

Iberian Dendrochronology and the Newport Medieval Ship

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At the time of the discovery of the Newport medieval ship, it proved impossible to date the timbers used in its original construction through dendrochronology. Associated British timbers and artefacts provided dating to the mid 15th century, with the latter pointing to strong Iberian connections. The development of regional oak ring-width chronologies in the Basque Country, and their extension back in time to overlap with the ring-width mean developed for the Newport Ship, has allowed absolute dating and provenance of timbers used in its original construction. Further research is required to clarify the geographical source of the timbers and to develop a high-resolution network of tree-ring data for the region.

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Key words: tree-ring research, dendro-provenance, Basque, timber supply.

This paper explores the challenges faced in successfully applying dendrochronology to dating the primary construction and original provenance of the ship timbers of the Newport Ship found in south-east Wales, complementing a summary of the excavation, recovery and post-excavation documentation (Nayling and Jones, 2013, this volume). In doing so, the development of regional chronologies in the north-east part of Iberia which allowed the breakthrough in dating is described.

Soon after its discovery in July 2002, samples for tree-ring research were taken from three framing timbers and four outer hull planks from the coherent remains of the ship itself. It was hoped that these would provide dates that would assist in assessing the significance of the find to inform management decisions regarding excavation strategy, and possible recovery for conservation, against the background of a delayed, high-cost building programme for a new performing arts centre on the site. These initial samples, while potentially suitable for dendrochronological analysis being oak (*Quercus* spp.) with more than 50 rings, could not be dated against existing regional ring-width chronologies in Britain or elsewhere in north-west Europe. However, further samples, that were not fastened to the ship but from a timber rough-out and a large knee forming part of a composite beam/knee group lying within the ship, were successfully dated

against British reference chronologies providing felling dates in the winter of AD 1467/8 and the winter of AD 1465/6 respectively. These results provided the first absolute dating of the site to the medieval period, and had a major influence on subsequent decisions which led to the ship being dismantled, recovered for detailed study, and conserved with a view to eventual display (a process which is still on-going). Post-excavation cleaning of the forward scarf of the keel revealed a recess into which a French silver *petit-blanc* coin minted in Crémieu between May and July AD 1447 (Besly, 2013) had been placed and then covered by the adjoining scarf of the stem. This implies that the ship could not have been constructed before May AD 1447.

During the excavation of the ship, multiple indications of Iberian contact or trade were found including four base-metal Portuguese issues of the 15th century struck at Lisbon were recovered from within the ship (Besly, 2013). Other possible indications of Iberian contact included numerous sherds of 'Mérida-type ware', otherwise known as 'Iberian Micaceous Red-ware', some of which come from the Alentejo area of Southern Portugal which, given a lack of repetitive forms and sooting, could represent crew use (Redknap, 2013). Sheets of cork were also recovered which, given the present day distribution of cork oak (*Quercus suber*), also suggest Iberian or more distant Mediterranean contact.

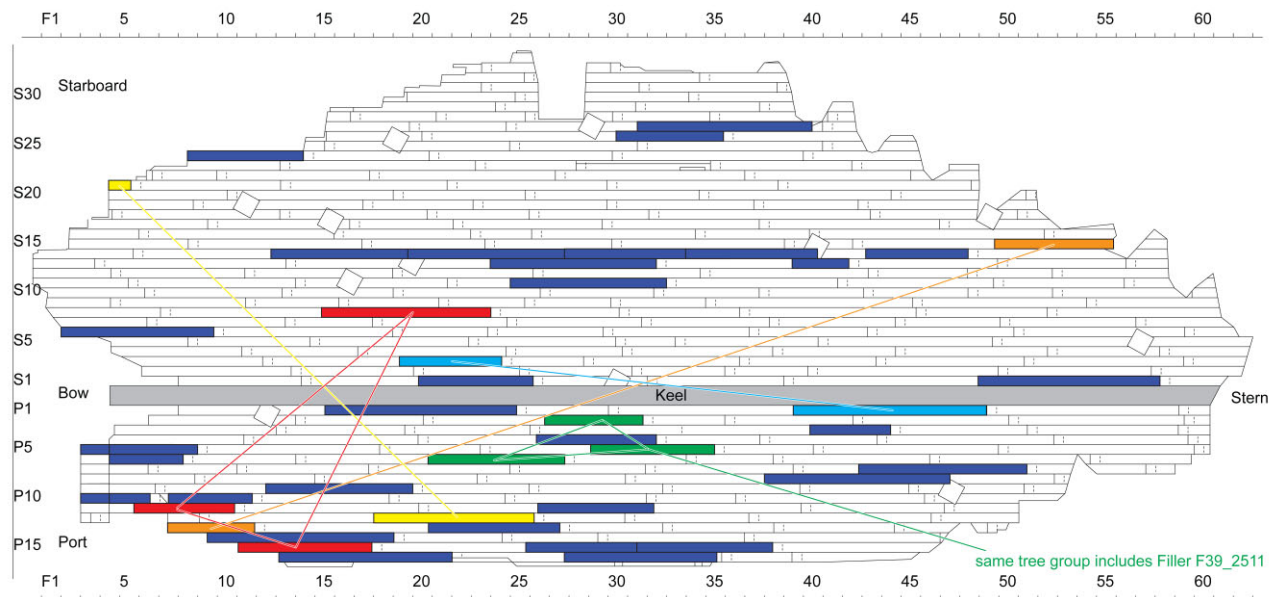


Figure 1. Schematic diagram of the hull planks of the Newport Ship with strake codes and frame stations indicated. Hull planks sampled for dendrochronology are shaded and timbers identified as deriving from the same parent tree colour coded. (Nigel Nayling)

Sampling and analysis

During post-excavation documentation of thousands of individual timbers recovered from the site, ship timbers were assessed for their suitability for tree-ring dating, and a programme of sampling was carried out once digital recording and photography on each structural group (such as hull planking) had been completed. A programme of selective sampling of the coherent ship remains which optimized the potential for dating and provenance was pursued, with selection being based in part on assessment of ring counts, and the presence/absence of sapwood. The dendrochronological dating of disarticulated ship timbers and structures associated with the ship using British reference chronologies has been summarized in a parallel paper (Nayling and Jones, 2013). The current paper focuses on the sampling and analysis of the articulated hull.

A total of 373 individual outer hull planks were recovered, from which 50 tree-ring samples were taken (Fig. 1), which is approximately 13% of the recovered outer hull planks of the Newport Ship. Samples were normally taken as hand-sawn slices. In two instances samples were taken to check whether disturbed fragments in the vicinity of the bow were derived from the same original timber (for example P10.1—the first plank on the tenth port strake, see Nayling and Jones, 2013: table 1 for an explanation of timber codes used). Some attempt was made to select samples across a range of strakes on both the port and starboard side, but also along strakes (for example S14) to see if planks from the same trees were being employed in close proximity in the hull. Three repair patches, or tingles, found fastened to the outboard face of the hull planks and

rebated on their inboard faces to accommodate the heads of clinker nails protruding on the outboard face of the hull (CT208 on strake P9, CT209 on P12, and CT344 on S31) had sufficient rings to warrant sampling. Seven further tingles without rebates for nail heads were also suitable for sampling (Fig. 2). It was hypothesized that the latter group might represent later repairs as the heads of the clinker nails had been removed to allow their placement, perhaps suggesting the nails had by this time deteriorated.

Thirty-two samples were taken from the 211 framing timbers (floors and side timbers) comprising 31 distinct timbers plus one sample from an uncoded frame-timber fragment. Samples were sometimes taken as a combination of a wedge sample of sapwood and the outermost heartwood and an increment core of heartwood with the two extracted ring sequences overlapping. Two samples were taken from futtock F33.2 and their sequences combined. Seven further samples came from fillers, timbers fastened over the inboard face of framing timbers before attachment of ceiling planks. Approximately 15% of framing timbers were sampled. An oak block (Block_CT734), found inserted over the keel at frame station 10 and wedged in place between framing timbers with small boards, is of uncertain function but was sampled as a possible repair or alteration with surviving bark edge providing the prospect of precise dating.

Relatively few samples were taken from the inner hull of stringers and ceiling planks. These timbers were often halved or tangentially converted and exhibited relatively fast growth rates leading to insufficient rings for dendrochronological analysis. Three starboardside, tangentially sawn ceiling planks (CS1.3, CS1.4 and

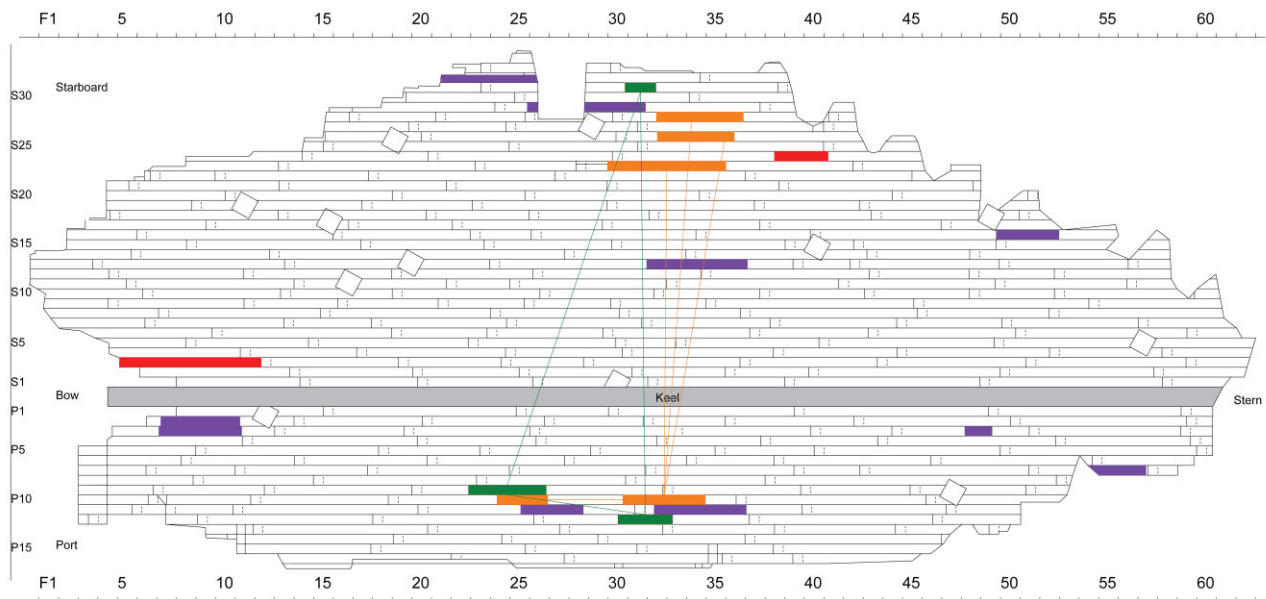


Figure 2. Schematic diagram of the hull planks of the Newport Ship indicating the location of repair patches (tingles) found fastened to the outboard. One group of tingles derived from the same tree (green) could not be dated absolutely. A further group of five tingles cross-matched to form a mean which dated against British chronologies (orange). Sampled but undated tingles (red) and unsampled tingles (purple) are also shown. (Nigel Nayling)

CS1.5) were sampled, as was BRP2, one of the 20 braces from around the swelling in the keelson which took the mast-step. Samples were also taken from six bilge boards, bevel-ended sawn oak boards used to seal the gap between the rebated upper edge of starboard stringer STRS4 (and presumably its portside equivalent which did not survive) and the inboard face of the outer hull planks, between the frames.

A single sample was taken from the end of one of the lifted sections of the beech (*Fagus sylvatica*) keel, where the bark edge of the parent tree was retained on one corner (see Nayling and Jones, 2013: fig. 10). Two of the four riders, found closely clasped over stringers (and in the case of the aft-most rider R4, over ceiling planking too) in the bow area, also proved suitable for sampling.

The total number of samples measured was intended to be sufficient to build a well-replicated mean sequence to maximize the opportunity for dating against external reference chronologies, which had not proved possible with the data from only a few planks analysed during the excavations.

Methods employed at the Lampeter Dendrochronology Laboratory in general follow those described in English Heritage guidance documents (English Heritage, 1998). The samples were cleaned using razor blades so that the ring sequence could be clearly discerned and measured. The complete sequence of growth rings in each sample was measured to an accuracy of 0.01 mm using a travelling stage connected to a computer with dedicated measuring software (Tyers, 2004). Cross-correlation algorithms (Baillie and Pilcher, 1973;

Munro, 1984) were employed to search for positions where the ring sequences correlated strongly against each other. The ring sequences were also tested against a range of reference chronologies from Britain and Northern Europe. The *t*-values reported are derived from the original CROS algorithm (Baillie and Pilcher, 1973). A *t*-value of 3.5 or higher is usually indicative of a good match, although this is with the proviso that high *t*-values at the same relative (between undated series) or absolute (against reference chronologies) position must be obtained from a range of independent sequences, and that satisfactory visual matching supports these positions. The visual check of the correlated positions was done using computerized ring-width plots.

Interim results

Keel

Lifting of the beech keel in six sections made access to the ring-width data straightforward, with a sample being taken from the after end of the second section from the bow, along with samples of the attached oak garboards. The 97-year sequence should be seen as an underestimate of the parent tree's age at felling as, although both pith and bark edge were present, the sample came from relatively high in the tree, at least 14 m above ground level. The ring-width sequence obtained could not be dated against oak series obtained from other timbers from the site sequences, nor against the (very limited) historical data for medieval beech in Britain (Tyers, 1998: 126) or a wide range of oak chronologies.

Table 1. Correlations (*CROS73 t-values*) between highly correlated ship timber samples (hull planks and one filler) interpreted as derived from the same parent tree

a) *NPGr1Tr1 Newport Ship Hull Planks Group 1 Tree1*

Filenames	P2.4_2339	P5.5_2343	P6.4_2345
F39_2511_Filler	11.23	15.21	11.97
P2.4_2339	*	11.87	14.05
P5.5_2343	*	*	10.2

b) *P11.2_P15.1_S8.3*

Filenames	P15.1_g1041	S8.3_2291
P11.2_2319	11.56	10.38
P15.1_g1041	*	12.93

Hull planks

Same trees

During the early stages of analysis of the ring-width sequences from individual timbers, a combination of high correlation values and close visual matching of ring-width patterns is used to identify timbers derived from the same parent tree. This can prove useful in analysis of construction sequence, and also in rejoining fragmented parts of timbers. Single ring-width series are normally calculated from these multiple sets of ring-width data so that subsequently, when mean sequences are constructed, repeated versions of the ring-width data from the same timber or parent tree are not used in this mean sequence.

Samples taken from heavily disturbed bow hull planks were used to confirm the correct equation of bow timbers with the less disturbed main part of the hull. Correlations were identified between planks in the fifth and tenth port strakes (P5.1_2920 and P5.1_2922 [$t = 19.09$]; and P10.1_2928 and P10.1_2930 [$t = 30.25$]) and the ring-width series of those elements were averaged into single raw ring-width series (P5.1 and P10.1 respectively) for subsequent cross-matching between individual timbers.

During cross-matching, high correlations and very close visual matches were also observed between the ring-width series from three pairs of planks (P1.5 and S3.3 [$t = 12.31$]; P13.1 and S15.8 [$t = 13.87$]; P13.3 and S21.1 [$t = 14.97$]), as well as between a group of three planks and a filler from frame station F39 (P2.4, P5.5 and P6.4 and F39_2511_Filler), and another group of three planks (P11.2, P15.1, and S8.3) suggesting that these were derived from the same parent trees (Table 1, Fig. 1). Again, average ring-width series representing individual trees were calculated for each of these groups.

While the group of three planks on the port side from the same parent tree (P2.4, P5.5 and P6.4) are

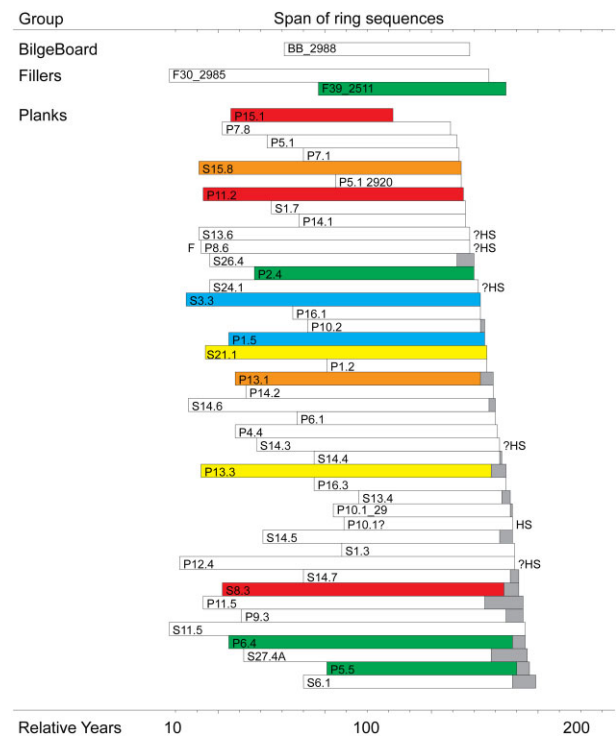


Figure 3. Bar diagram of relatively dated hull planks, fillers and one bilge board. Sapwood is shaded and heartwood/sapwood boundaries indicated. Timbers from the same parent tree are colour coded. (Nigel Nayling)

spatially clustered, some of the timber from this tree was also used much later in the construction process when a filler was fastened over the framing timbers at F39. Considering the spatial distribution of the other same-tree planks, some approximate 'symmetry' can be observed with planks from the same tree used on opposite sides of the ship at similar strake levels. A more comprehensive sampling strategy directed at answering how timber from the same tree was positioned in the ship might have allowed clearer indications of how planks from the same tree were used in the construction sequence, although it is clear that considerable mixing occurred.

Correlated hull plank sequences

The five combined sequences mentioned above, and the ring-width sequences from a further 31 hull planks, and another filler (F30_2985_Filler) were internally crossdated and correlated with one another (Fig. 3) (see Nayling, 2013, Table 8 for correlations). These crossdated sequences were averaged to create a 173-year mean sequence named **NewportT37**. During cross-dating of these sequences, two subgroups of sequences with higher correlations were noted. The largest group comprised 29 sequences derived from 36 individual hull planks and two fillers. A smaller group comprised five individual plank sequences. Three other plank sequences were not assigned to either group but

Table 2. Correlations (*CROS73* *t*-values) between synchronized samples from tingles forming means *TingleReb* and *5_Tingles*a) Three rebated tingles from a common parent tree (mean sequence: *TingleReb*)

FileNames	2286_T_S31	2287_T_P9
1744_T_P12	13.12	13.4
2286_T_S31	*	16.78

b) Tingles without rebates (mean sequence: *5_Tingles*)

FileNames	1774_T_P10	2276_T_S28	2278_T_S23	2281_T_S26
162_T_P10	14.96	3.85	7.53	3.63
1774_T_P10	*	10.36	13.12	7.11
2276_T_S28	*	*	8.57	5.84
2278_T_S23	*	*	*	7.08

correlated with a sufficient number of sequences to warrant inclusion in the overall mean of 37 ring-width sequences. This mean could not be dated against available chronologies and approaches were made to dendrochronologists throughout Europe in the hope of finding an absolute date for this sequence and hence a date, and provenance, for the timber used in the ship's primary construction.

Tingles

Tingles were found over a wide area of the surviving hull. These can be divided into those with rebates on their inboard face to accommodate nail heads protruding from the outboard face of the hull (of which three were sampled for tree-ring analysis), and tingles without rebates where the outer face of the hull had been cut flat removing remnants of the heads of fasteners before the tingle was fastened. The latter type could be thought more likely to be a later repair. Seven tingles of this latter type were sampled for tree-ring analysis (Fig. 2).

The three tingles without rebates cross-matched against each other with high correlations and close visual matches indicating that the timbers were derived from the same parent tree (Table 2a). A combined raw ring-width sequence for this parent tree, **TingleReb**, could not be dated against British or other European chronologies.

The sequences from five of the unrebrated tingles correlated with high *t*-values (Table 2b) and close visual matches. Two or three of these timbers could have derived from a common parent tree. A mean of these five correlated timbers, **5_Tingles**, cross-matched against a wide range of British chronologies (including Castle of Park, Scotland) and one Irish chronology. Assuming a British origin, a sapwood estimate of 10–46 sapwood rings was applied to this group (Bayliss and Tyers, 2004). Combining the felling-date ranges from two of these where partial

sapwood survived, assuming these represent a single repair event, suggests that the parent trees were felled between AD 1459 and AD 1483 (see Nayling and Jones, 2013, fig. 6). Given the tree-ring dating of a timber structure found under the ship to the spring of AD 1468, a reasonable inference is that the ship had undergone repairs, probably in a British or Irish port or harbour in the last decade of its working life.

Framing timbers

Correlations between the ring-width sequences from the 32 sampled framing timbers were limited, in contrast to the outer hull planks. Significant, replicated correlations and acceptable visual matching could be found within a group of seven framing timbers (Table 3, Figs 4 and 5), from which a seven-timber, 105-year mean, FramingT7, was calculated. It has so far proved impossible to date these sequences, or their mean against external, previously dated site masters or chronologies, including those available at the Arkeolan Foundation in the Basque Country (north-east Spain). The fact that five of the seven ring-width sequences all end in the same relative year of 105 with possible or definite bark edge supports the correlation of this grouping.

Fillers

Six samples derive from fillers, timbers fastened over the inboard face of framing timbers before attachment of ceiling planks. Two of these fillers (F30_2985_Filler and F39_2511_Filler) cross-matched against the outer hull planks and form part of the site master **NewportT37**. One of these fillers (F39_2511_Filler) was derived from the same parent tree as three portside hull planks (P2.4, P5.5 and P6.4). The remaining sequences from fillers could not be cross-matched against other site timbers, or against British or other European chronologies.

Table 3. Correlations (*CROS73* *t*-values) between samples from framing timbers forming the mean *Framing_T7* and Brace sample *BRP2_1752*

Filenames	F14.2_2912	F23.4_2833	F29.2_2883	F35.3_2840	F40.2_2848	F45.0_2855
BRP2_1752	—	3.20	—	5.41	6.80	—
F12.0_2914	—	5.18	5.1	3.44	3.11	—
F14.2_2912	*	—	4.25	3.94	6.52	3.64
F23.4_2833	*	*	—	—	3.8	—
F29.2_2883	*	*	*	4.65	—	3.64
F35.3_2840	*	*	*	*	4.49	—
F40.2_2848	*	*	*	*	*	3.69

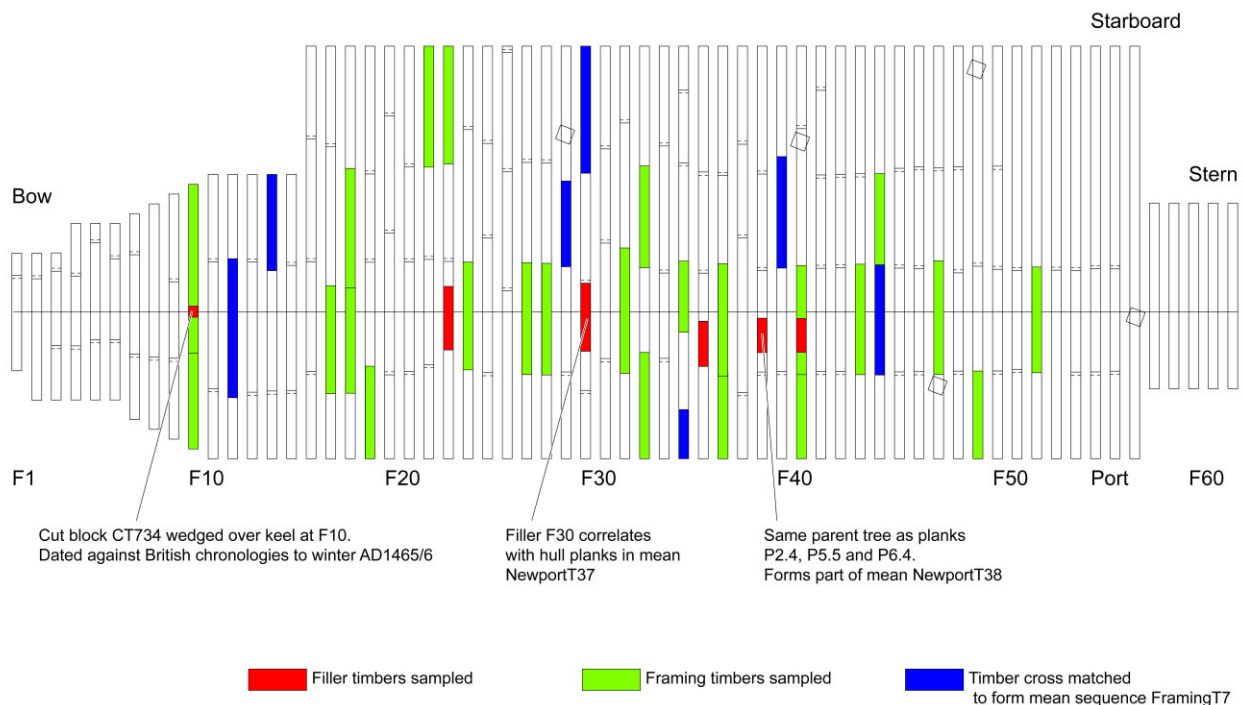
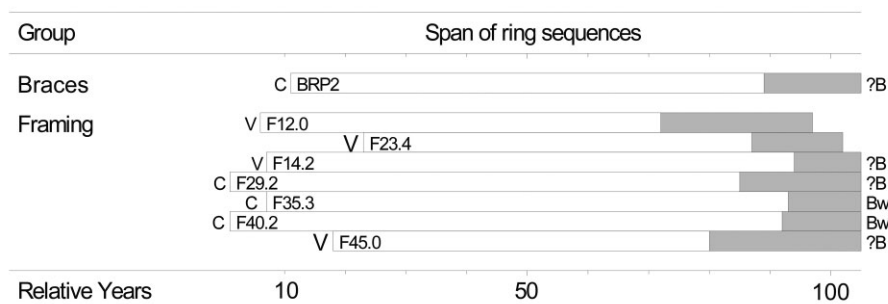
**Figure 4.** Schematic diagram of the framing timbers of the Newport Ship indicating the location of sampled timbers and timbers forming the floating mean *FramingT7*. (Nigel Nayling)**Figure 5.** Bar diagram of relatively dated framing timber ring-width sequences forming 105-year mean *FramingT7* and brace *BRP2*. The presence (C) or near proximity (V) of the pith is shown and the nature of bark edge indicated (B? = possible bark edge, B = bark edge, Bw = winter felled). (Nigel Nayling)

Table 4. Correlations (*CROS73* *t*-values) between synchronized samples of ceiling and bilge boards used to calculate mean CS1.5_BB

Filenames	BB_2988	BB_2989	CS1.5_2933
BB_2987	9.57	3.24	5.07
BB_2988	*	4.04	5.16
BB_2989	*	*	6.33

Ceiling planks

One of the two sequences could not be cross-matched against other site timbers or against British or other European chronologies. The other (CS1.5_2933) correlated against three bilge boards and the tree-ring sequences from these were combined into a single mean (see below).

Braces

A single chock or brace, BRP2_1752, has been analysed. Its ring sequence correlates against the framing mean FramingT7 with a *t*-value of 5.44 with its final ring dating to relative year 105 with surviving bark edge, the same relative felling year as the five cross-matched framing timbers with bark edge (Table 3, Fig. 5).

Bilge boards

Ring-width sequences were measured from six bilge boards and three (BB_2987, BB_2988 and BB_2989) found to correlate well with each other and with ceiling plank CS1.5_2933 (Table 4).

Finding a way forward

During the development of the Newport Ship ring-width means (derived largely from outer hull planks), the dating of this increasingly well-replicated site master remained problematic. Initial attempts to correlate sequences against established British and other European chronologies and site masters had proved unsuccessful. Appeals to dendrochronological colleagues for assistance led to the developing Newport Ship site master being compared with a wide range of ring-width data from across most of north-west Europe. It became increasingly clear that appropriate datasets for late medieval Iberia were not readily available. In 2006, the two authors started exchanging data having been introduced to each other by Xavier Agote, president of the Albaola maritime foundation based in Pasaje on the Basque coast (north-east Spain). Collaboration continued as work proceeded both on the Newport Ship post-excavation and in the Basque Country, where the Arkeolan Foundation continued to improve the time-depth, geographical extent and replication of their regional oak ring-width chronologies.

Tree-ring chronologies in northern Iberia

In many parts of north-western Europe, well-replicated ring-width chronologies have been established through dendrochronological analysis of a range of tree species exploited for shipbuilding, especially oaks and pines. The development of long chronologies providing reference data for dating historical buildings, wooden art objects and archaeologically recovered waterlogged wood structures (including boats and ships) has required decades of research by dendrochronologists in many parts of Europe. In the Iberian Peninsula, there is not a widespread or well-established tradition of such historical dendrochronological research, even though a number of suitably long-lived tree species are present in some parts of the peninsula today and a range of heritage assets including archaeological sites, historic buildings and archaeologically recovered ships survive in the region.

The Arkeolan Foundation is located in Irun, Gipuzkoa territory in the Basque Country, on the border between France and Spain. It was created in 1989 to undertake archaeological research and has run a wide range of projects including excavations, experimental archaeology, topographic studies and museum projects. Excavations in Irun in 1992 revealed waterlogged deposits on the site of the Roman port of *Oiasso* leading to the Arkeolan Foundation establishing a dendrochronology laboratory focused on the development of regional tree-ring chronologies to allow historical and archaeological dating. No regional chronologies existed for the area, so research started by sampling living oak trees (*Quercus robur* and *Quercus petraea*) (Fig. 6). The highly variable topography of the region presented a challenge—would the numerous valleys running through the often mountainous hinterland down to the coastal plain create micro-climates where oak trees' growth patterns would be very locally determined? While this might be appealing in terms of the potential for high-resolution dendro-provenancing, it also raised the possibility that only very localized chronologies could be constructed requiring a huge amount of work to produce regional coverage. A further challenge was the extent to which human exploitation and management of woodlands in the hinterland of urban centres, including ports and havens, had impacted on the surviving extent of woodland cover, on the age dynamics of trees available (that is few old trees with long ring sequences), and on the extent to which oak trees' growth had been affected by practices such as pollarding, reducing climatic response in trees and making correlations less pronounced.

A series of sampling campaigns within the territory were undertaken targeting suitable living oak trees in a wide range of environments including pollarded oaks, trees near historic Basque farmhouses known as *case-ríos*, specimens located in parks and semi-urban environments and larger forest areas with less human



Figure 6. Author Josué Susperregi taking increment cores from a living oak tree to begin construction of regional oak chronologies. (Arkeolan)

interference (Susperregi, 2007). In an attempt to cover all the Gipuzkoa territory, more than ten sites were sampled, including both coastal and inland forests. Tree ages varied from 100 up to 250 years, but in almost all cases growth was heavily disturbed by human activities. The great demand on wood from the numerous ironmongeries established from medieval times had stimulated practices such as oak and beech (and occasionally ash) pollarding. As a consequence, the use of the tree-ring series obtained for dendrochronological purposes was very limited.

In 2008, a sampling campaign was focused in the south-east part of the Alava (also called Araba) territory known as the 'Alava Mountains'. Three local chronologies were constructed from living *Quercus faginea* trees, many of which exceeded 400 years in age. The wood of this species of deciduous oak, sometimes confusingly called Portuguese oak, is presently indistinguishable from *Quercus petraea* and *Quercus robur* using microscopic wood anatomy (Domínguez-Delmás *et al.*, 2013b: 120–1). The forests from which these samples were taken (and their chronology names [in bold]) are Ermita San Cristobal (**OTE12**) and Camino De Los Alaveses (**CAV3**) near the town of Oteo, and La Muela (**BUJ3**) near the town of Bujanda (Fig. 7 and Table 5). High correlation values between these local chronologies allowed construction of a

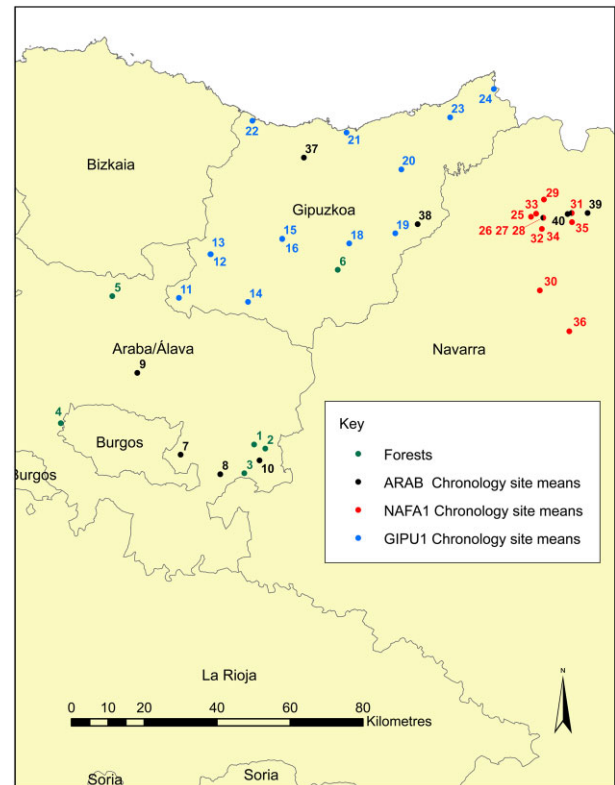


Figure 7. Locations of forests and historic buildings sampled and dated to construct regional chronologies for Alava/Araba, Gipuzkoa and Navarra. (Nigel Nayling and Josué Susperregi)

regional chronology (**MAV4**) covering the period AD 1565 to AD 2008. Significant correlations between the ring-width pattern of this regional chronology and climate variables of both winter temperature and summer precipitation indicated that trees of this species in this region contained sufficient climatic signal to permit construction of long chronologies (Susperregi and Gutierrez, pers. comm.). A further *Quercus faginea* forest near Ribera Alta in the south-west part of the Alava region was also sampled and a chronology dating from AD 1635 to AD 2003 (**QFAG3**) was constructed. Similarly, a *Quercus petraea* forest from northern Alava at El Torcornal dating from AD 1794 to AD 2006 (**MUR2**) was constructed. Thereafter, appeals were made to owners of historic buildings to allow their properties to be sampled for dendrochronological analysis and dating to increase the time-depth of this regional chronology. Samples were collected from a range of historic buildings in the region including an unnamed house in Marquinez, Venta Quintana in Quintana and Santa Cruz Monastery in Vitoria (Fig. 7), and from a carpentry workshop in Campezo where boards from historic buildings were being reused for building restoration and furniture making. Many of the historic timbers sampled comprised radial oak boards from relatively

Table 5. Dated oak ring-width means constructed at the Arkeolan laboratory from living trees, historic buildings and furniture from the Alaval/Araba, Gipuzkoa and Navarra regions. Site numbers relate to the location map

Site Number	Site Name	Town	Territory	Category	Start-date	End-date	Species	Chronology Name
1	Ermita San Cristobal	Oteo	Alava	Forest	1565	2006	<i>Quercus faginea</i>	OTEL2
2	Camino De Los Alaveses	Oteo	Alava	Forest	1582	2008	<i>Quercus faginea</i>	CAV3
3	La Muela	Bujanda	Alava	Forest	1574	2008	<i>Quercus faginea</i>	BUJ3
4	Ribera Alta	Ribera Alta	Alava	Forest	1635	2003	<i>Quercus faginea</i>	QFAG3
5	El Tocornal	Murua	Alava	Forest	1794	2006	<i>Quercus robur/peatraea</i>	MUR2
6	Lazkaomendi	Lazkao	Gipuzkoa	Forest	1810	2003	<i>Quercus robur/peatraea</i>	IBL04
7	Unknown House	Marquinez	Alava	Building	1520	1743	<i>Quercus spp.</i>	ARAB1
8	Venta Quintana	Quintana	Alava	Building	1494	1819	<i>Quercus spp.</i>	ARAB1
9	Santa Cruz Monastery	Vitoria	Alava	Building	1651	1757	<i>Quercus spp.</i>	ARAB1
10	Campezo Carpentry	Campezo	Alava	Building, Furniture	1277	1814	<i>Quercus spp.</i>	ARAB1
11	Soran Etxea	Leintz-Gatzaga	Gipuzkoa	Building	1487	1765	<i>Quercus spp.</i>	GIPU1
12	Iturrioz Street	Arrasate	Gipuzkoa	Building	1526	1597	<i>Quercus spp.</i>	GIPU1
13	Franciscanos Monastery	Arrasate	Gipuzkoa	Building	1528	1618	<i>Quercus spp.</i>	GIPU1
14	Aranzazu Sanctuary	Oñati	Gipuzkoa	Building	1697	1843	<i>Quercus spp.</i>	GIPU1
15	Iparragirre Street, N° 32	Urretxu	Gipuzkoa	Building	1569	1662	<i>Quercus spp.</i>	GIPU1
16	Iparragirre Street, N° 16	Urretxu	Gipuzkoa	Building	1445	1557	<i>Quercus spp.</i>	GIPU1
17	Iparrre Farmhouse	Redibia	Gipuzkoa	Building	1496	1639	<i>Quercus spp.</i>	GIPU1
18	Oriar House	Legorreta	Gipuzkoa	Building	1486	1630	<i>Quercus spp.</i>	GIPU1
19	Etxehaundi Farmhouse	Lizartza	Gipuzkoa	Building	1493	1599	<i>Quercus spp.</i>	GIPU1
20	Unknown Farmhouse	Andoain	Gipuzkoa	Building	1515	1675	<i>Quercus spp.</i>	GIPU1
21	Agerre-Bekoa Farmhouse	Zarautz	Gipuzkoa	Building	1495	1620	<i>Quercus spp.</i>	GIPU1
22	Bustiñaga House	Mutriku	Gipuzkoa	Building	1552	1709	<i>Quercus spp.</i>	GIPU1
23	Olalde Bekoa	Renteria	Gipuzkoa	Building	1712	1790	<i>Quercus spp.</i>	GIPU1
24	Tiendas Street	Hondarribia	Gipuzkoa	Building	1723	1797	<i>Quercus spp.</i>	GIPU1
25	Tolate House	Ituren	Navarra	Building	1511	1706	<i>Quercus spp.</i>	NAFA1
26	Batxillerenea House	Doneztebe	Navarra	Building	1548	1621	<i>Quercus spp.</i>	NAFA1
27	San Pedro Eliza	Doneztebe	Navarra	Building	1482	1584	<i>Quercus spp.</i>	NAFA1
28	Petritea House	Doneztebe	Navarra	Building	1627	1798	<i>Quercus spp.</i>	NAFA1
28	Petritea	Doneztebe	Navarra	Building	1335	1438	<i>Quercus spp.</i>	ARAB4
29	Etzegoien House	Sunbilla	Navarra	Building	1518	1667	<i>Quercus spp.</i>	NAFA1
30	Xabattenea House	Arraiz	Navarra	Building	1385	1681	<i>Quercus spp.</i>	NAFA1
31	Arretxea House	Oronoz	Navarra	Building	1477	1581	<i>Quercus spp.</i>	NAFA1
31	Arretxea	Oronoz	Navarra	Building	1299	1444	<i>Quercus spp.</i>	ARAB4
32	Donamaria Church	Donamaria	Navarra	Building	1557	1649	<i>Quercus spp.</i>	NAFA1
33	Maitxenea House	Elgorriaga	Navarra	Building	1520	1600	<i>Quercus spp.</i>	NAFA1
34	Martindonea House	Donamaria	Navarra	Building	1517	1739	<i>Quercus spp.</i>	NAFA1
35	Gorritxenea House	Zozaiia	Navarra	Building	1551	1638	<i>Quercus spp.</i>	NAFA1
36	Etzeberri House	Burutain	Navarra	Building	1386	1561	<i>Quercus spp.</i>	NAFA1
37	Lili Mansion	Zestoa	Gipuzkoa	Building	1339	1468	<i>Quercus spp.</i>	ARAB4
38	Sagastiberri Farmhouse	Berastegi	Gipuzkoa	Building	1284	1464	<i>Quercus spp.</i>	ARAB4
39	Jauregi Zahar Mansion	Arraioz	Navarra	Building	1307	1439	<i>Quercus spp.</i>	ARAB4
40	Gortaria	Oronoz	Navarra	Building	1335	1447	<i>Quercus spp.</i>	ARAB4
41	San Pedro Church	Bergara	Gipuzkoa	Building	1341	1591	<i>Quercus spp.</i>	IPB
42	Zupide Farmhouse	Bergara	Gipuzkoa	Building	1336	1489	<i>Quercus spp.</i>	CZB



Figure 8. a) Arretxea House in the village of Ornoz; b) Lili Mansion near Zestoa in the Urola valley; c) Jauregi Zahar Mansion in the village of Arraioz. (All Josué Susperregi)

slow-grown, mature oaks. Such radially split or sawn boards were found used as weatherboards on the gable ends of buildings, as roofs shingles, for floorboards and for furniture. An historical chronology for the Alava region (**ARAB1**) was constructed and cross-matched with the **MAV4** regional chronology, providing dating from AD 1466 to AD 1819 for this historical chronology.

Somewhat different strategies had to be employed in the Gipuzkoa and Navarra territories where long tree-ring sequences were rarely encountered and samples from boards were often rejected as they contained too few rings for analysis, with beams from buildings offering more dendrochronological potential. In Gipuzkoa territory, where the Arkeolan Foundation has an official heritage role, collaboration with a range of agencies facilitated the collection of samples from historic buildings which had either been demolished or were undergoing restoration. In the neighbouring region of Navarra (Fig. 7), public appeals were again used to gain access to historic farmhouses surviving in the small villages characteristic of the largely rural landscape. Mean sequences from these buildings were constructed and dated absolutely against the Alava **MAV4** living-tree regional chronology (Table 5).

In this way, it proved possible to establish three regional chronologies (**GIPU1** from Gipuzkoa dated AD 1445–1843; **NAFA1** from Navarra dated AD 1385–1798; and **ARAB1** from Alava dated AD 1466–1819), one for each studied territory, based on samples from historic buildings which were dated absolutely against the Alava **MAV4** living-tree regional chronology.

During discussions with carpenters who re-use historic timbers, it was noted that a particular form of oak board, converted by radial splitting and joined together in a ‘tongue and groove’ arrangement of longitudinal rebates, was associated with 15th and 16th-century Basque farmhouses. Samples from boards with these features were readily dated against the **ARAB1** chronology, with end dates in almost all cases confirming the suspected dating of these early Basque farmhouses. A new reference chronology for the Alava territory was then constructed including this new data, allowing extension back into the early 14th century.

Samples from all regions which had previously failed to date were then compared with the newly created chronology for the Alava region. This led to the absolute dating of timbers with end dates in the 14th and 15th centuries from buildings located in Gipuzkoa and Navarra, including earlier phases of two previously dated buildings; the Arretxea farmhouse in Ornoz (Fig. 8a) and the Petritea farmhouse in Doneztebe, both in Navarra. Absolute dates were also produced for the first time for the Lili Mansion in Zestoa (Fig. 8b) and the Sagastiberri farmhouse in Berastegi, Gipuzkoa territory, as well as for the Jauregizar Mansion in Donamaria (Fig. 8c) and the Gortaria house in Ornoz, in Navarra. The dated site means used in the construction of regional chronologies are indicated in Table 5, mapped in Figure 7 and shown graphically as bar diagrams in Figure 9.

The dendrochronological dating of buildings in Gipuzkoa and Navarra using historical timbers and living trees from Alava raises questions regarding timber transport and trade. The high correlations between the sequences suggests a common source, at least at a regional scale, and has led to the construction of an extended chronology from AD 1277–1819 named **ARAB4** with much greater replication in the early part of the chronology when compared with **ARAB1**. At present, however, it is not clear whether the source for this timber was in the Navarra or Alava region. It is interesting to note that Lili Mansion, located in the middle reaches of the Urola valley can be equated with *la casa de Lili* mentioned in a late 16th-century timber contract (Loewen, 2007: 288). Was this estate, or *casa*, involved not only in forestry but also, at least in the late medieval period, in trading timber from further inland down to the coast to supply contemporary ship-building industries?

Newport Ship—date and provenance

In 2006, when attempts were first made to date the Newport Ship tree-ring data against the Arkeolan Foundation’s growing dataset of ring-width site means and regional chronologies from the territories of Alava, Gipuzkoa and Navarra, the Iberian data did

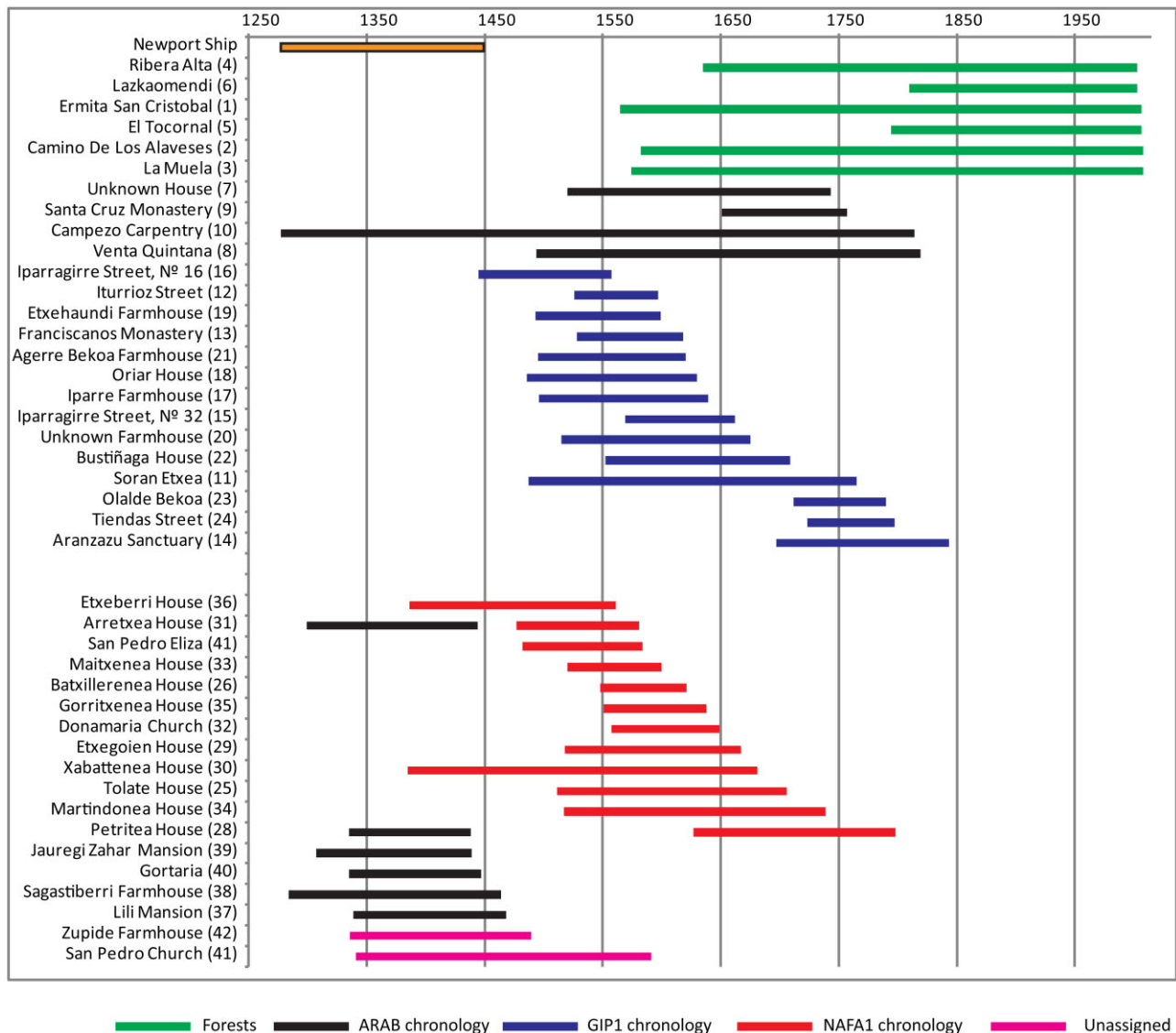


Figure 9. Bar diagram showing the absolutely dated living trees and site means used in the construction of regional chronologies for Alava/Araba, Gipuzkoa and Navarra. Numbers next to site names relate to the location map, Figure 7. (Nigel Nayling and Josué Susperregi)

not extend back in time sufficiently to provide well-replicated overlap with the Newport data. Tree-ring dating of British timber on the Newport Ship site pointed to original construction before AD 1468, and a coin found intentionally inserted into a rebate on the keel provided a *terminus post quem* of AD 1447. Low correlations between the Newport Ship mean and a range of regional chronologies from Britain, the Netherlands, Germany and France suggested a possible match for the Newport mean at AD 1277 to AD 1449. A chronology recently constructed by an independent researcher, Joxe Xabin Lizeaga, for the southern part of Navarra also overlapped this date range. However, correlations were too low to provide convincing evidence for dating, and hence this observation was not published. The low correlations achieved suggested

that no contemporary tree-ring chronologies had been constructed for the area from which the Newport Ship timbers had been derived.

In 2011, the **NewportT37** mean, notable for its high degree of replication (number of samples included), was carefully compared with the extended set of regional chronologies from the Arkeolan Foundation, and a high level of correlation was detected with the **ARAB4** chronology (Table 6). In 2012, more intensive data exchange, and a meeting of the authors at the Arkeolan Foundation, allowed confirmation of significant correlation between the Newport mean and the **ARAB4** chronology. These correlations (Table 7) suggest that the oak trees exploited to provide hull planks (and other timbers such as filler pieces and bilge boards) employed in the original construction of the

Table 6. Correlations (*CROS73* *t*-values) between site means making up the early part of chronology *ARAB4* against which the Newport Ship mean Newport T37 has been dated

Site Number	FileNames			Lili Mansion	Jauregi Zahar Mansion	Petritea House	Sagastiberri Farmhouse	Arretxea House	Gortaria
		start-dates	end-dates	AD1339 AD1468	AD1307 AD1439	AD1335 AD1438	AD1284 AD1464	AD1299 AD1444	AD1335 AD1447
10	Campezo Carpentry	AD1277	AD1689	5.63	6.16	7.1	4.32	6.41	5.41
37	Lili Mansion	AD1339	AD1468	*	6.6	3.69	3.98	3.99	4.19
39	Jauregi Zahar Mansion	AD1307	AD1439	*	*	5.79	3.16	5.45	5.1
28	Petritea House	AD1335	AD1438	*	*	*	—	4.06	3.88
38	Sagastiberri Farmhouse	AD1284	AD1464	*	*	*	*	6.8	4.38
31	Arretxea House	AD1299	AD1444	*	*	*	*	*	6.09

Table 7. Correlations (*CROS73* *t*-values) between mean NewportT37, its main subgroup NPG1T29, and from within that group NPGroup1Tree1 and regional chronology *ARAB4*, selected site masters used in its construction, and two buildings from Bergara which have yet to be included in any regional chronology

FileNames			NewpT37	NPG1T29	NPG1Tr1
	start-dates	end-dates	AD1277 AD1449	AD1277 AD1449	AD1305 AD1446
ARAB4 chronology	AD1277	AD1819	5.74	6.01	8.64
Campezo Carpentry	AD1277	AD1689	5.13	5.60	6.13
Lili Mansion, Zestoa	AD1339	AD1468	4.43	4.53	4.90
Jauregi Zahar Mansion, Arraioz	AD1307	AD1439	6.44	6.62	6.38
Petritea House, Doneztebe	AD1335	AD1438	6.32	6.04	4.62
Sagastiberri House, Berastegi	AD1284	AD1464	<3	<3	4.31
Arretxea House, Oronoz	AD1299	AD1444	4.38	4.84	5.78
Gortaria House, Oronoz	AD1335	AD1447	7.86	8.46	6.56
Zupide Farmhouse, Bergara	AD1336	AD1489	4.73	5.28	5.21
San Pedro Church, Bergara	AD1341	AD1591	4.04	3.64	4.19

Newport Ship were growing in the upland interior of the Basque coast of north-eastern Spain. The correlations support dating of the **NewportT37** mean to the date range AD 1277–1449. Although sapwood or the heartwood/sapwood boundary survived on some of the dated hull planks, in the absence of data on the sapwood behaviour of oak trees of similar age structure, species and growing location, sapwood estimates cannot be applied and hence no felling-date ranges can be determined (English Heritage, 1998: 13, fig 12).

Conclusions

At the time of the discovery of the Newport medieval ship, it proved impossible to date the timbers used in its original construction through the application of dendrochronology, and absolute dating was dependent upon associated artefacts and tree-ring dating of British timbers found underlying and overlying the ship itself. Even though collaboration with a network of European dendrochronologists was established during the subse-

quent years of post-excavation documentation of the ship and the tree-ring sequences for the ship were progressively improved, absolute dating of these sequences has only been achieved recently through improvement in the geographic and temporal coverage of oak ring-width chronologies in north-east Spain.

Dendrochronological studies undertaken by the Arkeolan Foundation have shown the usefulness of *Quercus faginea* as a species for tree-ring dating, including its ability to cross-match against other oak series (for example *Quercus petraealrobur*). Further work on the sapwood behaviour of these species is required in order to allow the production of sapwood estimates and hence felling-date ranges for dated series from archaeological and historic building timbers with partial sapwood survival. The recent felling of some 200 *Quercus petraealrobur* oaks for the construction of a replica of the *San Juan* in Pasaje may offer such an opportunity.

The advances in development of regional chronologies of oak for the Basque Country have allowed

absolute dating of the Newport Medieval ship and emphasize the importance of continued improvement in the spatio-temporal coverage of tree-ring data in this and other parts of the Iberian Peninsula. In particular, such developments will help to increase our understanding of timber supply and technological development in the shipbuilding industries of the region. Nautical archaeologists have benefited immensely in other parts of north-west Europe from the presence of dense networks of tree-ring data allowing, in some cases, a geographically precise provenance of the timber used in construction. While most of the historic buildings against which the Newport Ship sequence has been dated are located in a relatively small part of the Baztan valley, many more buildings covering the same period in Navarra and Alava need to be sampled and dendrochronologically researched if we are to locate the growth area for the ship's timbers with high precision. Only then will a suitably nuanced understanding of contemporary timber supply be developed,

both for such buildings and also the shipbuilding industry on the Basque coast. Previous attempts to construct regional chronologies with which to date the Red Bay wreck 24M (*San Juan*) proved challenging and ultimately unsuccessful (LaRoche, 2007), even where historical accounts appeared to indicate a clear pattern of near-coastal timber supply (Loewen, 2007).

Continued research focused on developing well-replicated regional tree-ring chronologies in north-east Spain, and indeed the rest of Iberia, is needed in order to realize the full potential of the dendrochronological approach throughout Europe. In developing this key tool for nautical archaeologists, we will need to concentrate our efforts on areas which supplied shipbuilding centres, but should not assume that these are all located in the immediate hinterland of the coast, as exploitation of river transport and land routes (for example Domínguez-Delmás *et al.*, 2013a: 650) made upland inland forests a viable timber resource.

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References

- Baillie, M. G. L. and Pilcher, J. R., 1973, A simple crossdating program for tree-ring research. *Tree Ring Bulletin* **33**, 7–14.
- Bayliss, A. and Tyers, I., 2004, Interpreting radiocarbon dates using evidence from tree rings. *Radiocarbon* **46.2**, 957–64.
- Besly, E., 2013, *Newport Medieval Ship Specialist Report: Coins*. Newport Medieval Ship Archive, Archaeological Data Service, York.
- Domínguez-Delmás, M., Alejano-Monge, R., Ważny, T., and García González, I., 2013a, Radial growth variations of black pine along an elevation gradient in the Cazorla Mountains (South of Spain) and their relevance for historical and environmental studies. *European Journal of Forest Research* **132.4**, 635–52.
- Domínguez-Delmás, M., Nayling, N., Ważny, T., Loureiro, V., and Lavier, C., 2013b, Dendrochronological Dating and Provenancing of Timbers from the Arade 1 Shipwreck, Portugal. *IJNA* **42.1**, 118–36.
- English Heritage, 1998, *Dendrochronology: guidelines on producing and interpreting dendrochronological dates*. <http://www.english-heritage.org.uk/publications/dendrochronology-guidelines/> (accessed 18/11/13).
- LaRoche, D., 2007, A Synthesis of Dendrochronological Studies, in R. Grenier, W. Stevens, M. A. Bernier (eds), *The Underwater Archaeology of Red Bay: Basque shipbuilding and whaling in the 16th century*, V-75-299. Ottawa.
- Loewen, B., 2007, The Basque Shipbuilding Trades: Design, Forestry and Carpentry, in R. Grenier, W. Stevens, M. A. Bernier (eds), *The Underwater Archaeology of Red Bay: Basque shipbuilding and whaling in the 16th century*, III-253-299. Ottawa.
- Munro, M. A. R., 1984, An improved algorithm for crossdating tree-ring series. *Tree Ring Bulletin* **44**, 17–27.
- Nayling, N., 2013, *Newport Medieval Ship Specialist Report: Tree-ring Analysis*. Newport Medieval Ship Archive, Archaeological Data Service, York.
- Nayling, N. and Jones, T., 2013, The Newport Medieval Ship, Wales, United Kingdom. *IJNA* **43.2**.
- Redknap, M., 2013, *Newport Medieval Ship Specialist Report: Pottery and Tile*. Newport Medieval Ship Archive, Archaeological Data Service, York.
- Susperregi, J., 2007, Oak dendrochronology studies in the Basque Country, in *TRACE-Tree Rings in Archaeology, Climatology and Ecology: Volume 5*, 35–42.
- Tyers, I., 1998, Beech Dendrochronology, in N. Nayling (ed.), *The Magor Pill medieval wreck*, 123–8. London.
- Tyers, I., 2004, *Dendro for Windows Programme Guide*. Unpublished report.