

The Dover Boat—a Reconstruction Case-Study

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The Bronze-Age Dover boat, reconstructed and published by Owain Roberts in 2004, is discussed in regard to the general considerations of reconstructing ancient boat structures in the previous paper. The archaeological evidence shows that the boat had a bottom shape different from that shown in the 2004 reconstruction, and various other aspects, such as the general shape and strength of the hull and the calculation of potential speed when paddled, are questioned, partly drawing on the author's experience with the reconstruction of the Hjortspring boat. A re-assessment of the evidence is called for before any attempts to build a full-scale version of the Dover boat for sea-trials.

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Key words: Dover boat, Bronze-Age boatbuilding, Hjortspring boat, double-boats, reconstruction, experimental boat archaeology.

In this paper on the Dover Bronze-Age boat from c.1550 BC (Fig. 1), various aspects of its reconstruction as presented in two recent publications (Clark, 2004a; Clark, 2004b) will be discussed. These notes do not represent the work of an inter-disciplinary group of scholars, nor do they claim to identify the one and only solution to the reconstruction problem.¹ However, they may serve as a first step in a reappraisal of the boat, hopefully leading to a fruitful discussion about aspects of the construction as well as the propulsion and seafaring ability of this vessel, which are so important for our understanding of Bronze-Age boatbuilding and seafaring.

The Dover boat monograph, edited by Peter Clark (2004a), is a fine example of a comprehensive publication of a prehistoric boat find. It contains detailed and well-illustrated chapters on the remains of the boat itself by Peter Marsden, and Richard Darrah describes the pioneering effort to determine the original shape and size of the heavily-degraded timbers that had been buried for millennia. Conclusions concerning Bronze-Age woodworking technology derived from study of the original timbers and a full-scale, 3m-long midships section are described by Richard Darrah and Damian Goodburn, whereas the naval architectural aspects of three alternative reconstructions, one of which is given special attention, are presented by Owain Roberts. Other chapters deal

with the excavation, the context of the vessel, as well as various environmental aspects.

Regrettably, this monograph had not yet been printed when the Dover Bronze-Age Boat Trust arranged a conference in Dover in 2002 on the boat and its context. For this reason a serious discussion of the proposed reconstruction(s) could not take place, but a number of papers presented then summarised aspects of the monograph as well as discussed other Bronze-Age finds with regard to topics such as criteria for seaworthiness of ancient vessels and the social and religious context of Bronze-Age boats. These papers have now been published (Clark, 2004b), thus enabling others to assess the proposed reconstructions and their suggested seaworthiness (or lack of it) against the documentation of the find.

In the monograph, Owain Roberts publishes his plans of the reconstructed boat, presenting three versions, Dover 1–3, for discussion (Fig. 2). They are all laid out with two flat bottom planks, and on each side a curved *ile*² and one flat side plank. The surviving, presumed bow, end is shown as closed with a sloping board as indicated by the preserved complex fastenings for this element. The three versions are identical except for differences in the length and the way of closing the presumed stern. Dover 1 is 11.7 m long and closed aft with a vertical transom board inserted inboard close to the end of the preserved parts of

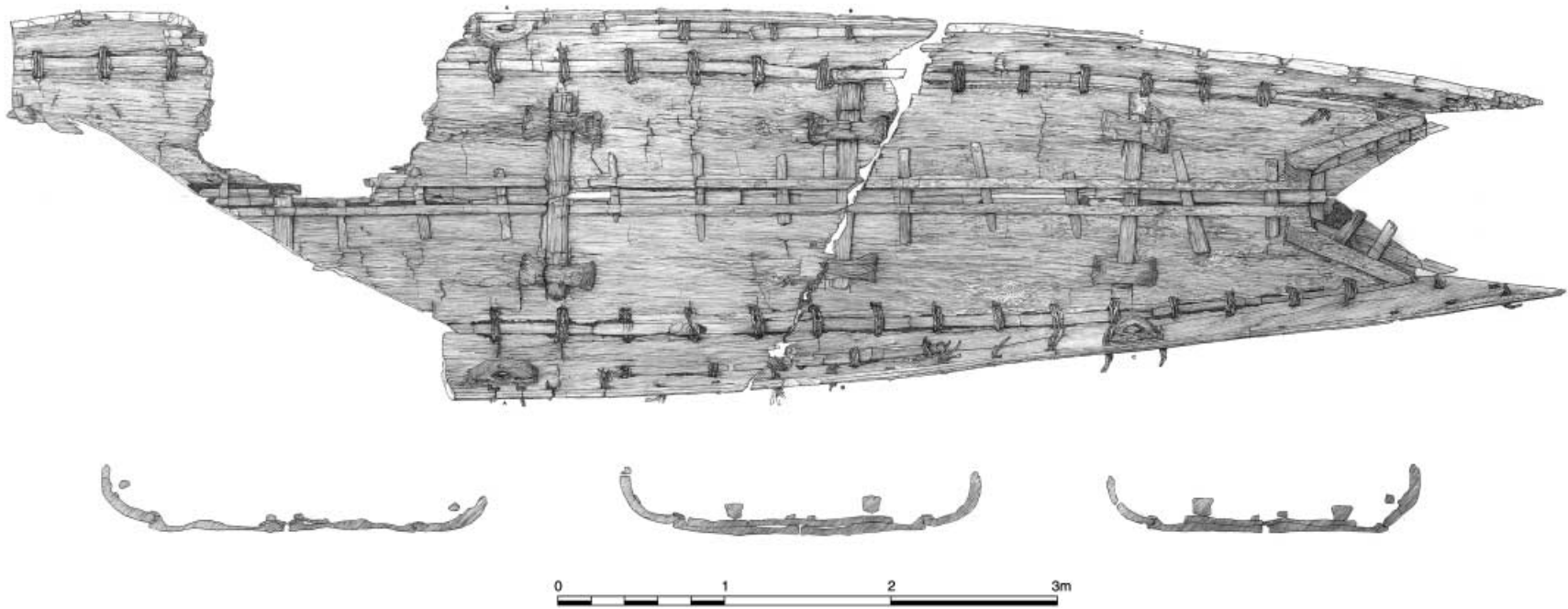


Figure 1. The inboard surface of the Dover boat with three cross-sections of the hull. (From Marsden, 2004a, fig. 5.1. Copyright Canterbury Archaeological Trust)

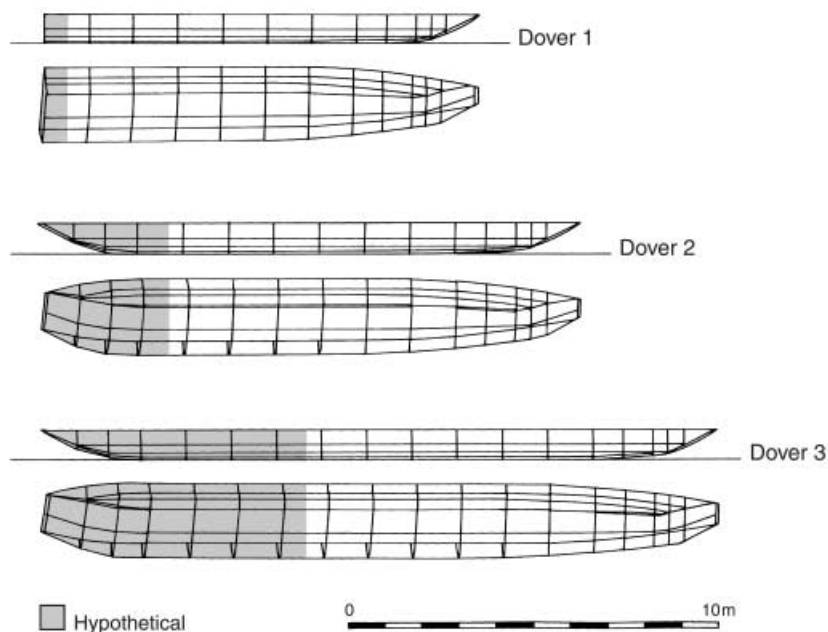


Figure 2. The lines of Owain Roberts' three hypothetical reconstructions of the Dover boat. (From Roberts, 2004, fig. 10.5. Copyright Canterbury Archaeological Trust)

the boat. The hulls of the two other versions, Dover 2 and 3, have lengths of 14.2 m and 18 m respectively, and here the after ends are indicated as closed in an identical way to the bow of Dover 1.

A suggestion has recently been presented by Peter Clark that the Dover boat should be subjected to a re-appraisal, testing several of the conclusions reached in this hypothetical reconstruction. This may be seen as a first step along a path which may lead to the construction and trials of a full-scale version of the boat, matching the consensus of a broader panel of qualified scholars since, to quote Seán McGrail: 'without such a re-appraisal, "replica" building is wasted effort' (McGrail, 2004: 53). Here a number of aspects of Robert's reconstructions will be briefly discussed in light of the general methodological considerations presented in the previous paper.

The shape of transverse and longitudinal sections

The timbers of the boat were covered by a 6 m-thick overburden of sediments compressing the heavily-degraded timbers to various degrees against layers of silt, sand and gravel immediately underneath the find (Fig. 3). Consequently, the work of Richard Darrah trying to re-shape individual elements by analysing the deformation of the medullary rays is crucial, as an attempt to

establish the original cross-sections of the planks before these were moulded to a shape partly determined by the surrounding soils. He concludes that the method 'gives reasonable estimates for thickness of planks, although their exact shape was harder to ascertain with any reliability' (Darrah, 2004a: 104). However, Peter Marsden states that the boat 'was originally built with flat transverse and longitudinal profiles. It was a flat-bottomed boat' (2004a: 94). This position is fully adopted by Owain Roberts and shown in his plan of the restored vessel with a plane underside of the bottom planks, transversely as well as longitudinally, except for a slight curvature upwards near the bow to meet the sloping end board (Fig. 4). It seems that Marsden and Roberts, working from the two-dimensional documentation evidence, are here affected by the 'straight-lines-and-flat-boards-syndrome' discussed in the previous paper in relation to the naval architectural approach to reconstruction problems. Evidently this 2004 reconstruction was not based on a model-building phase at small scale aimed at determining the precise three-dimensional shape and structure of the preserved parts of the hull of the Dover boat.

The shortcomings of this approach are illustrated, among other things, by the uneven distribution of wear-marks from beaching or grounding on the exterior of the bottom of the boat (Figs 5–6). In the central part of the bottom there are no signs

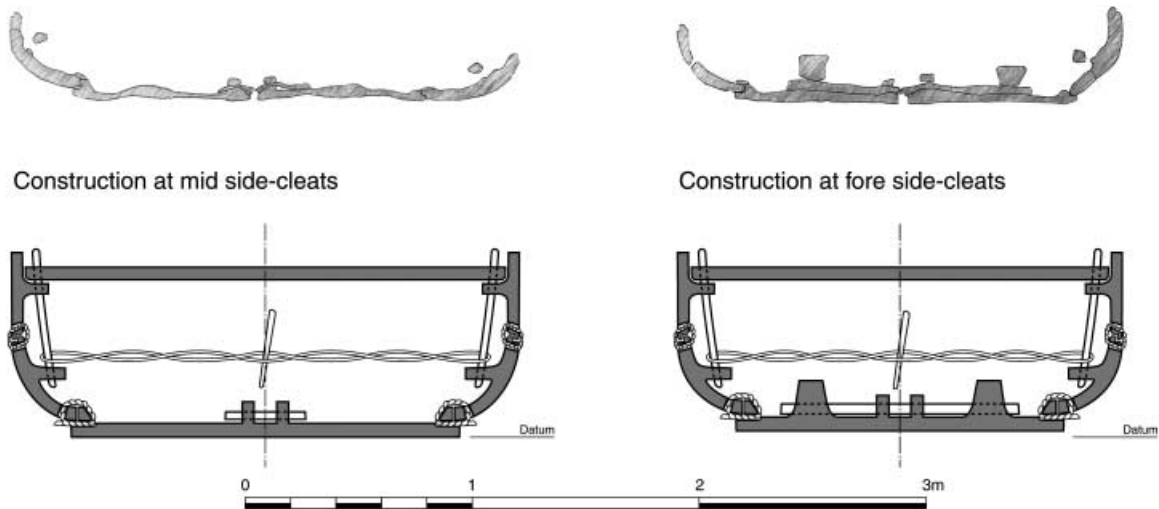


Figure 3. Two cross-sections of the Dover boat with the distorted structural elements shown as found (above) and as reconstructed by Owain Roberts (below). (After Clark, 2004a, figs 5.1 and 10.2. Copyright Canterbury Archaeological Trust)

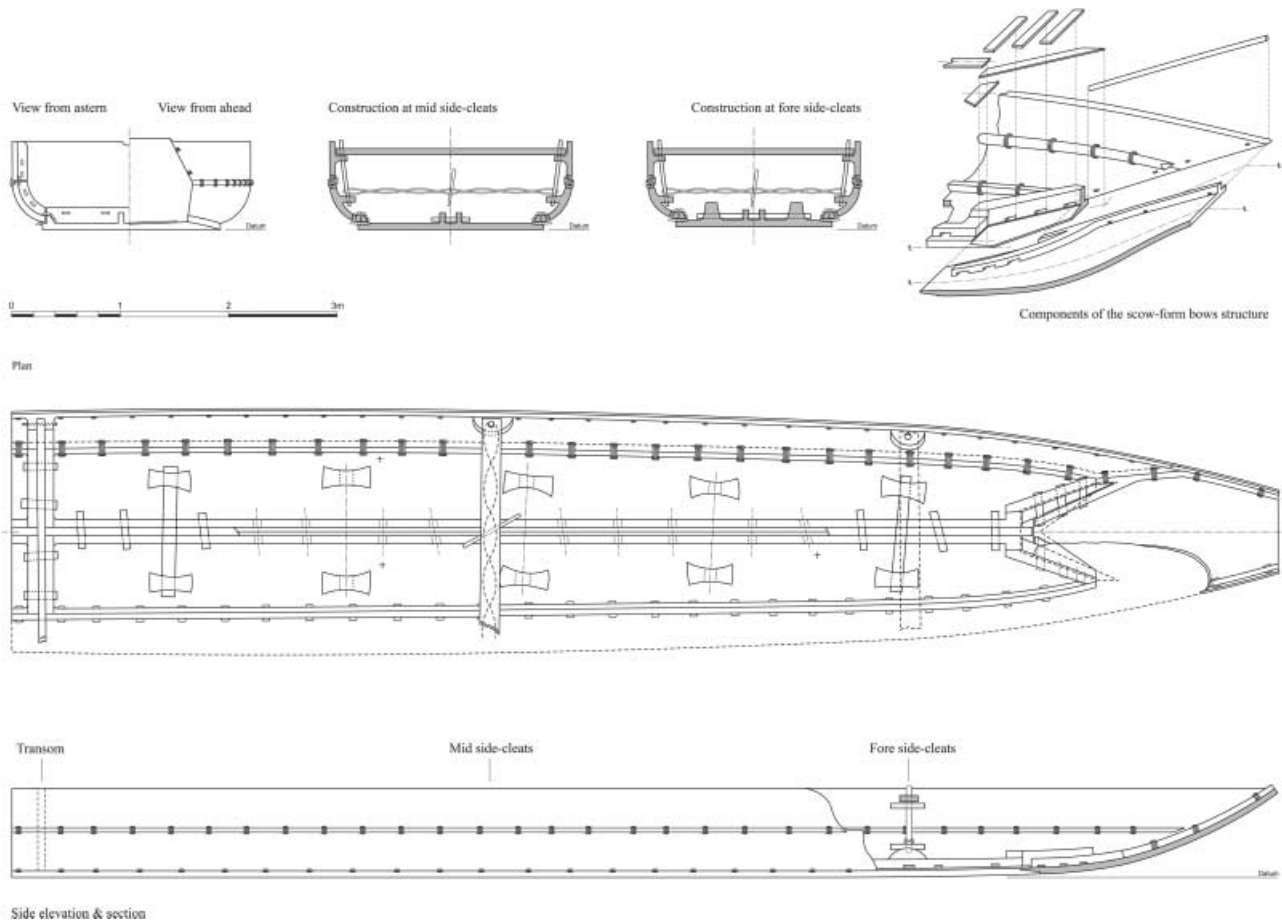


Figure 4. Dover boat 1, hypothetical reconstruction by Owain Roberts. (From Roberts, 2004, fig. 10.1+2. Copyright Canterbury Archaeological Trust)

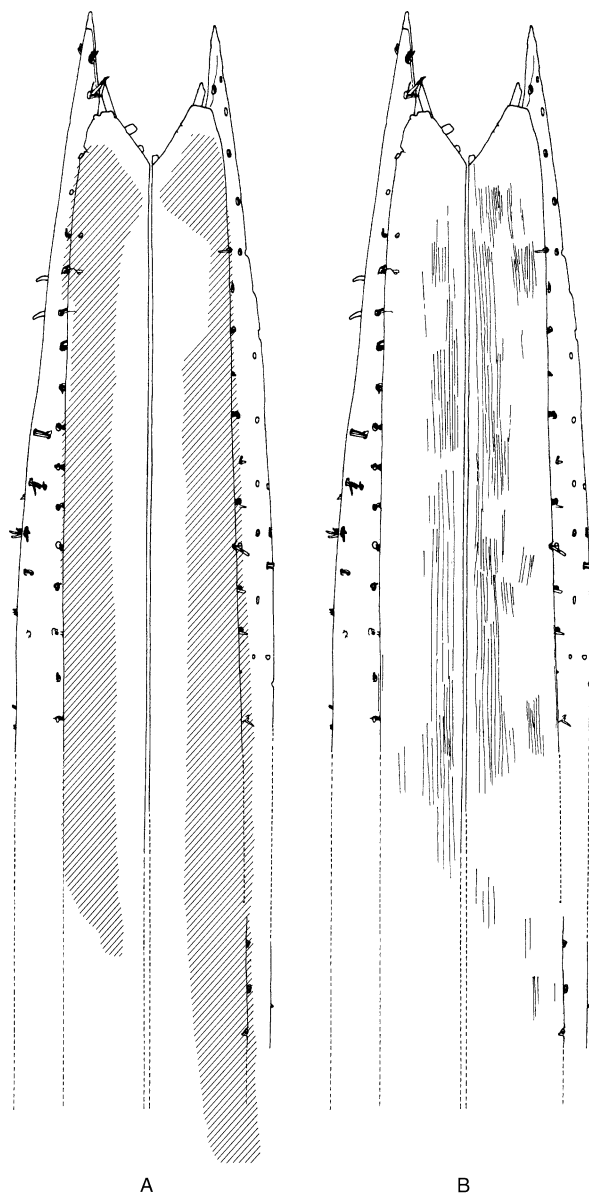


Figure 5. Plan of the outboard surface of the Dover boat with indication of the areas of wear from grounding or beaching of the boat (A), and of the preserved tool-marks (B). After Marsden, 2004a, fig. 5.58 and a corrected version of fig. 5.23 (subject to a printing error in the monograph). (Copyright Canterbury Archaeological Trust)

of wear, and tool-marks are well preserved, whereas both sides of the bottom are worn from the boat being beached. Marsden explains this feature as an effect of buoyancy arching the two bottom planks upwards along the centre line, so that only the outer edges of both planks ran aground (2004a: 84; 2004b: 17). However, bending the cross-section of these thick oak bottom boards is not realistic, and a tilting downwards of the

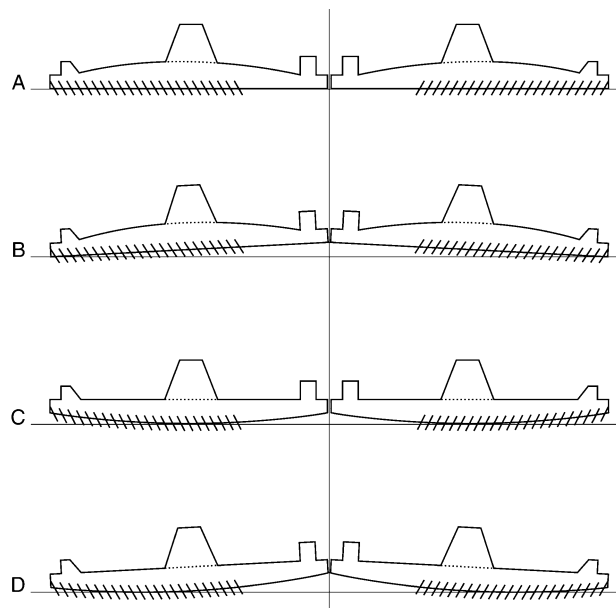


Figure 6. Four possible configurations of the two bottom planks of the Dover boat shown in cross-section. The areas affected by beaching or grounding are hatched.

A: Flat bottom and curved top (after Darrah, 2004c, fig. 9.28). The flat shape underneath does not match the pattern of wear against the sea-bed.

B: As A, but tilted to explain the pattern of wear, as suggested by Marsden (2004a: 84).

C: Modified cross-section of planks with curved outside and flat, horizontal inside, as suggested by the present author.

D: As C, but with the planks tilted to account for the pattern of wear against the sea-bed.

outer edges of both planks being flat underneath does not account for the position of the wear marks (Fig. 6B) and can therefore be ruled out. The pattern of wear is much more likely to be an indication that the boat was deliberately built with an underside that was not flat. A first step is to suggest that both bottom planks had an underside that was slightly curved downwards and a flat upper side, being a minor modification of Darrah's plank shape without questioning the scantlings (Fig. 6C). With planks of this shape, slightly tilted up towards the centreline, the boat would touch the beach or ground with the underside precisely where the traces of wear were actually recorded (Fig. 6D). In addition to explaining the wear pattern, this would emphasise the special nature of the central seam in the boat. As a side-effect of the tilting of the bottom planks, the central caulking seam would open slightly upwards to receive the moss. Such a caulking seam would correspond to that of later boats, and it would be more efficient than the one suggested

in the 2004 reconstruction where the moss only covered the upper surface of the joint.

Since the specific nature of the bottom planking as shown in Fig. 6D was not accounted for in the reconstruction, similar modifications may also be relevant for the *iles* and the side strakes. These questions could probably best be studied in a three-dimensional model. At the same time the longitudinal shape of the elements should also be addressed. It is not likely that the original curvature of the *iles* or the planks would have survived the deformations *in situ*. By studying the cross-sections of the timbers in relation to idealised, perfectly straight and circular trees with medullary rays all flawlessly radial, Darrah, however, is able to suggest that 'there was some bending and tensioning when the sections of the boat were joined together. This probably resulted in a slight rocker in the bottom of the boat' (2004b: 113). Thus, the published flat-bottomed and 'punt-like' reconstruction of the Dover boat evidently needs revision affecting the cross-sections and probably the longitudinal profile of the boat.

Closing the ends

A vertical stern bulkhead was deemed necessary by Roberts in the reconstruction of the boat in response to the need to close the hull with a strong transverse element. Since no traces of such an element or its fastenings were found, the position was chosen so as to give a minimum additional length of reconstructed hull beyond the preserved parts of the vessel. A key element in the argument was the position of the side cleats which were interpreted as parts of a system to hold the sides together. Since only two sets of these cleats were found (at the forward end and 'amidships') and not a third set in the after part, the argument was that the structure needed the transverse support provided by a transom aft, fastened with wedges into a hypothetical groove in the planks (Roberts, 2004: 191). However, if the spacing between the side cleats was the same along the length of the vessel, a third set of side cleats would not have been positioned within the preserved part of the structure, as claimed by Roberts, but c.0.8 m further aft, thus invalidating this argument (cf. Fig. 1).

The idea of a transom is based on evidence from the logboats from Brigg (c.800 BC) and Hasholme (c.300 BC) from the Humber region (McGrail, 1978; Millet and McGrail, 1987). These early logboats were carved out of huge oak trees,

13–15 m long and 1.6–1.9 m in diameter at their bases. Trees of this size very often have a rotten core which would considerably ease the work of hollowing out the trunk. But the vessel then needed to be closed in some way at the lower end of the tree, and sometimes also at the upper end, by inserting a bulkhead aft and a suitable block of wood at the forward end, such as in the Hasholme logboat.

In prehistoric Britain, this type of stern transom with parallels from Mesolithic logboats finds in Denmark and elsewhere (Andersen, 1987; Arnold, 1996) is one way of closing the after part of the logboat. It is not known, however, to have been used in plank boats. Consequently, in a plank boat of a type that is not based on or developed from a single central element in logboat style, it must be considered an alien element. In the Bronze-Age boat Ferriby 1, the hull is built up from a central plank. The upturned end of this 'foundation plank' is recorded in the presumed bow, and the carved elements added to form the sides follow the same general pattern at both ends. Consequently, Ferriby 1 is likely to have had the same general character at both ends. This example indicates that the ends of the Dover boat would probably also have been near-identical in design and at least not truncated aft with a square stern transom that gives an unfavourable flow of water around the after part of the hull when paddled.

The bow end element had been removed before the Dover boat was covered by sediments. Some of the wedges holding it in position in the intricate structure of the bow had been cut across in order to pull out this element. If a single element, it could not have been removed undamaged, judging by the position of the wedges holding it in place (Clark, 2004: 310). Evidently it was a valuable timber that might be reused in the construction of another vessel, possibly together with the upper planks for which the withies had also been cut across. This is a strong indication that boats of the Dover type were regularly built and used in the area at the time. Considering the complex layout of the fastenings for the bow transom, it may well have had a shape different from the flat panel shown in the reconstruction. If the width of 1.2 m is correct, it is an open question whether it was made of one or more pieces of wood. On the other hand, the revision of the curvature and overall lines of the hull suggested above, possibly including increased bottom curvature, may give a different shape to the bow area of the boat with the forward ends of the vessel's sides being set

closer together than indicated by the flattened-out and partly distorted shape found *in situ*. In view of these reservations, the ends of the boat may also need further study, including small-scale model-building, taking into consideration the methodological and technological points raised here.

Strength calculations and flexibility

According to Roberts' strength analysis (2004: 193–202), the shorter Dover 1 version of the boat is the only one of his reconstructions which would have had sufficient strength to withstand the forces acting on the hull in longitudinal bending. The calculations are based on the hull floating in hogging and sagging conditions in a standard wave pattern and at various loading conditions and sea-states. Such calculations are indispensable at the planning stage leading up to the construction of modern boats and ships as they can be compared with the empirical knowledge gained from the use of similar vessels in the real world. The value of these calculations, however, is dependent on calibration factors derived from design experience, and on approximations applied to the vessel in question in order to bring this into a form that can be dealt with mathematically. These approximations are based, among other things, on the hull fastenings being able to prevent the planks from moving in relation to each other when the hull is subjected to waves. The description of the Dover boat, however, gives several indications of slight wear between the wooden parts as well as of moss caulking being replaced as a result of the boat's fastenings yielding slightly during the active life of the vessel.

In Roberts' discussion of the strength and seaworthiness of the boat, these traces of wear are seen as an undesirable weakness: 'No allowance is made in these calculations for the flexibility of the seams, which in any case, is destructive both to the stitches and to the luting' (Roberts, 2004: 196–7). So it is, when seen from the point of view of modern strength calculations which do not account for this 'instability' and the moderate flexibility of a hull of this kind. In reality, however, the situation is different: in the sewn plank boat, *masula*, from the south-eastern coast of India, small bundles of vegetable fibres are stitched onto the seams in much the same way as the moss and thin laths were held by the stitches of withies in the Dover boat, keeping the vessel watertight. In both cases, this feature also functions to keep the structure elastic when compressed, reducing excess

stress applied to the joints when afloat (Kentley, 2003a; Arnold, 2004: 86).

The maximum bending moments and shearing forces for the 4th-century BC Hjortspring boat were calculated from a similar set of approximations as those used by Roberts for the Dover boat. The slender structure of lime (*Tilia* sp.) of the Hjortspring boat, with a waterline length of c.14 m, was subjected to a standard trochoid wave, 0.65 m high, giving a maximum sheerstrake stress of 3.5 N/mm² in hogging condition and a maximum sheer force of 5.2 N/mm (Hocker *et al.*, 2003: 95–100). Experiments were also carried out with a test-panel of planks to investigate the mechanics of sewn joints, and the full-scale reconstruction *Tilia Alsie* went through extensively trials in 2000–2001. Measurements were taken regarding the effects of deflection with and without a trussing rope running from stem to stern, as well as of the speed of the boat being paddled by a team of experienced paddlers in calm weather and in waves (Fig. 7).

These figures may now be compared to those calculated by Roberts for the much more solidly-built Dover boat in order to re-evaluate his conclusion that neither of the suggested Dover 2 and 3 reconstructions, exceeding 11.7 m in length, would be strong enough for regular use at sea. Attention should also be drawn to the calculations of the strength of the yew withies, based by Roberts on figures from similar-sized hemp rope. However, in Roskilde, experience using hemp rope versus withies to hold side-rudders in Viking-ship reconstructions has shown a very considerable difference in favour of withies for such a function, and this would probably also apply to withies used in stitches.

Propulsion

In principle, all potential types of active and passive propulsion should be taken into consideration in the study of the Dover boat. Arguments for and against the various means of propulsion should draw on archaeological and iconographic evidence, as well as on technological considerations. Although working the tides and an element of deliberate drifting with the wind and currents is usually disregarded in technological studies, these actions should also be given attention since they may well have played an important role in Bronze-Age seafaring. Among the potential active means of propulsion, paddles are known from several Northern European Stone-Age sites,



Figure 7. The Hjortspring reconstruction *Tilia Alsie* undergoing trials in 2000 and 2001 under various weather conditions. (From Crumlin-Pedersen and Trakadas, 2003. Copyright Viking Ship Museum, Roskilde)

in addition to numerous paddles and paddlers illustrated on Bronze-Age rock carvings and bronze objects found in Scandinavia. Numerous narrow-bladed paddles were found with the Hjortspring boat, and copies of these were tested during the sea trials with the reconstruction *Tilia Alsie* as well as studied in relation to paddles from other finds (Haupt and Fenger, 2003).

In contrast to paddles, representations of oars and rowing are not known from northern and north-western Europe before the Iron Age. In southern Norway a small number of rock-carvings from the Early Iron Age depict vessels that appear to be rowed (Østmo, 2003). The Irish Broighter gold model of a boat with oars, steering oar, and mast with a yard, probably from the 1st century BC, demonstrates the likely use of these means of active propulsion in the Irish Sea, albeit at a date *c.* 1500 years after the construction of the Dover boat (Farrell and Penny, 1975). Without giving references, Roberts states (2004: 208) that oars were regularly used around the Mediterranean from at least 2500 BC, and that this technology may have spread northwards in the Bronze Age and may consequently also have been applied in the Dover boat.

In his argument for the possible use of oars and a sail with the Dover boat, Roberts refers to ship depictions on two Danish Bronze-Age razors (Roberts 2004: 207–8). The Viemose razor depicts two ships with features taken by him to represent

rowlocks, although no oars are present. A serrated ornament along the edge of the razor is simply continued along the sheer-line of one of the vessels, and in the other vessel the ends of the frames are evidently shown protruding above the upper line of the hull as in the paddled Hjortspring boat. Thus, none of these features supports the idea that these boats were rowed. The evidence offered to suggest the use of a sail comes from a razor from Hvirring, depicting a mushroom-shaped figure in a ship. Figures of a similar kind are portrayed on a number of other razors, clearly showing these features to be part of the cult scenery displayed on the artefact, and probably representing a sacred tree (Kaul, 1998, 2: 38, 111). Thus there is at present no archaeological basis to support the use of either oars or sails in northern Europe at the time of the Dover boat. Consequently, focus can be concentrated on propulsion of the vessel by means of paddling in conjunction with a knowledgeable exploitation of tidal streams, considering the location of the find. Hypothetically, even rowing may be a viable possibility, whereas any kind of advanced sail propulsion must be considered unrealistic.

The kinematics of paddling the long and slender Hjortspring war-canoe reconstruction has undergone detailed studies, and the actual achievements of a crew of international-level 'dragon boat' paddlers have been published (Vinner, 2003). The cruising speed maintained in the tests by 18 paddlers

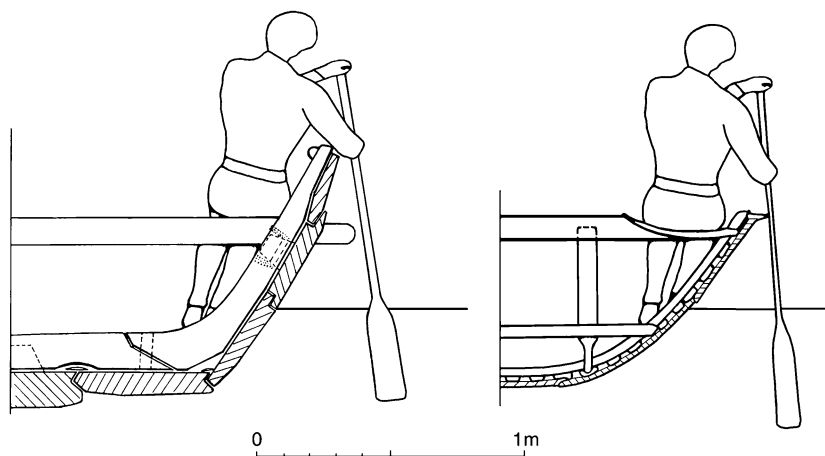


Figure 8. Cross-sections of Ferriby 1 and Hjortspring with paddlers, compared at the same scale to illustrate the obvious difference between the heavy British Bronze-Age boats and the Danish Iron-Age tradition of slender boats. (From Crumlin-Pedersen, 2003. Copyright Viking Ship Museum, Roskilde)

over 2.2 hours was 4.7 knots, while a sprint speed of 7.6 knots was maintained for 5 minutes by 20 paddlers. As these results are probably equivalent to the standard that young Iron-Age warriors such as those originally manning this boat could achieve, it seems overly optimistic for Roberts to state that for the much heavier and less streamlined Dover 1 reconstruction, a speed of 5 knots 'is so comfortably achieved and maintained that it could be relied upon for most voyaging in good conditions' (Roberts, 2004: 206) (Fig. 8). Even here, the Dover boat calculations need re-assessing.

Seaworthiness

The potential danger of seepage through the seams is frequently mentioned in the description of the Dover boat, and there are traces of repairs to the moss caulking, showing that some action was needed during the working life of the boat. However, since wax has been identified as one of the sealing ingredients in the vessel's joints, it is likely that the seams were actually more watertight than suggested, even though they may not have lived up to today's standards. Originally Marsden interpreted the Dover boat as a river-craft based on the general features of the Dover 1 reconstruction as 'punt-like' and in the inefficiency of the fastenings for the central plank joint. He simply considered the vessel too dangerous to use on extended voyages at sea. This standpoint was later abandoned, however, as sediments found in the boat demonstrated that it had actually been used in local coastal traffic³—but 'longer voyages, particularly across the Channel to France, were

probably out of the question unless the vessel had very substantial strengthening—for which there is no evidence' (Marsden, 2004b: 17–19).

As demonstrated above, several of the assumptions and calculations on which the Dover 1 reconstruction is based need to be re-assessed and revised. This process will probably lead to alternative suggestions for the original appearance of the boat. At this stage, renewed calculations may be based on specific tests relating directly to the Dover evidence, taking the experience from the Hjortspring trials into consideration. In the end, discussions among the members of a panel of specialists may reduce the number of choices and lead to the approval of one or two prototypes to be studied as small-scale models in various trials, and possibly one of them as an eventual full-scale reconstruction. At this stage, the seaworthiness of the vessel can be fully investigated following similar procedures as applied to the Hjortspring reconstruction but taking the nature of the Channel tidal conditions into consideration. If the evidence permits, one or more crossings of the Channel might be included in the trials, with the reconstructed vessel equipped with GPS to plot its actual track over the sea-bed, as well as various types of modern safety and emergency equipment.

Concept and parallels

It is not the aim of this paper to present a ready-made alternative reconstruction of the Dover boat. These notes have instead pointed to several subjects that need to be analysed and discussed

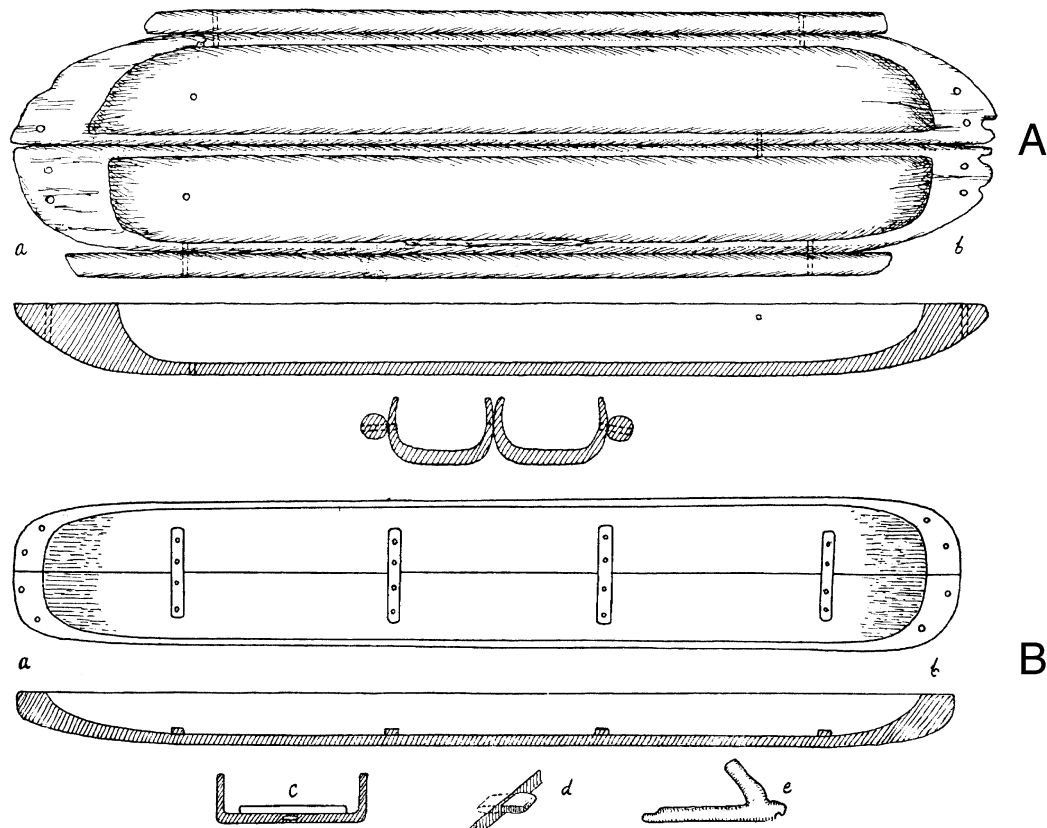


Figure 9. Two Finnish boats, each made from two logs assembled along the centre. (From Itkonen, 1941)

before any definitive proposals can be prepared. At the present stage, however, there may be a point in discussing the constructional concept of the boat, an aspect which has hardly been touched upon in the publications this far. In principle, the Dover boat can be understood as a 'double-boat' made up of two sewn boats joined in the middle by the transverse timbers held by the cleats, and by the wedges locking the central seam. The technique of joinery in the central seam and at the bow is entirely different from those found in seams elsewhere in this vessel or in the other British Bronze-Age boat finds. At the same time it demonstrates that the Dover boat was not constructed in a process starting with a central element. This is a strong indication of a different background of building tradition for this vessel compared to those of the Ferriby and Brigg 2 traditions where construction of the boats evidently started from one or more central planks.

Recent examples of double-boats made from two logboats joined into one hull may serve to illustrate the basic concept that initially produced the Dover boat. Such double-logboats have been recorded in various shapes from Finland and

Macedonia (Figs 9–10) as well as from several areas outside Europe. Here, stages in the integration of the two logboats into one vessel are represented with their assembly along the centreline fastened in various ways involving cross-timbers and iron staples. When this double-logboat concept was taken as the starting point for the construction of larger boats, each of the logboats could be fitted with planks sewn or lashed along the edges of the logboat base. When joined together, the resulting cross-section of the composite vessel might still have preserved features reminiscent of the genesis of the concept, such as the concave bottom and the central seam of a nature different to that of the other seams in the vessel, as in the Dover boat.

This illustration of the basic concept of the Dover boat is based upon examples of early 20th-century inland boats from remote corners of Europe, and they may seem irrelevant to the relatively large and complex vessel discussed here. However, a considerable number of prehistoric, medieval and early modern craft, characterised by their two *iles* of rudimentary logboat character, have been found as various types of barges, primarily in Central and Eastern Europe (Ellmers,

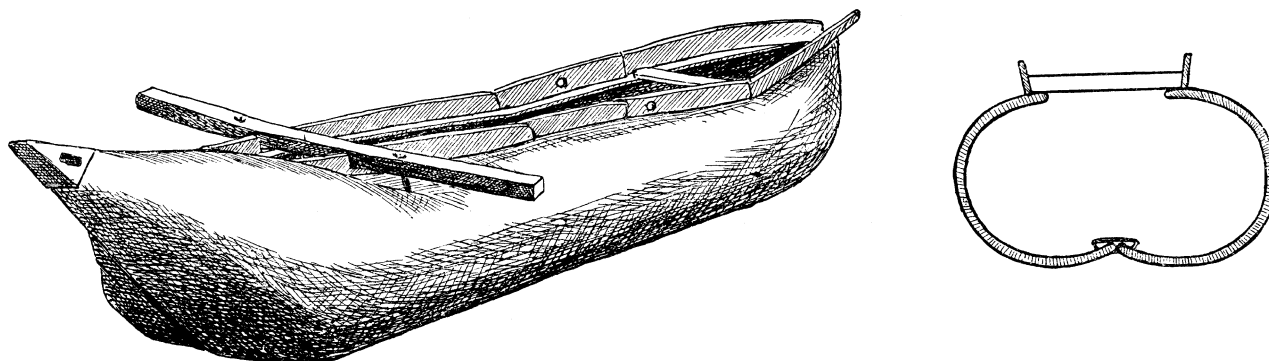


Figure 10. A double-logboat from the Ostrovo Lake in Macedonia, fastened with iron staples along the centreline. (From Traeger, 1904)

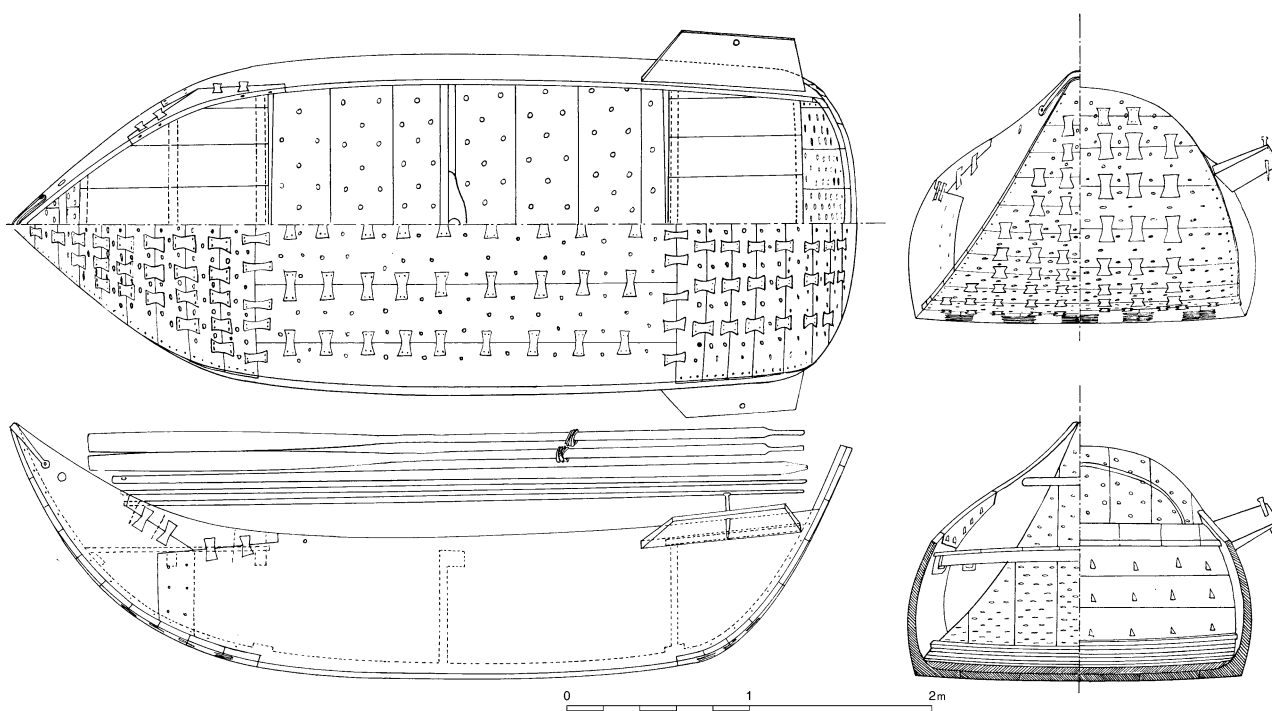


Figure 11. A tilhole from the Adour River in France, 18th century. (From Beaudouin, 1970)

1984; Arnold, 1992; Bockius, 2000; Kentley, 2003b; Nakoinz, 2005). Here construction starts with the shaping of the two *iles* and positioning these on building stocks, with the bottom planking being fitted in between during the next phase. This procedure was even followed in some places at a time when the carved-out *ile* had been replaced by two sawn planks fitted against each other at an angle (Ellmers, 1984: 159).

Elaborate versions of this basic concept were also previously used in some of the boats on the Adour River in France (Fig. 11) (Beaudouin, 1970), showing that the principle was not exclusively used for barges. In Sri Lanka, modern seagoing

vessels of the *madel paruwa* type, built on the same principle with logboat *iles* and concave bottom planking, have recently been recorded (Fig. 12) (Kentley, 2003b). The *iles* in these vessels must clearly be seen as rudimentary logboat partners in a double-boat. In both these cases the area between the *iles* has been built out with planks to form the bottom of these relatively complex vessels.

In light of these modern examples of simple as well as complex double-boats, the basic concept of the Dover boat must be understood as two logboats extended by sewn planks along both sides and integrated into one hull. By the time the Dover boat itself was built, the two parts of

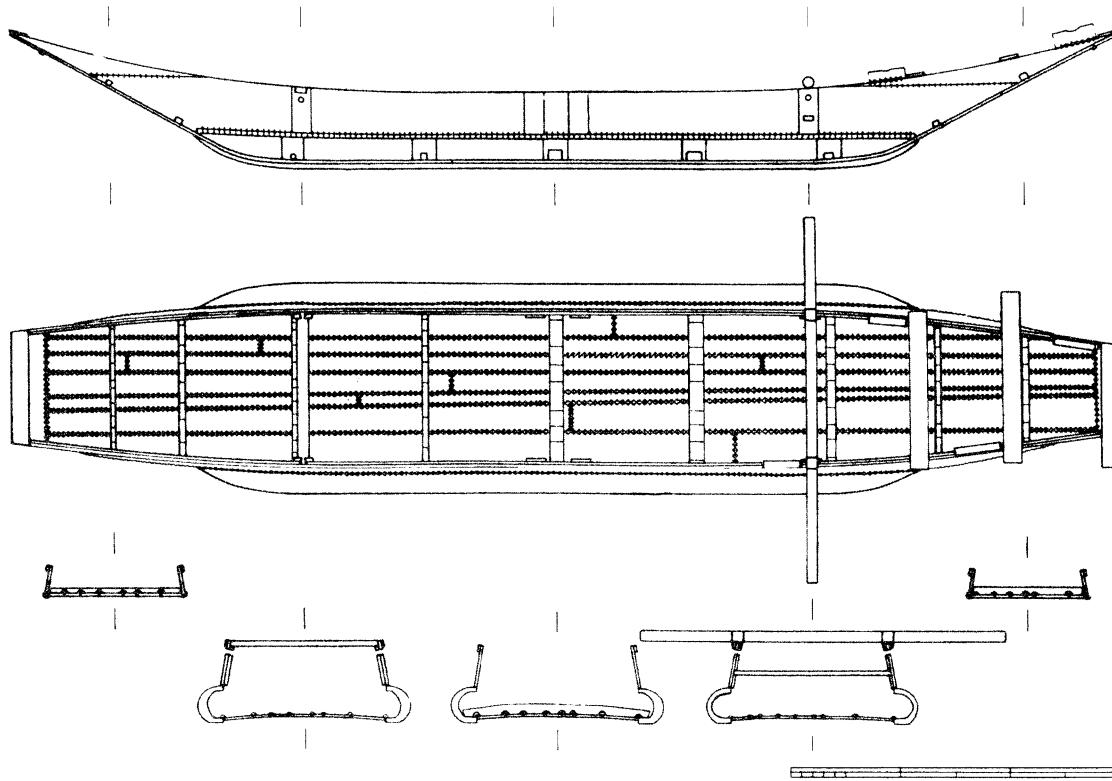


Figure 12. A *madel paruwa* from Sri Lanka (scale in metres). (Kentley, 2003b, fig. 6.2, reproduced with permission)

the double-boat had been partially moulded into a shape that was oriented towards the final shape of the vessel, though with features pointing to the origin of the constructional concept, such as the up-curved central part of the bottom in cross-section and the 'zipper-like' central assembly with wedges.

Conclusion

When a detailed re-assessment of the Dover boat is undertaken, with consideration of these and other comments on the first published reconstruction, the study will have to deal with several issues: The curvature of the *iles* and the shape and size of the side planks will need reconsideration as well as the role of the end pieces. The fitting together of the two parts of the double-boat probably took place at a late stage in the construction process, rather than as a first step, and this procedure must be investigated.⁴ This study will no doubt benefit from a small-scale model building approach, where the individual timbers are cut to scale in wood, starting from Richard Darrah's critical assessment of the original wood and the longitudinal curvature of the *iles*. After carving out these, a flexible model version of a bottom plank

with corrected cross-section as well as a side plank should be sewn onto each of the *iles*. When these two parts of the boat have been joined together with transverse timbers and locked at the centreline with wedges, probably resulting in a slightly curved bottom line, the available space for the bow timber should be studied in order to determine its most likely shape and function in relation to the two boat parts. This process would lead to a 'torso-model' showing only what was found of the boat. In building this three-dimensional mini-version of the boat, several questions will have to be dealt with, probably requiring further studies. The model itself will serve as a more realistic basis than a set of drawings prepared entirely at the drawing-table, in order for the discussions to follow to arrive at a fully-functional version of the original boat.

At that stage, the possible need for additional means to strengthen the hull longitudinally and transversely may be discussed together with renewed calculations of hydrostatics. Discussions must also occur regarding the propulsion and the optimal timing for possible trials that would involve a future full-scale version of the boat heading upriver, down the coast, and maybe even across the Channel to France.

Notes

1. The author is grateful to Peter Clark, Peter Marsden and Seán McGrail for a constructive dialogue on the Dover boat reconstruction.
2. In the Dover boat monograph, the two curved elements between the bottom and the sides are called *iles* or 'chine girders' whereas other scholars prefer the terms 'chine strakes' or 'transition strake'. Since the terms girder and strake are usually applied to beams and planks respectively, the term *ile* is preferred for these carved-out transitional elements between bottom and side in the Dover boat and in other vessels with similar elements.
3. Sediments found at the bottom of a shipwreck may represent traces of ballast or cargo carried on board in addition to local sediments deposited after the wrecking. In medieval times and later ballast may have been reloaded several times in ports, so that it may have come from another area than that of the loading of the ship (McGrail, 2004: 51–2). For the Dover boat, however, the evidence of sediments that are 'foreign' to the Dover area, but found further down the coast at Folkestone and beyond, must be taken as proof of the use of this vessel in coastal traffic since there would be no need for ballast if the boat had been used locally in the river only.
4. The transverse timbers in the bottom of the boat were damaged and deformed by the weight of the sediments above, like the other elements of the boat. There is no clear indication that these timbers tapered in thickness towards one end as suggested by Darrah (cf. Marsden, 2004a, fig. 5.57, and Darrah, 2004c, fig. 9.28). One of the transverse timbers (341) is slightly broader at one end, but this may be the result of deformation since it is described as so badly damaged that detailed accurate measurements are not possible. Consequently, it is likely that these timbers were not inserted during an early phase in the construction of the boat as suggested in the monograph, but in the process of assembling the two parts of the double-boat—a subject for further study at the model building phase.

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