was most likely situated. There is no space for the mast step in front of this floor timber so it was probably positioned just aft of floor timber 0. The fact that there are extra-strong knees at the end of the beam at this position is yet another structural parallel to Skuldelev 3 and confirms that frame-position 0 was in fact the mast-frame.

Rigging details

Over the oarports in the sheerstrake between 5A and 7A, there are two groups of holes along the upper edge of the strake which are probably related to the rigging. There are two holes at 5½A and four at 6½A, spaced 8-14 cm apart (Fig. 23). Cleats for belaying the sheet may have been fastened with treenails here.[5]

The recorded diameters of these holes, before conservation, are 3.5-4.0 cm. Owing to the fact that the sheerstrake was exposed for some time after the ship's sinking to active biological degradation and strong currents transporting sand across the area, the decayed surface layers of that plank detached themselves at an early stage. Because of this, the surface character of the wood changed, reducing the size of the plank and increasing the diameter of holes. Therefore, the present diameter of the holes may be a result of these factors.

As the upper strakes are missing forward of 3½F, no evidence is preserved as to the arrangement of the tack from the forward edge of the sail. Nor are there any indications of the points of fastening the shrouds or the stays in the hull.

Oarports and shield-rack

As many as fourteen holes for oars have been cut through the 7.7 m-long middle length of the port sheerstrake of ash (Figs 24-25). Initially, they appear confusing but they clearly match two different systems. One system, which consists of a line of round holes, also has several holes that have been closed from the outside with small patches of oak. The distance between the holes, from centre to centre, varies between 70 cm and 88 cm, averaging 78 cm. This length of plank evidently came from another ship that had an average frame distance of ca 78 cm, which accommodated the first system of circular oarports.

The other system took advantage of a few of the holes from the first system, but was otherwise based on holes cut in a roughly square shape. These oarports were positioned in between the frame stations of Skuldelev 5 with a medial distance of 91 cm that corresponds to the average spacing of the frames in this ship.[6] Although this distance varies considerably from 80 cm to 102 cm, it roughly follows the irregularities in the spacing of the floor timbers. Thus the port sheerstrake plank had been reused in this ship, despite the inconvenience of cutting new holes or reusing holes that were not placed at optimal positions.

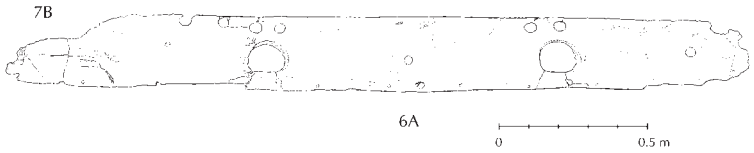

Fig. 23. Skuldelev 5. The sheerstrake 7B around 6A, seen from the inside with oar-holes at 5½A and 6½A and two groups of holes above the oar-holes. Scale 1:20.

The aftermost preserved part of the sheerstrake is of oak and displays no evidence of having been reused (cf Fig. 23). Here are oarports at 5½A and 6½A, spaced 96 cm from centre to centre, and in their present degraded condition slightly oval in shape.

The high degree of decay that affected the greater part of the sheerstrake makes it difficult to establish the exact original size and shape of most of the holes. However, the best preserved holes from the first system measure 9 cm in diameter and those from the second system 9-10 x 10-11 cm. The holes of the first system that were reused in the second system were not cut square to match the shape of the new holes.

Several interesting features, including the rack for mounting the shields of the warriors/oarsmen on the outside of the sheerstrake, were badly affected by the ship's post-depositional, *in situ* decay and erosion. Luckily, however, a small part of this particular element survived amidships (Fig. 26, cf Figs 5 and 25). It is of oak with a preserved length of 1.48 m, made from a ca 5 x 5 cm lath that had been cut in such a way that the full thickness is only preserved in a few small areas held against the upper edge of the sheerstrake with small treenails, ca 1 cm in diameter. In between these points of attachment, the thickness narrows to 2 cm, leaving a 3 cm-wide slot between the outside of the sheerstrake and the rack. In these slots, the shields of the warriors would be mounted outboard as illustrated in several Viking-Age depictions.

The preserved shield-rack is fastened at 0, at the mast-frame position. The forward end was evidently scarfed by means of a small rivet to another piece, now lost, and for which there is only an attachment point at frame 3F. The other end of the rack is worn off just before its attachment point at 1A, but the thickness of the rack increases towards this end and there is a hole for a small treenail in the plank here.

Further holes for the small treenails that held the shield-rack are present at 3A and 4A, which allows the study of the

5. Andersen & Andersen 1989: 213-216, see also Volume II.
6. The difference between the medial distance of the floor timbers of 0.90 m and of the oarports of 0.91 m is explained by the curvature of the sheerstrake giving this a slightly greater length than the keel between the frame-stations forward and aft.

Fig. 24. Skuldelev 5. Fragment of the sheerstrake, seen from the outside (above) and from the inside (below). To the left is a covered-over oar-hole from the first system and to the right one from the second system, positioned at 1½F.

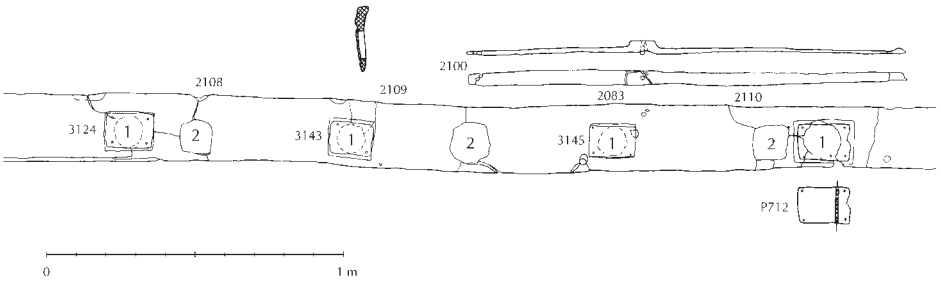

Fig. 25. Skuldelev 5. A section amidships of the port sheerstrake plank of ash, seen from the outside. Two systems of oarports are marked out by the numbers 1 and 2. The shield-rack is shown above the plank. Scale 1:20.

positions of the shields in relation to the oarports in this part of the ship (cf Fig. 25). The slot for the shield to be positioned between 0 and 1A was 78-80 cm wide in order to hold a shield with a diameter of 80-85 cm. When the shield was in position here, the oarport could not be used for rowing. When the ship was under sail, a mounted row of shields could have offered some protection for the crew against enemy arrows, as well as prevent water entry through the oarports, but proper lids[7] would have been more efficient for the latter purpose. It is likely that the shields were mounted outboards on special occasions, such as when riding at anchor at a fleet review prior to action, or possibly when the ship was approaching an enemy coast under sail.

5.5.3 Reconstruction of the ship in torso

The restored Skuldelev 5 ship as exhibited in the Viking Ship Museum (Figs 27-29) is a distinctive and interesting torso of the remains of the original ship. The ship holds vast potential as a source for the study of this particular ship type of the past, as well as an individual vessel with its own history. It is, however, not the best source for the recording of the ship's original shape in detail. All original parts of the ship were assembled soon after the opening of the museum in 1969, and at the beginning of this work, the restoration virtually had to start from scrap since no preparatory model-work had taken place. The ship under restoration was built up from the keel. Compromises had to be incorporated in the assembly in order to account for shrinkage and other features, such as the fact that the keel was laid out horizontally but had originally been deeper aft (cf Chapter 4.3). The present shape of the hull as exhibited in the museum is therefore not a fully correct representation of the shape of the original ship.

In contrast, the torso reconstruction drawing of Skuldelev 5 presented here (Fig. 30) is based entirely on the pre-conservation documentation and other evidence of the original, preserved parts. In order to study the individual elements in their original three-dimensional position in the ship, the lines of the planking during the last active phase of the ship have been established by working with a model based on scaled-down versions of the drawings of all parts of the hull.

Models

After the conclusion of the analysis of Skuldelev 3 and the construction of *Roar Ege* in the years up to 1984 (cf Volume II of this monograph), the documentation of Skuldelev 5 formed the basis of a detailed analysis in 1985, leading to the suggestion that it might have been a ship of the *leiðang* organisation.[8] At the same time, aspects of the rigging problems in this ship were studied by Erik Andersen on a 1:10 workingmodel built up from cardboard 'planks'.[9]

Fig. 26. Skuldelev 5. The shield-rack in position along the upper edge of the sheerstrake.

Working with the cardboard model was complicated owing to the fragmentary state of several of the planks and the eroded edges of some of the upper planks. By using the same technique as described for Skuldelev 1, 2, and 3, it was possible, however, to build up the bottom part with keel, stem, and planking to establish the original outline of the hull with a slightly curved keel and a stem that was less raked than that of Skuldelev 3.

As the upper strakes were added, it became evident that the ship was deeper and slightly wider aft than forward. Once the sheerstrake had been mounted, it became clear that the upper edge of this plank had to have been horizontal amidships in the original ship, in order for the oarports to be located at optimal positions for the oarsmen. The overall shape of the hull was relatively well defined, even near the missing after stem, owing to the preserved port planking, floor timbers, knees, and breast-hook aft. A hypothetical outline of the after stem could then be drawn that closed the hull's lines, leaving a very narrow margin for variation as to the total length of the ship.

Based on the results of the work with the cardboard model, a wooden model of Skuldelev 5 at a scale of 1:10 was built by Morten Grønbech for exhibition in the Viking Ship Museum. This model served as an important guide in the 1990-91 work of building the full-scale reconstruction of this ship, *Helge Ask*, as described in Volume II.

7. There are no traces in the planking of lids of the revolving type known from the Gokstad ship, Nicolaysen 1882: Pl. IV, but several other versions are known from Hedeby. Crumlin-Pedersen 1997a: 126-27
8. Crumlin-Pedersen 1988
9. Andersen & Andersen 1989: 212-217

Fig. 27. Skuldelev 5. The restored ship in the Viking Ship Museum, seen from aft.

Fig. 28. Skuldelev 5. The restored ship in the Viking Ship Museum, seen from the bow.

Fig. 29. Skuldelev 5. Interior of the hull, looking forward.

Lines and torso-drawing

Based on the cardboard model, a torso-drawing of Skuldelev 5, showing the hull with all its preserved parts in their original shape, size and interrelationship, was prepared by Werner Karrasch (Fig. 30). The model in turn provided the basis for an inner edge line drawing, used by Kenn Jensen in his studies of the hydrostatics and strength properties of the original ship,[10] as described in Volume II.

A final version of the inner edge lines was generated in 2000 by Vibeke Bischoff in AutoCAD, with the aid of a script-file from the NMFC-module developed by Kenn Jensen (Fig. 31). This drawing reflects the general *shape* of the hull as established in working with the models, whereas the individual *lines* of the planking in this case have been faired to adjust for irregularities caused by repairs, etc. The intention is to present what was probably the *ideal* set of lines for the ship at which the shipbuilder was aiming during its construction. In fact, some of the planks from the construction phase did not follow these *ideal* lines closely, since these planks were not edge-trimmed to give a good fairing of the lines of the hull but were evidently used at a maximum width, even when the lines were slightly broken at the scarf to the next length of plank (cf Fig. 10). As the drawing shows the lines of the inner edges of the planks, a computer transformation programme to the outer hull was used to calculate the coefficients and hydrostatics of the ship.[11]

Type and size of the ship

Skuldelev 5 has been preserved to such an extent in the port side that the lines and most of the structural details of the original ship are known or can be deduced with a high degree of certainty, provided that the ship was built symmetrical port and starboard, as is to be expected. A full reconstruction of the hull, closely based on the archaeological evidence, could therefore be drawn on paper as well as built at full scale in 1991 as the reconstruction *Helge Ask*.

As recorded on the basis of the inner edge line drawing in Fig. 31, the original dimensions of Skuldelev 5 were 17.3 m in overall length and 2.47 m in maximum width. The height amidships would have been 1.16 m. A standard draught of 0.54 m amidships would have given a waterline length of 15.6 m and the vessel a displacement of 6.1 tons.

By the time this ship became part of the barrier in *Peberrenden*, it was old. The planking had been construc-

10. Jensen 1999: 55-113
11. Jensen 1999: 15-22

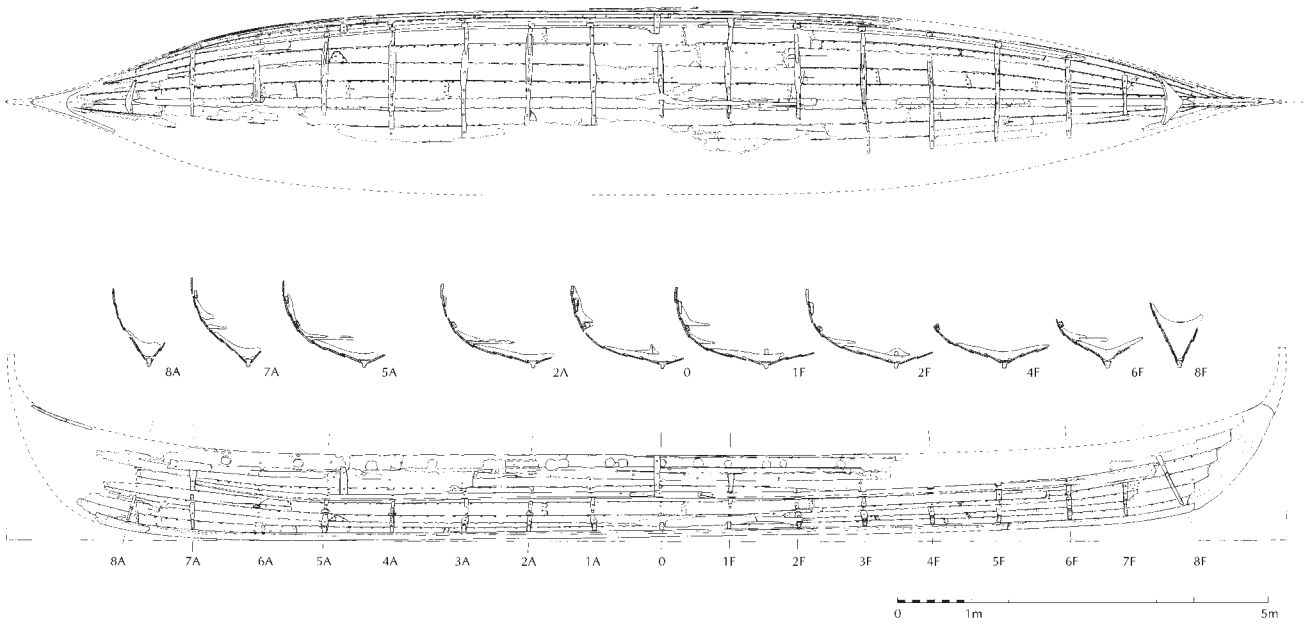

Fig. 30. Skuldelev 5. Torso-drawing of all recovered parts of the ship. Scale 1:80.

ted from materials of a variety of species and origins, including some that had been re-used. The ship had been heavily worn due to use and had been repaired more than once, not to mention the major repair undertaken shortly before the ship sank. Apart from being old and run-down by the time it was selected for its last voyage, the planking of Skuldelev 5 was not quite of the same standard as that of the other ships in the barrier. On the other hand, such details as the stem, floor timbers, beams, and knees were properly executed and structurally sound.

Evidently the construction of the ship was carried out under the control of a skilled shipbuilder, who was trained within the same tradition and normally worked to the same standards as the one who built Skuldelev 3. The floor timbers even have the same decorative mouldings along the edges. This is also the case with some of the repair planks which were built into the ship by professionals used to giving a final touch to their work in this way. This discrepancy between the moderate standard of the original part of the planking and the normal standard followed in other elements of the ship will be discussed below.

The ship was evidently relatively long, with a relationship of 7.3 between length overall and maximum width. This fact, as well as the row of oarports, the fixed beams/thwarts and the loose decking all the way from fore to aft leave no doubt that the ship was constructed for oar-propulsion. At the same time, the keelson demonstrates that the ship also had mast and sail. These means of propulsion had already been taken into consideration in the construction phase for the ship, and the proportions and lines of the vessel reflect a compromise between a whole series of functional demands, including the adaptation of the hull to allow easy beaching of the ship.

Oarports for use in this ship are preserved in the port side of the ship from 6½A to 3½F, eleven holes all together (cf Fig. 30), and there would no doubt originally have been two more holes forward with the last one at 5½F. With a similar number on the other side this would give a total number of 26 rowers in the ship when fully manned. The shield-rack preserved around amidships is a clear indication that these rowers were warriors, leading to the conclusion that Skuldelev 5 was constructed as a warship for a ship's company of ca 28 men, including 26 warriors serving as rowers when needed.

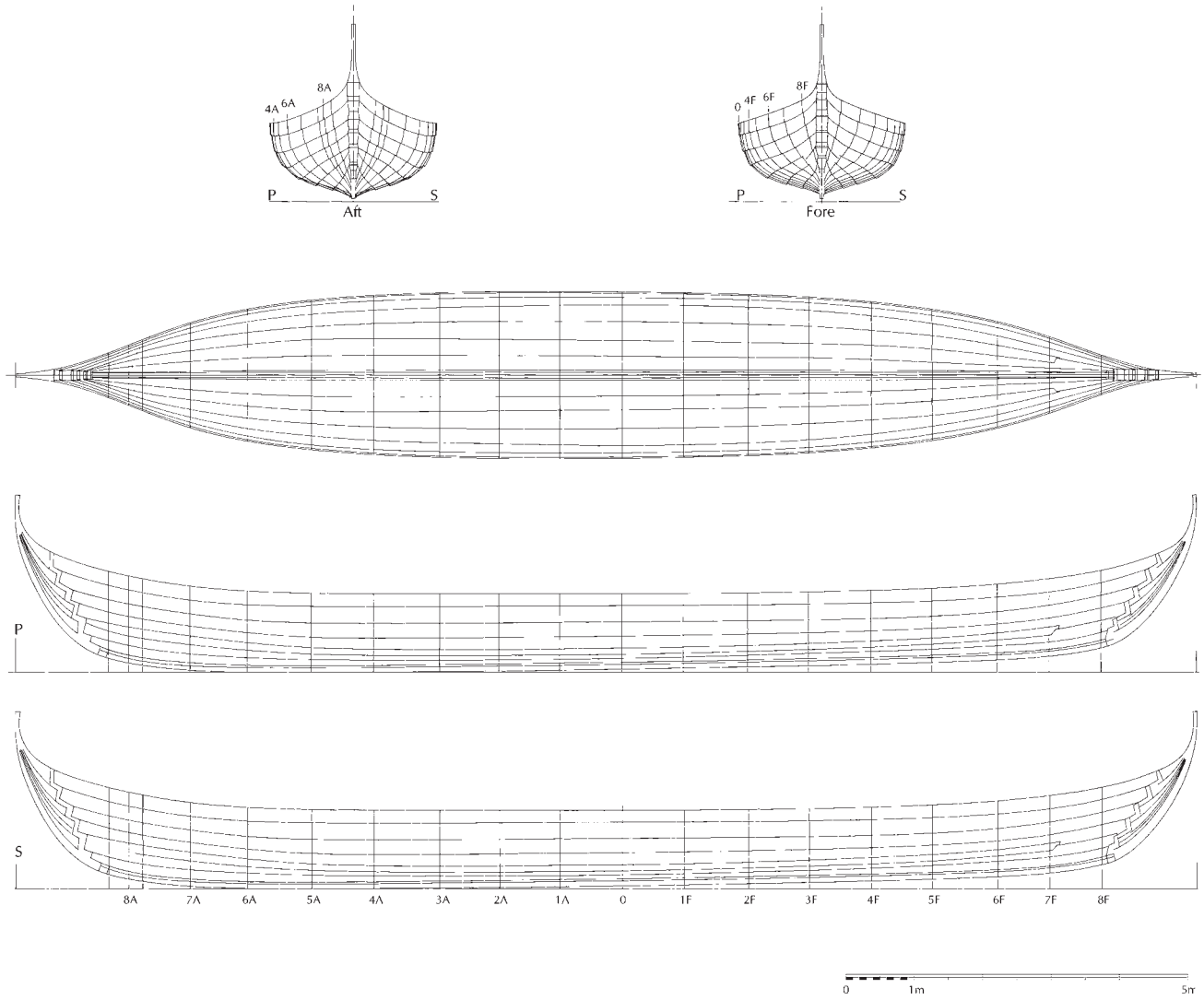

Fig. 31. Skuldelev 5. The hull-shape as reflected by the faired inner, upper edges of the strakes from port side. Scale 1:80.

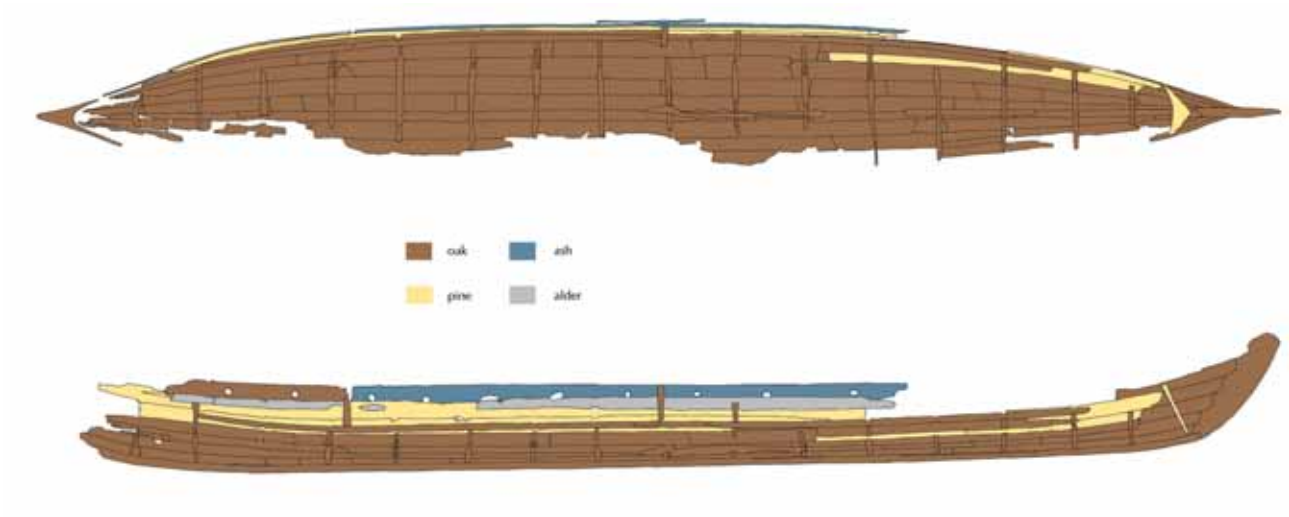

Fig. 32. Skuldelev 5. Torso-drawing with colour codes for the species of wood used in the ship.

5.5.4 Analysis of the ship from construction to scuttling

When compared with Skuldelev 3 as the closest parallel to the present ship in design principles, the planking of Skuldelev 5 evidently needs further analysis in an attempt to find a reason for the difference between the first class oak planks used in Skuldelev 3 to suit the needs of a quality-conscious customer (cf Section 3 in Chapter 5.3), and the planking of the warship Skuldelev 5 with materials of a variety of species and origins, including recycled planks.

Reused parts and repairs

A crucial point in the analysis is the degree of certainty in the distinction between reused and previously unused materials utilised during the construction phase and repairs (Figs 32-34). Could the odd character of the upper strakes with their reused planks in pine and ash be the result of a major alteration or repair to the ship at a certain stage of its active period - or were these planks actually built into the ship during its construction?

The regularity of the structure of 11th-century Nordic ships is comparable to that of a human skeleton,[12] and this normally enables us to distinguish between features such as fastening holes and other features that are relevant to a vessel under analysis and those which are not. In order to be able to make such a distinction, it is necessary to present an explicit set of criteria for the analysis of the types of materials used in the planking: *New planks* or *Reused planks*, in combination with their use during the *Construction phase* or for *Alterations or repairs*. This leads to the following distinction between the two groups of planks:

• *New planks:* planks which only display features relevant to their use in the present ship, including possible fastening holes for elements of the structure which have been altered or have not survived. Such planks will normally have come from newly felled trees and have been cut specifically for the present purpose.

• *Reused planks:* planks that have been part of another structure prior to their use in the actual ship. These planks may be identified by fastening holes etc. which do not fit into the system of the present structure and are often blocked with plugs.

Both types of planks may have been inserted into the ship either during its construction or during one or more phases of repairs or alterations. The criteria for determining whether a plank represents the initial or a later phase of the history of the ship include:

• *Construction phase:* planks which match the standard procedures for the planking in original fastenings, scarfs, etc., which have left no traces in adjacent planks and frames of having been inserted secondarily, and which display a similar degree of wear as other elements from the construction phase.

12. Crumlin-Pedersen 1997a: 15

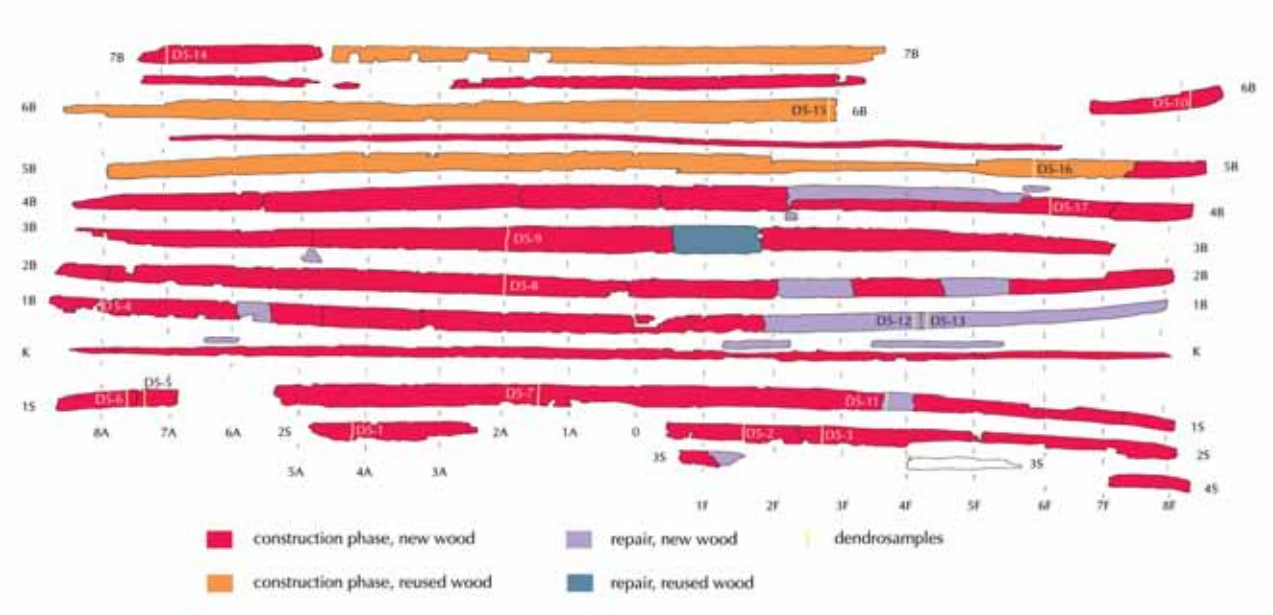

Fig. 33. The planking of Skuldelev 5 with colour codes for the use of new wood or reused wood during the construction phase and in repairs or alterations. Positions of dendro-samples are marked out.

Table 2. Skuldelev 5. Irregularities in the planking.

Strake	position	no.	scarfs		treenail holes			fast. in adj.planks		degree of wear			material				length m	character
			irregular	regular	none	irregular	regular	irregular	regular	no	medium	strong	new	reused	?	species		
2S	0.4F/2.4F	2045		x			x		x			x	x			oak	1.8	part of late repair complex
1S	st./7.4A	2017+		x			x		x			x	x			oak	1.1	part of late repair complex
1S	3.6F/4.2F	2053		x	x			x		x			x			oak	0.5	part of late repair complex
1B	5.5A/5.9A	2023	x		x			(x)			x		x			oak	0.5	isolated repair, new oak
1B	1.8F/4.3F	3022		x	x			x		x			x			oak	2.2	part of late repair complex
1B	4.2F/st.	3048		x	x			(x)			x		x			oak	3.4	part of late repair complex
2B	2.0F/3.3F	2068		x			x	x		x			x			oak	1.1	part of late repair complex
2B	4.5F/5.5F	2065		x			x	(x)		x			x			oak	1.0	part of late repair complex
3B	0.5F/1.8F	2071		x		x		x			x			x		oak	1.3	isolated repair, reused oak
4B	2.2F/5.7F	2062	x		x			x			x		x			oak	3.4	isolated repair, new oak
4B	2.3F/4.5F	2063		x			x		x			x			x	pine	2.0	construction phase - reused?
4B	4.4F/7.3F	2061	x			(x)	x		x		x				x	pine	2.6	construction phase - reused?
5B	8.0A/7.4F	2055+		x		x	x		x			x		x		pine	14.0	reused long pine plank, construction
6B	8.0A/3.0F	2079+		x		x	x		x			x		x		pine	10.5	reused long pine plank, construction
7B	4.6A/3.6F	2074+	x			x			(x)			x		x		ash	7.7	reused long ash plank, construction

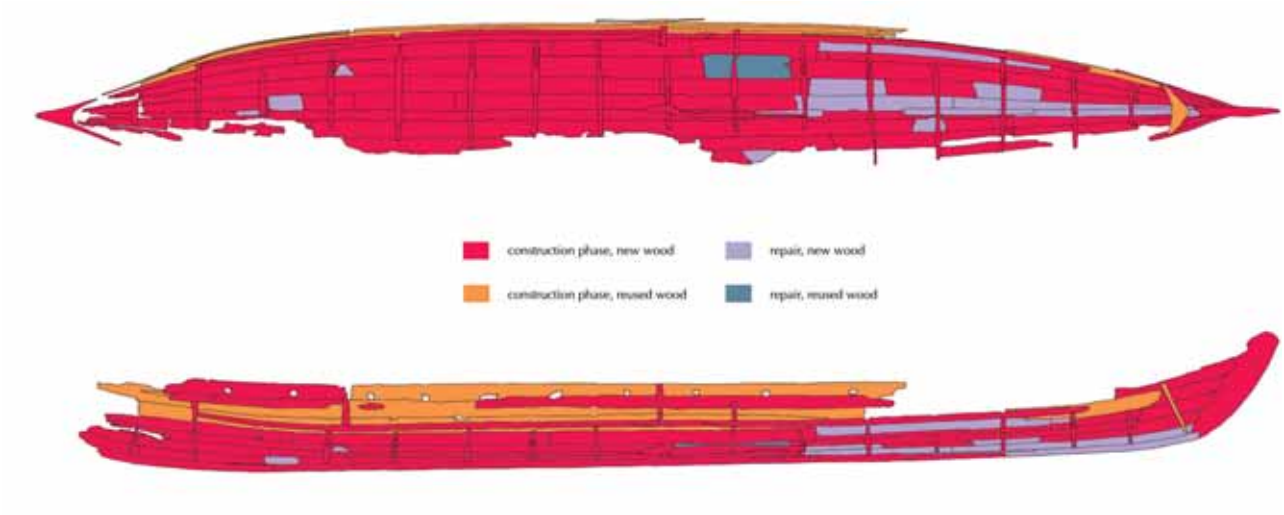

Fig. 34. Skuldelev 5. Torso-drawing with colour codes for the use of new wood or reused wood during the construction phase and at repairs or alterations.

• *Alterations or repairs:* planks for which the fastenings at the frame positions differ from the standard pattern (nails driven into the frame instead of rivets between planks, treenails to frames not replaced or replaced by new treenails of a slightly different orientation or by nails). In some cases the forward plank-scarfs open forward on the outside. In the adjacent planks from the construction phase or previous repairs, 'extra' rivet holes may represent the fastenings previously used.

Quite evidently the use of these criteria for an analysis of the planking of the Skuldelev ships, especially in the present complex case, relies on the detailed recording at scale 1:1 of all the elements of the structure, carried out before conservation and reassembly of these for display. Fortunately such a documentation is available in this case, but even then the analysis is hampered by the strong degree of erosion of the starboard planks as well as of the edges of several of the upper planks. The results of the analysis of all those elements of the planking of Skuldelev 5 which differ from the standard oak planking of the construction phase, are given in Table 2, for details see Fig. 10.

The first two entries in the table refer to repair planks from the starboard side of the bottom which could not be identified as repairs on the basis of the criteria given above. These planks have been proved by the dendroanalysis to have come from the same tree as some of the planks of the large repair forward in the bottom, and consequently they were most probably built into the ship on the same occasion. The reason for the failure of identification in this case seems to be a combination of the severe wear to the starboard planking and of the careful way in which this repair was carried out, where old holes were reused for the fastenings.

In the bottom of the hull of Skuldelev 5, a clear pattern emerges (Figs 33-34). A broad, reused plank has been inserted in 3B at 1F to make up for a damaged part of this strake as well as the edges of the planks above and below. Most of the remaining repairs in the bottom are concentrated in the forward part of the hull, but in the course of this extensive repair, parts of the planks further aft were also replaced with short lengths of new planks.

This large repair, involving the replacement of at least 11.1 m of the bottom planking, was carried out with a high degree of craftsmanship. At this stage in the active life of Skuldelev 5, much of the planking as well as the lower end of the stem and the forward part of the keel had evidently been in need of replacement. The original materials were weak and decayed, and the hull may have been damaged at the forward part when lying at anchor[13] or during a landing operation.

For the new length of keel to be safely connected to the old keel, a long narrow board was mounted on top of the keel over the keel scarf. Towards the stem, the new keel had to be raised slightly to meet a new scarf at the lower end of the stem. In order to do this, the floor timber at 7F, and possibly those at 4F-6F as well, were removed[14] and the original lowest part of these with limber holes for draining the water along the keel were cut away at 5F-7F to allow

13. This was evidently the case for the mid-12th-century Lynæs ship.Crumlin-Pedersen 1979; Englert forthcoming
14. The repair planks 1B and 2B had been riveted underneath the floor timber 7F, showing that this element was not in position during the riveting.

space for the keel at its higher position (cf Fig. 16). After the new keel was mounted, parts of strakes 1B and 2B were renewed, whereas the forward length of 1S was reused. However, in the case of this last re-use, new holes for spikes to the keel were drilled above the old ones and the lower edge of 1S cut away. Finally, the floor timbers were carefully mounted again, reusing the old treenail holes.

This repair was carried out with first rate, new materials in spite of the fact that the ship itself was in a dilapidated state. The good quality of the craftsmanship, as demonstrated by the decorative mouldings cut along the edges of the new planks, and the care taken to reuse the old fastening holes wherever possible, presents a contrast to the standard of the repair amidships at strake 3B involving reused planks.

For the three uppermost strakes, 5B-7B, there is clear evidence that these had been taken from other ships to be reused in Skuldelev 5. In the sheerstrake 7B, made of ash, this is evident from the double set of oarports. In the long and broad pine plank 6B, there are numerous plugged holes without any connection to the structure of Skuldelev 5 and now covered over by the stringer. For the extremely long pine plank 5B, there are several extra treenail holes fore and aft, in addition to one or two extra treenail holes at each frame station that exceeds the number needed for fastening the stringer and the beam-knees in the present ship. There can be no doubt, therefore, that these three planks had their 'second life' in this ship. The transitional fourth strake between the bottom and the side also includes two lengths of pine planks between 2F and 7F. A new oak plank has been inserted as a repair in the upper half of these pine planks. Therefore, it is not possible to accurately determine whether they were new planks or had previously been used elsewhere before they were built into the ship.

The planking was consequently built up with the bottom part, the first three strakes in each side of the keel, originally made from new oak planks, some of which were of moderate quality. The transitional fourth strake was primarily built up of new oak planks but with some pine planks used. The three upper strakes included long lengths of reused planks in pine and ash, used here in conjunction with short lengths of new oak planks at the ends. There are no indications whatsoever of the pine planks being inserted secondarily in the ship as repairs. If this had been the case, it would have been visible in the rivet pattern along the edges of the fourth strake, following the division line between oak planking below and pine planks above. Consequently, the materials used by the shipbuilder at the construction stage included long lengths of pine and ash planks taken from other ships.

Beside the planks, another element of the ship, the bulkhead-like *rong* at 8F, is distinctively also made of pine (cf Figs 16 and 34). There are several fastening holes in this element, only some of which match holes in the planking of Skuldelev 5, strongly indicating this part's prior use in another ship.

One might expect that the long pine planks and ash plank would have been taken from one ship and reused in the present ship, possibly together with the *rong* and a similar set of planks on the starboard side. This was not the case, however, to judge from the pattern of treenail holes and oarports in the long, upper planks. The average frame distance between the oarports of the first system in 7B, the sheerstrake, is 0.78 m, whereas the extra holes in the 14 m-long pine plank in 5B follow the average frame distance of 0.90 m of Skuldelev 5, except at the ends. In the pine plank in 6B, no evident pattern has been identified for the many extra treenail holes.

The long upper planks were then evidently taken from at least two different ships, and their plank edges with the original rivet fastenings were chopped away to release the planks, and possibly also the rivets, for reuse. At the after end of the pine plank in strake 5B, there are traces of half holes for rivets used during the first phase, but otherwise the edges were smoothed off, thereby reducing the original width of the planks by at least ca 3 cm.

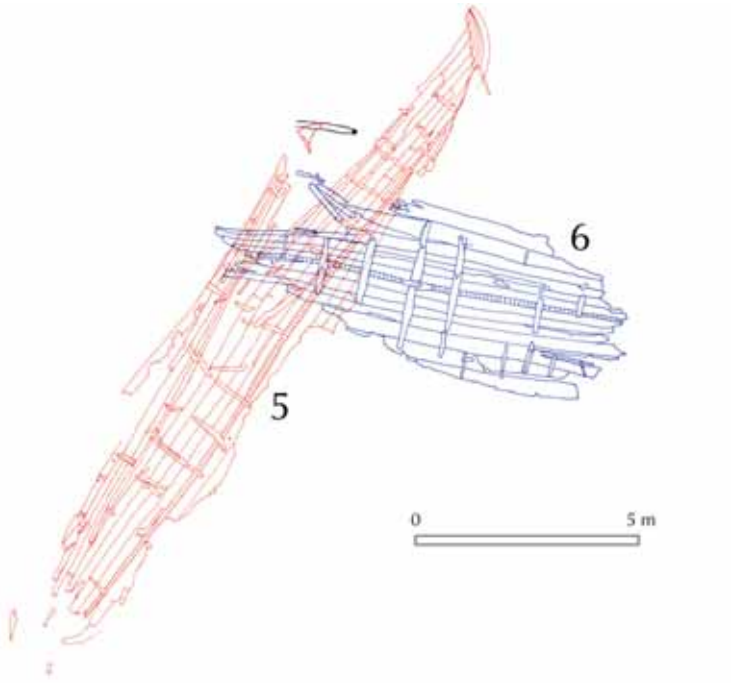

Fig. 35. Plan of the Skuldelev 5 wreck in situ *with Skuldelev 6 scuttled across a part of the ship forward of amidships.*

Considering that large pine trees were not available locally in southern Denmark in the 11th century, the ship from which the planks and *rong* of pine come would have originated in another part of Scandinavia, as discussed below in Section 5 of the present chapter. For some reason it ended its days in Roskilde Fjord. The only constructional features to be established with some certainty for this ship are the clinker construction and the frame distance matching that of Skuldelev 5 as well as several other Nordic warships and cargo-ships of the tenth and eleventh centuries.[15]

The ash plank with many oarports came from a vessel of the personnel-carrier or warship category. With an average frame distance of 0.78 m on this plank, the ship from which it came belonged to a group of contemporary vessels that had a rowing modulus between 0.78 m and 0.84 m.[16] As no base-curves for dendrochronological studies of ash are yet available, it has not been possible to investigate the date and origin of this element beyond the fact that it must antedate the construction of Skuldelev 5.

As demonstrated here, the wreck of Skuldelev 5 incorporates parts of at least three ships in its structure. However, it is only the last one of these ships, Skuldelev 5 itself, for which there is sufficient evidence for further analysis of its construction and use.

The construction phase

The stem

The construction of Skuldelev 5 followed the same basic principles that were applied to Skuldelev 3. The stem had the same character in both ships, although in Skuldelev 5 it consisted of two parts, the lower of which is preserved. In both ships the number of steps cut in the stem for the strakes was one less than the actual number of strakes in the ship, and in both cases it was the transitional plank between the bottom and the side which was not given its own step, or taken all the way into the stem.

Planking

The planking analysis presented above has singled out the repair elements and thereby enabled us to describe the original planking as a mixture of new oak planks in the bottom and at both ends, combined in the upper part of the ship with long, reused pine and ash planks with plugged treenail holes and oarports. It was evidently of crucial importance for the strength of this relatively long, slender ship that the upper strakes were built from long, continuous lengths of planks. The bottom strakes included planks of lengths up to 7.1 m, but these are of moderate quality.

Most of the plank edges have no decorative mouldings, and the outer edges of the strakes were not always faired from one length of plank to the next across a scarf.[17] This was probably done because not all the planks acquired for building the ship were wide enough to ensure such fairing. Some of the scarfs were cut obliquely, probably in order to use the full length of the planks, starting from the root-end of the logs that were cut off at an angle when the trees were felled. None of these features was otherwise common in the other Skuldelev ships, except when repairs were made.

Thus, several features of the planking of Skuldelev 5 demonstrate that less emphasis than normal was placed on the visual qualities of the lines of this ship. The shipbuilder did not have access to - or did not want to use - a sufficiently large amount of high-quality materials for the planking, in order to match the standard of other contemporary ships, such as the Skuldelev 3 ship.

Internal timbers

In contrast to the planking, the preserved parts of the framing timbers, with the exception of the *rong* forward at 8F, were all cut from previously-unused wood, from oak trees grown to the necessary shape for maximum strength, and carefully shaped. The floor timbers were cut to the same general shape as those in Skuldelev 3, with rectangular cross-sections decreasing in width towards the ends and across the keel, and with decorative moulding along the edges, only now visible in a few un-eroded areas.

Design principles

The stem of Skuldelev 5 lacks its top, and is therefore less well preserved than that of Skuldelev 3. The forward edge of the stem follows an arch of a diameter of 2.7 m, except at the bottom where it was affected by the repair to the forward part of the keel. In this case there is no obvious, simple relationship to the present total keel-length of 14.9 m. This is not the original keel-length, however, and is a result of the modification forward. Previously, the scarf between keel and stem would probably have been ca 0.1-0.2 m further aft. It is possible that originally there had been a short *lot* forward, similar to the one aft, and that these both were not included in the keel-length measurement used to determine the proportional dimensions of the stems and other elements in the ship.

When building the 1:10 cardboard model of the ship, it was stunning to see that these heterogeneous planks, with broken lines at some of the strake edges, nevertheless were united into the distinct hull, providing a well-faired overall shape with the greatest beam and depth aft of amidships. It is quite evident that a skilled shipbuilder was in charge of building the ship to match a specific design. He was getting the best from the available planks, and those parts of the structure which required specialist construction knowledge, such as the stem and the floor timbers, were cut and decorated to normal standards.

15. E.g. Ladby, Skuldelev 1, 3 and 6, all with an average distance of 0.90-0.95 m.
16. Hasnæs 2, Hedeby 1, Roskilde 6, Fotevik 1 and 5.
17. E.g. in strake 3B at 4.8A and strake 4B at 5.6A where the plank-width at the scarfs varies 2-3 cm from one length to the next.

Wear and other traces from the active use of the ship
As stated above, Skuldelev 5 was an old ship by the time it sank or was scuttled. The surface of the bottom planks was worn down from above as well as below, and the flanks of the keel were decayed and crumbling. A number of repair patches were built into the hull to cover such things as leaking scarfs, etc. Together, a new length of keel and planks were inserted, primarily in the forward part of the bottom, and are a striking contrast to the surrounding elements since they have sharp edges and their original surfaces are very well preserved. These attributes give a strong indication that this repair was done shortly before the sinking of the ship. In addition, this late repair was carried out at a professional level and with considerable care.

As a result of the degradation of the upper strakes immediately following the sinking of the ship, wear marks from the oars in the oarports have been obliterated, and similarly no wear-marks from the rigging have been preserved.

The scuttling and subsequent disintegration
It is not evident whether Skuldelev 5 had been deliberately scuttled or whether it sank or was swamped after having grounded close to its intended position in the barrier. Most likely, the ship had to be given up after grounding, and as a result possibly played only a peripheral role in the northern part of the barrier.

As the ship sank, parts of the upper strakes forward in the port side broke off when some stones rolled out of the ship, and the remaining planks of these strakes projected from the side of the channel well below the other parts of the ship. This situation lasted long enough for these planks to deteriorate seriously before their fastenings loosened and the planks sank further down and were covered over by the sediments that had already started to protect the remaining part of the wreck.

After sinking, the after stem disappeared and the starboard side began to break down. Most of this side was lost, and only parts of the bottom planking of that side were left exposed along the northern edge of the channel. Here they were effected by biological decay and eroded by current-carried sand until, after some years, Skuldelev 6 was scuttled across the forward part of Skuldelev 5 (Fig. 35). The newly-sunk vessel thus prevented further erosion of the planks of Skuldelev 5 below it. The planking, the ends of the frame elements, and the central part of the keelson, lay outside the area covered over by Skuldelev 6 and continued to erode. However, the stone-filled new wreck lying at right angles to the bank of the channel no doubt blocked the current locally and furthered sedimentation on both sides of Skuldelev 6, especially around the bow of Skuldelev 5.

Soon after the scuttling of the longship Skuldelev 2, several of its frames were scattered around the area by ice (cf Chapter 5.2.2). One of these frames settled in the sediments below one of the aft planks of Skuldelev 5. Most likely, this indicates that the total collapse of Skuldelev 5 had not yet taken place at the time when the elements of the longship Skuldelev 2 were scattered soon after its scuttling. This strongly indicates that both of these two ships were positioned in the barrier within a narrow time-span. After that, the exposed parts of the Skuldelev 5 wreck eroded further and gradually the ship disappeared completely below the sediments and remained undisturbed until it was discovered in 1959 and excavated in 1962.

5.5.5 Dating

When establishing a date for this ship, it is important to observe the relative ages and different origins of the individual elements of the structure. This is relevant for all three methods applied to date this vessel: the comparative stylistic criteria of the *Ringerike* motif, the ^{14}C-datings, and the dendrochronology.

The *Ringerike* art style is known from late Viking-Age stone carvings and metalwork found in Scandinavia and the British Isles. It is named after a group of rune stones decorated in this distinctive style, found at Ringerike north of Oslo, Norway. Its main motifs are the lion, the snake, and plant tendrils sprouting in all directions. In the case of Skuldelev 5, the decoration on the outside of the strake 6B aft is an isolated tendril, but it has clear parallels with other ornaments, for example the Källunga weather vane and a Viking grave-slab from St Paul's churchyard in London (Fig. 36). The *Ringerike* style is generally considered to have succeeded the *Mammen* style of the last half of the 10th century and to have been replaced by the *Urnes* style by the mid-eleventh century in Scandinavia.[18] This established motif chronology would date this carving to within the period of ca 1000-1050. As the surface of the plank was partly decayed and eroded, no traces of paint or further decorative components are present.

Since this decorative element was found on one of the long, reused pine planks from another ship, it is in no way certain that it was used for display in Skuldelev 5. Instead, it is much more likely that the tendril served as a decoration for the ship from which this plank originally came, especially in the light of the generally careless finish of the planking in Skuldelev 5. No direct parallels are known for the use of decorations of this character on the upper strakes of Viking ships, but from the early Viking Age, some examples of other types of decoration on ships have been found in Norway. The ninth-century Oseberg ship is a well-known example of a vessel with lavishly decorated stems,[19] and on the Grønhaug and Gokstad ships, the uppermost

Fig. 36. The Ringerike *motif from Skuldelev 2 compared with similar elements from the eleventh-century vane from Källunga and the grave-slab from London. After Klindt-Jensen & Wilson 1980.*

18. Klindt-Jensen & Wilson 1980; Fuglsang 1980
19. Brøgger *et al.* 1917
20. Shetelig 1902; Christensen 1979
21. Nicolaysen 1882, Pl. V and IV; Crumlin-Pedersen 1997a: 127
22. Sample of wool and wood-tar, K-875: 990 ± 100 BP. The caulking sample was taken at strake 2S at 1F-2F.
23. Bonde 1991

strakes have incised zigzag patterns, probably carved as guides for the painting of these parts with alternating colours, possibly yellow and black as suggested for the Gokstad ship.[20] On the rowlocks of the boats found with the Gokstad ship, there are a number of incised decorative masks, and there are other motifs on oarport locks from the Gokstad ship and from the harbour of Hedeby.[21]

A ^{14}C dating test was conducted at an early stage of the investigation on a sample of caulking from the ship's construction phase.[22] By the early ^{14}C-standards, the date was published as 960 ± 100 AD, but with the 1993 calibration standard for radiocarbon the date was readjusted to 1030 AD, the period 980-1170 AD covering ± 1 standard deviation.

A number of dendro samples have been extracted from this ship for examination and analysis (cf Chapter 3.3). A series of fourteen samples[23] were all taken from oak planks, nine of these from the construction phase and five from the late repair in the bottom. None of these samples included any sapwood, nor did any of these planks have features indicating that they were reused. They were evidently all new and cut specifically for use in this ship. In Fig. 33 the position of the samples are marked out.

The last annual ring among the nine samples representing the construction phase was found in sample D5-9 and dated to 1009 AD, whereas among the five repair samples, the last one was found in D5-2 and dated to 1040 AD. With the addition of a minimum of sixteen sapwood rings this would give the earliest possible dates of 1025 AD for the construction of the ship and 1056 AD for the late repair. When using the same criteria as applied to the samples of Skuldelev 3 (a hypothetical maximum of 50 mm of edge-trimming), an extra 25 years could be added for the date of the construction phase, and an extra 38 years added to the last preserved annual ring for the late repair, to give the years 1034 and 1078 as the likely upper limits for these two events respectively, cf Tables 3 and 4.

Consequently the felling of the oak trees for the construction phase is dated to the period ca 1025-1034 and for the late repair to ca 1056-1078. The character of the five repair samples, representing a compact series of planks from three trees, indicate that relatively young trees with a moderate number of sapwood rings and a small number of heartwood rings trimmed off the edges were used for the work. This suggests that the felling date for these trees was most likely closer to 1056 than to 1078.

The analysis of the dendro-dates from the oak planks thus gives the relatively firm dates of ca 1030 for the construction of Skuldelev 5, and ca 1060 for the major repair undertaken to the ship after a generation of frequent use as a light warship. The oak timber seems to have grown in eleventh-century Denmark according to the correlation values, pointing to a likely local origin for this ship.

5.5.6 General conclusion and parallels

Summary of the Skuldelev 5 evidence

The wreck of Skuldelev 5 is a very important primary source for the study of the organisation and means of local defence and warfare in general in eleventh-century Denmark. In spite of the battered condition of the ship, the analysis based on the documentation presented here is clear: Skuldelev 5 was a small longship, ca 17.3 m long, 2.47 m wide and 1.16 m high amidships, built locally ca 1030 to accommodate 26 rowers/warriors, a steersman, and a lookout, as the ship's standard company.

The construction of the ship was under the control of a competent shipbuilder. He had a clear concept for the structure and shape of the ship that was necessary to ensure the required strength and suppleness for a lightly-built ship with a length/beam ratio as high as 7.3. The design was suited for a ship for inshore and coastal navigation under sail and oars, as well as for landing operations on the open beach, where the crew would be capable of pulling the ship ashore without the use of rollers or winches.

The good workmanship of this vessel is reflected in the careful finish of the stem and the floor timbers. The materials for the planking, however, came from reused planks of pine and ash in addition to new oak planks, some of which were of inferior quality. In building up the planking, considerable emphasis was placed on the use of long lengths of planks, especially for the three uppermost strakes. For this purpose, materials scrapped from at least two other ships were used. One of these was a 'foreign' ship of unknown type, built of pine. The other was a warship of unknown origin, built with an average spacing of only 0.78 m between the oarports in the sheerstrake, instead of the 0.90 m-spacing found in Skuldelev.

As the hull was built up, the available planks were not always wide enough to ensure a proper fairing of the lines of the strakes, and little attention was paid to the decorative moulding that was cut along the edges of the planks, as found in most other ships. In the reused planks, numerous holes from previous uses had to be plugged, and those oarports that could not be reused, not even in slightly inconvenient positions, were blocked from the outside. These features may not have been visible at a distance, especially if they were painted over on the outside, but they would have been noticeable upon closer inspection. There is no reason to believe, however, that such flaws would have seriously affected the structural integrity of the hull.

After a period of ca 30 years, the ship was in a dilapidated state with a crumbling keel and bottom planks that were worn down to half their original thickness. At this stage the ship was ready for scrapping. Nevertheless, a major repair was undertaken instead, with the replacement of over 11 m of the lower planking and a 2.7 m-long length of the keel. This repair was carried out carefully and to a high standard of workmanship, in contrast to that of the original planking, but evidently the vessel was only used for a very short period before it ended its active life on the northern bank of *Peberrenden.*

D5-no.	strake/position	average width of last 30 years	last annual ring dated AD	number of years missing to 1034	approx. lacking plank-width to 1034
9	3B/1.9A	2.00 mm	1009	25	50 mm
7	1S/1.5A	0.82 mm	1004	30	25 mm
8	2B/2.0A	1.87 mm	999	35	65 mm
1	2S/4.3A	1.11 mm	996	38	42 mm
10	6B/8.5F	1.53 mm	971	63	96 mm
3*	2S/2.7F	0.98 mm	968	66	65 mm
4*	1B/7.8A	1.37 mm	946	88	121 mm
5*	1S/7.6A	1.24 mm	913	121	150 mm
14	7B/6.8A	0.83 mm	913	121	100 mm

Table 3. Skuldelev 5. Dendro-dated samples of planks from the construction phase.
** three planks from the same tree.*

Table 4. Skuldelev 5. Dated samples from repair planks.
** two planks from one tree*
*** two planks from another tree*

D-5 no.	strake/position	average width of last 30 years	last annual ring dated AD	years missing to 1056	approx. lacking plank-width to 1056	years missing to 1078	approx. lacking plank-width to 1078
2*	2S/1.6F	1.31 mm	1040	16	21 mm	38	50 mm
11*	1S/3.6F	1.38 mm	1030	26	36 mm	48	66 mm
6**	1S/7.8A	1.98 mm	1028	28	55 mm	50	99 mm
13**	1B/4.3F	2.14 mm	1027	29	62 mm	51	109 mm
12	1B/4.0F	1.84 mm	1014	42	77 mm	64	118 mm

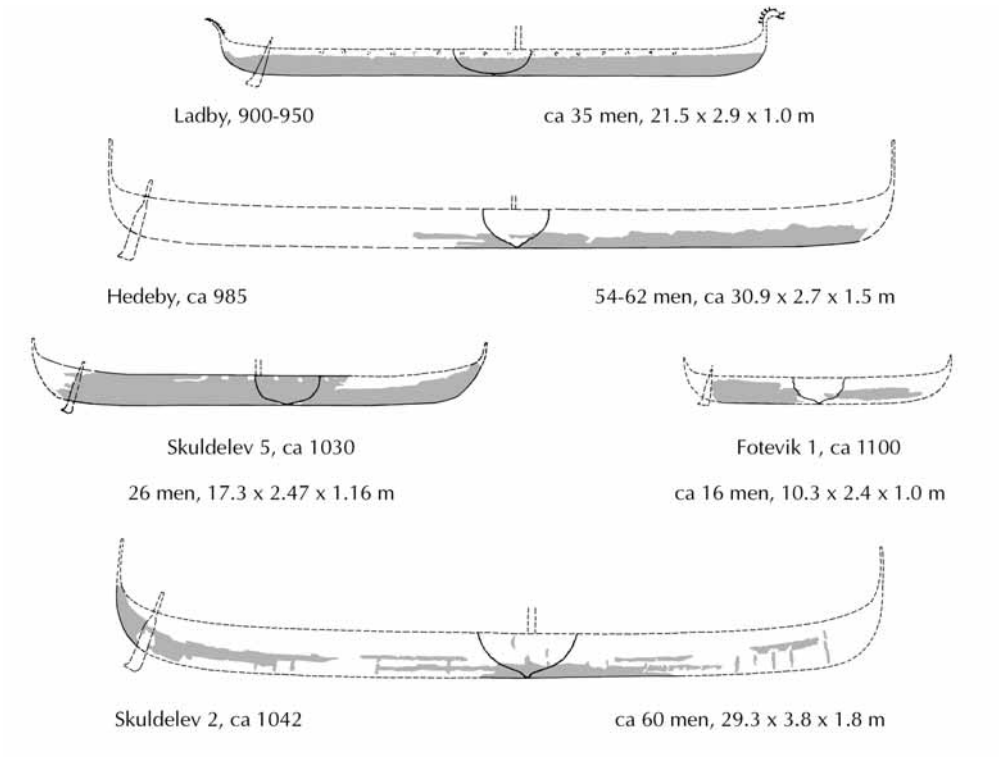

Fig. 37. Warships of the tenth and eleventh centuries drawn to the same scale with an indication by shading of the recorded parts of the vessel. The cross-sections are indicated amidships. After Crumlin-Pedersen 1997b, revised.

Parallels in other Scandinavian finds

Parallels to Skuldelev 5 are found only with individual features of this ship. As a warship of the period 975-1075, only three other longships found within the area of Late Viking-Age Denmark can be used for comparison: the Hedeby 1 longship[24] constructed ca 985, probably in the Schleswig region, the Roskilde 6 longship[25] built after 1025, and the Irish longship Skuldelev 2, described in this volume. These 30-36 m-long ships are, however, up to twice as long as Skuldelev 5. At Fotevik in Scania,[26] the remains of five ships, probably from the later part of the 11th century, have been found. They may all belong to the warship category, and are of different size groups, but only one, a 10.3 m-long vessel for 12-14 oars, has been properly investigated (Fig. 37).

Against this background, then, there are at present no comparable parallels to Skuldelev 5, that match closely in function, size, and date. The same is the case with regard to the peculiarities of the planking. However, the quality in materials and craftsmanship of the planking is markedly better in the other longships, with the Hedeby and Roskilde longships displaying a 'royal' standard, Skuldelev 2 a more 'normal' standard, and Skuldelev 5 a 'discount' version.[27]

In regards to the structural lay-out of Skuldelev 5, a close parallel is the small cargo-ship Skuldelev 3, matching in date, origin, and configuration, but not in function or in the careless details in the planking. The only recorded example of a roughly contemporary vessel with a considerable amount of reused elements in its structure is the Hedeby 2 vessel,[28] which has a strange combination of wood species and construction techniques, mixing elements of Slav and Nordic features in a hull with reused floor timbers.

At Maglebrænde on the Fribrødre River in Falster, Jan Skamby Madsen has investigated a site which evidently represents a scrapping yard for ships of the eleventh century.[29] Here, large quantities of ships' elements were found discarded after having been torn out of ships. The keels and

24. Crumlin-Pedersen 1997a: 81-95, 224-235
25. Bill *et al.* 2000: 215-224
26. Crumlin-Pedersen 1984
27. Crumlin-Pedersen 2002
28. Crumlin-Pedersen 1997a: 96-98, 242-251
29. Skamby Madsen 1991

stems, the planking, beams, and loose boards, of these ships were all absent. This site illustrates that timber from old ships was systematically collected for various other purposes, such as gang planks and revetments, as is known from excavations in the waterfronts of eleventh-century towns such as Schleswig, London and Dublin.[30] Whether the materials from the Fribrødre site were reused in the construction of new ships, is not know for certain.

In Chapter 6.2.2, the historical context for this particular warship, Skuldelev 5, and its relations to other warships of its period, is discussed in the light of the information resulting from the analysis of this primary archaeological source.

30. Schleswig: Crumlin-Pedersen 1997a: 105-147, 252-288; London: Marsden 1994: 141-158; Goodburn 1994; Dublin: McGrail 1993

Fig. 38. Skuldelev 5. Exhibition model at scale 1:10 of Skuldelev 5, built by Morten Grønbech with the rigging reconstructed by Erik Andersen and Vibeke Bischoff.