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ORIGINAL PAPER

The Wreck of the *Pettu* as an Example for Nineteenth Century Rural Shipbuilding in South-Western Finland

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Abstract Although the design and construction of wooden merchant vessels in the nineteenth century is generally considered to be well understood, the excavation and subsequent analysis of the wreck of the wooden Finnish topsail schooner *Pettu* (1865) revealed a number of unexpected features, which prompted the authors to take a closer look at the ship. In the following study, it will be attempted to gain an insight into the society that produced and used the merchant vessel through a detailed analysis of its construction and an investigation into the concept behind its design. The wreck of the *Pettu*, which, considering its loss in 1893, is barely covered by the 100 year rule in Danish heritage legislation, is a good example for the archaeological potential of even relatively 'modern' wreck sites, adding to their significance.

Keywords Finland · Maritime Archaeology · Maritime history · Shipbuilding · Ship design

The Excavation of the *Pettu*

In October 2010 a swimmer reported the exposed remains of a wooden shipwreck about 100 m from the shore in a bay north of Bagenkop, a small fishing village on the southern tip of the Danish island Langeland (Fig. 1) to the responsible authority, Øhavsmuseet. This triggered a whole chain of events, which ultimately led to a three-week summer field school organised as a co-operation between Øhavsmuseet and the Maritime Archaeology Programme at the University of Southern Denmark in 2012.

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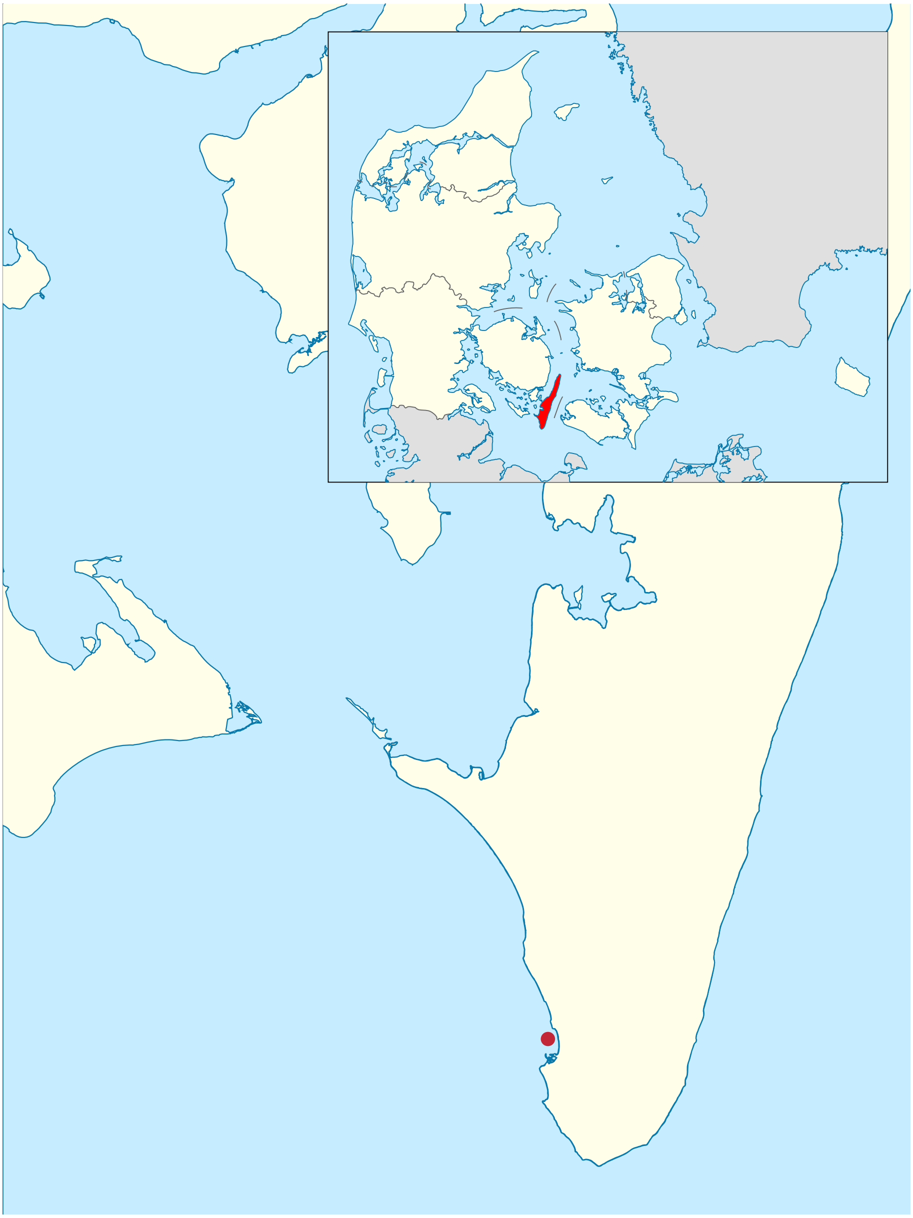

Fig. 1 The wreck location in a bay north of Bagenkop on the southern tip of the island of Langeland. Auer (2014), based on Kort 10 geodata, Geodatastyrelsen and a.svg file by Los688, wikimedia commons

As character and date of the wreck were unclear, the field school aimed at partial excavation to a level sufficient for detailed recording and analysis of the remaining structure. Between July and August 2012 a 12 m long hull section near the bow of the wreck and the stern area were uncovered. Excavated areas were documented with offset scale drawings and positioned with the help of a total station on the shore (Fig. 2). The

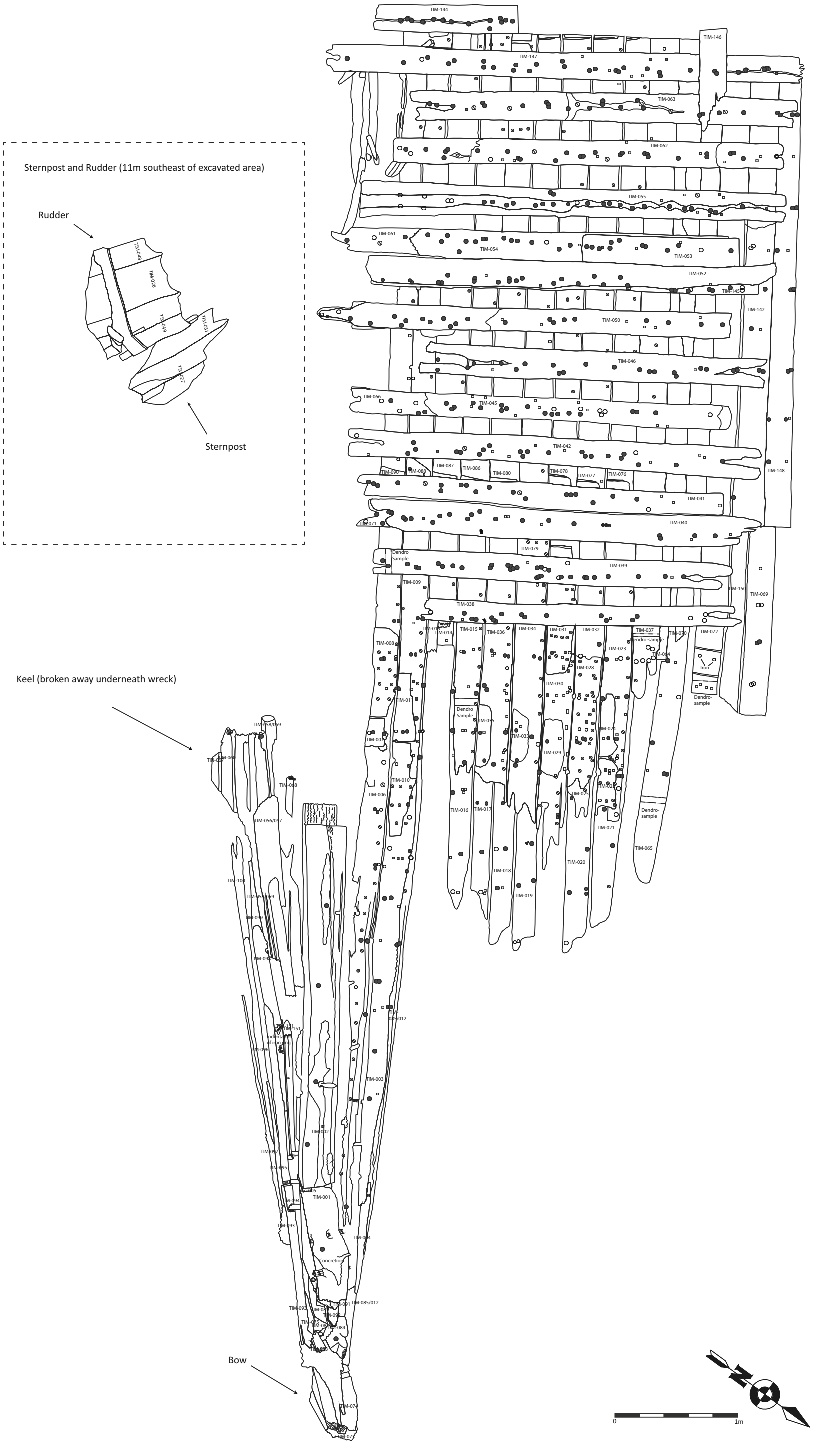

Fig. 2 Overview over the excavated remains of the wreck. Auer (2014) based on the site plan digitized by Cattrysse (2012)

recorded structure was later analysed in detail and the results were published in the form of a fieldwork report (Auer et al. 2013b). As an immediate result of the field school, matching the outcomes of the in situ recording with historical records could identify the wreck. Based on the preserved archaeological remains, an original ship length of 25–27 m and a beam of at least 7 m were assumed. The ship was built entirely out of softwood and the analysis of dendrochronological samples indicated an eastern Baltic origin for the timbers and a construction date after 1846. As there was no sapwood present on any of the sampled timbers, more accurate dating could not be achieved using this method (Auer 2013). With this information in mind, the stranding records for the district of Langeland were searched for possible matches. Five likely candidates were identified and researched further in historical newspaper articles. This process led to the identification of the wreck as the Finnish ‘skonert’ *Pettu* from 1865. Once the name of the vessel had been established, a wealth of historical documents could be located in the maritime museum of the original homeport, Rauma on the Finnish west coast. These included crew lists, log books, ownership and registration documents and charters (Visser 2013). Based on these documents, it was not only possible to reconstruct the ‘life’ of the vessel, but also to attempt combining archaeological and historical information in order to arrive at a visual reconstruction of the appearance of *Pettu* (Ditta 2013) (Fig. 3). According to the registration documents, *Pettu* measured 26.37 m in length (between perpendiculars), 8.13 m in width (measured to the outside of the planking) and had a depth in hold of 3.19 m. The net tonnage of *Pettu* is stated as 150.11 register tons. The vessel stranded in the early hours of the 10th December 1893 near Bagenkop while en route from Flensburg to Rauma carrying only ballast. The wreck was sold to a consortium of local fishermen, who were planning to refloat *Pettu*, but

Fig. 3 Artistic interpretation of Pettu under sail. In historical documents the *Pettu* and similar ships are referred to as ‘skonert’ or schooner. However contemporary ship paintings depict these vessels rigged as brigantines (as shown here) (Ditta 2013)

salvage attempts were unsuccessful and the wreck was broken up on the beach and the salvaged goods were sold on an auction on 6th January 1894 (Visser 2013).

Analysing the Construction of *Pettu*

Muckelroy considered the ship as the "largest and most complex machine" produced in any preindustrial society (Muckelroy 1978). The production of a ship required not only considerably resources, but also technological skill. Consequently, as Adams points out, their remains offer the potential of revealing "aspects of society unavailable from land sites or other classes of society" (Adams 2013). In the following, it will be attempted to apply Adams' ideas and gain an insight into the society that built and used the merchant vessel by analysing its construction and the concept behind its design.

Already during the first week of excavation a number of aspects or features were noted that did not seem to fit into the established perception of how a nineteenth century merchant vessel should be built. And as the excavation continued more and more 'oddities' or unexpected features came to light.

The most striking elements of construction were planking and framing. The outer planking of the vessel consists of two separate layers. The inner layer is constructed in lapstrake or clinker fashion from the garboard strake to a point below the turn of the bilge, where it turns to carvel. To the outside of this, a second layer of carvel planking has been applied. Wooden chocks level the clinker steps of the first layer and provide a smooth surface for the carvel layer.

All planks are tangentially sawn from pine. Clinker planks have an average width of 20.5 cm and are around 4.5 cm thick. Carvel planks of the inner layer are slightly narrower at 16 cm average width and have an average thickness of 5 cm. Planks in the outermost carvel layer have an average width of 18–23 cm with a thickness varying between 7 cm near the keel and 5 cm near the turn of the bilge.

There is a noticeable absence of metal fittings and fastenings on the wreck. Plank overlaps of adjoining strakes are fastened with small wooden nails of 15 mm diameter, which are secured with hardwood wedges. Adjoining clinker planks in the same strake are not scarfed together as known from traditional clinker building, but are laid edge to edge. The resulting butt joints are sealed with thin pine boards nailed with small softwood nails over mats of waterproofing material to the inside of the planks (Fig. 4). The overlying framing has been rebated to fit over the sealing boards.

During the excavation twenty framing elements were uncovered. While the majority of these are single frames, partially joggled to fit over the clinker planking at the bottom of the hull, every fifth frame is a pre-assembled composite carvel frame.

All frames are made from softwood and well squared.

The single framing timbers reflect the underlying planking. They are joggled from the keel up to the level of the tenth strake. Where framing timbers are located on top of sealing boards, the joggles are extended to accommodate these. With the transition from clinker to carvel planking, the outboard faces of single frames are smooth. The moulded dimension of single frames varies between 25 and 30 cm and the frames are between 16 and 27 cm sided (Fig. 5).

The preserved parts of the composite frames are assembled from up to five individual elements, which are scarfed together and fastened to adjoining timbers with horizontally driven trenails. Timbers in the composite frames are slightly less substantial than those in

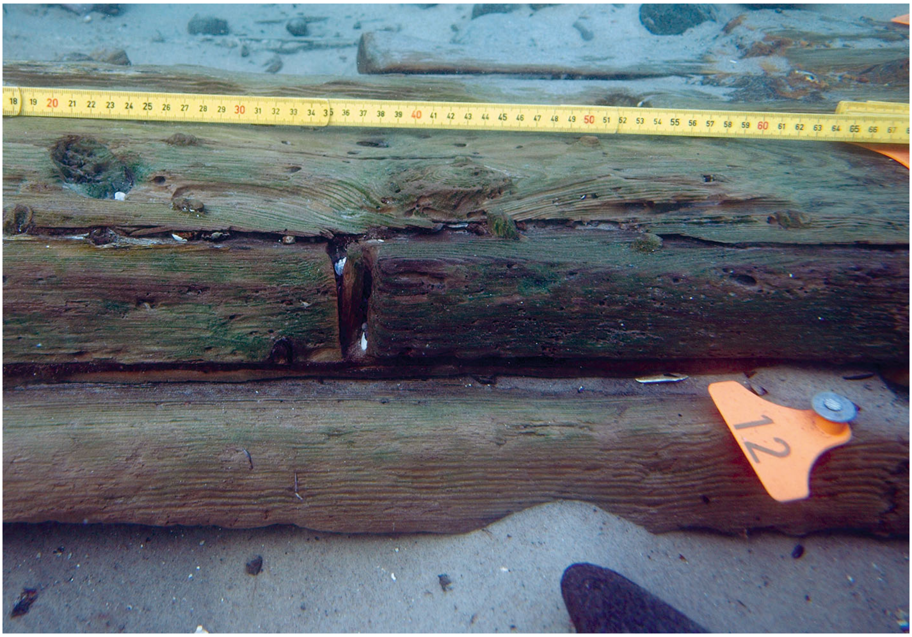

Fig. 4 Composition of the hull. From *top* to *bottom*: sealing board, abutting clinker planks, thin boards to even out clinker steps and carvel outer plank of the second phase (12). Auer (2012)

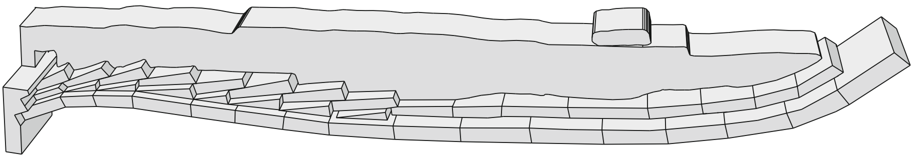

Fig. 5 Cross-section through a single frame. The keel is not preserved and has been reconstructed freely. Ditta (2013)

the single frames. Moulded dimensions vary between 17 and 25 cm and the timbers are between 19 and 25 cm sided. In order to fit the carvel frames into the stepped clinker shell, small wooden levelling boards were applied to the inside of the clinker planking underneath the frames (Fig. 6).

All frames are fastened to the underlying planking with wooden trenails, some of which are secured with wedges. Generally, trenails are spaced very closely, and in many cases intercutting nails were observed. This is probably a result of the multiple phases of construction evidenced by the outer hull planking.

It is interesting to note that the framing follows a regular pattern. Composite carvel frames are spaced approximately 2 m apart (measured from centre to centre). Based on the length of the vessel, there would have been a total of seven of these frames in the construction. Between each pair of carvel frames there are four single frames spaced at 38 cm intervals.

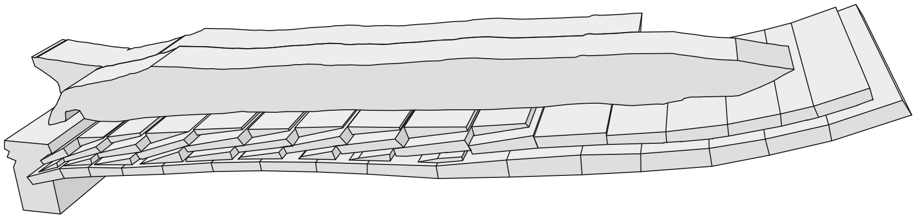

Fig. 6 Cross-section through a composite carvel frame. The keel is not preserved and has been reconstructed freely. Ditta (2013)

The construction features observed on the wreck immediately lead to a number of questions:

Pettu had a bottom built up from clinker planks with the sides planked in carvel fashion. Framing consisted of single clinker frames and composite carvel frames. How exactly was the sequence of construction? And why this choice of construction method? At some point *Pettu* received a second flush skin of carvel planking. When did this happen and why? The choice of construction material and the remarkable absence of iron fastenings also warrant further investigation.

The Sequence of Construction

However, in order to discuss the concept behind design and construction of the ship, it is important to understand how it was built. Based on the archaeological evidence it was attempted to reconstruct the sequence of construction:

The construction of *Pettu* would probably have started with laying the keel and erecting stempost and sternpost (Fig. 7).

The next step leaves more room for interpretation. Based on the fact that clinker planking is generally an indication of the 'shell-first' concept (Hasslöf et al. 1972), it would

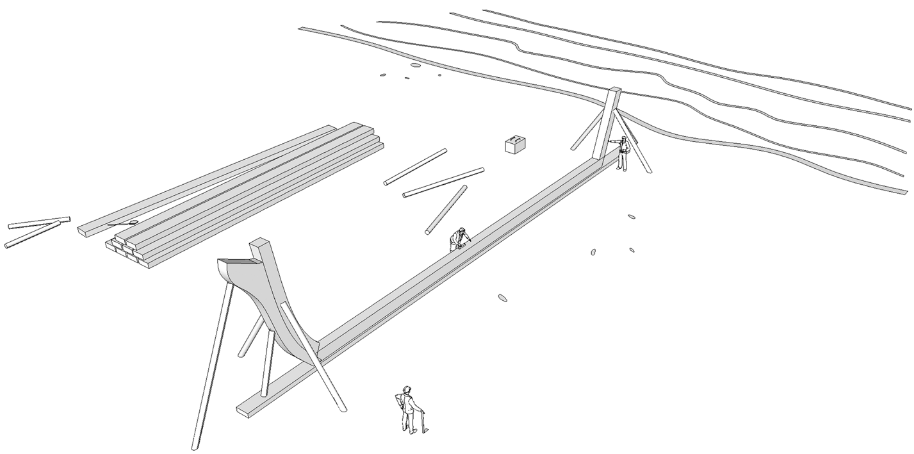

Fig. 7 Laying the keel and erecting the posts. Ditta (2013)

seem highly probable that the first ten clinker strakes were fastened next. Strake overlaps were secured with small wedged wooden trenails and strake planks butted against each other. The butt joints were sealed by thin boards trenailed over mats of waterproofing material to the inside of the clinker planks (Fig. 8).

Theoretically it is also possible to first erect the composite carvel frames and afterwards start planking up the clinker strakes. This would, however, be quite difficult, especially as sealing boards, as well as filling boards would have to be nailed over plank joints prior to fastening the planks. The sequence of construction in this case is directly related to the question why clinker planking was used for the lowermost strakes in the ship. As this question in turn relates to the concept behind clinker and carvel construction and the phenomenon of half-carvel vessels, it is discussed in more detail later.

After planking up the clinker strakes, the seven composite carvel frames would have been erected, evenly spaced apart at a distance of 2 m on the keel. In order to fit the carvel frames into the clinker shell, small boards were nailed to the inside of the clinker planking, effectively filling the space between planks and providing a smooth surface. As individual components of the composite frames are fastened to each other with trenails, it is clear that the frames were pre-assembled before being fastened to the keel. The shape of the frames must have been based on the existing clinker shell and could have been determined using a number of different methods, which are discussed later.

Figure 9 shows the use of moulds as one possible method of taking off the clinker shape and determining frame shape.

With the composite frames in place, the skeleton of the ship was finished. Composite frames and posts could now be connected by ribbands in order to visualise the three-dimensional shape of the hull (Figs. 10, 11). Using the ribbands as a guide, the remaining filling frames could be made and inserted. Floor timbers were joggled to fit over clinker strakes and sealing boards at the bottom of the vessel. Now internal members, such as keelson, beams and knees could be inserted and the hull could be planked up, either

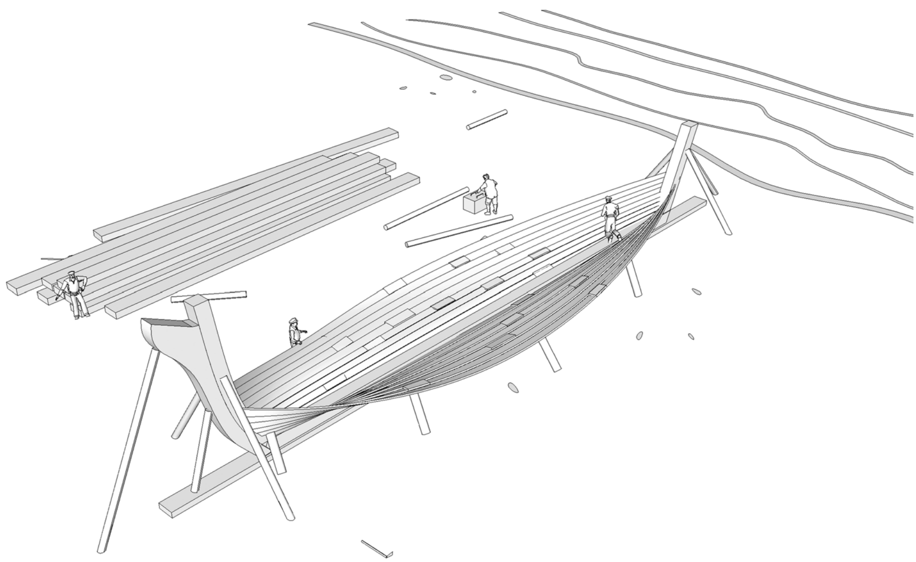

Fig. 8 Constructing the clinker bottom. Ditta (2013)

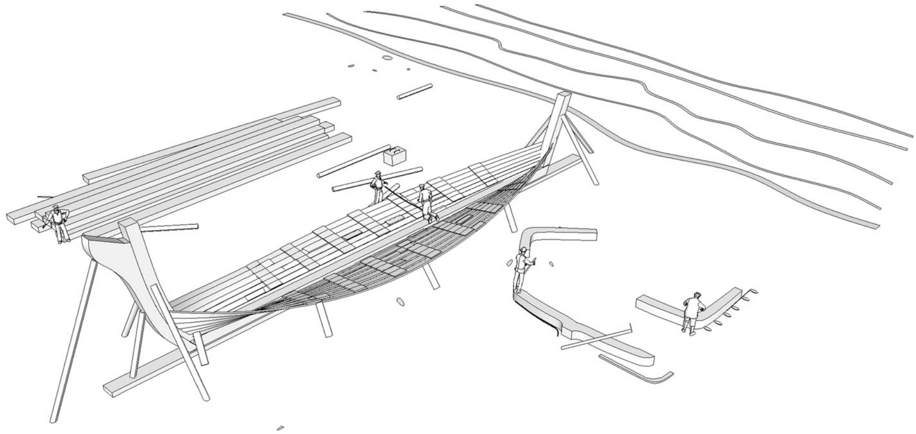

Fig. 9 Preparing for the insertion of the composite frames. Ditta (2013)

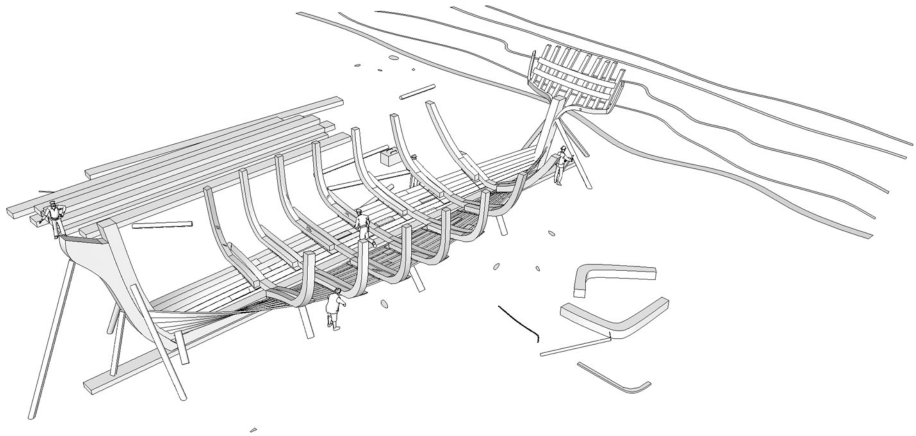

Fig. 10 Setting up the composite carvel frames. Ditta (2013)

starting from the sheer or from the edge of the clinker planking below the turn of the bilge (Fig. 12). This concludes the construction of the ship with a single layer of outer hull planking.

But what about the second, carvel layer of outer hull planking? Was it applied during initial construction, or does it represent a later modification? And what purpose does it serve? Keel and posts would probably offer vital clues as to the answer of those questions. However, the keel was heavily fragmented and the posts were only partially accessible. Based on the fact that clinker planking of the inner shell and carvel planking of the outer shell seem to run into separate posts at the bow, a construction in two phases is currently assumed. This assumption is supported by a very deep keel, which seems to consist of multiple layered elements and the possible presence of a second rabbet underneath the first. At the stern, however, only a single rabbet was observed.

The presence of many intercutting trenails and the careful fastening and waterproofing of the lower clinker strakes and the inner carvel layer also speak for a construction in two

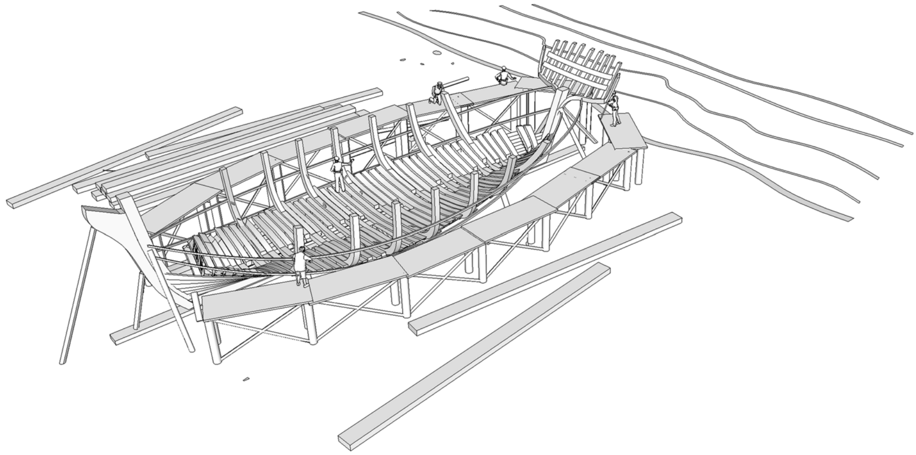

Fig. 11 Fastening ribbands and inserting filling frames. Ditta (2013)

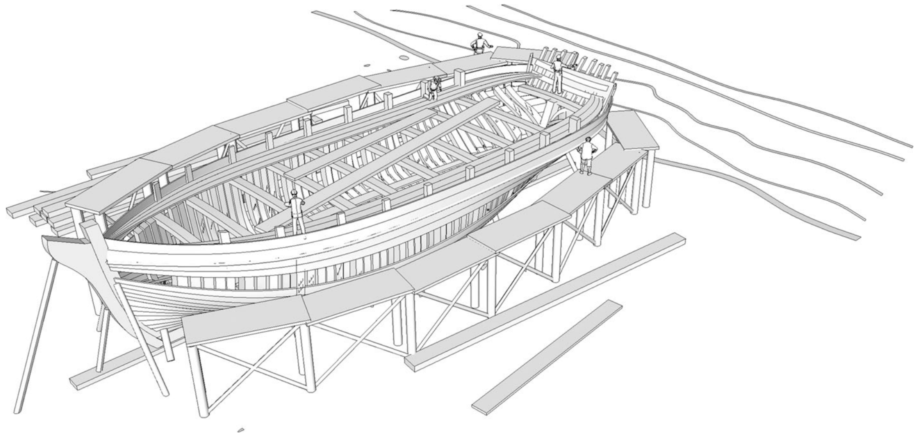

Fig. 12 Planking up. Ditta (2013)

stages. Had the inner shell only been intended as a strengthening or shaping element, it would not have been necessary to fasten and waterproof it in such an elaborate way.

If the second layer of outer hull planking represents a later modification, this would have changed the vessel significantly. Not only by adding extra weight to the outside, but also by changing the shape of the lower hull. The deep keel and added stempost assembly could thus also be an attempt to improve the ship's sailing abilities after the modification.

Having established the likely sequence of construction, it is possible to investigate the concept behind it. In the registration documents from 1891, *Pettu* is described as "carvel-built" (009 PETTU 05a 1891; 009 PETTU 02 1891). However, the ten lowermost strakes in the inner shell of *Pettu* are clinker laid with overlapping strakes, effectively making the ship what Hasslöff calls a half-carvel (Hasslöf et al. 1972). But while in other half-carvels, clinker planking usually extends to or past the turn of the bilge to the waterline (Hasslöf et al. 1972; Eriksson 2008, 2010; Alopaeus et al. 2011), the clinker planking of *Pettu* stops well below the turn of the bilge.

Clinker Aided Carvel? The Design of *Pettu*

The appearance of half-carvels seems to be limited to the Eastern Baltic with archaeological remains known from Sweden and Finland. The oldest half-carvel found to date was built in 1577 (Eriksson 2008), but the majority of finds date to the eighteenth and nineteenth century (Eriksson 2010). But why build a half-carvel? In an interview in 1938, the Swedish shipbuilder Anders Mattsson of Kongsviken stated:

> "It's a bit tricky, carvel- building. You see, you have to knock up the ribs first. Then you can't see what sort of a bottom she's going to get. And that's the most important part of a ship, after all. Now when you build clinker, the ship takes shape under your hands. And if it don't turn out right, you can put it right, just like it should be. But once you've got over the bilge, the worst's over. Then you can put in the futtocks and raise the top timbers. They can only go one way. And then you can fill in the rest carvel-fashion. And you can use thicker planks; too, when there's a rib you can pull against to get a bend in the thick stuff. Well, you need it for the big 'uns" (Hasslöf et al. 1972).

Is this the main reason for half-carvel construction? The desire to built a carvel vessel combined with the inability to use the design- and construction techniques related to the skeleton-first principle? Or as Eriksson puts it:

> "If you only have the know-how to build a clinker, but you have the social ambitions of the owner of a carvel ship, the technique of the former and the look of the latter form a perfect compromise: you make the ship a half-carvel!" (Eriksson 2010).

Or could there be other, more practical or construction related reasons for half-carvel construction? Was the clinker bottom maybe considered advantageous in terms of flexibility or strength? This seems unlikely considering how little of the ship's lower hull is clinker-built. In addition, the use of sawn planks and butt joints between strake planks was probably fast and economic, but would certainly have had a limiting effect on hull strength.

If the reasons for using clinker in the lower hull of *Pettu* are to be sought in the ship design and construction process, this aspect warrants a closer investigation. As mentioned before, only a very small part of *Pettu*'s lower hull is clinker built. The argument put forward by Anders Mattson in 1938 can therefore not be applied to *Pettu*. In addition, the use of composite carvel frames, which seem to be contemporary with the inner shell is generally associated with frame-led construction and thus directly contradicts the argument put forward by Hasslöf and Eriksson (Hasslöf et al. 1972; Eriksson 2010). So how was *Pettu* designed?

In the 19th century, a variety of different methods of ship design were available to the carvel shipbuilder. Ships could be built according to lines plans or geometrical systems, or their shape could be visualized using block models or they could be shaped on the stocks, either with shell building techniques or with a method known as building on one or more ribs in English (Hasslöf et al. 1972) or as "klampbygning" in Danish (Møller Nielsen et al. 2000). While the use of drawings or lines plans was becoming more widespread in the course of the nineteenth century, the majority of smaller merchant vessels were still designed based on practical experience of the shipwright (Hasslöf et al. 1972; Møller Nielsen et al. 2000; Greenhill and Manning 2009). In Northern Europe, this generally meant either the use of block models or the aforementioned building on one or more ribs. Both methods are based on the same principle: The shape of a vessel is "sculpted" by the shipbuilder, based on experience and requirements. When using block models, the shaping process is undertaken at reduced scale prior to construction, while building on ribs meant integrating the process of shaping the hull into the construction. As late as 1917 the Finnish schooner Ingrid was built based on an up-scaled half-model of an earlier and smaller vessel (Greenhill and Manning 2009), and Hasslöf observed the practice of building on a rib on small Swedish shipyards in the 1950s (Hasslöf et al. 1972). With the exception of the shell-first carvel technique practiced in the Netherlands, all of the methods mentioned above would or could result in systematically placed composite carvel frames as observed in *Pettu*. However, none of the methods would necessitate a clinker-laid bottom, as hull shape is defined by the skeleton of frames.

Of the geometrical ship design methods, the "moulding with adjustable templates" is probably the most common. This method with its variations can be found from the Mediterranean to the Atlantic coasts. It uses a number of simple geometrically-based devices to generate smooth curves suitable for the adjustment of frames along a hull, provided that the interval between stations is uniform for each curve (Auer et al. 2013a). In the English shipbuilding tradition a similar method to the "moulding with adjustable templates" is known under the name of "whole-moulding". McKee describes this method as "a stage between building by eye and the preparation of a draft using sweeps, the radii of which change every station" (McKee 1983). In its simplest form, this method only needs a two-dimensional outline of the vessel consisting of sheer line, rising line and maximum breadth of sheerline, as well as a mould for the master frame and three aids (Fig. 13): The rising square is a batten with the heights of floors taken from the rising line marked for every station. The breadth mould has the shape of the midship section and three sets of marks for rising line, floor heads and breadth. The rising line marks give the narrowing of the mould and align with the ones of the "rising square". The rising line sirmarks are taken from the breadth of the sheer line on the plan. The sirmarks for the breadth are taken from the height of the sheer line on

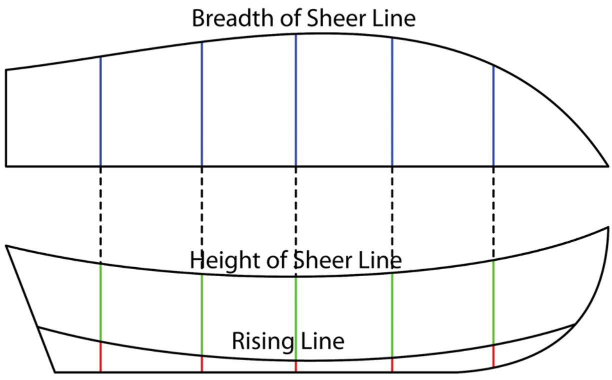

Fig. 13 Schematic representation of a possible outlines plan that could be used as a basis for whole-moulding. The sections are used to extract the different sirmarks on the moulds. The *red lines* give the sirmarks for the rising square. The *blue lines* provide the *rising line* sirmarks on the breadth mould for the narrowing. The *green lines* give the breadth sirmarks on the breadth mould Ditta (2013) (Color figure online)

the plan. The hollow mould has its sirmarks set on the rabbet line and is positioned tangentially to the breadth mould in order to form the reverse curve (McKee 1983). Using this system, a whole hull can be drafted without the use of diagrams or geometrical reduction methods. The hull shape can be modified simply by changing the curves of moulds or altering the placing of sirmarks. However, as McKee observes, this system "expresses boat shape in terms of the hull sections rather than in the run of planks and ribbands" (McKee 1983).

If the concept of whole-moulding was to be applied to *Pettu*, the first ten clinker laid strakes would provide the shipbuilder with two important lines. The rising line and the narrowing line of the floor for the frames could have been extracted by dividing the clinker bottom at regular intervals, and transferred to paper or a moulding loft. These lines could then be translated to sirmarks and could be used to reduce a given master mould. This means the shipbuilder would only have needed the height of the sheerline and a simple master mould in order to design a frame first carvel vessel, based on clinker shipbuilding experience (Auer et al. 2013a) (Fig. 14). With only a small number of pre-erected frames, ribbands would have helped to fair the overall shape of the hull. Mathematical knowledge or geometrical skills would not have been required.

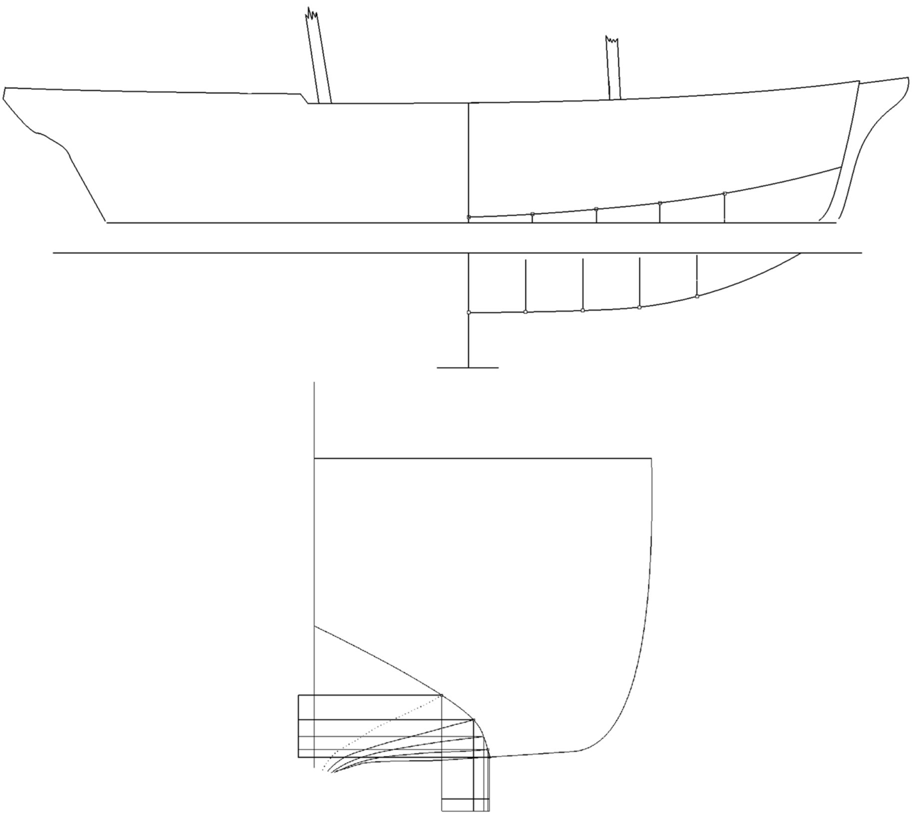

Fig. 14 Taking the lines from the inside of the hull of Pettu at the preserved composite frame stations, it becomes visible how the *rising* and *narrowing lines* of the floor are formed. These lines and sections could be used to extract the sirmarks for the breadth mould Ditta (2013)

In this case the clinker bottom would have been used as an aid for designing *Pettu*'s carvel hull. Hidden from view below the waterline, it would have been invisible to the eyes of any observer. Could a ship built in this way have been called a "carvel-built vessel", as stated in the registration documents from 1891?

While entirely speculative, this theory is currently thought to be the most likely explanation for the partial clinker construction observed on the wreck of the *Pettu*. Unlike a range of other vessels from the same period and area (Gustafsson 1974a), *Pettu* is not recorded to have been converted from clinker to carvel, or half-carvel to carvel for that matter. Instead she is registered as carvel-built in 1865. Most of the construction features observed in *Pettu* are typical for frame-led carvel vessels. If the invisible clinker strakes in the bottom of the ship were merely a design aid, *Pettu* could well have passed as a carvel ship.

Considering the period and the tradition in the area in question, most shipbuilders would have been used to the construction of clinker ships. Papp states, that it was only during and after the Crimean War that carvel built ships became more common in the Åland isles. In 1852, the total tonnage (in lasts) of carvel-built ships in the Åland isles was 573, 34, while the tonnage of clinker built vessels was 4872, 42 (Papp 1977). In 1865, the year *Pettu* was built, carvel construction would still have been a fairly recent phenomenon in southwestern Finland. Thus using the old knowledge of clinker shipbuilding as an aid for designing a carvel vessel with new techniques would not seem unlikely. If this the case, *Pettu* would be a 'clinker-aided carvel', and as such another instance of the "merging of the two methods", which, as Jonathan Adams points out, demonstrates "that shipwrights through time have had no conceptual problems in adapting their procedures in the face of various stimuli, even though it may involve overriding ideological objections and preferences" (Adams 2003).

A Second Carvel Skin

If *Pettu* was indeed seen as a carvel vessel, why would a second carvel skin have been applied and when did this happen? Based on the archaeological evidence, it is currently assumed that the second skin was applied at some point after the initial construction. However, the exact point in time is hard to determine without the possibility of a detailed dendrochronological analysis. The historical documents, which are preserved for *Pettu*, do not offer any information on a major repair or possible conversion.

The oldest converted or carvelled clinker vessels found, date back to the sixteenth century (Mäss 1994; Ossowski 2006; Auer 2010; Grundvad 2010), but the phenomenon is also known from the eighteenth, nineteenth and even the twentieth century. The reasons for conversion vary. The sixteenth century Maasilinn wreck found in Estonia is thought to have originally been built with two layers of planking. In that case, the clinker layer would purely have been a design feature, allowing a clinker shipbuilder to produce a carvel vessel (Mäss 1994). This interpretation has, however, been doubted by other scholars (Grundvad 2010). In Sweden, carvel vessels were eligible for tax reductions during the seventeenth and eighteenth century, a fact that seemingly prompted some owners of clinker ships to have these converted to carvel (Eriksson 2010).

Practical reasons for the application of a second outer carvel skin could also be protection against ice or the preference of a flush outer hull for fishing with nets. As carvel planking is far easier to maintain, repair and to keep watertight, a carvel skin could also represent a measure to repair a clinker vessel, or to prolong the life of a well designed clinker ship. This was most likely the case with a sixteenth century converted clinker vessel, parts of which were found on the beach on the German Baltic coast. Here, the original, radially split clinker planking and the tangentially converted carvel planks were sourced in different areas (Auer 2010; Grundvad 2010). Hasslöf reports an extreme case of rebuilding. In 1892, the clinker 'jagt' *Liljan*, built in 1880 was converted to a carvel galleass. During the conversion, the clinker ship was cut in half and lengthened in the midsection. In bow and stern, the clinker planking stayed in place underneath the new carvel skin, effectively making *Liljan* a converted clinker vessel (Hasslöf et al. 1972) If *Pettu* was originally seen as a carvel ship, rather than a half-carvel, a conversion for design, or tax reasons can be ruled out. This leaves repair or rebuilding as the most likely causes for the application of a second carvel skin. Considering the relatively long life of the vessel (28 years), she would almost certainly have undergone minor or major repair or even rebuilding, a common practice according to Papp and the ship list compiled by Gustafsson (1974a) and Papp (1977).

The Choice of Building Material

Another aspect, which warrants a closer look, is the choice of softwood as main building material and the absence of metal fastenings in the construction of the ship. Built in 1840, the British brig *Water Nymph*, comparable in size to *Pettu*, was made almost exclusively from oak sourced from England, France, the Baltic, North America and Africa. The oak planking was fastened with trenails and copper bolts, and major construction elements were held together by large copper alloy bolts. Breast hooks and crutches were partially of iron, and the deck beams were held in place by a combination of iron bands and hanging knees (Auer and Belasus 2008). *Pettu* was built from pine and spruce, both of which were considered lower quality timber and therefore generally not used for hull construction (Murray and Creuze 1863). The lowermost clinker strakes and the associated sealing boards were exclusively fastened with small wooden trenails. Iron nails were seemingly only used to fasten ceiling planks in some cases and some major construction elements in bow and stern. The use of butt joints and sealing boards instead of the traditional scarf joints between clinker planks is another noticeable feature. In a direct comparison with Water Nymph, *Pettu* appears almost archaic.

Looking at the way *Pettu* was designed, her builder certainly had his roots in clinker shipbuilding. He was, however, knowledgeable about the design of carvel ships. Without resorting to drawings, he found a way to combine both methods. Using his experience of traditional clinker shipbuilding, he shaped the difficult part of the underwater hull and innovatively used it as an aid to building a carvel ship with a skeleton of pre-assembled frames. Small resulting problems, such as fitting the pre-assembled carvel frames into the clinker shell were overcome in a simple, but effective manner, with levelling boards.

The absence of metal in the construction could point towards a lack of availability, but it could also be a result of economical thinking. Considering the very labour-intensive process of trenail fastening, it would certainly seem that cost of labour was less important than the cost of material or at least metal. The use of pine and spruce, lower quality timber, for the construction might reflect the same constraints: This wood could probably easily be sourced locally and was affordable. And it might have been considered 'good enough', when balancing factors such as the life expectancy of the vessel and the expected profit that could be earned through its operation. Finally the choice of detailed solutions in timber connections, such as the use of butt joints instead of the more traditional scarfs between clinker strake planks is interesting. One could argue that this is faster and easier, however, fastening sealing boards with a multitude of small trenails and then cutting frames to fit over those would also be work intensive. Could this be indicative of the work being carried out by people who are not trained as shipbuilders?

Pettu in Context: Rural Shipbuilding in Finland

Being in the fortunate position of having identified the wreck and having original sources on the construction and use of *Pettu* available, it is possible to take a closer look at the country, the vessel was built in, and the circumstances it was built under.

Pettu was built on a small rural shipbuilding site, the *Pettu* shipyard of Finnby kapell in the parish of Bjerno in the southwest of Finland. Her 'bilbref' or building certificate was issued on the 2nd of October by master shipbuilder Justus Wilhelm Jansson (18730514 PETTU skonert certificat C–D 1873). With bow loading hatches, *Pettu* was likely built for the timber trade. Until her home port changed to the staple town Rauma on the southwest coast of Finland in 1873, she was probably operated out of the Bjerno archipelago (Visser 2013).

The Finland of the 1860s was still very rural in character with the majority of the population living from subsistence agriculture. Finland had been part of the Swedish kingdom since the Middle Ages, but was incorporated into the Russian empire as autonomous Grand Duchy after the Finnish War in 1809. During the first half of the nineteenth century, economic development in Finland remained relatively slow. Tar and sawn timber were the main export products and these were produced using preindustrial methods (Kaukiainen 1993). From the 1830s cargo volumes of Finnish export started to increase dramatically. At the beginning of the 1870s sawn goods and timber made up 85 % of the outward cargo space (Kaukiainen 1993).

By 1830 all coastal towns were allowed to trade abroad with their own vessels and farmers were allowed to trade within the Baltic. From the 1840s farmers, mainly from the Turku archipelago and the Åland islands, started sailing to German and Danish ports carrying sawn goods and timber from Finland and northern Sweden. With this development, the traditional clinker-built vessels were gradually replaced by schooners and brigs (Kaukiainen 1993). After the Crimean War Finnish coastal towns started rebuilding the merchant fleet, which had suffered considerable losses. This was encouraged by the state in the form of loans to ship owners and the abolition of all custom dues on shipbuilding materials. The government also allowed Finnish merchants to charter farmer's vessels for trips no farther than England or the North Sea. When *Pettu* was built on a rural shipyard in 1865, her construction was probably a solid economic investment. But what did 'rural shipbuilding entail?

The building process of a "peasant" vessel is described by several authors (Gustafsson 1974a; Papp 1977; Greenhill and Manning 2009). It started with finding shareholders who would help financing the construction and part own the vessel. This could be done by walking around villages and farms with a list (Papp 1977) or, as was the case with the schooner *Ingrid* built in 1906, it could be the result of a winter party (Greenhill and Manning 2009). The number of shareholders varied, but could easily reach 200 or more, especially in the 1860s and 1870s (Papp 1977; Greenhill and Manning 2009). Shares could be bought with money, or raw material needed for the construction. Next, a suitable building site near the beach was found and a temporary shipyard was established. A master shipbuilder was hired by the shareholders, as were workers. However, *Ingrid* was built by 20 of the shareholders, who paid for their shares with manual labour (Greenhill and Manning 2009). In later periods, the shipbuilder was responsible for providing the workforce (Papp 1977). Construction timber was mostly sourced from local forests (Gustafsson 1974b; Papp 1977) and iron was bought cheaply at auctions (Papp 1977) or reused from older or wrecked vessels in order to minimise cost. Even the expensive rig was often taken from older vessels, which had been wrecked or were decommissioned. Greenhill calls the construction of the schooner Ingrid:

> "…the common venture of a highly democratic and relatively prosperous agricultural community with a strong seafaring tradition" (Greenhill and Manning 2009).

Seen against this background, the construction details observed on the wreck of *Pettu* clearly reflect the process and resources of rural shipbuilding and in a wider context also the society behind it. Master shipbuilder Justus Wilhelm Jansson was probably hired by the local community of Finnby kapell to build the ship and applied his knowledge to the design of the vessel. Jansson likely had a background in clinker shipbuilding and thus made use of this experience in his design methods.

Pine and spruce were locally available and were thus chosen for construction. The raw material for iron fastenings would almost certainly have been more expensive than the production of small trenails, which could be made locally. Even the name *Pettu*, which translates to 'pine bark' reflects the wood-culture which produced the vessel (1). And in a small rural community, the cost of labour would have been low. Finally, if the work was carried out by farmers or agricultural workers not otherwise trained in shipbuilding under the supervision of a single shipwright, this might also explain the use of butt joints between outer planks in the clinker strakes.

It is interesting to compare the process of rural shipbuilding and shipping in south-western Finland with the Swedish East coast on the other side of the Gulf of Bothnia. Both areas were in direct economic competition and Karin G:son Berg's detailed account of shipowners in Roslagen in Vätö parish northeast of Stockholm paints a very similar picture to the situation in Finland. Ships are built locally under the supervision of migrating shipbuilders (Berg 1984, p. 136f). Materials are primarily locally sourced and pine is a common building material with the use of oak governed by economical factors (Berg 1984, p. 250). The majority of ships were either clinker built or half-carvels, with the first carvel ships only making an appearance in the late 1850s (Berg 1984, p. 130).

Through careful analysis, the wreck of *Pettu* has indeed provided an insight into different parts of the Finnish society of the nineteenth century. From her construction in a rural coastal community to her use by merchants in a staple town in the southwest of Finland the ship reflects the ideology, tradition and technology of the society that produced and used her. *Pettu* is an example of rural or peasant shipbuilding in south-western Finland, a fairly unique, but by no means singular phenomenon in an otherwise industrialised Europe—and a subject not yet fully archaeologically explored. Stimulated by a growth in timber trade in the 1840s, the nineteenth century saw a gradual transition in Finnish merchant shipbuilding, from the production of smaller clinker vessels to larger carvel ships. Although built in the second half of the nineteenth century, *Pettu* as a 'clinker aided carvel vessel' still reflects this transition—and shows the ability of her master shipwright to innovatively adapt his methods and combine elements of both technologies to arrive at the desired result.

Finally, the preserved archival material shows that *Pettu* is a typical example for a vessel used for trading timber in the Baltic, a niche trade, which allowed the profitable use of sailing ships well into the twentieth century and the age of steam.

With the recent re-analysis of two ship finds in Mecklenburg-Vorpommern on the German Baltic coast, which had initially been dated to the medieval period (Förster 2009), the 'body' of archaeological evidence for rural shipbuilding in Finland has grown (Belasus 2014). *Poel 11*, an approximately 28 m long and 8 m wide clinker built vessel could be dated to the late eighteenth century and was most likely built in southwestern Finland (Belasus 2014, p. 171ff). *Hiddensee 12*, was an approximately 20 m long clinker vessel with a carvel skin, which dates to the late eighteenth or early nineteenth century and based on similarities in construction to *Poel 11* is thought to originate in the same area. It is possible that the carvel skin was applied during the initial construction process in order to produce a carvel vessel on the basis of clinker technology (Belasus 2014, p. 177ff).

Both ships are interpreted as products of rural shipbuilding and although clinker built, show a number of interesting adoptions of technical solutions derived from carvel shipbuilding (Belasus 2014, p. 177ff and p. 285ff). While the construction of both vessels shows a number of similarities to that of *Pettu*, there are some marked differences as well, such as e.g. the fastening of strake overlaps with double bent iron nails.

Just as the later *Pettu*, these two earlier examples of rural shipbuilding illustrate the ability of rural shipbuilders to combine their knowledge of clinker construction with a wide variety of clever technological adoptions from carvel technology to produce large economically competitive merchant vessels. These adoptions ranged from minor alterations in the construction all the way to producing carvel vessels as the *Pettu* or carvel-like vessels as *Hiddensee 12* if the second carvel skin was applied during the construction process.

On a different note the survey of the wreck of the *Pettu* clearly shows the limitations of historical sources abundant as they might be in a period as recent as the nineteenth century. While registration documents, logbooks and other sources provide a wealth of information on the general characteristics of the ship, its ownership and use and the life on board, the rural community which produced the merchant vessel only becomes visible through a careful analysis of the archaeological source, in this case the hull remains of *Pettu*.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

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