An Evaluation of Dendrochronology as a Tool for the Interpretation of Historical Shipwrecks

Pearce Paul Creasman
Laboratory of Tree-Ring Research
The University of Arizona
105 West Stadium Dr.
Tucson, AZ 85721-0058

This paper investigates the application of dendrochronological methods, broadly conceived as dendro-analysis, to advance our understanding of historical shipwrecks. Dendrochronology is not limited to providing a date and location. As date and location are often accounted for on historical shipwrecks by the artifact assemblage, it is not surprising that dendrochronology is underused.

Dendro-analysis is more useful than its current rate of application would suggest and can contribute to a better understanding of historical and New World shipwrecks. Despite certain limitations, it offers distinct advantages and solutions to problems posed by historic shipwrecks.

Introduction

For as long as people have taken to the seas, ships have served as one of the primary vectors of cultural and technological exchange. A shipwreck or boat burial offers a glimpse of the past but is only the last chapter in a complex story. While the past 50 years of nautical archaeology have rewritten a number of these ultimate chapters, much of the information unrelated to a ship's final voyage remains a mystery. Portions of that mystery can be exposed, however, by an examination of the ship itself, especially the wood.

Any study of the vessels that shaped the world in which we live is incomplete without an understanding of the resources required to construct them: specifically, timber. Since wood has in all ages, including the present, been an important commodity, it has always been exploited and manipulated (Hanceca, Katarina, and Beeckman 2009; see also Perlin 1989 for an introduction to the history of wood use). Throughout history, the restrictions of timber reserves have often dictated politics, military tactics, social relations, and economics (Meiggs 1982; Corvol and Amat 1994; Horden and Purcell 2000). Such stresses on resources often contributed to or caused lasting modifications in ship construction (Bill 1994) that remain visible in the material record today (Creasman 2010). Not infrequently, these modifications contributed to or caused the demise of the ship itself. In short, maritime prowess is and has been dependent on access to the terrestrial products from which watercraft are made (Albion 1926; Lane 1975).

A ship embodies the culture that produced it, reflecting material and conceptual matrices in its design, construction, and operation. In its materials it displays the ability of its society to procure resources, the construction process reflects the level of organization of labor in a society, and even the size of a ship is indicative of the risks willing to be assumed by the society that produced it (or at least by those who financed and crewed it). These aspects leave their traces somewhere in a shipwreck.

Archaeologists operate under a simple maxim: when a person modifies a raw material, distinctive evidence of the process remains. This is certainly the case for ship timbers, each of which is an individual article that can and should be analytically studied to expose cultural and environmental information that extends far beyond the scope of a ship's final voyage or trade route. Ship timbers therefore remain a largely unharvested trove of answers to critical questions that ship archaeologists seldom ask: how many trees were harvested to build a certain boat or how was it obtained? Societies that build wooden ships had timber economies, and an investigation of ship timbers can address these questions with answers that have gone generally unrecorded even in recent historical times.

Reasons for Resistance

Dendrochronology, broadly conceived as "dendro-analysis," encompasses more than merely counting tree rings and deriving climate data (Stokes and Smiley 1968; Fritts and Swetnam 1989; Dean 1996). Like nautical archaeology, the field has advanced rapidly in recent years (Eckstein and Schweingruber 2009). For some time, its investigations have surpassed simply providing date, species, and location, although these remain its most common archaeological applications. The assumption that this is all of the information that can be derived from dendro-analysis is probably the greatest impediment for the application of dendrochronology to historical shipwrecks.

The study of historic, as opposed to ancient, shipwrecks generally finds adequate lines of evidence from which to draw to answer these basic dating questions without turning to tree rings: a coin with a date, for instance, provides a reasonably reliable *terminus post quem*. It is thus understandable why dendrochronology has not been more common in historical nautical archaeology. Tree rings and wood can, however, provide answers to broader questions about the natural and cultural world, including inquiries very specific to shipbuilding and shipwrecks.

Currently, the relationship between dendrochronology and nautical archaeology is one more of opportunity than practice. In only three times and places worldwide do the disciplines intersect with regularity: archaeological remains in Northern Europe and Scandinavia from approximately the last 1,000 years (Daly 2007), the French Mediterranean region (Guibal and Pomey 2004), and the eastern Mediterranean (Liphschitz 2007). With the rare exception, the rest of the seafaring world has yet to see substantial benefit from the merger of these fields.

Although dendrochronological studies are not uncommon in the investigation of ancient and Old World wrecks, historical and New World shipwreck studies rarely include dendrochronology. This is both counterintuitive and unfortunate. Wooden archaeological remains, including shipwrecks, and sufficient parallels from which to build a reliable chronology are far more abundant for the historical period. Tree-ring data and chronologies associated with the historical period are thus more complete or often easily compiled.

If, however, historical New World shipwrecks are already adequately explored using other techniques and avenues of inquiry, then why bother adding dendrochronology to the research repertoire?

Benefits

There are three basic dendroarchaeological lines of investigation: chronological, environmental, and behavioral (Dean 1996). All of these have potential to contribute to the study of ships. Not all ship remains contain artifacts to aid in their dating. Old and decrepit vessels were often intentionally sunk to provide a base for a wharf, pier, harbor works, or (to stretch beyond the strictly "historical" period) in the case of the Skuldelev hulls, to limit the size of ships that can berth in a harbor. In such cases, when a watercraft has been stripped for abandonment, it is the timbers themselves that will provide evidence of a date. Even comparison of the tree-ring data within a single ship can be revealing, especially regarding repair history and the working lifetime of a vessel (Crumlin-Pedersen 2002).

Timbers can also reveal origin. To draw again from Viking-era Denmark, timbers revealed that Skuldelev II, a longship, had been built of wood from Dublin (Crumlin-Pedersen 2002). This revelation of not only date but also of economics and environment was made possible by the use of that most basic dendrochronological technique, the comparison of tree-ring data.

Use of data drawn from ship timbers will facilitate the growth of and bridging between chronologies, particularly in regions that have long been densely populated, where living trees and terrestrial resources are regularly reused.

Dendrochronology also holds promise for historical archaeology (Stahle and Wolfman 1985:290, 296). An historic shipwreck might be dated with a high degree of confidence because of an insurance claim, for example. Wood from the hull could subsequently be used to help extend the climate data or bridge a chronological gap. There are distinct needs for such data. It has, for example, been difficult to extend teak chronologies because the wood has been valued for so long for architectural and ornamental purposes that reuse has considerably complicated the establishment of a dating sequence. One relatively dated shipwreck constructed of Indian teak from the Portuguese era could double the length of the current chronology. Even a small boat of under 10 meters can yield a chronology spanning 300 to 500 years, depending on the species. The possibilities contained in a large vessel with a long working life and several repairs are, of course, correspondingly greater.

Requirements

There are three primary compounding factors when seeking useable dendro samples, assuming the usually conditions are met (see Dean 1996):

1) Preservation: there must be enough wood available for analysis. In some cases, an entire timber (or most of one) is used as a sample. Unlike most ancient wrecks, historic wrecks typically present large amounts of timber, allowing for development of good sampling theory and for procurement of extra samples.

2) Modification: the timbers have been worked to fit their purpose. Internal framing members, masts, and spars are generally the most desirable for dendrochronological study. Since they more closely follow the natural growth of trees than do many other construction elements, these tend to have the greatest number of remaining rings.

Although planking is often the most heavily worked type of timber on a ship, especially if pine (which is long, straight, and often presents quick and complacent growth patterns), although these too have their dendroanalytical uses. The very methods of productions that spoil even hardwood planks for chronological purposes reveal some aspects of the culture that built the ship. Wasteful production methods suggest either an abundance of resources (either the timber itself or some other capital) or sufficient need to override usual economies, perhaps a "special" purpose or client. Shipbuilders soon discover that certain cutting patterns yield certain results and come to use methods that optimize costs and benefits in a manner best suited to their situation (McGrail 1997).

3) Recovery: archaeologists compete with treasure hunters, who, in the course of their quest for commodities, typically destroy hulls because they lack market value.

Results

A standard type of dendro-analysis helps to establish "characteristics" of a particular shipbuilding tradition, such as species use: oak for structural members, for example, or pine for hull planking. Construction-to-species relationships are now new, but extrapolation from this kind of data can help to identify other ships built in a similar tradition or to define a regional tradition if the relationship changes over time. This is especially important because a great deal of shipbuilding tradition is unrecorded, passed orally and through demonstration from master craftsman to apprentice.

For example, the Pepper wreck, a Portuguese Indiaman sunk in 1606 and excavated from the Tagus River at Lisbon, revealed certain behavioral practices in Portugal of the period (Castro 2005). The timbers are very small, and the entire boat seems to have been fitted together as if a puzzle had been assembled. The use of small, lower-quality cuts of timber for what should have been a highly profitable ship implies lack of resources. Lack of resources, a problem encountered worldwide, calls for ingenuity in ship construction. Shipbuilders devise technological solutions, such as new methods of joinery, and often these changes, proving technologically and economically effective, become standard practice.

The most thorough behavioral studies of historic ship timber have come from a very small group of well preserved ships considered to be in the "Basque" tradition. In Brad Loewen's study of the 24M wreck found at Red Bay, Canada, he combined archaeological, historical and economic evidence drawn from the timbers to delve deep into a cultural understanding of the Basque shipbuilding system (2007). Similarly, the oak timbers of the Cavalaiere-sur-Mer wreck (c. 1479), resulted in a wide range of findings (Loewen 2000).

1) Comparing the grains at either end of a finished timber and reconstructing the size of the raw timber revealed that the finished timbers did not deviate significantly from the natural shape of the raw material. This is exceptional given the volume of wood needed.

2) Structural timbers were never the result of splitting a timber in half to obtain similar pieces for opposite sides of the ship. This indicates the existence of ample trees of similar age and size from which to choose the best timber.

3) All of the structural timbers seemed to be free of knots. Such regularity implies deliberate management of forest resources, in this case the pruning of lower branches and sprouts to prevent the formation of knots.

4) Dendrochronology revealed that the majority of the trees used to build the ship had been felled at about 65 years of age. Age clusters appeared for several different kinds of timbers, specifically the framing and planking groups. Such remarkable uniformity cannot have been coincidental among timbers selected from a natural forest. The suggestion is that the trees had been cultivated and harvested as a single crop for the specific purpose of shipbuilding.

Loewen's analysis of Basque ships is integrated with discussions of forest economics, naval forestry, timber supply, hull design and several other trades associated with shipbuilding the vessel but still cannot source the ship to the yard where it was built.

This leads back to a recurring problem known since the very beginning of nautical archaeology. In the first article of the first issue of the *International Journal of Nautical Archaeology*, Lucien Basch (1972) stated that "The most important limitation [of nautical archaeology]…is the virtual impossibility of deducing the shipyard where a vessel was built." This statement applies to many historic wrecks, and only recently has there been any hope of resolving this issue. Records of naval timber trade, even in the recent historic period, are not exceptionally plentiful, and reconstruction of localized timber economies by the study of the ship timbers would be a major step toward a deeper understanding of the people who built the ships.

Aoife Daly has laudably used the growing chronologies of oak in Northern Europe to begin localizing source information. Her work is limited to that region from about A.D. 1000, but it is only by growing chronologies at local levels that archaeologists will be able to narrowly source individual ships with great confidence. It is likely that an approach combining Daly's and Loewen's methods could completely resolve Basch's concerns regarding ship origins, especially for historic ships.

Much work remains to be done, but the benefits are evident. Using dendro-analysis more extensively and consciously will help realize the full potential of the under-utilized data present in historical-era shipwreck timbers. Further investigation of the questions and methods presented above can be found in Creasman 2010, on which much of the above was based.

References

Albion, Robert G.
1926 *Forest and Sea Power: The Timber Problem of the Royal Navy 1652-1862*. Harvard University Press, Cambridge, MA.

Basch, Lucien
1972 Ancient Wrecks and the Archaeology of Ships. *International Journal of Nautical Archaeology* 1(1):1-58.

Bill, Jan
1994 Ship Construction: Tools and Techniques. In *Cogs, Caravels and Galleons: The Sailing Ship 1000-1650*, R. W. Unger, editor, pp. 151-159. Chartwell Books, Edison, NJ.

Castro, Filipe Vieira de
2005 *The Pepper Wreck*. Texas A&M University Press, College Station.

Corvol, Andre, and J-P. Amat
1999 *Forêt et Marine (Forêt et Marine: Paris, 10-13 Septembre 1997)*. L'Harmattan, Paris.

Creasman, Pearce Paul
2010 *Extracting Cultural Information from Ship Timber*. Doctoral dissertation, Texas A&M University, College Station, TX.

Crumlin-Pedersen, Ole
2002 Documentation, Analyses and Dating. In *The Skuldelev Ships I: Topography, Archaeology, History, Conservation and Display*, O. Crumlin-Pedersen, and O. Olsen, editors, pp. 49-68. The Viking Ship Museum, Roskilde.

Daly, Aoife
2007 *Timber, Trade and Tree-rings: A Dendrochronological Analysis of Structural Oak Timber in Northern Europe, c. AD 1000 to c. AD 1650.* Doctoral dissertation, University of Southern Denmark, Copenhagen.

Dean, Jeffrey. S.
1996 Dendrochronology and the Study of Human Behavior. In *Tree-rings, Environment, and Humanity*, J. S. Dean, D. M. Meko, and T. W. Swetnam, editors, pp. 461-471. Radiocarbon, The University of Arizona, Tucson.

Eckstein, Dieter, and Fritz Schweingruber
2009 Dendrochronologia—A mirror for 25 Years of Tree-ring Research and a Sensor for Promising Topics. *Dendrochronologia* 27(1):7-13.

Fritts, Harold C., and Thomas W. Swetnam
1989 Dendrochronology: A Tool for Evaluating Variations in Past and Present Forest Environments. *Advances in Ecological Research* 19:111-188.

Guibal, Frederick, and Patrice Pomey
2004 Dendrochronologie et construction navale antique. *Revue'Archéométrie* 28: 35-42.

Hanceca, K., Č. Katarina, and H. Beeckman
2009 Oaks, Tree-rings and Wooden Cultural Heritage: A Review of the Main Characteristics and Applications of Oak Dendrochronology in Europe. *Journal of Archaeological Science* 36(1): 1-11.

Horden, Peregrine, and Nicholas Purcell
2000 *The Corrupting Sea: A Study of Mediterranean History*. Blackwell Publishing, Malden, MA.

Lane, Frederick Chapman
1975 *Venetian Ships and Shipbuilders of the Renaissance*. Greenwood Press, Westport, CT.

Liphschitz, Nili
2007 *Timber in Ancient Israel: Dendroarchaeology and Dendrochronology*. Institute of Archaeology at Tel Aviv University, Tel Aviv.

Loewen, Brad
2000 Forestry Practices and Hull Design, ca. 1400-1700. In *Fernando Oliveira and his Era: Humanism and the Art of Navigation in Renaissance Europe (1450-1650)*, I. Guerreiro, editor, pp. 143-151. Patrimonia, Aviero.

Loewen, Brad
2007 Volume III: the 24m Hull. In *The Underwater Archaeology of Red Bay*, R. Grenier, M-A. Bernier, and W. Stevens, editors, pp. 1-319. Parks Canada, Ottawa.

McGrail, Seán
1997 *Studies in Maritime Archaeology*. BAR British Series 256, Oxford.

Meiggs, Russell
1982 *Trees and Timber in the Ancient Mediterranean World*. Oxford University Press, Oxford.

Perlin, John
1989 *A Forest Journey: The Role of Wood in the Development of Civilization*. W.W. Norton & Co., New York, NY.

Stahle, David and D. Wolfman
1985 The Potential for Archaeological Tree-Ring Dating in Eastern North America. *Advances in Archaeological Method and Theory* 8: 279-302.

Stokes, Marvin A., and Terrah L. Smiley
1968 *An Introduction to Tree-Ring Dating*. University of Chicago Press, Chicago, IL.

ACUA
Underwater Archaeology
Proceedings
2010

edited by
Chris Horrell and Melanie Damour

An Advisory Council on Underwater Archaeology Publication

ISBN: 978-1-4276-4839-6

Made possible in part through the support of
the Society for Historical Archaeology.

SOCIETY *for*
HISTORICAL
ARCHAEOLOGY