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The Bøle Ship, Skien, Norway—Research History, Dendrochronology and Provenance

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The wreck-site at Bøle near Skien was first reported in 1950 during dredging in the river. The Bøle ship is one of the most significant medieval ship-finds in Norway, and the manner of its discovery is referred to as a tragedy in ship archaeology. New investigations at the site in 2004–2006 revealed more fragments from the vessel and its cargo, and the ship is now the object of new studies. This article presents a description of the ship and its context, and the results of an initial dendrochronological analysis and provenance determination.

Key words: medieval cargo ship, dating, provenance, dendrochronology, trade.

'Bøleboen' is the name given to a point in the middle of the Skien River in Telemark, Norway (Fig. 1). The Norwegian word 'boe' is a local place-name for a bank or dangerous part of the navigation channel, but the name 'Bøleboen' does not have this association today—there is no longer any obstacle to shipping traffic at this spot. However, there was formerly an obstacle and in 1959 it was considered necessary to dynamite the bank which had long caused difficulties for shipping bound for the port of Skien. It emerged that what was thought to be a natural formation was a shipwreck with an almost-intact hull, full of sand and clay (Molaug, 1960: 7). In retrospect this find, hereafter called the Bøle ship, is one of the most significant medieval ship-finds in Norway—and the manner of its discovery is referred to as a tragedy in ship archaeology (Nymoen, 2005).

The preserved remains of the ship and its cargo are now the object of new studies. This article is a short introduction to the history of the find,

Figure 1. Map showing A: the Telemark region, B: the sea route to Skien and C: section of the Skien River where the location of the 'Bøleboen' is reconstructed on the basis of old and new maps (geo-referenced). The positions of registered ship's parts are marked. (Jostein Gundersen)

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Figure 2. The sight that confronted museum representatives when they visited the site. The find is seen as a tangle of loose parts stored on a barge. The ship's keelson can be glimpsed in the middle of the photograph. (Varden newspaper, 29 September 1959).

the ship and its context, together with related archaeological issues. Moreover the article provides a presentation of the results of an initial dendrochronological analysis and provenance-determination conducted in 2006 on oak from the ship.

Research history

When it became known that what had been dug up from the river was an old ship, the Norwegian Maritime Museum was alerted. The director at the time, Svein Molaug, who immediately visited the place to view the remains, wrote in a short item in the museum's annual report that year: 'The wreck was completely torn apart by the dredger bucket and was stored on a barge. It is a clinker-built ship. The dimensions of the keel and hull are unusually large' (Molaug, 1959: 10). A photograph in a local newspaper illustrates the sight that confronted the museum representatives when they arrived to look at the find (Fig. 2). Marine archaeology was in its infancy in Norway in 1959 and the museum did not have resources to conduct archaeological investigations at the find-site. However, all the ship's parts dug up from the river were taken care of, drawings were made of the majority of them, and they were then transported to the museum where they have been stored ever since.

For a long time there was uncertainty as to the age of the ship and it was assumed that it was from the Middle Ages. However the first two ^{14}C-datings carried out in 1961 did not lead to clarification; they gave 1400+/–100 BP (T240A) and 1300+/–100 BP (T240B) respectively. Reidar Nydal commented on these results as follows: 'No ^{13}C analysis made on the two (independent) samples, but the error from isotopic fractionation would hardly exceed 100 yr. On the other hand it is hard to believe that the material was *c*.1000 yr old when the ship was built. Other possible sources of error in the ^{14}C measurement are considered negligible' (Nydal, 1962: 178).

When the Bøle ship was found, archaeological knowledge of medieval ship-types was relatively limited. Typological dating was based solely on a few other finds in Scandinavia. For example, a considerable amount of fresh knowledge about vessels and construction-details from that period was gained from the publication of investigations in Kalmar (Åkerlund, 1951) and from the Kolding ship in Denmark (Hansen, 1943). In Norway the comprehensive archaeological excavation of medieval cultural layers at the Bryggen wharf in Bergen, beginning in the 1950s, provided new source-material for ship research. More than 500 boat-parts were registered there and Christensen (1985: 47) describes one of these in the following manner: 'From the deep foundations built after 1332 came the huge beam. ... At first this carefully-squared timber with its curious heads at either end caused much speculation, until with help of

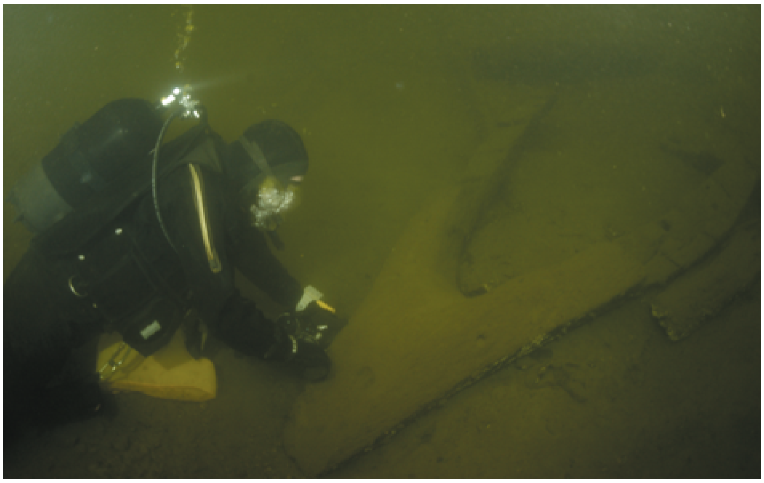

Figure 3. Documentation of loose ship's parts from the Bøle ship found in 2005. (Yngve Ask)

Åkerlund's Kalmar publication it was finally determined to be a ship's beam. Such head-crossbeams were also among the ship's parts that came up in the dredging of the Skien River and they constituted an important element in the typological dating of Bøle ship (Molaug, 1960: 7; Christensen, 1962; Nydal, 1962: 178).

An important part of the historical impact of the Bøle ship-find is the interest and involvement it created and the many questions it raised. Not least the divergence between ^{14}C and the presumed typological dating, which generated a lot of discussion. Long after the find, quite heated discussions were conducted in newspapers about what kind of vessel it had been and how old it was (Hvitsand, 1960; Falck-Muus, 1962; Molaug, 1962; Østvedt, 1962; Hvitsand, 1977). The story of the Bøle ship-find enjoys a special place in Norwegian ship-archaeology, particularly because it increased awareness of underwater cultural heritage. It became a milestone in the development of the administration of ship-finds in Norway, both because the potential acquisition of completely fresh knowledge about underwater cultural heritage became so concrete, and because it provided such a clear illustration of the threats to such finds. The newly-acquired recognition that there might be well-preserved ships and boats hidden in sea and inland waters led shortly afterwards to the incorporation of provisions on ship-finds into the Norwegian Cultural Heritage Act. In writings preparatory to the Act, experiences from the Bøle ship-find and the damage that occurred are mentioned explicitly (Proposition no. 23:1 to the Odelsting). During the almost-50 years that have passed since the ship was found, more than 20 medieval vessels have been found in Norway (Nævestad, 1999). Few of these lie in fresh water and none of them can be said to be as well preserved as the Bøle ship. Among other factors that make this find unique are the type of ship, the cargo and the context of the find. The ship is described in books and articles on local history, and in a wide range of media coverage from 1959 to the present time. However, it has not been the object of more comprehensive research and scientific publication.

The Bøle ship is once more in the news, again due to planned construction work in the Skien River. The difference is that this time the Norwegian authorities require the developer to undertake an archaeological investigation of the find-site. In 2004 extensive underwater-archaeological investigations were started on site (Nymoen, 2005). This was the first time that dives had been carried out in this locality and there was great surprise when it was discovered that several parts of the vessel were visible on the river-bed (Fig. 3). A new ^{14}C sample was taken from these new finds, this time from the outer wood of one of the framing timbers. The result gave 630+/–50 BP (2 Sigma cal. AD 1280 to 1420 (Beta-190133)). Although the latter dating gave a more probable result, tests using ^{14}C dating reveal that in some cases, radiocarbon determinations, when calibrated, can produce date ranges which archaeologists find unacceptable, particularly in historic periods.

A decisive factor for the methodical demarcation of the area to be investigated was the discovery of a hand-drawn topographical map of the river in

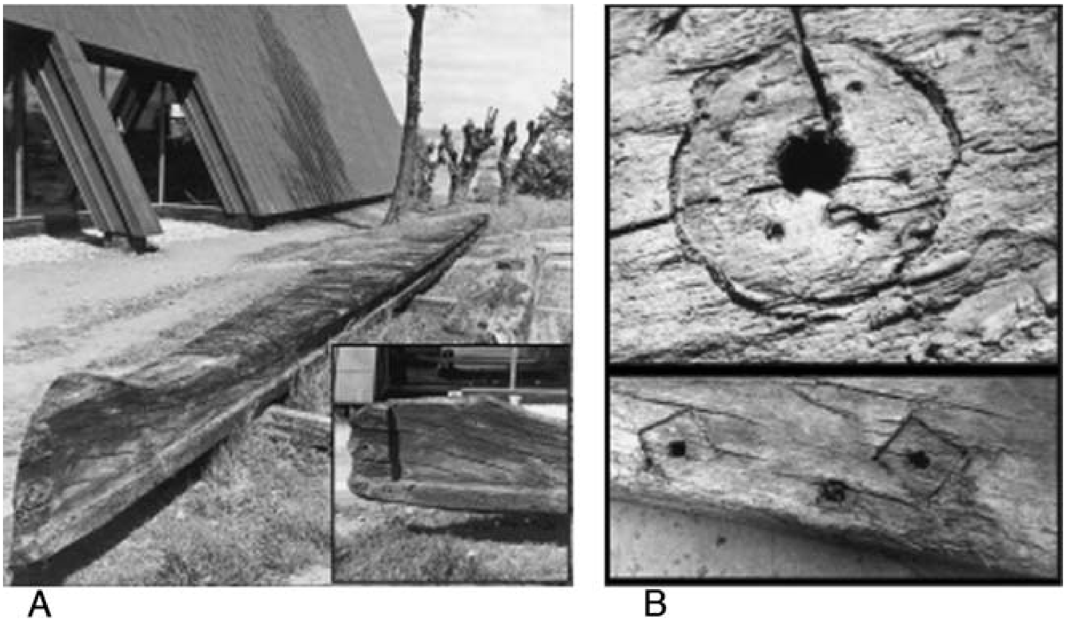

Figure 4. A: the ship's keel suggesting a stern rudder, and B: marks on the timbers of the ship's fastenings. (Norwegian Maritime Museum)

the archives (Dahl, 1937). The map was made prior to the start of the dredging operations to remove the ship, and it shows the position of the 'Bøleboen'. This map has therefore been geo-referenced to a modern contour map, so that the earlier topographical situation could be re-created. In this manner new finds of ship's parts and cargo from the vessel can be measured and plotted on the old map (Fig. 1c). The field investigation, which was completed in December 2005, resulted in the discovery of important construction details, most of which were extremely well preserved, providing opportunities to study the traces of tools and other details.

The ship

A key issue in the project has been to find out as much as possible about the building method and construction of the vessel. All the parts which have been preserved have been drawn and form the point of departure for a cardboard model at the scale of 1:10 that will also be scanned. It is quite a challenge to form the clearest possible picture of the vessel's construction from a huge jigsaw puzzle with 600 pieces. Since the work is still in the initial phase, we can only make a qualified guess about the shape of the ship. Based on finds made in the most recent investigations, collated with the parts preserved as a result of the dredging in 1959, it appears that the ship was somewhat longer than 20 m. A low, broad 16-m oak rabbetted keel has been preserved. The Bøle ship was apparently a mixture of both the cog and Nordic building traditions. An example of the cog influence is the use of caulking laths on the inside of the strakes (Christensen, 1985: 100–101, 111 fig. 18). The ship was clinker-built and it appears that it was mostly built of oak. There are traces on some strakes that may indicate that they had been sawn. Marks in the strakes show that the iron nails had round heads up to 5 cm in diameter (Fig. 4B). On the inside the nail-heads had several small pins which went into the timber, presumably to lock the iron nails into place and to prevent the planks from cracking. Similar marks made by nails were found in the Kollerup cog as well as other ships (pers. comm. Flemming Rieck; Bill, 1994: 57 fig. 2).

The hull of the Bøle ship was stiffened with cross-beams and the head of the beams was visible on the outside of the ship. The mast-fish and keel suggest that the vessel had a mast placed amidships. The shape of the keel's stern suggests that there was a stern rudder (Fig. 4A), while the fastening of the stem-block indicates that the bow was slightly curved. The investigations of the preserved parts so far indicate that this was a capacious and stable cargo vessel with a curved stempost and a relatively straight sternpost (Fig. 5). In other

Figure 5. A wooden model on the scale of 1:10 composed of the parts of the Bøle ship that were preserved after the dredging activities in 1959. (Norwegian Maritime Museum)

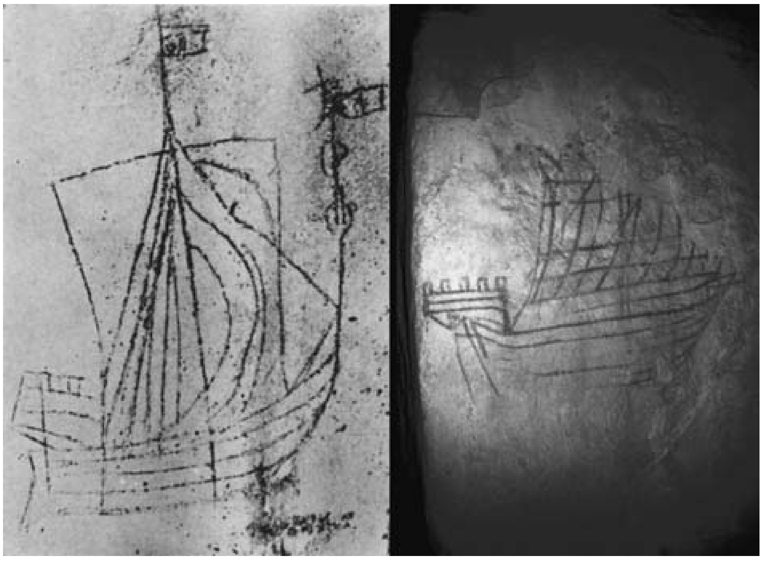

Figure 6. Two drawings of ships from the 14th century. Left: Trondenes Church, Nordland, Norway. (Pettersen, 1965: 53) Right: Siljan Church, Telemark, Norway. (Pål Nymoen)

words this is a vessel built for large cargoes and for ocean travel. With some reservations the boat can be pictured as similar to a number of boats in 14th-century chalk paintings of ships in Norwegian churches (Fig. 6). A medieval wooden ship-model preserved in a church in Ebersdorf, in Germany (Steusloff, 1983), may be regarded as an interesting parallel to the Bøle ship. The model (Fig. 7) shows a clinker-built boat with an inward-curving bow, straight stern and cross-beams with protruding heads, a shape that may prove to be a distinguishing feature of the so-called 'hulk' type of ship. A cross-beam over the sternpost may indicate that the model originally had an aft-castle that was similar to the drawings of medieval ships shown in Fig. 6. Christensen (1987: 70) regards the 'hulk'—a designation used of large northern-European trading vessels from the mid-to-late Middle Ages as a 'ship which has borrowed constructional details from both cogs, Nordic keeled vessels, and also probably from the older holk type'. The ship-type 'hulk', used of medieval trading and cargo vessels, is primarily derived from different historical sources and illustrations. Up to the present there are few archaeological examples and according to

Figure 7. Professor W. Steuslof, Deutsches Shiffahrtsmuseum Bremerhaven with ship-model from Ebersdorf. (Arne Emil Christensen, with permission)

Christensen (1987: 70): 'So far the only ship-find which can possibly be interpreted as a holk is the wreck from Bøle in the Skien river, Norway, briefly published by Molaug'.

Context of the find

Large quantities of light-grey schist were found together with parts of the Bøle ship. These stones are in all probability raw material for whetstones, and the find is interpreted as being part of the cargo (Nymoen, in press). The provenance of the stones has been analysed by a geologist who considers Eidsborg in Telemark to be the most likely source, based on studies of the mineral's petrography (Dons, 1990). The cargo of whetstones therefore indicates that the most probable maritime explanation for the accident is that the ship was on its way down-river bound for Skagerrak when it sank, only some 100 m from the harbour in the town of Skien (Fig. 1B). Archaeological investigations in Skien have revealed that the first stage of a permanent settlement there can be dated to the early Middle Ages (Myrvoll, 1992a), and that trade in whetstones played an important role in the growth of the town (Myrvoll, 1984; Myrvoll, 1985; Myrvoll, 1992b). The Telemark region is also well known for other export articles such as iron and timber, but in archaeological studies of the trade in commodities from the region there is a special focus on whetstones. It is uncertain when trade with whetstones from Eidsborg began but finds from England (Ellis, 1969; Moore, 1978), Germany, Poland, Sweden and Denmark (Mitchell *et al.*, 1984) indicate that considerable quantities of whetstones were quarried and freighted to Skien as early as the 10th century.

From the Middle Ages onwards whetstones became one of the most important export articles from the region and from the 12th century they are to be found in all the major trading centres in the countries around the North Sea (Myrvoll, 1986: 174; Elfwendahl and Kresten, 1996: 80). There are also several examples from the Middle Ages onwards of written sources which document the export of whetstones from Norway (Falck-Muus, 1920; Bugge, 1925; Nedkvitne, 1983). A clear picture of the importance of the medieval trade in whetstones is given in a Letter of Privilege from the King conferring on Skien status as a market town in 1358. In this letter it is stated that the citizens of the town can 'engage in trade in whetstones and other items in accordance with old practice' (Seierstad, 1958: 36; Johansen, 1963: 18). In a written source from the second half of the 16th century mention is made of the loading of whetstones on board ships in connection with the export of timber from the region (Friis, 1877; Østvedt, 1963). The source indicates that whetstones functioned at this time as combined ballast and goods, and also paints a clear picture of the export of whetstones as a part-load in the timber trade. The close links between the shipment of timber from Skien and the freight of stones down the 120 km of waterways from quarries in Eidsborg to Skien has been well documented in recent times (Tveitane, 1981; Livland, 1992). Despite the extensive export of whetstones over a long period, only a few shipwrecks are known of in northern Europe in which this commodity has been found to be part of the cargo (Nymoen, in press).

To sum up this introduction to the Bøle ship, it can be said that despite the regrettable way the vessel was found and also the fact that there are so many loose parts, the ship is a very well-preserved medieval cargo ship. The fact that the ship was buried in sand in brackish water has resulted in the preservation of a considerably larger part of the ship than is often the case with ship-finds in salt water. Thus the ship constitutes important source material for the study of a ship-type that is little known.

Moreover we note that the ship sank with its cargo close to the port of trade that stood for the main supply of whetstones to the countries around the North Sea in the Middle Ages. The context of the find therefore constitutes an unusual direct source of knowledge of several stages in a maritime trade-route branching out along waterways far inland. The Bøle ship also represents a valuable source for the study of transport-networks and the trans-shipment of particular commodities around the North Sea and this raises a number of interesting questions in a cultural-heritage perspective as regards extent, continuity and organisation.

A more precise dating of the construction of the vessel than that provided by the ^{14}C method was regarded as of importance. For this reason a dendrochronological investigation was given priority in the follow-up work. In addition, clarification of the provenance of the ship's timber was also regarded as of key significance, particularly in connection with further studies of the ship-type and the source value of the find.

Dendrochronology

Dendrochronology is a precise method of dating ancient timber. When bark is preserved on a timber from an archaeological excavation or from an ancient standing building, a date to an exact calendar year is possible. This means that activity at archaeological sites, and phases of construction in buildings, can be compared with the historical record, allowing an enhanced understanding of the past, enriching both the archaeological and historical disciplines. Trees produce a tree-ring annually and a tree-ring is wide if the tree is thriving and narrow if conditions are not favourable. Two trees of the same species, growing simultaneously in the same region, have similar patterns of wide and narrow rings, as the climate (temperature and precipitation) of the region affects the trees similarly. Dendrochronologists have been working throughout Europe over the last 40 years building 'chronologies', where samples from living trees are 'cross-matched' with tree-ring measurements from historic buildings and archaeological sites, gradually building a reference of the annual ring width for every year, covering several millennia in certain regions, for several tree species. The tree-rings of new timber finds, of unknown date, can be measured and compared with these regional chronologies, and when the position where the tree-ring curve fits with several chronologies with high statistical correlation, the sample is dated.

Provenance

Dendrochronology though, offers additional information about ancient timber. The greater the distance between trees, the less similar the tree-ring pattern is. When chronologies are built for certain regions, a dated timber of unknown origin should be most similar to the chronology for the region from which the timber comes. Having found the date for an oak shipwreck, its tree-ring pattern is tested against a network of oak chronologies, using a correlation statistic (in dendrochronological analysis the most widely-used correlation statistic is the *t*-value (Baillie and Pilcher, 1973)). Thereby, the degree of similarity between the ship and the different chronologies is measured. The higher the *t*-value achieved, the more similar the ship's tree-ring curve is to the chronology.

Current research into the way in which the determination of the provenance of ancient oak timber is carried out has its emphasis on refining the method so that provenance can be determined to within smaller areas. Oak tree-ring data from Northern Europe, analysed in dendrochronology laboratories in several countries and collected into a large database for an EU-funded project in the 1990s entitled 'Tree-ring Evidence of Climate Change in Northern Eurasia During the Last 2000 Years', is the data source for this research. (The initial EU project was extended to 'Analysis of Dendrochronological Variability and Associated Natural Climates in Eurasia—the last 10,000 years', and results are published in *Holocene* 12.6 (2002), where a whole volume is devoted to presentation of the work. One of the papers on the oak results is for example Kelly *et al*., 2000). The oak tree-ring data consists of measurements of single trees, both living trees and from historical/archaeological building timber, from 2304 sites. This data is being grouped into smaller units, to move away from the large regional chronologies (Daly, 2007a).

The provenance-determination method can now often be carried out on three levels. First the ship is tested against the large regional master-chronologies, secondly against the site-chronologies,

Figure 8. The pile of Bøle ship timbers found in the 1959, in storage at the Norwegian Maritime Museum. (Aoife Daly)

and thirdly against all single trees in the dataset. Using GIS to plot the results geographically, distributions of correlation for a ship can then be produced, which can be used both to interpret and to illustrate the result. Consistency in the colours used in the maps means that the reader is never in doubt as to which test level is illustrated: Blue dots indicate the first level test, against master-chronologies; green dots the second-level test, against site-chronologies; and red dots the third-level test, against individual trees (Daly, 2007a; 2007b).

The results

Timbers from the original dredging in 1959 were still stored at Norsk Sjøfartsmuseum, and it was decided that these could be examined with a view to choosing suitable timbers for an initial, exploratory dendrochronological analysis. When sampling took place on 19 April 2006, by conservator Pål Thome from Norsk Sjøfartsmuseum and the authors, it was found that a great many suitable timbers were available, including many planks and a big pile of frames (Fig. 8). Despite these timbers having been salvaged from the fjord nearly half a century ago, their condition of preservation was quite remarkable. Only superficial treatment of the timbers' surface had been carried out, but the pieces were solid, dry and in a stable condition. Two timbers from the recent (2005) salvage were also examined. From the large pile of timbers it was not easy to extract many timbers, and it was preferred that timbers which were already incomplete (broken in the dredging operation presumably) should be sampled, while more-complete timbers should not be sawn, out of concern for a future museum display of the ship. It was therefore difficult to find timbers with sapwood preserved, but of course the samples were sawn at the place where the outermost rings were preserved. In the end ten samples were sawn, four planks, and six beams/frames, providing a potentially good basis for this initial analysis. On one of the planks, sapwood was preserved. The dendrochronology sample from this plank is shown in Fig. 9, where the sapwood-rings are clearly visible on the prepared section.

Figure 9. Of the samples analysed, just one had sapwood preserved, clearly visible in this photograph of the outermost portion of plank Z005007 (x3). (Aoife Daly)

All ten samples were measured and nine are dated. All the timbers were from very slow-grown trees, that is, the tree-rings were very narrow. The plank timbers had a quite regular growth though,

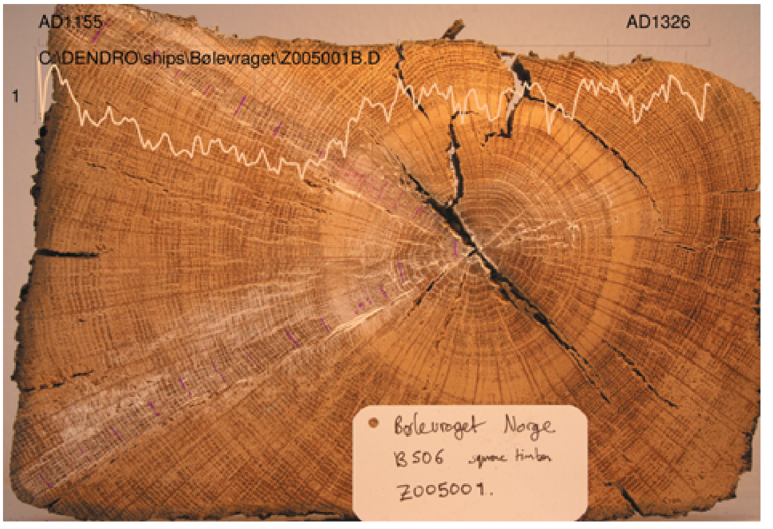

Figure 10. Photo of the tree-rings for sample Z005001 (B506) (Aoife Daly) and the tree-ring curve produced from the measurements. Note the period of very narrow growth. Only the outer 92 rings of this sample were used in the dating and provenance determination analysis.

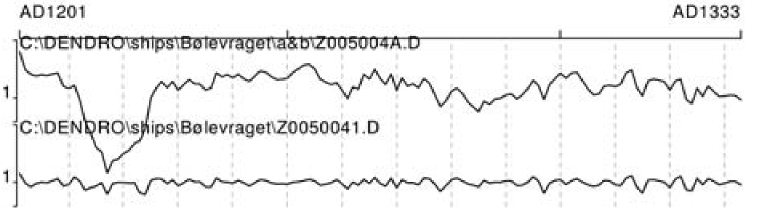

Figure 11. Diagram showing the actual measurements of sample x1 (Z005004A) and the calculated filtered tree-ring curve for the same sample (X0050041), thus reducing the extremely narrow portion at the start of the tree-ring sequence.

in contrast to the timbers used for the frames/beams. Two of the frame/beam timbers showed periods where the tree had formed extremely-narrow rings, in one case so narrow that it was impossible to achieve a reliable measurement of the rings across that phase (Fig. 10). For this sample, only the outermost 92 rings were included in the analysis. The tree-ring measurements from the second beam, Z005004 (X1), with an extremely narrow band of rings, was filtered with a five-year running mean to reduce the extreme jump in the tree-ring curve as illustrated in Fig. 11. The filter replaces each tree-ring width with an average of itself and the two widths on either side of that width (5 year running mean (Tyers, 1997)).

The diagram (Fig. 12) shows the chronological position of the nine dated timbers. The sapwood preserved on sample Z005007A (X3) is indicated in darker grey. Allowing for missing sapwood, using a sapwood statistic for Polish timber of *c*.15 rings (−5+15) or in other words adding an estimate of missing sapwood from between *c*.10 to 30 rings (Ważny 1990, 184–7), the felling-date for the tree from which this plank was made is calculated to lie in the range AD 1376–96. The ship was most probably built in this period. Of course, a more specific date for the felling of the timber for the ship requires that samples with complete sapwood to bark edge preserved be analysed. This would be one of the aspects to be addressed in any future dendrochronological study of the ship.

The internal correlation matrix (Fig. 13) gives an indication of the internal correlation between the dated timbers. The planks have a relatively high internal correlation, but these match not so high with the frames/beams. Four of the frames/beams similarly match well together, while a fifth only matches well with one other. The correlation of the tree-ring curves from the ship can indicate several sources for the timber, where the planking is made from oaks from one source, while two sources for the frame/beam timbers might be represented. Two means have been made of the tree-ring data from the ship. One (Z005M003) is

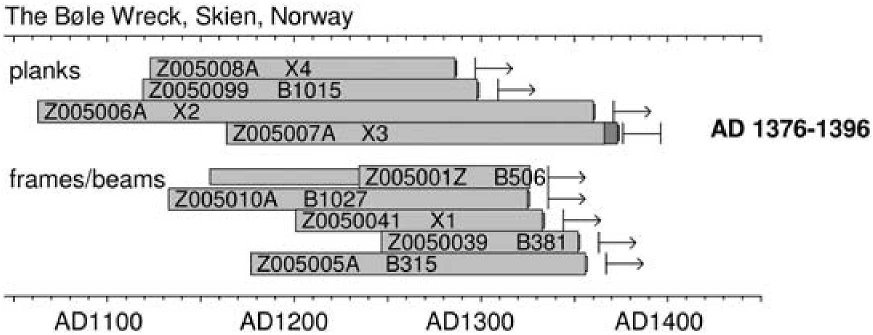

Figure 12. Diagram showing the relative position of the dated samples from the Bøle ship. Each bar represents the period covered by the tree-ring curves. Heartwood is coloured light grey, while sapwood is in dark grey. (Rings that have been counted but not measured are represented by a narrower bar, as in the case for Z005001 (B506), as shown in Fig. 10.) One sample had sapwood preserved, allowing a felling date for the trees to be estimated. The oaks were felled within the period AD 1376–96.

		Z0050041	Z005001Z	Z0050039	Z005005A	Z005010A	Z005006A	Z005007A	Z005008A	Z0050099
BEAMS	Z0050041	*	3.23	4.02	4.52	< 3	3.82	4.64	4.17	< 3
	Z005001Z	3.23	*	10.63	< 3	< 3	< 3	< 3	< 3	3.10
	Z0050039	4.02	10.63	*	5.12	< 3	< 3	3.84	< 3	< 3
	Z005005A	4.52	< 3	5.12	*	5.34	< 3	5.19	3.84	< 3
	Z005010A	< 3	< 3	< 3	5.34	*	< 3	3.34	< 3	4.13
PLANKS	Z005006A	3.82	< 3	< 3	< 3	< 3	*	7.39	4.75	3.41
	Z005007A	4.64	< 3	3.84	5.19	3.34	7.39	*	6.92	< 3
	Z005008A	4.17	< 3	< 3	3.84	< 3	4.75	6.92	*	5.00
	Z0050099	< 3	3.10	< 3	< 3	4.13	3.41	< 3	5.00	*
		1	1	1	1	1	1	1	1	1

Figure 13. Internal correlation matrix (t-value) for the Bøle ship.

the mean of the measurements from the four planks, while the second (Z005M002) is a mean from the four beams/frames that match best together (Z005001Z, Z0050039, Z0050041 and Z005005A). Using these two means, and the remaining single sample measurement (Z005010A), three maps can be produced at the first-level provenance test, the ship's three possible source groups against the large regional master-chronologies.

Frames/beams

First we will take a look at the results for the ship frames/beams. The correlation result for the four frames/beams averaged together (Z005M002) against master- and site-chronologies for Northern Europe, is shown in Fig. 14. In this map, two levels are included in the provenance test. The test with master-chronologies is shown in blue, while the second-level test with site-chronologies is in green, as described above. The highest values are labelled and are achieved with several sites from along the southern Baltic coast. By far the highest value, t = 12.07, is with a chronology from Kołobrzeg on the western Polish coast. Note also the high values from other Polish sites around the Gulf of Gdansk. Two quite high values

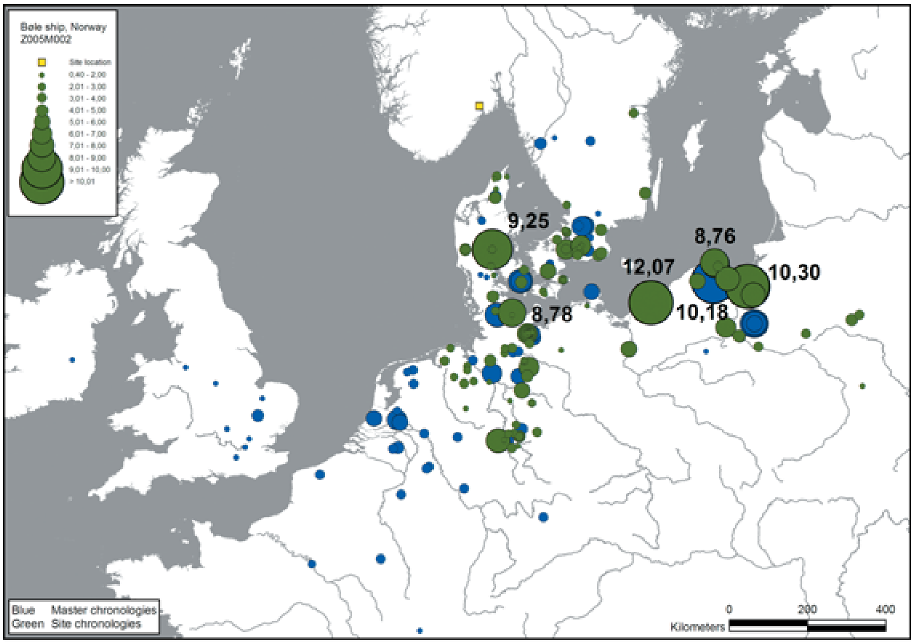

Figure 14. Map of Northern Europe showing the distribution of correlation values (*t*-values) between the tree-ring curve from four beams from the Bøle ship (Z005M002) and master and site chronologies in Northern Europe.

appear further west, one in Northern Germany, which will be discussed below, and another in Denmark. The Danish material that the Bøle beams match so well with ($t = 9.25$) is actually a barrel, from a late-14th-century fortified site at Boringholm in Jutland (Daly, 2005). The barrel is made from southern Baltic oak.

It might be noted here that the site-chronologies for the Scandinavian and German sites are built from the EU-project data described above, while the site-chronologies used in this and the following maps for the Polish region have been built by Ważny (Haneca *et al.*, 2005). Another aspect which should be noted is that the EU-project data has accumulated in the different dendrochronology laboratories until 1996. The last ten years of dendrochronological data production is missing from the single-tree dataset. This is significant here, as some of the Polish chronologies used in this and subsequent maps have been built by Ważny since the EU-project data gathering (pers. comm. Tomasz Ważny).

The test of the provenance of the beams from Bøle, at the third level, with single trees, illustrates what this means (Fig. 15). In this, where the beam average is tested against single trees, the highest value is with a tree-ring sequence from Gdansk, but note that the next highest is with a timber from Kiel. Several aspects need to be explained in this result. Firstly, why do no high values appear with single trees from Kołobrzeg, when the Kołobrzeg chronology gave the highest correlation in the provenance-test against the master-chronologies? This is quite simply because the tree-ring data used in Ważny's Kołobrzeg chronology is not included in the EU-dataset and hence no single-tree data from this chronology are available for comparison.

What then explains the very high value with the 'Alte Feuerwache' site in Kiel? When the sample and site-mean from the Kiel site are tested against the Northern European master chronology network, it becomes clear that the timber from this site was imported from the southern Baltic region. The Bøle ship is actually allowing the identification of southern Baltic timber in Western European historical sites. The two provenance tests for the frames/beams from the Bøle ship allow the conclusion that indeed the source of the timber for the ship frames is in the coastal southern Baltic region. The test, however, also clearly illustrates some of the problems which can be encountered when dealing with a dataset that is only partly complete, and in a period where problems of exported/imported building timber in the provenance determination tool are emerging. The gap in the single-tree data for the north-eastern German region is also obvious in this case. Future collaboration should rectify this problem, and, in the future, detailed

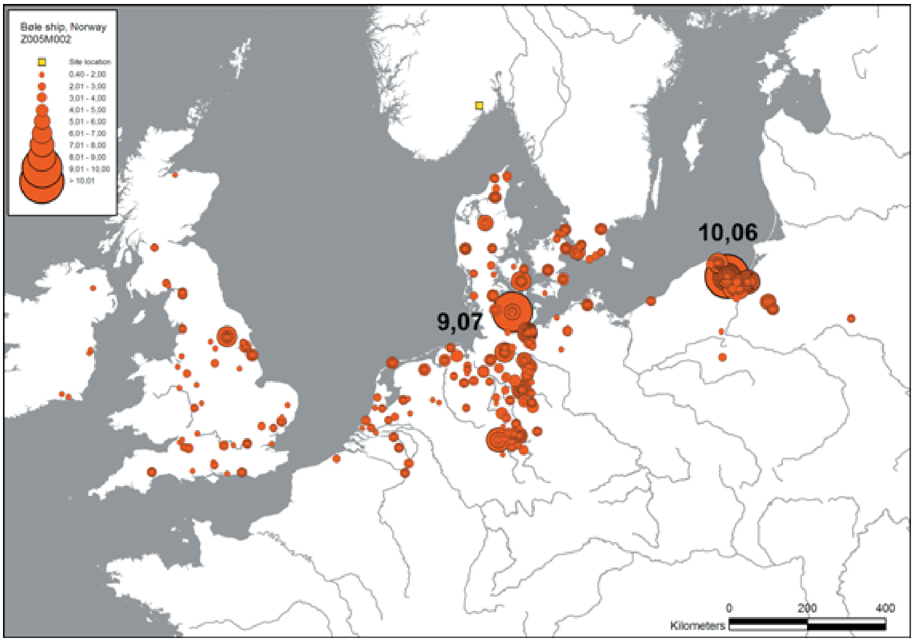

Figure 15. Map of Northern Europe showing the distribution of correlation values (*t*-values) between the tree-ring curve from four beams from the Bøle ship (Z005M002) and individual tree-ring measurements from sites in Northern Europe.

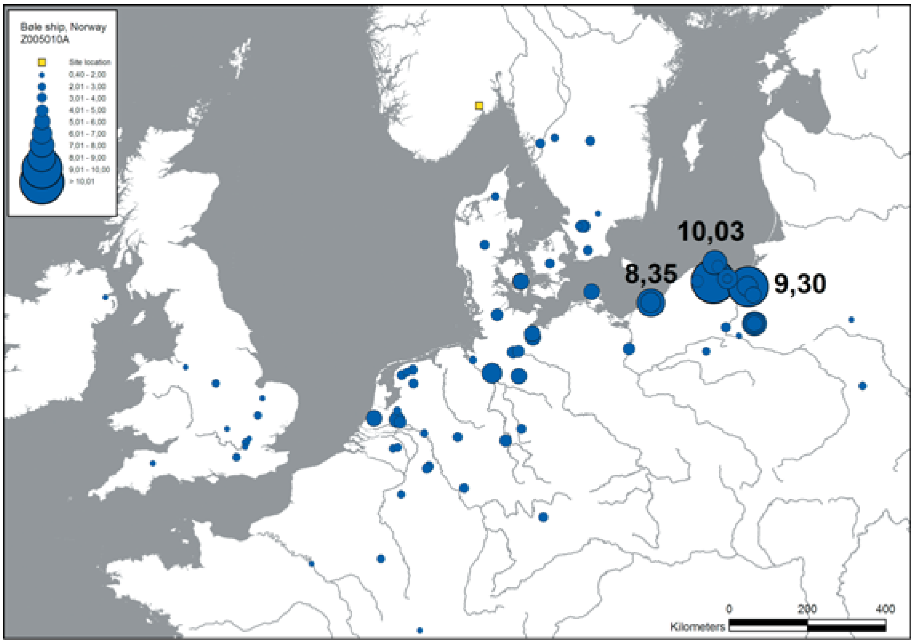

Figure 16. Map of Northern Europe showing the distribution of correlation values (*t*-values) between the tree-ring curve from one beam from the Bøle ship (Z005010A) and master-chronologies in Northern Europe.

provenance determination for many of the southern Baltic timber finds in the European archaeological record might be improved.

The remaining beam, Z005010A (B1027), is dealt with separately as the correlation between it and the other analysed samples from the ship is not strong. The map illustrated in Fig. 16 shows the correlation for this beam with master-chronologies, the first-level provenance test. Even though we are here dealing with just a single sample, a very clear correlation distribution indicates that this tree grew in the coastal region

Table 1. *Table showing the correlation between tree-ring curves from the beams from the Bøle ship and a selection of master-, ship- and barrel-chronologies.*

	start dates	dates end	M004 AD1235 AD1352	0041 AD1201 AD1333	005A AD1177 AD1356	
Denmark	109BC	AD1986	—	3.20	5.46	Jutland Funen (NM)
Germany	AD1023	AD1723	—	3.09	4.78	Lübeck (HU)
	AD436	AD1460	—	4.36	7.41	Schleswig-Holstein (HU)
	AD915	AD1873	—	5.36	6.34	Lower Saxony (GU)
Poland	AD1100	AD1529	—	3.14	4.04	Vistula (pers. comm. Tomasz Ważny)
	AD1121	AD1398	5.19	5.35	6.07	Gdansk St. Nikolaus (pers. comm. Tomasz Ważny)
	AD996	AD1985	4.64	4.99	9.90	Gdansk Pomerania (Ważny, 1980)
	AD980	AD1347	3.66	4.70	11.14	Elblag (pers. comm. Tomasz Ważny)
	AD1067	AD1393	7.28	6.39	9.51	Kolobrzeg (pers. comm. Tomasz Ważny)
Ships of Polish	AD1109	AD1370	6.80	7.84	9.62	Vejby ship, Denmark (Bonde and Jensen, 1995)
provenance	AD1155	AD1353	6.96	4.52	8.90	Lille Kregme ship, Denmark (Eriksen, 1992)
	AD1117	AD1391	5.46	4.70	8.74	Avaldsnes ship Norway (Daly, 2007)
Barrel	AD1145	AD1368	5.15	5.94	7.13	Boringholm barrels 2 lids & 3 staves (Daly, 2005)

around the mouth of the Vistula river, matching best with a large chronology for Gdansk-Pomerania (t = 10.03). Why is this t-value distribution much clearer than the distribution for the four beams which have been dealt with as a homogeneous group? For the single beam Z005010A a neat cluster of high values appears. For the four-beams group though, the very high values are quite widely spread geographically, which leads to the possibility that the four frames/beams in fact should not be grouped together after all. Looking at the correlation matrix again it might be argued that in fact these four frames are not so homogeneous, and that only two, Z005001Z and Z0050039 should be averaged together. In other words, the source of the timber represents a wider geographical region.

What then happens if we subject the tree-ring data from the frames individually to the provenance determination test? The match between Z005001Z and Z0050039 is very strong, so we can at least treat these two timbers as one unit. Correlation then between the three tree-ring curves and a selection of chronologies is illustrated in Table 1. Clearly the highest values appear in all three tree-ring curves with Polish references. There is, though, a difference as to which of the chronologies each curve matches best with. The average values for each tree-ring curve are different, with generally higher values for 005A, which is most likely due to the fact that its tree-ring sequence is longer than the other two (005A contains 180 rings, while M004 and 0041 contain 118 and 133 respectively). Note, then, that 005A achieves the highest t-value with a chronology from Elblag, near the Gulf of Gdansk, while the highest values for the other two curves appear with the chronology from Kołobrzeg, further west along the Polish coast. (In fact, the three samples which seem to match best with the north-west Polish chronology are the two which have bands of extremely narrow rings (Z005001Z and Z0050041) and the one which fits very well with Z005001Z (Z0050039). Its centre was decayed away so it cannot be determined as to whether it also had a band of extremely narrow rings, but the decayed portion is at the same chronological position as the other samples' narrow ring phases.)

We might be seeing here evidence for several sources for the oak used for the frames. Analysis of a larger number of frame timbers might allow a better grouping of the oak internally in the ship, allowing a clearer picture of the timber groups, and perhaps allowing a clearer provenance conclusion.

Planks

As explained above, the planks are dealt with separately from the beams/frames. Four planks were analysed and dated and the tree-ring curves from these four have been averaged to a mean curve (Z005M003), which is 311 years long. This mean curve is tested against available Northern European master- and site-chronologies, and the results are plotted in Fig. 17. High values appear with master-chronologies from Elblag, on the Gulf of Gdansk.

For the test of the tree-ring mean from the ship planks with the Northern European single-tree

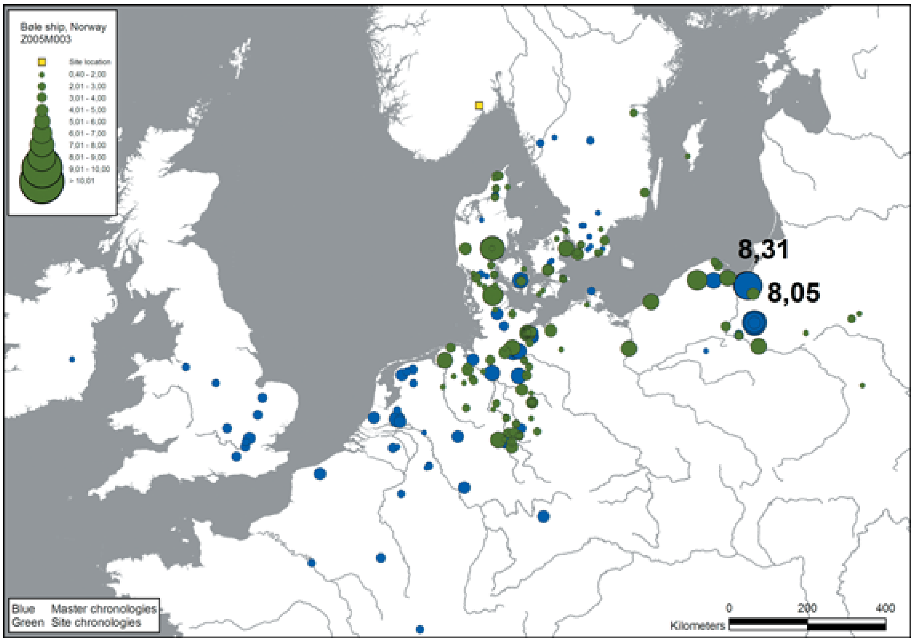

Figure 17. Map of Northern Europe showing the distribution of correlation values (*t*-values) between the tree-ring curve from four planks from the Bøle ship (Z005M003) and master- and site-chronologies in Northern Europe.

dataset, the map in Fig. 18 shows the resulting distribution. Again the problems of the appearance of Polish timber in Western Europe, for this period, become obvious. The tree that the ship planks match best with was used in a construction in England (New Baxtergate, Grimsby). The timber was identified as imported from the Eastern Baltic region at the time it was analysed (Groves, 1992). In fact, the timbers were found as part of a waterfront, and those of Eastern Baltic origin were in fact from the remains of a clinker-built boat, re-used in the revetment (pers. comm. Cathy Groves, now Tyers). When the site-mean for the timbers from the New Baxtergate site is tested against European master-chronologies, we find that this timber is clearly imported from the southern Baltic region.

Another high value appears with a second English site, York Minster. Again we have oak timber imported into England from the southern Baltic region. The tree-ring measurements come from doors and cupboards from the minster (Fletcher and Morgan, 1981), in other words panelling; the typical timber product exported from the southern Baltic region in the late-medieval period. A third high *t*-value appears with a timber from Kiel in Northern Germany. The site is mentioned above in the description of the beams, and is named 'Kiel, Alte Feuerwache' (Kiel, Old Fire Station). It would be interesting to know what kind of ancient timbers were analysed from here. There are five timbers from the Alte Feuerwache site, and they match well together and have been grouped into a site-mean. The outermost tree-ring for each of these timbers is dated to 1300. When the site-chronology from this Kiel site is tested against the masters, it agrees best with the southern Baltic chronologies and, of those, the best match is with Elblag.

Discussion

If we look at the result of the two third-level tests (single trees) for the Bøle ship (Figs. 15 and 18), we can see that for the beams and planks, the site at Kiel shows up strongly for both types of structural elements in the ship, while the two English sites only in the case of the planks. What this shows is that we can begin now not only to date the Bøle ship, and identify the region of origin for the ship, but we can also find other connections to increase our picture of the connections between different sites, in terms of the timber-supply reaching those regions, and in terms of finding connections between ship-finds in the archaeological record over long distances. A new discovery in the provenance-determination analysis, which has emerged in this case, is that a clinker-built ship re-used in revetments in New Baxtergate, England, is similar, in terms of the

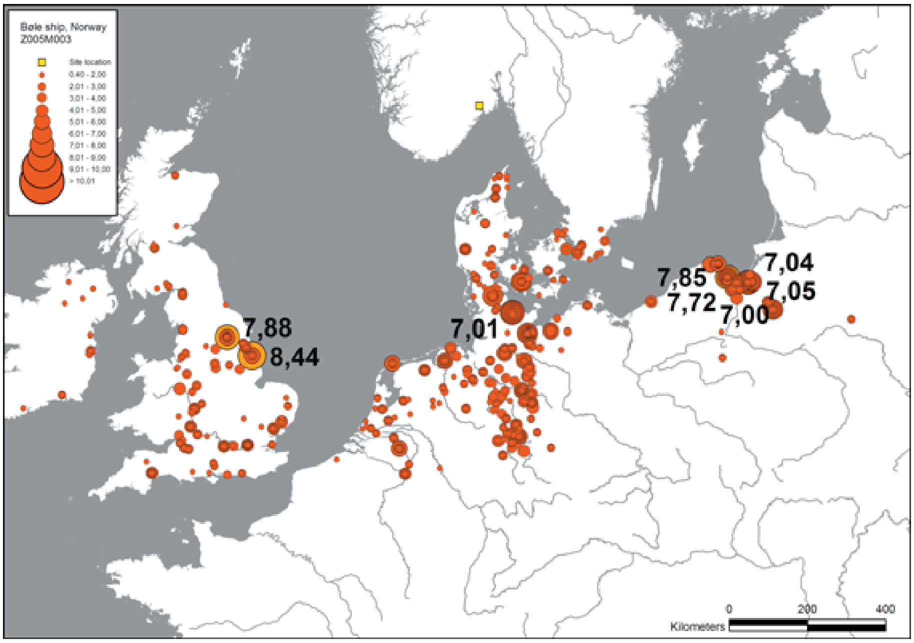

Figure 18. Map of Northern Europe showing the distribution of correlation values (*t*-values) between the tree-ring curve from four planks from the Bøle ship (Z005M003) and individual tree-ring measurements from sites in Northern Europe.

tree-ring pattern in the timber, to the Bøle ship planks. This discovery should lead to an archaeological assessment of the shipbuilding tradition to which the New Baxtergate ship belongs, to see if similarities can also be seen in the construction of the two ships.

However, the implications of the increasing number of ship-remains from western Europe which are of southern Baltic origin presents us with new possibilities in terms of analysing aspects of medieval timber-trade. This is particularly because when we, through dendrochronology, can determine the origin of the timber used in a ship, the question still remains; where then was the ship built? Medieval ships were built with green wood, not seasoned wood (Rackham, 1990), but if timber can be transported before the wood is seasoned, theoretically the ship can have been built anywhere! We can see that the transport of oak panels, a specialised timber product, from the southern Baltic region took place in the late-medieval period. How widespread was the transport of specialised ship-timbers and how early did export/import of shipbuilding timbers take place? A comparison of the shipbuilding tradition/technology evident in the archaeological finds of ships from England, Norway, Denmark and so forth, which are manufactured with southern Baltic oak, will help to shed light on this question. If the southern Baltic timber ships in England from the late-medieval period are built in a local tradition, then we are dealing with the transport of the timber as a commodity. If, on the other hand, all or many of the ships of southern Baltic timber belong to a southern Baltic shipbuilding tradition, then we have a clear sign that the ships were built close to the timber source.

One final aspect in the analysis of the Bøle ship-timbers involves the comparison of the tree-ring curves with other ships of the period. Particularly as the original reason for the interest in this ship dendrochronologically was in the light of the findings for a similar ship found at Avaldsnes, in south-west Norway. This ship was surveyed by Endre Elvestad of Stavanger Sjøfartsmuseum (Alopaeus and Elvestad, 2004) and one of the features it was found to include was the smooth-curved stem and the angled stern. Samples from four of the ship's frames were retrieved in 2004 for dendrochronological analysis. One of the samples had sapwood preserved which meant that the date for the felling of the timber could be estimated to the period AD 1392–1410. The analysis showed also that the timbers had grown in the southern Baltic region (Daly, 2007a).

Having made the analysis of the Bøle ship and assembled the data into the different groups, the Bøle tree-ring curves have been tested against

Table 2. *Table showing the correlation (t-value) between the tree-ring curves for the Bøle ship and tree-ring curves from other ships found in Northern Europe, but built of timber of Southern Baltic origin.*

Filenames	—	—	010A	M002	M003	M004	
timbers	—	—	beam	frames	planks	2frames	
—	start	dates	AD1133	AD1177	AD1063	AD1235	
—	dates	end	AD1325	AD1356	AD1373	AD1352	
0207M002	AD1200	AD1402	—	3.54	3.21	—	Dokøen Wreck 3 (Bonde and Eriksen, 2002)
00751M01	AD1113	AD1463	3.69	3.81	3.59	4.29	Vejdyb ship (Daly, 1997)
lskn_a1	AD1153	AD1372	—	4.42	—	3.39	Skanör cog (pers. comm. Marek Krąpiec)
P0013009	AD1200	AD1404	5.84	5.10	3.66	—	Copper Ship (pers. comm. Tomasz Ważny)
0204M001	AD1187	AD1414	5.03	6.32	4.50	3.50	Tårnby ship (Daly, unpubl.)
02071M01	AD1126	AD1414	4.19	6.73	8.20	3.78	Dokøen Wreck 2 (Eriksen, 2001)
P0011009	AD1103	AD1403	4.69	7.36	5.39	3.49	Copper Ship Wainscots (pers. comm. Tomasz Ważny)
Z002M001	AD1117	AD1391	3.45	9.17	5.39	5.46	Avaldsnes (Daly, 2007)
00121M01	AD1155	AD1353	4.42	9.87	5.64	6.96	Lille Kregme cog (Eriksen, 1992)
0045M002	AD1109	AD1370	8.32	12.28	4.63	6.80	Vejby cog (Bonde and Jensen, 1995)

average tree-ring curves from a selection of medieval ships from Scandinavia. Table 2 shows the results of this exercise. Only ships where a high *t*-value appears are listed. Taking the single beam 010A, it can be seen that the ship it matches best with is the Vejby cog, found in Denmark but which was built of southern Baltic timber (Bonde and Jensen, 1995). The mean curve from the other frames/beams in the Bøle ship, M002, also match best with the Vejby cog, but note also the high values with the Lille Kregme cog and the Norwegian Avaldsnes ship. It here might be pointed out that the comparisons cannot be taken at face value: in the Vejby cog dendrochronological analysis, 26 samples were examined, for Lille Kregme 11 samples were analysed, while only four were analysed from the Avaldsnes ship. In fact, when we look at the *t*-values that the tree-ring mean from the four frames from the Avaldsnes ship achieve, when compared with chronologies and other ships from the period, the highest is with the mean of the frames from the Bøle ship. Given the similarity of the two late-14th-century cargo ships from Norway in their construction, a more detailed and extensive dendrochronological analysis of the Avaldsnes ship would clearly be an interesting exercise. Even though the highest correlation between the Bøle ship and the selected ships here is with the Vejby cog, given the large number of samples analysed from Vejby, and the very low number from Avaldsnes, a full conclusion as to the similarity, dendrochronologically, of the two Norwegian ships cannot as yet be reached.

The mean curve for the Bøle planks achieves the highest *t*-value with Dokøen wreck 2, one of the ships found in the harbour of Copenhagen at Dokøen, in 2001 (Gøthche and Høst-Madsen, 2001). Again in this comparison, the Bøle planks give a different result from the frames/beams, indicating again the possibility of quite different sources for the two timber types.

Summary

To conclude, let us summarise the research history and the result from the dendrochronological analysis of the Bøle ship, Norway. Ten samples, one of which had sapwood preserved, were analysed and nine of these are dated. Estimating for missing sapwood rings, the felling of the timber dates to the period AD 1376–96, or, put another way, for simplicity, the timber was felled around the 1380s. The tree-ring patterns of the timber achieve the highest correlation with chronologies from coastal Poland, chiefly around the Gulf of Gdansk, but some frame timbers might come from further west along the Polish coast.

The applicability of the dendrochronological provenance-determination technique in maritime archaeology is demonstrated with the example of the Bøle ship. The information that might be attained by similar studies of other wrecks, not just from Norway but from the whole of northern Europe, would allow a detailed description of the movement of ships and their cargo, and of timber as a building commodity. The results of the dendrochronological analysis have great significance for further study of the Bøle ship. First, dendrochronology provides a more precise date for the vessel than C-14 dating could. Second, the determination of the provenance of the wood used to construct the ship opens new possibilities for the study of the trade of timber in the middle ages. Since the source of the whetstones being carried as cargo on the ship has been identified, the Bøle ship helps to provide a date for a sequence in the export history of this product as well.

The context of the find constitutes an unusual direct source of information about several stages in a maritime trade-route which ultimately extended along waterways far into the interior. The find represents a valuable source for the study of transport-networks and the shipment of particular commodities around the North Sea, and it raises a number of interesting questions, from a cultural-heritage perspective, as regards the extent, continuity and organisation of trade.

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References

Åkerlund, H., 1951, *Fartygsfynden i den forna hamnen i Kalmar*. Uppsala.

Alopaeus, H. and Elvestad, E., 2004, Avaldsnesskipet-et “nordisk” skip fra Polen? in Tormod Torfæus (ed.), *Mellom Vinland og “Ringenes herre”, Karmøyseminaret 2004*, 73–86. Karmøy Kommune.

Baillie, M. G. L. and Pilcher, J. R., 1973, A simple crossdating program for tree-ring research, *Tree-Ring Bulletin* **33**, 7–14.

Bill, J., 1994, Iron Nails in Iron Age and Medieval Shipbuilding, in C. Westerdahl (ed.), *Crossroads in Ancient Shipbuilding*, ISBSA **6**, 73–6. Oxford.

Bonde, N. and Eriksen, O. H., 2002, Dendrokronologisk undersøgelse af tømmer fra skibsvrag fundet på Dokøen, Holmen, København. “Vrag 3”. *Nationalmuseets Naturvidenskabelige Undersøgelser rapport* 4/2002. Copenhagen.

Bonde, N. and Jensen, J. S., 1995, The dating of a Hanseatic cog-find in Denmark. What coins and tree rings can reveal in maritime archaeology, in O. Olsen, J. S. Madsen and F. Rieck (eds), *Shipshape. Essays for Ole Crumlin-Pedersen. On the occasion of his 60th anniversary February 24th 1995*, 103–21. Roskilde.

Bugge, A., 1925, *Den Norske Trælasthandels historie I. Fra de ældste tider indtil freden i Spier 1544*. Skien.

Christensen, A. E., 1962, Innberetning om befaring i forbindelse med båtfunn i Skienselven, Unpublished note, *Universitetets Oldsakssamling, top ark*. Oslo.

Christensen, A. E., 1985, Boat finds from Bryggen, in A. Herteig, (ed.), *The Bryggen Papers, Main series Vol I*, 47–278. Bergen.

Christensen, A. E., 1987, A medieval ship model, *IJNA* **16**.1, 69–70.

Dahl, 1937, Bølebåen, Skienselven—Opmåling, utgangspunkt for dybder i Havnevesenets vannstannsmåler 0—punkt. Målestokk 1:200, *Original map, 118 x130 cm. Skien Kommunes kartarkiv*. Skien.

Daly, A., 1997, Dendrokronologisk undersøgelse af skibsvrag fra Vejdyb udfor Hals, Aalborg Amt. *Nationalmuseets Naturvidenskabelige Undersøgelser rapport* 12/1997. Copenhagen.

Daly, A., 2005, Dendrokronologiske dateringer og proveniensbestemmelser, in E. Roesdahl and J. Kock (eds), *Boringholm, en Jysk Træborg fra 1300-årene*, 41–7. Århus.

Daly, A., 2007a, *Timber, Trade and Tree-rings. A dendrochronological analysis of structural oak timber in Northern Europe, c. AD 1000 to c. AD 1650*. Ph.D. thesis submitted February 2007, University of Southern Denmark.

Daly, A., 2007b, The Karschau Ship, Schleswig-Holstein: Dendrochronological Results and Timber Provenance, *IJNA* **36**.1, 155–66.

Dons, J. A., 1990, Brev fra Mineral Geologisk Museum. UIO –til Norsk Sjøfartsmuseum, Sjøfunnarkivet NSM nr 08060001. Oslo.

Elfwendahl, M. and Kresten, P., 1996, Provenance of Quernstones, grindstones, and hones from Sweden, in V. Mejedahl and P. Siemen (eds), *Proceedings from the 6th Nordic Conference on the Application of Scientific Methods in Archaeology, Arkæologiske rapporter nr 1 1996, Esbjerg Museum*, 77–94. Esbjerg.

Ellis, S. E., 1969, The petrography and provenance of Anglo-Saxon and Medieval English Honestones, with Notes on Some Other Hones, *Bulletin of the British Museum (Natural History) Mineralogy*, II, pt. 3, 135–87.

Eriksen, O. H., 1992, Dendrokronologisk undersøgelse af skibsvrag fra Lille Kregme, Frederiksborg amt. *Nationalmuseets Naturvidenskabelige Undersøgelser rapport* 31/1992. Copenhagen.

Eriksen, O. H., 2001, Dendrokronologisk undersøgelse af tømmer fra skibsvrag fundet på Dokøen, København. *Nationalmuseets Naturvidenskabelige Undersøgelser rapport* 23/2001. Copenhagen.

Falck-Muus, R., 1962, Vraket av “fønikerskuten” fra Skiensfjordens bund, *Varden* **16**.10. Skien.

Falck-Muus, R., 1920, Brynesteinsindustrien i Telemarken, *Norges Geologiske Undersøkelser Årbok* 1920, 5–179. Oslo.

Fletcher, J. M. and Morgan, R. A., 1981, The dating of doors and cupboards in the Zouche Chapel, York Minster, *Yorkshire Archaeological Journal* **53**, 45–9.
Friis, P. C., 1877, *Samlede skrifter*, in G. Storm (ed.), *Samlede skrifter*. Kristiania.
Groves, C., 1992, Dendrochronological analysis of timbers from New Baxtergate, Grimsby, Humberside, 1986, *Ancient Monuments Laboratory Report* **8**.
Gøthche, M. and Høst-Madsen, L., 2001, Middelalderlige vrag på Dokøen, *Marinarkæolologisk Nyhedsbrev fra Roskilde* **17**, 28–34.
Haneca, K., Wazny, T., Van Acker, J., and Beeckman, H., 2005, Provenancing Baltic timber from art historical objects: success and limitations, *Journal Of Archaeological Science* **32**.2, 261–71.
Hansen, K. E., 1943, Kolding Skibet-Foreløbig meddelelse om fund af middelalderskib, in *Handels og Sjøfartsmuseet paa kronborg, Aarbog* 1944, 118–29.
Hvitsand, J., 1960, Er båten fra Bølebåen en gammel fønikerskute? in *Varden*, Skien, 23.03.1960.
Hvitsand, J., 1977, Vraket av Bølebåten, *Telemark Arbeiderblad*, Skien, 19.04.1977.
Johansen, P., 1963, *Fra kaupang til moderne handelsby*. Skien.
Kelly, P. M., Leuschner, H. H., Briffa, K. R., and Harris, I. C., 2000, The climatic interpretation of pan-European signature years in oak ring-width series, *Holocene* **12**.6, 689–94.
Livland, H., 1992, Frakt av Eidsborg-bryner til Skiensfjorden i nyere tid, *Tidsskrift for Telemark Historielag Nr*. **13**, 173–77.
Mitchell, J. G., Askvik, H., and Resi, H. G., 1984, Potassium-argon ages of schist honestones from the Viking Age sites at Kaupang (Norway), Aggersborg (Denmark), Hedeby (West Germany) and Wolin (Poland), and their archaeological implications, *Journal of Archaeological Science* **11**, 171–76.
Molaug, S., 1959, Norsk Sjøfartsmuseum Årsberetning 1959:10. Oslo.
Molaug, S., 1960, Norsk Sjøfartsmuseum Årsberetning 1960:7. Oslo.
Molaug, S., 1962, Bølebåten er frå mellomalderen, *Varden* 27.08.1962. Skien.
Moore, D. T., 1978, The Petrography and Archaeology of English Honestones, *Journal of Archaeological Science* **5**, 61–73.
Myrvoll, S., 1984, Trade in Telemark and the Earliest Settlement in Skien, *Offa Band* **41**, 41–55. Neumunster.
Myrvoll, S., 1985, Fra Eidsborg til Svendborg med brynestein i middelalderen, *Årbok for Svendborg & Omegns Museum*, 1985.
Myrvoll, S., 1986, Skien og Telemark-naturressurser, produkter og kontakter i sen vikingtid og tidlig middelalder, *Viking* 1985/6, 160–80.
Myrvoll, S., 1992a, Handelstorget in Skien. A study of activity on an early medieval site, *NUB* **2**. Bergen.
Myrvoll, S., 1992b, Det eldste Skien—struktur og funksjon, *NUB* **3**, 105–24. Bergen.
Nævestad, D., 1999, Lokaliserte middelaldervrak i Øst Norge, in Kolltveit (ed.), *Norsk Sjøfartsmuseum Årbok* 1998, 159–205.
Nedkvitne, A., 1983, *Utenrikshandelen fra det vestafjelske Norge 1100–1600*, doktoravhandling, Universitetet i Bergen.
Nydal, R., 1962, T-240A, T240B—Shipwreck at Skien, Oslofjord, *Radiocarbon. The American Journal of Science* **4**, 177–8.
Nymoen, P., 2005, Bølevraket i Skienselva i Telemark—Foran en ny undersøkelse av et gammelt skipsfunn, in B. Kolltveit (ed.), *Norsk Sjøfartsmuseums årbok* 2004, 45–76. Oslo.
Nymoen, P., in press, Fatal feilnavigering med tung last? Om en samling brynesteinsemner i Kvåsefjorden, Kristiansand.
Østvedt, E., 1962, Bølebåten, *Varden*, Skien, 21.08.1962.
Østvedt, E., 1963, *Fløtning i Telemark gjennom 300 år*. Skien.
Ot prp. nr. 23, 1962–63, *Om lov om endring i lov om fornminne frå 29 juni 1951*. Tilrådning frå Kyrkje- og undervisningsdepartementet 21 desember 1962, godkjend ved kongeleg resolusjon same dag.
Pettersen, L., 1965, Et vrakfunn i Folderøyhavn, Bømlo, Sunnhordland, *Sjøfartshistorisk Årbok*. Foreningen Bergens Sjøfartsmuseum. Bergen.
Rackham, O., 1990, *Trees and Woodland in the British Landscap* (rev. edn 2001). London.
Seierstad, I., 1958, *Skiens historie, bind I fra 1184 til ca 1814*. Skien.
Steusloff, W., 1983, Das Ebersdorfer Koggenmodell von 1400, *Deutsches Shiffahrtsarchiv* **6**, Bremerhaven.
Tyers, I., 1997. *Dendro for Windows Program Guide*. Archaeological Research and Consultancy at the University of Sheffield, Report 340.
Tveitane M., 1981, Kviteseid—Eidsborg. Om namn, eigedomsforhold og samferdsel i Vest Telemark i eldre tid, *Heimen* 1981 XVIII, 635–50.
Ważny, T., 1990, Aufbau und Anwendung der Dendrochronologie für Eichenholz in Polen, unpublished Ph.D. dissertation, University of Hamburg.

