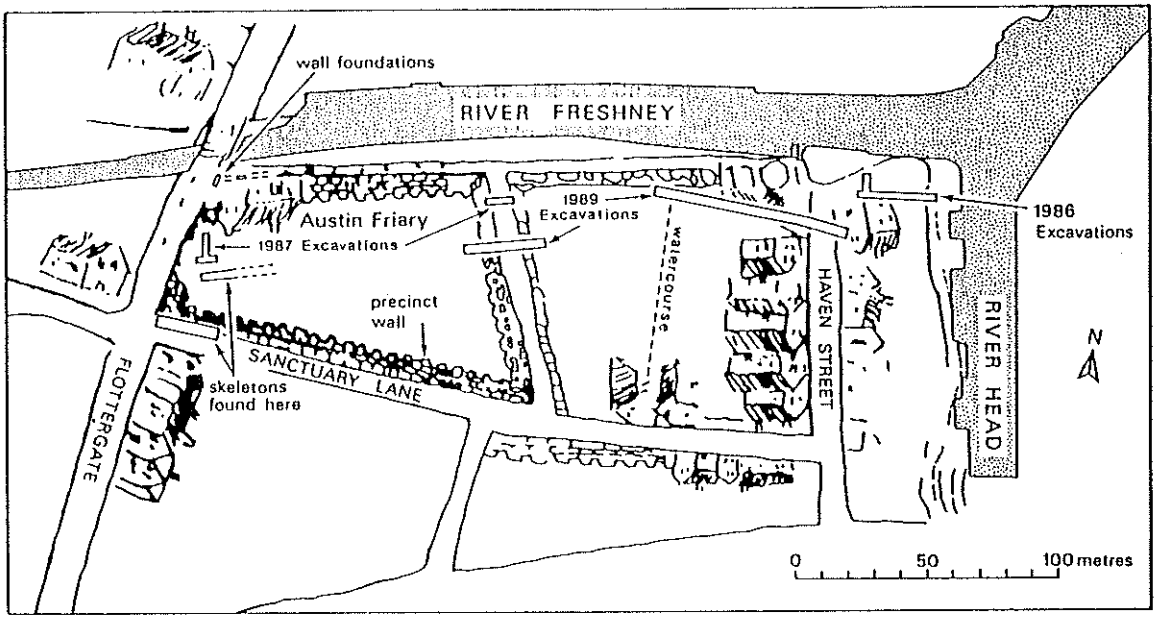


Figure 1: Plan showing the location of the excavations in Grimsby 1986-1989 (reproduced by courtesy of Humberside Archaeology Unit).

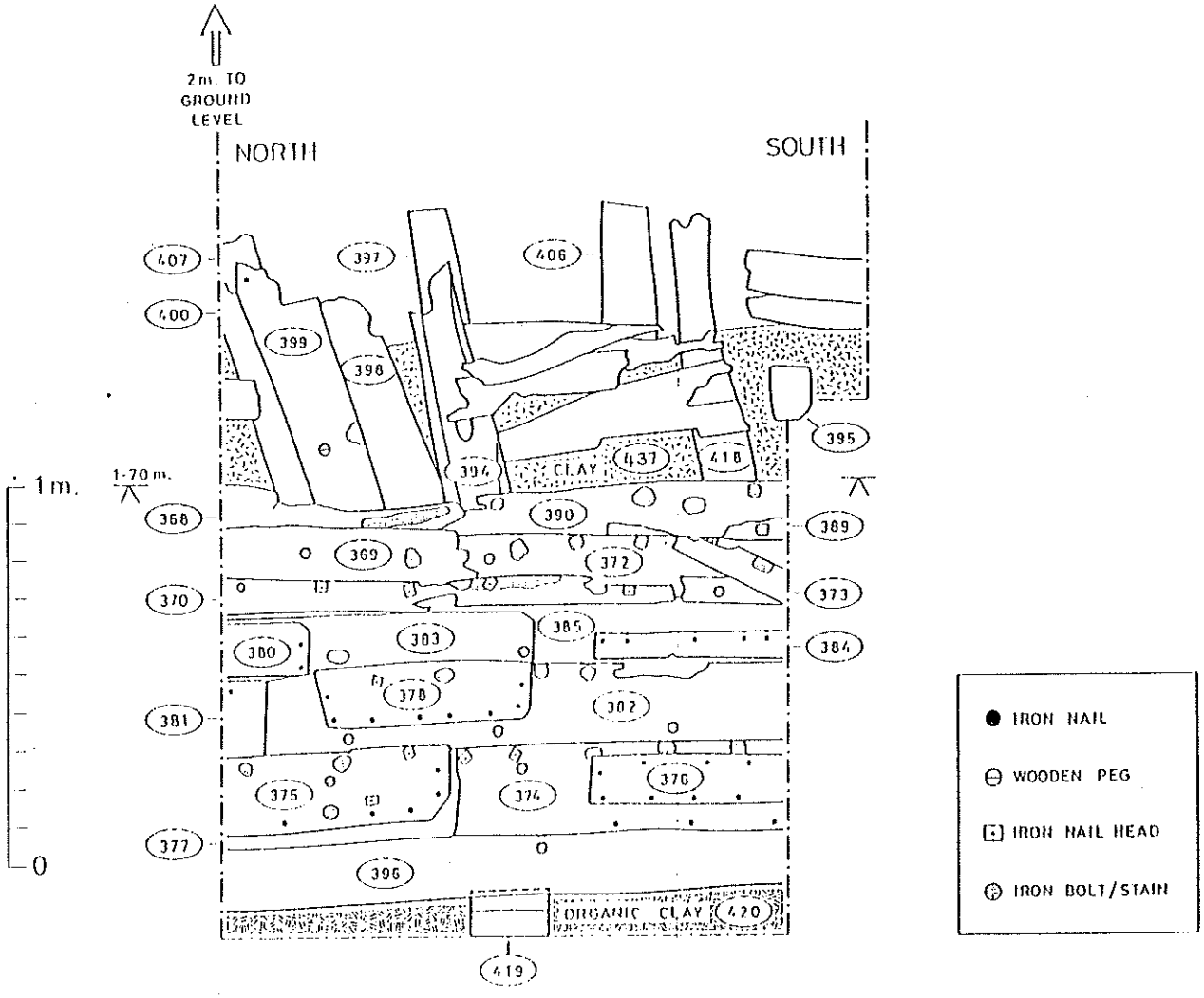


Figure 2: Diagram showing the position of the timbers in the phase II medieval waterfront structure (reproduced by courtesy of Humberside Archaeology Unit).

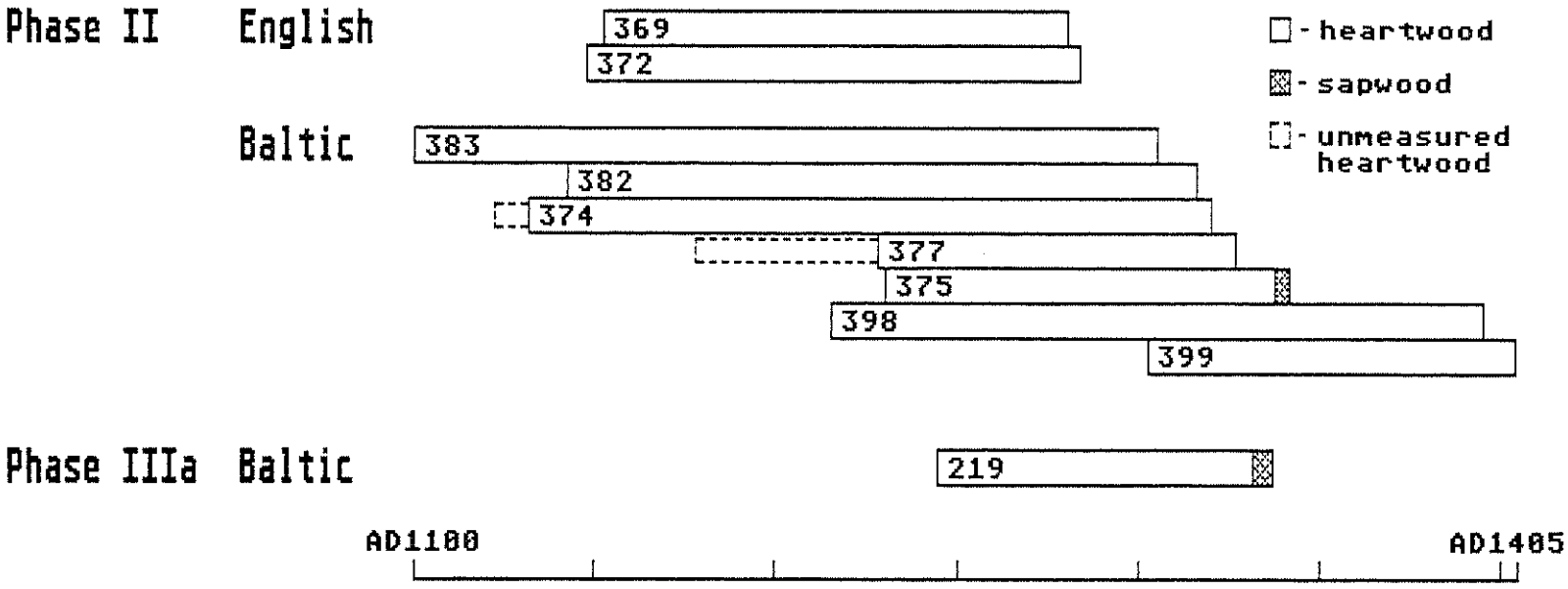


Figure 3: Bar diagram showing the relative positions of the dated samples from New Baxtergate, Grimsby.

Table 1: Details of the samples; sketches are not to scale.

Context	Function	Phase	Length	Sapwood	Av width mm	Sketch	Dimensions mm	Comment
219	unknown	IIIa	94	5	1.2		115x20	-
368	secondary planking	II	36	0	2.2		80x25	-
369	shuttering	II	129	0	1.6		215x40	reused basal strake
372	shuttering	II	137	0	1.3		190x35	reused basal strake
374	shuttering	II	190	0	1.0		210x30	reused upper strake
375	shuttering	II	113	4	1.6		195x25	reused repair tingle
376	shuttering	II	45	0	2.9		130x15	reused repair tingle
377	shuttering	II	100	0	1.0		150x20	reused upper strake
378	shuttering	II	87	15	1.8		165x20	reused repair tingle
382	shuttering	II	175	0	1.3		230x35	reused upper strake
383	shuttering	II	207	0	1.0		210x30	reused basal strake
394	upright	II	46	18	2.9		215x170	felled winter
395	tieback	II	30	10	2.8		140x115	felled winter

Table 1: Details of the samples; sketches are not to scale.

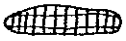
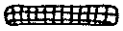
Context	Function	Phase	Length	Sapwood	Av width mm	Sketch	Dimensions mm	Comment
398	secondary planking	II	181	0	1.0		195x45	-
399	secondary planking	II	103	0	2.0		215x25	?reused

Table 2: The ring width data of the New Baxtergate master curve, GRIMSBY1.

years	ring width data (units of 0.01mm)										number of samples per year									
AD1100										159										1
AD1101	126	133	146	150	168	118	141	106	93	120	1	1	1	1	1	1	1	1	1	1
	148	130	119	111	169	154	108	131	125	163	1	1	1	1	1	1	1	1	1	1
	172	185	141	132	149	116	131	124	117	147	1	1	1	1	1	1	1	1	1	1
	132	102	119	132	116	102	107	121	96	118	1	2	2	2	2	2	2	2	2	2
	128	117	130	119	125	140	140	153	150	137	2	2	3	3	3	3	3	3	3	3
AD1151	123	131	154	130	144	118	126	139	163	187	3	3	3	3	3	3	3	3	3	3
	141	144	129	164	158	129	125	168	110	116	3	3	3	3	3	3	3	3	3	3
	135	136	145	130	115	120	102	113	121	114	3	3	3	3	3	3	3	3	3	3
	128	114	159	157	180	173	149	149	109	147	3	3	3	3	3	3	3	3	3	3
	130	124	111	113	151	135	127	130	149	160	3	3	3	3	3	3	3	3	3	3
AD1201	149	110	146	126	115	105	104	110	105	114	3	3	3	3	3	3	3	3	3	3
	106	96	106	127	109	90	93	91	135	106	3	3	3	3	3	4	4	4	4	4
	92	84	82	74	95	83	85	88	98	108	4	4	4	4	4	4	4	4	5	5
	104	110	90	110	96	103	141	127	105	93	6	6	6	6	6	6	6	6	6	6
	85	76	85	82	97	86	98	98	117	110	6	6	6	6	7	7	7	7	7	7
AD1251	109	115	127	115	140	131	124	98	120	97	7	7	7	7	7	7	7	7	7	7
	81	102	86	109	94	114	104	119	118	103	7	7	7	7	7	7	7	7	7	7
	134	111	111	128	134	111	105	92	107	117	7	7	7	7	7	7	7	7	7	7
	132	110	111	105	116	111	99	107	98	106	7	7	7	7	7	7	7	7	7	7
	113	97	98	118	113	127	113	128	137	117	7	7	7	7	7	7	7	7	7	7
AD1301	135	134	121	98	94	112	120	134	140	120	7	7	8	8	8	8	7	7	7	7
	130	144	167	130	143	157	127	139	142	126	7	7	7	7	7	7	7	6	6	6
	133	137	123	89	129	127	140	154	177	178	6	5	5	5	5	5	5	5	4	4
	128	135	99	159	133	146	149	140	145	112	4	4	4	4	4	4	4	4	3	3
	143	126	151	146	136	140	114	106	111	116	3	3	3	2	2	2	2	2	2	2
AD1351	189	141	153	136	120	108	107	114	176	167	2	2	2	2	2	2	2	2	2	2
	102	159	160	145	133	192	176	148	154	145	2	2	2	2	2	2	2	2	2	2
	112	117	118	118	197	166	187	255	218	205	2	2	2	2	2	2	2	2	2	2
	202	206	232	212	203	122	168	156	163	160	2	2	2	2	2	2	2	2	2	2
	130	138	160	145	136	145	113	151	204	223	2	2	2	2	2	2	1	1	1	1
AD1401	206	254	111	172	171						1	1	1	1	1					

Table 3: The ring width data of the New Baxtergate master curve, GRIMSBY2.

years	ring width data (units of 0.01mm)										number of samples per year									
AD1148								156	227	161								1	1	1
AD1151	159	126	265	231	177	192	135	111	166	183	1	1	2	2	2	2	2	2	2	2
	153	163	173	188	136	110	116	157	216	136	2	2	2	2	2	2	2	2	2	2
	174	170	161	158	185	151	120	121	158	184	2	2	2	2	2	2	2	2	2	2
	178	167	213	139	173	154	202	155	134	193	2	2	2	2	2	2	2	2	2	2
	142	130	174	179	193	179	165	135	152	103	2	2	2	2	2	2	2	2	2	2
AD1201	116	128	168	129	118	113	107	139	118	154	2	2	2	2	2	2	2	2	2	2
	151	93	94	106	105	103	133	107	136	134	2	2	2	2	2	2	2	2	2	2
	131	106	124	134	130	116	127	124	121	100	2	2	2	2	2	2	2	2	2	2
	81	82	82	104	124	74	105	112	128	99	2	2	2	2	2	2	2	2	2	2
	95	88	139	140	168	181	250	158	168	175	2	2	2	2	2	2	2	2	2	2
AD1251	196	140	190	200	216	167	187	170	188	206	2	2	2	2	2	2	2	2	2	2
	200	256	195	179	130	167	148	189	156	150	2	2	2	2	2	2	2	2	2	2
	187	137	113	96	104	112	135	120	133	137	2	2	2	2	2	2	2	2	2	2
	151	121	182	188							2	1	1	1						

Table 4: Results of comparisons between Grimsby1 (AD1100-1405) and Grimsby2 (AD1148-1284) with reference chronologies from Europe spanning the medieval period. The England, East Midlands and Southwark boats chronologies are composite chronologies containing data from many English sites.

Reference chronology	t value Grimsby1	Grimsby2
England (Baillie & Pilcher pers comm)	/	6.46
East Midlands (Laxton & Litton 1988)	/	8.88
Beverley: Eastgate (Groves 1990)	/	5.10
Hall Garth (Hillam 1981)	/	6.26
Bradwell Abbey barn, Bucks (Bridge 1988)	/	4.91
Carlisle medieval (Baillie & Pilcher pers comm)	/	5.65
Droitwich: Upwich2 (Groves & Hillam 1991)	/	3.55
Exeter Cathedral medieval (Mills 1988)	/	4.72
Glastonbury Abbey barn, Gloucs (Bridge 1988)	/	5.70
Hull: Chapel Lane (Hillam 1979)	3.69	7.84
London: Billingsgate 8-11 (Hillam 1990)	/	4.30
Southwark_T93 (Tyers pers comm)	/	5.09
Reading (Groves *et al* 1985)	3.78	5.42
Stafford (Groves unpubl)	/	5.06
York: Coppergate medieval (Hillam 1989)	/	5.93
Queen's Hotel (Groves 1990)	/	4.82
Germany: Schleswig Holstein (Eckstein pers comm)	4.68	/
South (Becker 1981)	/	4.97
Weser & Leine (Delorme 1972)	3.02	4.33
West (Hollstein 1980)	/	4.02
Poland: Gdansk Pomerania (Wazny & Eckstein 1991)	8.65	/
Imports: Hull, Blaydes Staithe (Hillam 1991)	3.00	/
Ipswich, Bridge Street (Hillam 1985)	5.95	/
London, Abbots Lane 185 (Tyers 1990)	7.08	/
Abbots Lane 193/195 (Tyers 1990)	6.78	/
Fennings Wharf (Tyers 1990)	4.91	/
Gun & Shot Wharf (Tyers 1990)	7.83	4.47
Symonds Wharf (Tyers 1990)	8.72	/
Southwark boats (Tyers 1990)	10.11	3.99
Sutton House 1/4 (Tyers 1991)	3.63	/
Sutton House 2/3 (Tyers 1991)	4.55	/
York, Zouche Chapel (Fletcher & Morgan 1981)	6.98	3.86
Ref1 (Fletcher 1977)	4.78	/
Ref2 (Fletcher 1977)	6.25	/
Ref4 (Fletcher 1977)	10.03	3.49
Type A (Fletcher data; reworked Hillam)	7.72	/
Type B (Fletcher data; reworked Hillam)	9.17	/

Table 5: Details of the results; date of heartwood/sapwood transition is given in brackets.

Context	Phase	Action	Years spanned	Felling date	Origin
219	IIIa	measured	AD1245-1338(1333)	AD1340-1369	Baltic
368	II	rejected	-	-	-
369	II	measured	AD1153-1281	after AD1291	England
372	II	measured	AD1148-1284	after AD1294	England
374	II	measured	AD1132-1321	after AD1328	Baltic
375	II	measured	AD1231-1343(1339)	AD1346-1375	Baltic
376	II	rejected	-	-	-
377	II	measured	AD1229-1328	after AD1335	Baltic
378	II	measured	-	-	Baltic
382	II	measured	AD1143-1317	after AD1324	Baltic
383	II	measured	AD1100-1306	after AD1313	Baltic
394	II	rejected	-	-	-
395	II	rejected	-	-	-
398	II	measured	AD1216-1396	after AD1403	Baltic
399	II	measured	AD1303-1405	after AD1412	Baltic

Table 6: Matrix of t values produced between the dated individual ring sequences in the site master curve GRIMSBY1; values of less than 3.0 are not given.

	374	375	377	382	383	398	399
219			5.0			4.9	
374		5.3		5.5	7.1	3.4	
375							
377					3.6	6.2	4.8
382					4.2	4.3	
383						3.0	
398							3.7

Table 7: Matrix of t values produced between the dated individual ring sequences in the site master curve GRIMSBY1 and reference chronologies from foreign timbers; values of less than 3.0 are not given. The Southwark boat curve is a composite chronology containing data from several London sites and is therefore not independent; see Table 4 for details of the chronologies.

		219	374	375	377	382	383	398	399
Germany:	Schleswig Holstein		6.1	3.3		4.3			
	South		3.9	3.4		3.7			
	Weser & Leine		3.9	3.5					
	West		4.7	3.1		3.1			
Poland		5.2	7.1	5.8	3.3	8.3	3.9	5.4	3.7
Imports:	Hull, Blaydes Staithe		3.4					3.7	
	Ipswich, Bridge Street		5.0	4.0		6.0	4.1		
	London: Abbots Lane 185	3.0	3.9	4.5		5.1	3.4	3.3	
	Abbots Lane 193/195					3.6		5.5	5.9
	Fennings Wharf	4.6					3.5	3.8	
	Gun & Shot Wharf	3.5	6.3	4.1	4.6	6.1	5.0	4.9	
	Symonds Wharf	4.1	5.1	3.3	3.7	7.4	3.9	4.8	
	Southwark boats	5.0	7.1	4.5	5.0	8.5	5.1	7.7	4.7
	Sutton House 1/4	4.3							
	Sutton House 2/3								4.0
	York, Zouche Chapel	3.1	5.3	3.4	5.1	5.6	4.3	5.2	
	Ref1	5.4	3.2			3.5		4.4	3.0
	Ref2	3.8				3.8		4.6	5.6
	Ref4	4.9	7.4	4.8	5.8	7.3	5.3	7.9	4.7
	Type A	5.4	4.8			5.3	4.6	4.1	3.6
	Type B	4.3		3.8	4.8	4.6		5.6	7.8