

Continuity and change in Dutch shipbuilding in the Early Modern period. The case of VAL7 and the watership in general.

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Review data
Submission 1/3/2012
Revision 10/4/2012
2nd submission 25/6/2012

available online at www.jalc.nl and www.jalc.be

Abstract

The sixteenth and seventeenth centuries are characterised as a period of rapid growth in Dutch shipbuilding in which Holland has a central role. Holland is one of the seven provinces at the time in the newly founded Dutch Republic. Ships in Holland grow bigger with multi-mast rigging to carry more cargo over larger distances across the world. In the case of the locally operated watership this is not so apparent. In fact, the general opinion is that there was continuity in the remarkably robust medieval design of this ship type up to the point that the last ships were built at the dawn of the nineteenth century. This article will feature the VAL7 watership recently lifted from the river bottom near Amsterdam to highlight constructional differences with other wrecks from waterships found in the reclaimed land area of the former Zuiderzee. This will be generalized to reveal indications for change in watership design. At least two major design changes have been identified involving increased dimensions and better manoeuvrability. Also a transition from a lap-strake hull to a flush hull is made in the case of the watership. An effort is made to find drivers for change in the context of a rapidly developing maritime infrastructure in Holland. It is appreciated that changing functional requirements and shipbuilding economics at a local level drive design change. The case of the watership shows that dynamics in society are reflected in the design and subsequent construction of ships.

Keywords: Watership, VAL7, construction, design, shipbuilding, economy, change, tradition, Early Modern period.

1 Introduction

At the dawn of the seventeenth century a Dutch skipper is sailing his watership towards the fish market in Amsterdam. A precious load of flounders is kept alive in the brackish river water that flows through tiny bottom piercing holes into a fish well contained in the hold amidships. The skipper must have seen the skyline of Amsterdam disappear when for some reason the ship goes down in at least four metres of water, not to be found again until the year 2007.¹ The surviving fish bones are still contained in the fish well of the shipwreck designated VAL7.²

When the wreck is lifted from the river bottom in September 2009 for the purpose of archaeological research, a newspaper asserts that this *workhorse* of the Golden Age in the Dutch Republic must have been a successful ship type.³ Not only did famous Dutch seventeenth century painters feature the watership as a symbol of economic power, it also serves as an example of tradition in Dutch shipbuilding. The watership has distinct features that essentially remain unchanged over the four centuries of its existence. As the newspaper argues, why should money and effort be spent on experimentation with a ship design if it works?

This paper is based on the excavation report of VAL7 (Waldus, 2010) and on data from the NWO Odyssey program.⁴ The watership is one of those archaeological gems of which forty wrecks have been registered over time in reclaimed land from the former Zuiderzee as local farmers detected them while working the land (fig. 1). Twelve of these have been sufficiently documented to enable a more detailed analysis. In two cases sufficient archaeological data was available for a reconstruction model (fig. 2). Notably the first model is lap-strake while the later model has a flush hull. More construction differences were found when analysing the VAL7 wreck found in a river entrance to Amsterdam and the twelve documented waterships from Flevoland.

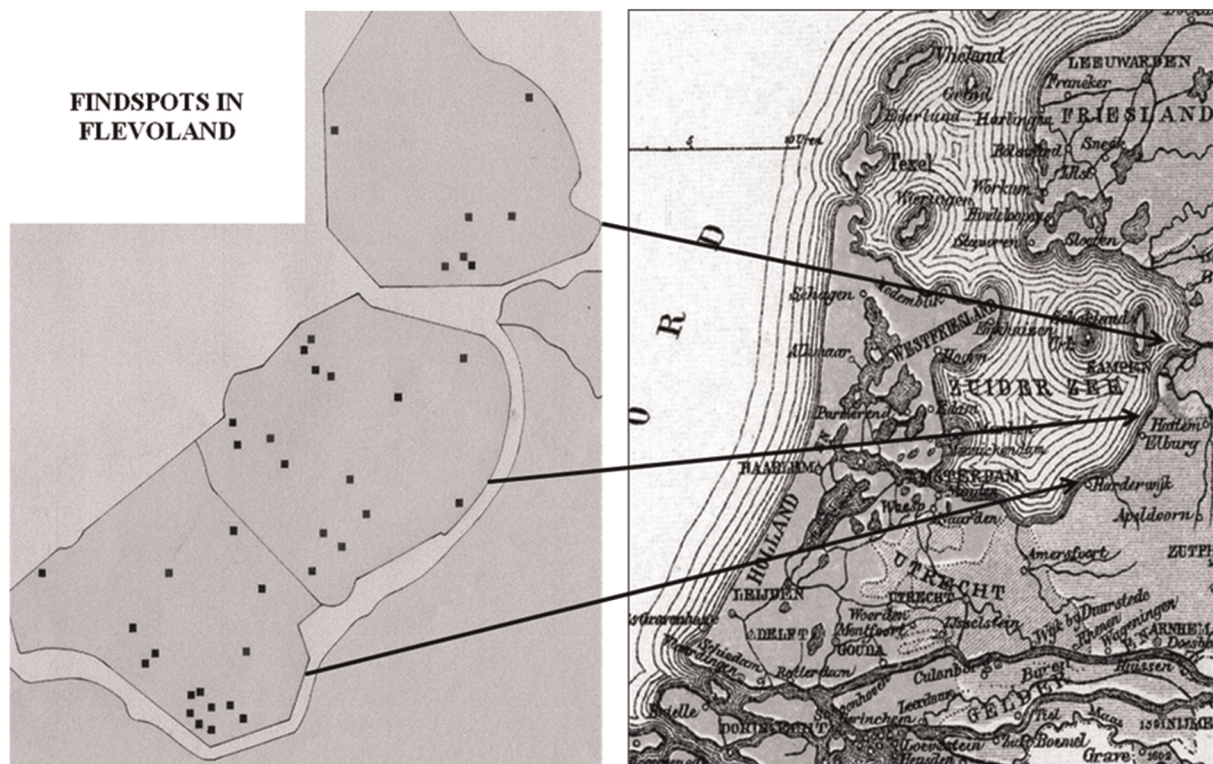


Figure 1 Location in Flevoland of 40 wrecks of waterships from the sixteenth and seventeenth centuries (courtesy of André van Holk). Flevoland is reclaimed in the twentieth century from the Zuiderzee. The reference map on the right depicts the Zuiderzee area and the region of Holland in 1610, just before the lakes north of Amsterdam are reclaimed (Brinkman 2005).

The VAL7 is the first watership wreck underwater that is raised from the bottom. This article will start with a brief account of this event as an example of how underwater archaeology is conducted in The Netherlands. The VAL7 will then be compared to other watership wrecks to identify constructional differences, after discussing some considerations on the dataset. Finally the data is assessed on a more general level to find indications for change in ship design. The central question is how observed changes in construction and design should be interpreted? What is driving change, is it ship function dynamics or do variations and trends in Dutch



Figure 2 Archaeological reconstruction models of the watership hull. Left the lap-strake model of ZM22 and right the flush hull model of OW10. (Photo Cultural Heritage Agency dept. Lelystad).

shipbuilding practice change ship design? What is revealed about the dynamics in Dutch shipbuilding in general?

A glossary at the end of this article will help to navigate through the unfamiliar terms related to ships and shipbuilding.

2 The raising of the VAL7 watership

In May 2007 some wreckage material surfaced in the river entrance *Buiten IJ* near Amsterdam during dredging operations (fig. 3). The location was marked and operations continued as demands for a deep commercial shipping channel had to be met.

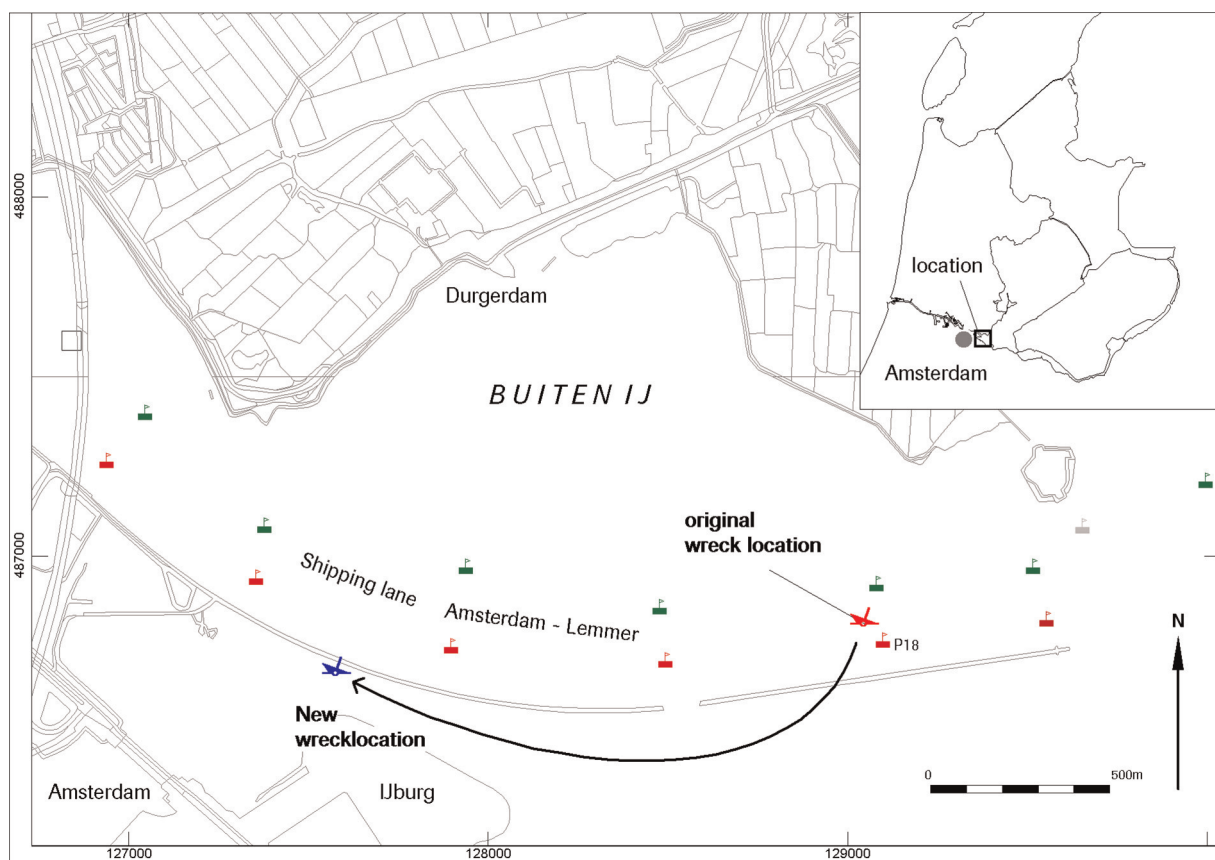


Figure 3 Wreck location VAL7 east of Amsterdam in the shipping lane (Waldus 2010).

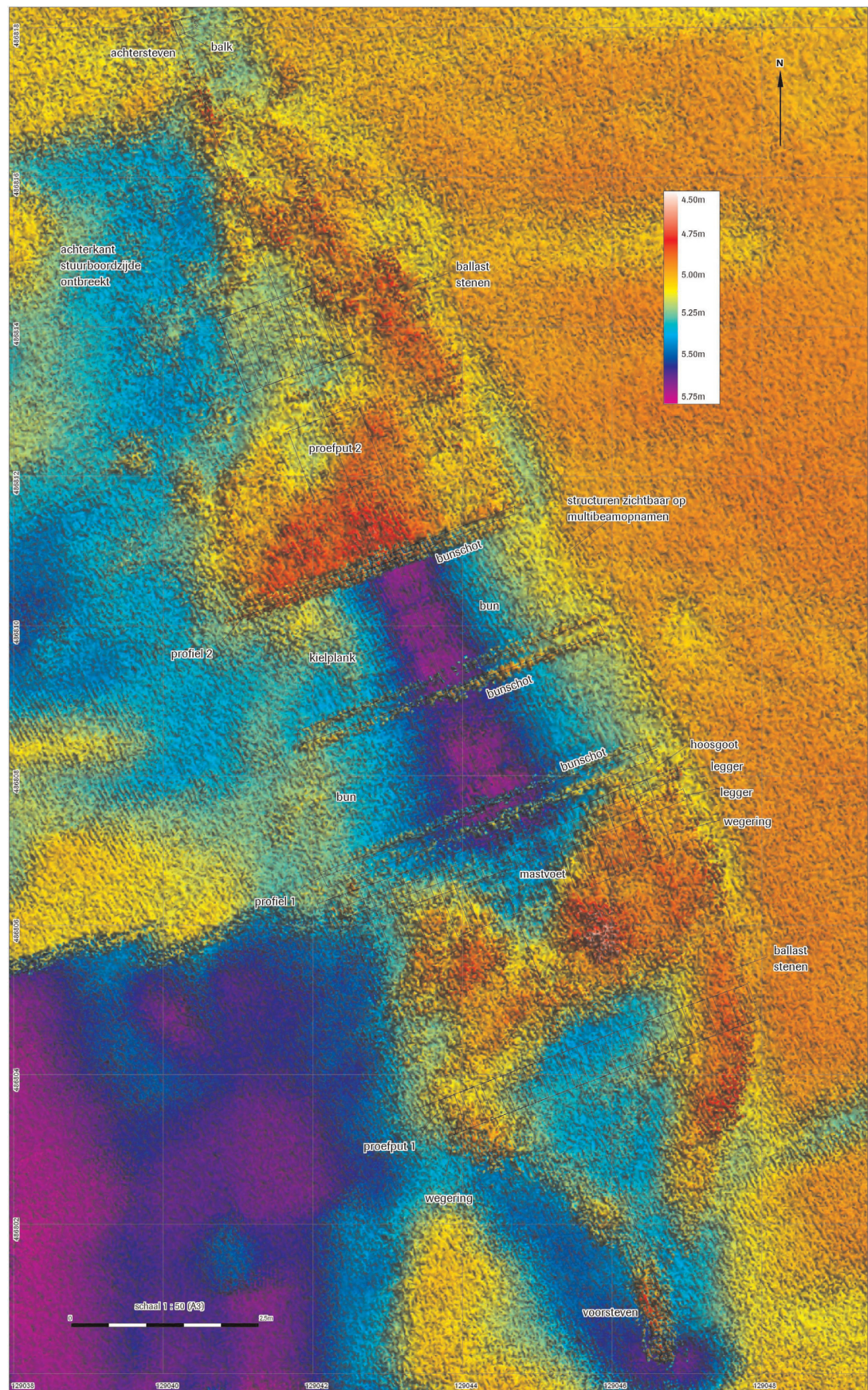


Figure 4 This multibeam image clearly reveals the shape of the hull. The fish well area in the middle is divided into two sections, and the bow area is located at the bottom of the image. The dark square left bottom is the spot where dredging stopped (Waldus 2010).

The unknown wreck was reported immediately as it may have historic value, but clearly was an obstacle in the future shipping lane. Authorities subsequently ordered an onsite dive inspection and a geophysical survey to be executed. Multibeam sonar images revealed the contours of what appeared to be a watership (fig. 4).

Divers observed that the wreck with an overall length of 17.5 metres was well preserved under a layer of ballast stones. A sample from the wooden structure was taken for dendrochronological analysis onshore, and revealed that the watership must have been constructed after 1585. Further analysis of ceramics and a coin found during the dive inspection indicated that the ship was wrecked around the year 1600. General policy is to preserve a high value wreck like the VAL7 in situ, but in this case the obstacle had to be removed from the shipping lane. It was decided to raise the wreck and bring it ashore for detailed study. In September 2009 a salvage vessel was contracted, equipped with diving gear, pumps and hoses for sediment removal, a sonar and a 200 ton crane. The divers used surface supply equipment with built-in communication and video. Ship archaeologists, hydrographic surveyors and diving technicians made up the excavation team, with an underwater archaeologist in charge.

The divers first removed the ballast stones by hand from the wreck, they amounted to around five tons of jagged football-size boulders located in the holds fore and aft of the fish well. Some elements of the original ship's inventory were retrieved from between the boulders, their exact locations being plotted on the multibeam image of the wreck site. With the ballast stones gone, a layer of sediment was uncovered that settled in the wreck over time. This layer was systematically removed by pumping the sediment upward through a sieving construction on the salvage-vessel deck. Small finds like fish bones could thus be separated from the sediment, while find-spots were immediately marked in close liaison with the diver through the communication system. Finally the site was fully recorded with a sector scanner, revealing that the hull was now free of sediment and stone.

It was assessed that the wreck would break up during lifting operations as the construction had lost much of its structural strength. This would defeat the purpose of recording and analysing the construction in detail once it was lifted ashore. Therefore the decision was made to carefully cut the wreck into three parts with an underwater chainsaw. First the divers used a suction pump to carve out trenches under the ship structure at predetermined sawing locations. Next the wreck was cut into three parts. Finally trenches were carved out under each of the three construction parts to rig the slings for lifting. The slings were connected to a lifting frame that prevented the construction from crumbling under its own weight while being lifted onto the salvage vessel. The three parts were lifted one by one and placed on a bed of sand onshore near the site for detailed study (fig. 5). Upon completion of the research the VAL7 wreck was repositioned in a new location underwater making it accessible to sports divers (fig. 3).

The VAL7 has a sharp hull shape underwater, just like the other watership wrecks found in Flevoland. This is an exception to the general observation that ship types indigenous to the Zuiderzee area are flat bottomed (Petrejus 1964, 148). The function of the ship is clearly illustrated by the finds of inventory and cargo. A number of rounded net weights of stone in the holds indicate a function as fishing vessel or trawler, towing large fishnets across the Zuiderzee (fig. 6). The unusual high concentration of fish bones of flounder in the fish well (Waldus 2010, 41-43) tells us that fish was kept alive for the market. The wreck shows the typical watership layout of a centrally located fish well split into two by a bulkhead, and storage space fore and aft of the fish well. Judging from the remaining dimensions, its length to width ratio approximates 3 : 1, and its overall length must have been around 20 metres. The reason for the fish not to swim out of the fish well after the sinking of the ship may have been a cover blocking the entrance to the fish well. Other explanations may exist.

The VAL7 appears to have the same robust construction as the other wrecks from Flevoland. However it has a flush hull while many older wrecks have a lap-strake hull, and it seems to have been longer than the other wrecks. It is built on a keel plank where a keel beam was



Figure 5 The VAL7 wreck lifted ashore for documentation purposes (Waldus 2010).



Figure 6 Watership as trawl net fishing vessel. In the drawing the ship is offloading fresh fish into a small boat at Amsterdam roads for the local market. The long pole on the side, the ropes and net weights (rounded stones) dangling off the side are part of the fishing equipment. (Detail from a pen drawing by Ludolf Backhuysen c. 1660 (collection Maritime Museum Amsterdam).

expected as in the case of other contemporary wrecks. More constructional differences with other shipwrecks were observed. So the question is where the VAL7 shipwreck actually fits in the total picture. The answer must be found in the total dataset, that is subject to scrutiny in the next paragraphs.

3 Scope of the dataset

Neither archaeology nor archives have revealed a clue yet that waterships were ever constructed outside the region that is nowadays called the province of North-Holland. Hence the scope is limited to this region (fig. 7). The period in which the watership occurs spans at least four centuries. Its genesis and original appearance remains obscure since fourteenth and fifteenth century waterships did not show up yet in the archaeological record. Its demise, well known from archival information, is 1827 when the Dutch Navy decommissions the last watership from the service as a tug (Koningsberger & Oosting 1994; Boven & Hoving 2009, 55).



Figure 7 The present-day province of North-Holland in 1350. Each opening to the sea has a dam. The black lines represent the layout of the dyke system. (Boschma-Aarnoudse, 2003, 41). The lakes are turned into land between 1612 and 1624.

The concept of a ship transporting live fish in a fish well is not unique to the watership, as it was already practised in Roman times (Boetto 2003). It is postulated that the first waterships were local vessels used in the many lakes and creeks of North-Holland, in the 14th century, to collect fish, transporting the catch to local markets and production centres. However it is not known what these ships looked like, since one of the oldest wrecks revealing relevant data is

the ZN₄₄ constructed somewhere around 1500. In Dutch archives the first scant reference to a watership is made in 1339. An English archive from 1420 indicates that it may have exported live fish across the North sea. Dutch archives refer to waterships in 1494 transporting live eel to Belgium and other provinces in the Dutch Republic (Ypma 1962, 44). Edam is mentioned as a town that owns a watership in 1462, equipped with trawl nets (Boschma-Aarnoudse 2003, 146 & 159). The archaeological and archival information is sufficiently convincing to identify the function of the watership in collection and transport. The export function of live fish to distant markets is not yet archaeologically proven, but likely (Ypma 1962, 33-36, 42, 44-45). This function, with a need to sail at sea and in coastal waters, may explain why the ship is built with a keel plank, S-shaped bottom fore and aft, and a strong lap-strake hull (fig 2). On the other hand many flat bottomed ship types, some with a fish well, are known to have sailed coastal waters and the North sea. This paper will not address the issues related to the genesis and original appearance of the watership, as adequate data are lacking.

The scope in this paper is the watership originating from North-Holland in the sixteenth and seventeenth century, since the dataset of 41 shipwrecks does not extend beyond this timeframe. This dataset was explored in search for a consistent and uniform basis that would allow for variables to be compared. It appeared that substantial reduction of data was needed, as well as a renewed effort to derive geometric measurements from field drawings in a uniform manner. Different reports show different gaps in the listing of geometric data, use different reference points, or mention no reference at all. For example ship length was measured or estimated in many different ways, depending on what was remaining of the wreck and the goal of the field investigation. Local differences in deposition processes account for differences in the way wrecks deteriorate. Sometimes a rudder or sternpost is all that remains, sometimes almost a full hull is available. Therefore consistency and uniformity in geometric data is always a stretch. Twenty-one wrecks were not sufficiently documented to meet these demands. They are also not available for additional retrieval of data in the future. However this limited dataset is not useless, as it still contains valuable qualitative information on construction details that is used in the assessment of change (table 1).

From seven wrecks only basic information is gathered, but there is potential for retrieval of information through additional fieldwork in the future (table 2). These wreck have only been explored in situ and covered again for preservation in situ.

Finally thirteen wrecks are sufficiently documented for the retrieval of comparative data in both a geometric and qualitative sense (table 3). These wrecks could be sequenced in time, based on an accuracy estimate of 25 years for the construction date of a new ship. The construction date estimates in table 3 are derived from several dating methods and from the appreciation that the life span of a ship must have been around 20 years. A seagoing ship had an operational life of fifteen years on average (Boschma-Aarnoudse 2003, 234). Two waterships served the Navy for 25 years between 1802-1826 (Acts 3161 and 3247, Notary Archive Monnickendam, nr 3584). The age of wreck ZN₄₂₋₁ was over 20 years old when wrecked (Pedersen 1996, 67). The expected life of 20 years seems reasonable for a ship in the sixteenth century engaged in heavy duty trawling. This also means that the waterships in table 3 cover a period of eight to nine generations of newly constructed waterships. This should be enough to allow for change in ship building practices.

For the wrecks ZN₄₄, OG_{33/34} and OU₈₆ the original field data were consulted, as stored in the maritime archaeological archives of the Cultural Heritage Agency in Lelystad. For the other wrecks, listed in table 3, also well documented reports were used (van Gent 2002, 92; van Holk 1983; van Holk 1986, 20-21; van Holk & Immink in prep. a, b, c; Hulst & Vlek 1985; Pedersen 1996; Reinders 1986). The sintel typology method of Vlierman was used (Vlierman 1996).

4 Constructional differences

Designation	Exploration year	Excavation year	Hull construction	Remains of interest in addition to ship bottom fragments	Bracket of live span
OG64	1963	1968	lap	stem, stern, hanging knees	15d 16ab
ZN113	1972.198		flush	deck, stem, stern	16ab
ZJ40/41	1972.198		flush	deck, stern	16ab
OK84-2	1964	1971	lap	fairly complete	16abc
ZG13	1981		lap	stem, rudder, possibly not watership	16abc
OQ55	1957.1964		flush	two bulkheads	16bc
ZO39	1982		flush	stem, stern	16bcd
ZG80	1978,1980,2003		flush	deck aft, stern, covering board	16bcd
ZN61	1979		lap	deck aft	16cd
OB20	1964.1975		flush	no information	16cd
OU41	1965.1989		flush	stem, stern	16d 17a
OJ9	1963.1989		flush	heavily fragmented	16d 17abcd
NC12	1983		flush	deck, stem, stern, covering board	16d 17abcd
NP4-1		1944	flush	deck aft, stern, frame	17ab
ZO69	1975.1976		flush	deck, bulkheads, frame, hanging knees	17abc
OT23	1964	1969	flush	fairly complete, built after 1628 (dendro)	17bc
OU113	1968.1981		flush	hanging knees	18bcd
ON10/11	1958.1981	2001	lap	deck aft, stern, frame, covering board	unknown
ZK53	1984	1985	flush	heavily fragmented, possibly not watership	unknown
NQ65-1		1944	flush	no information, covering board	unknown
ZO73	?	?	?	no information	unknown

Table 1 Watership wrecks not documented enough and no future potential

Designation	Exploration year	Hull construction	Remains of interest in addition to ship bottom elements	Status	Bracket of live span
ZO31	1972.198	lap	deck, stem, stern	preserved in situ	15d 16a
ZK47	1984	flush	almost complete	monument request	16abc
OC18	1983.1994	flush	fairly complete	monument request	16cd
ZA79	1975.198	flush	deck, stem, stern	monument request	16d 17a
OF12	1974.1982	flush	deck, stem	preserved in situ	around 1600
ZH9	1979	flush	deck, stem, stern	preserved in situ	16d 17abcd
OC60	1967.198	flush	deck, stern, hanging knees	preserved in situ	17abcd

Table 2 Watership wrecks not documented enough but future potential

Designation	Excavation year	Hull construction	Live span indicators	Construction year estimate
ZN44	1979	lap	coins 1521-1555 & 1507-1520; ceramics & sintel type F 16ab	15d 16a
NP33	1958	lap	ceramics & sintel type F16ab; stratum 16c	16a
ZM22	1978	lap	dendro 1520-1532; coins 1496, 1519; sintel type F 16ab	16b
ZN42-1	1979	lap	dendro 1527-1531; sintel type F 16ab; ceramics 16bc	16b
ZN74-1	1982	lap	dendro 1525-1526; sintel type F 16ab; stratum 16c	16b
ZN74-2	1982	lap	dendro 1525-1627; sintel type F 16ab; stratum 16c	16b
NP40	1950	lap	ceramics 16bc; stratum before 1600	16b
OW10	1975	flush	dendro 1547; floor tiles 1561; sintel type F 16ab	16b
OG33/34	1967	flush	ceramics & tiles 16cd; stratum after 1600	16d
VAL7	2009	flush	dendro after 1585; coin1596; ceramics 16d-17a	16d
OU86	1972/73	flush	ceramics 1608; coin 1610; ceramics 17ab	17a
NR13	1946	flush	coin 1623; ceramics 17ab	17a
NE160	1954	flush	dendro 1642-1654; tiles 17cd	17c

Table 3 Watership wrecks documented enough and excavated

Tables 1, 2 and 3 do indicate that flush hulls started to appear from the second quarter of the sixteenth century onwards, while lap-strake hulls disappeared from the archaeological record in the early second half of that same century. Table 4 indicates that the transition from keel

plank to a heavier keel beam did not fully coincide with the transition to a flush hull, OW10 and VAL 7 being the exception. The record however only lists keel beams from the seventeenth century onwards.

The bottom of the VAL7 wreck was differently shaped in the stern than older shipwrecks. The garboard strakes aft did not end up in a rabbet in the sternpost but extended alongside the sternpost (table 4). This helped to create a better S-shape in the underwater hull aft. Only late sixteenth century and seventeenth century wrecks have this trait. The stem of VAL 7 was also differently constructed than observed in older wrecks. It was much less curved in the vertical plane and positioned on top of a longer keel (fig 2, fig. 5 and fig 11). The stem post was extended with a skeg and cutwater. The net effect was an increase in the lateral surface area of the forward underwater hull. The exact stem construction differed from ship to ship, but a gradual change in curvature and extension over time is observed (table 4).

Designation	Hull construction	Keeltype	Garboard strake to sternpost connection	Stem well rounded	Stem extended	Compass timbers	Stringer configuration	Spike plugs	Construction year estimate
ZO31	lap						open		15d 16a
OG64	lap	plank							15d 16ab
ZN44	lap	plank				no	open		15d 16a
OK84-2	lap						open		16abc
NP33	lap	plank	rabbet	++	-	no	open	no	16a
ZM22	lap	plank	rabbet	++	-	no	open	no	16b
ZN42-1	lap	plank	rabbet	++	-	no	open	no	16b
ZN74-1	lap	plank	rabbet	+	+	no	open	no	16b
ZN74-2	lap	plank	rabbet	+		no	open	no	16b
NP40	lap	plank	rabbet	+	+	no	open	no	16b
OW10	flush	plank	rabbet	+	+	yes	less open		16b
ZN113	flush							yes	16ab
ZJ40/41	flush						closed		16ab
ZK47	flush						closed		16abc
OQ55	flush						open		16bc
ZO39	flush						open		16bcd
ZG80	flush						closed		16bcd
OB20	flush						closed		16cd
OG33/34	flush	beam	along	-		yes	less open		16d
VAL7	flush	plank	along	-	++	yes	open	yes	16d
OU86	flush	beam	along	-	+	yes			17a
NP4-1	flush	beam	along						17ab
NR13	flush	beam		-	++	yes	closed		17a
ZO69	flush	beam		-			closed		17abc
OT23	flush	beam	along	-	++	yes	closed		17bc
NE160	flush	beam		-	++	yes	less open		17c
OU113	flush								18bcd

Table 4 Ship construction details.

The frame system of VAL7 was different from what is known in lap-strake ships, where futtocks are connected on top of the floor timbers. In VAL7 futtocks were scarfed in several different ways to the floor timbers, and compass timbers were added in between two successive floor timber-futtock combinations. The whole arrangement was less regular but more robust than what is observed in lap-strake ships. The lack of standardization is obvious. In OW 10 the framing system was more regular like in lap-strake ships, but it was the first flush hull ship that included compass timbers in its design. This may suggest that OW10 is an example of a design in transition. The frame construction differed in detail from ship to ship, but in flush hull ships they all included compass timbers in the framing system.



Figure 8 One fish well compartment with relatively few rounded timbers and numerous water inlet holes in VAL7 (Waldus 2010). This is similar in all waterships. The smoothly finished frame construction served the purpose of maximising space and minimising damage to the fish swimming inside the fish well.

All waterships have in common that the framing system in the fish well was not robust (fig. 8). Heavy bulkheads compensate for the loss of lateral strength in the fish well area.

Table 4 indicates a tendency toward increased density in the stringer configuration in flush hull wrecks. Lap-strake wrecks featured an open configuration, while in flush hull wrecks the stringers were positioned at closer intervals or even edge-to-edge (closed). VAL 7 is an exception having an open configuration.

The variability observed in stem construction, frame construction, stringer density and keel type hint toward a unknown degree of variability in ship construction methods. The differences from wreck to wreck may partially indicate a pattern of change, but different shipyards possibly also employed different methods as an individual signature. The dataset does not allow for a more detailed analysis on this matter.

In the VAL7 wreck several construction details were observed that point to a *shell first* assembly sequence of the flush hull. In the first place small dents were detected in the middle of the keel plank and the garboard strake near the stern. This indicates that the shipwright marked the location of the frame timbers to be positioned *after* the first strakes were put in place. Secondly spike plugs, filling former iron nail holes on the inside and outside of the planking, indicate the use of clamps (fig. 9). The only other wreck in which spike plugs were observed is the ZN113, but a combination with scratch marks is missing. The function of former iron nails was to temporarily connect the strakes while the frame timbers were not put in position yet. Finally the absence of interconnections between the floor timbers, futtocks and compass timbers indicate that the strakes were positioned prior to positioning frame timbers. The assembly sequence as described is called the *Dutch flush* method (Maarleveld 1992, 156). It is typical of the Dutch approach to ship construction.

In the case of the VAL7 the information on deck construction, deckhouse and rigging is lost. As a result of post depositional processes the remains beyond the level of the fish well bulkheads were gone. Even the bulkhead itself did not fully survive in its original dimensions, which could have been helpful in calculating the fish well volume. In the next paragraphs the



Figure 9 The square small spike plug fills a former nail hole in a starboard strake. Its dimension is 0.5 x 0.5 cm. Left of the spike plug a treenail is protruding. (Waldus 2010).

shipwrecks from table 3 will be geometrically assessed. Are there any clues that may reveal continuity or change in ship design and construction?

5 Indications of change

Basic design considerations in wooden shipbuilding relate to intended use of space or function, structural strength and stability for safe sailing in the context of its area of operations, and manoeuvrability for specific purposes like for example trawling. These considerations must be sufficiently accommodated in the resulting hull form and construction. Additionally, there may be other design factors like the cost of maintenance, intended operational life, crew accommodation requirements, type of working equipment and rigging needed. Finally, the cost of construction with associated labour and logistics must be taken into account. Up to the eighteenth century geometric design methods were not used in Holland (Hoving 2006). The shipwright used rules of proportion from experience in which all ship elements were interrelated. Therefore inferences made from the analysis of hull form and ship construction should tell us something about the mindset of the shipwright as it relates to ship design. Data from archives, paintings and models help to interpret design changes. The wreck data reveal that two design changes occurred in the sixteenth century.

The first design change involved an increase in linear dimensions of more than 20 per cent, which translated into more inboard working space and more fish well volume. Table 5 gives the numbers showing an increase of length (length of hull minus length of fish well) and an increase in width and height. This first design change also involved a change from a lap-strake

shell to a flush planked shell (table 4) with an average increase in planking thickness of more than 30 per cent (table 5). The frame density increased, the average distance between frames being 25 per cent less (table 5).

Designation	Length of hull (m)	Length of fish well (m)	Max. width of fish well at 1st bulkhead (m)	Deck height above keel base (m)	Fish well volume (m ³)	Average shell planking thickness (cm)	Average distance between frames (cm)	Construction year estimate
ZN44	10.3	3.62	4.4		10.1	3	45	15d 16a
NP33	10.92	3.62	4.6		11.1		47	16a
ZM22	10.03	3.61	4.3		9.9	3.5	45	16b
ZN42-1	10.95	3.7	4.6	2	11.7	3	45	16b
ZN74-1	10.67	3.64	4.2	1.85	10.5	4	46	16b
ZN74-2	10.84	3.62	4.24	1.8	9.7	4	46	16b
NP40	9.8	3.65	4.3		10.1		44	16b
Mid value	10.4±0,6	3,65±0,05	4,4±0,2	1,9±0,1	10,7±1	3,5±0,5	45,5±1,5	
OW10	12.53	3.86	4.95	2.25	13.2	5	37	16b
OG33/34	13.56	3.58	5.55		13.3	5	37	16d
VAL7	13.8	3.82				4	30	16d
OU86		3.66	4.96			4.5	30	17a
NR13	12.36	3.42	5.17		11.7	4.5	35	17a
NE160						6	38	17c
Mid value	13.1±0,7	3,64±0,22	5,25±0,3	-	12,5±0,8	5±1	34±4	

Table 5 Changes in volume and strengthening (see note 5).

The geometric data indicate that working space and storage volume increased commensurate with additional strengthening measures to the ship construction. The function of compass timbers (table 4) in this context was to strengthen the chine of flush hull ships. From the tables 3 and 5 it can be concluded that the first design change occurred within one or two generations of waterships in the second quarter of the sixteenth century. The data from tables 1, 2 and 4 do not indicate otherwise, but the dating bracket is very large in some cases. OW 10 is interpreted to be a watership in transition, as not all constructional change had been adopted yet.

Designation	Ratio length outside hull to length inside hull	Keel depth under the hull (cm)	Stem angle from vertical (degrees)	Stern angle from vertical (degrees)	Ratio length aft to length forward of 1st bulkhead	Ratio mast distance from 1st bulkhead to ship length	Construction year estimate
ZN44	0.26	15			2.03	0.12	15d 16a
NP33	0.24	13	45	30	2.02	0.12	16a
ZM22	0.26	13	45	30	2.27	0.09	16b
ZN42-1	0.25	12	45	30	2.17	0.11	16b
ZN74-1	0.25	13	35	25	1.94	0.12	16b
ZN74-2	0.25	15		25	2.57	0.12	16b
NP40		13	35	35	2.44	0.1	16b
OW10		15	45	30	2.15	0.09	16b
Mid value	0,25±0,01	13,5±1,5	40±5	30±5	2,3±0,3	0,10±0,02	
NP40	0.37						16b
OW10	0.3						16b
OG33/34		34	18	30	1.68	0.06	16d
VAL7	0.27	20	5	35	1.55	0.08	16d
OU86		34	25	25			17a
NR13	0.35	28	15		1.56	0.07	17a
NE160			20				17c
Mid value	0,32±0,5	31±3	15±10	30±5	1,62±0,07	0,07±0,01	

Table 6 Changes in relation to manoeuvrability (see note 5).

More changes in the ship construction and space distribution are observed when shipwrecks are compared. But data is lacking too much to confidently label them as design changes. For example, the use of king planks in the deck construction may have been omitted (OW10 seems to have been the last one, however ZO69 had notches that instil doubt). Also data indicate that hanging knees have replaced the rider beams in the deck construction over time (OG33/34, NP4-1, ZO69, OC60, OT23, OU113, NQ65-1). An interpretation is that this would increase safety on deck as the workspace was more obstacle-free. There are indications that by the end of the sixteenth century the fish well volume decreased, possibly suggesting changing priorities in ship function (NR13, NE160). The increasing use of a covering board on top of the ship sides may have improved the water tightness of the hull (NC12, NQ65-1, OG33/34, ON10/11, OU86, ZG80). The manner in which strakes were scarf-joined show an increasing amount of variation over time (OW10, OG33/34, VAL7, NR13, NE160). Some wrecks show an additional use of rope-like fibres and tar in the seams of the strakes (VAL7, NE160), while earlier shipwrecks only showed the use of moss. This may be an indication of changing production and maintenance methods in shipyards. Economic pressures may have existed like an increasing scarcity of moss of the right specimen or some gain in costs as the application of rope fibres is less labour intensive.

Many constructional differences found in the watership wrecks as well as the additional data from archival records indicate that more design changes must have been made than only the two identified in the sixteenth century. The large degree of variability found in ship construction data may be a focus for future research, when archaeological data from other local ship types are studied.

6 Indications of continuity

Paintings and models hint towards continuity in characteristics like the general shape of the hull, the high and wide forward deck area, the small and low stern, the short spritsail mast tilted forward and the rounded deckhouse in the middle giving access to the fish well and living quarters. The archaeological data set additionally indicates that:

- the internal layout of the ship did not change;
- the rigging and handling equipment on deck like winches, fife rails and bitts, show no signs of significant change over time in form, fit or function;
- the medieval hull shape remains unchanged;
- stability characteristics did not critically change;
- local shipbuilding traditions were followed.

The internal layout of the watership and the equipment on deck did not change over time. This is apparent from a scan through the wreck data, and can be visualised when the archaeological models (fig. 2) are compared to an early 19th century model of the watership (fig. 11).

Optical difference is the rounded deckhouse which is not present in the archaeological models, as it was not found in the associated wrecks either. However the layout did not change i.e. a forward storage and work space, a fish well area, a living area (two bunks and a stove), an aft storage and workspace. The deck equipment may have incidentally changed position, but from a technical and operational point of view it was essentially the same equipment indicating that technology and working procedures did not substantially change over time (OW10, ZK47, ZM22, ZO69). Even the early nineteenth century watership models still featured the specific cleats needed to tie the long trawl net poles to the ships hull during trawling operations (fig. 6, fig. 14). Indications of change in living and working conditions on board were also not found when sifting through archives of seventeenth and eighteenth centuries watership inventories.



Figure 11 Shipmodel of a Marker watership from around 1800. Characteristic is the high bluff bow, the low stern, the rounded deckhouse and the short spritsail mast tilted forward with rounded mast top. (Collection Maritime Museum Rotterdam model M199).

They did not reveal any time-related changes suggesting a change in design or function (van Holk 1994).

The models (fig. 2, fig. 11) show a sharp underwater hull fore and aft while in between there is very little deadrise. From the keel upward the rounded underwater hull is curved in an S-shape. This is a medieval underwater hull shape typical for the cog-like ships of the Hanse period. The cog design disappeared in the Early Modern period. There was a tendency in the Zuiderzee area to resort to flat bottomed ships with side-mounted retractable leeboards. The watership however retained the medieval hull shape over its life trajectory.

Another indication of continuity is revealed via a study on stability characteristics of the watership (Folkersma 1987). These characteristics relate to the vital concern that a ship will not sink or falter if heavily loaded or pushed on its side by sail and waves. The study concluded, based on the well-documented and reconstructed wreck OW10, that the metacentric height of the watership meets more than twice the present-day requirement of trawl fishing vessels, even without ballast and water on board. This made the ship very stable in the mindset of today. The OW10 weighed 52 ton of which 10 ton is attributed to ballast stones. The ballast served three purposes. First it helped to increase the draft of the ship, thus allowing the fish well to be filled completely with water. Secondly it helped to trim the ship in such a way that the rudder had enough water pressure for steering. The ship was difficult to control if the ballast was not on board while sailing. Finally the stones helped relieve the material stress in the fish well area which had relatively little longitudinal strength. The stones were not needed for sufficient stability, contrary to what is intuitively thought. Compared to the OW10, the other watership wrecks in the design analysis did not vary that much in hull form and construction that buoyancy and stability were at risk. It is safe to assume that in this respect the design did not significantly change over time.

In maritime archaeology reference is made in general to at least three distinct shipbuilding traditions i.e. a Nordic, a Northwest-European and a Mediterranean tradition. This is as it appears not a perfect grouping of shipwrecks. Close examination shows that many shipwrecks often had features from more than one tradition. This may be particularly true in the historic Dutch lowlands infrastructure, which was a crossroad of maritime trade routes in Europe. As it appears the older watership wrecks had a lap-strake hull, and the younger ones a flush hull.

The continuity in this one time change in hull construction philosophy is that both followed local shipbuilding traditions. The remaining text in this paragraph will elaborate on this.

One of the oldest wreck revealing relevant data is the ZN₄₄ constructed somewhere around 1500. This watership was built in a hybrid style in the sense that its wreckage material displayed features of the Nordic tradition mixed with features from the Northwest-European tradition. The Nordic tradition (Crumlin-Pedersen 2004) has three key characteristics. First key characteristic is a backbone consisting of a keel, a stem, and a stern. The garboard strakes are rabbetted in the keel, stem and stern post. This was also observed in the lap-strake watership. The remaining strakes are rabbetted in stem and stern post. Second key characteristic is the lap-strake clinkered hull. Last key characteristic is a light framing system in comparison to the other shipbuilding traditions. The strakes give the ship its primary strength. The strength philosophy is therefore *shell based*, implying a notion of a strong but flexible rounded hull to cope with the Baltic, North sea, and even Atlantic environment. Although not archaeologically proven yet, it is very likely that shipwrights in North-Holland built ships with Nordic features, but in a local style that shares key characteristics with this tradition. In Flevoland seven wrecks have been found dating back to the fifteenth and sixteenth centuries that fit the Nordic profile, all between 17 and 30 metres in length (Overmeer 2008, 41-56). A study model was made of one of those seven wrecks, the sixteenth century freighter OM₁₁, for analysis purposes (Blok 2010). The conclusion was that the watership resembles the OM₁₁ in underwater shape, dimensions and applied construction techniques.

The lap-strake watership also shared features with the Northwest-European tradition. The strength philosophy in this tradition is *bottom based* (Hocker 2004a, 65-94), the notion being that shipwrights construct a strong flat bottom to cope with the many maritime shallows and flats in the region, while the strength of the sides is of secondary importance. The bottom is always flat, flush planked, and consists of heavy strake planking and floor timbers. The sides however may be lap-strake. Indeed the hull and framing system of the watership was more heavily built than in the Nordic tradition, but the bottom was lap-strake as in the Nordic tradition. Another feature is that the lap-strake watership used twice bent nails, like the cog, as opposed to clinker nails as a means of fixing the overlapping strakes to one another. Also the keel was a plank instead of a beam. Finally the luting technique used in the watership was the same as in the case of the cog. Moss was used as opposed to animal hair which is generally associated with the Nordic tradition. In conclusion the lap-strake waterships, built in North-Holland, shared characteristics of the Nordic tradition mixed with features of the Northwest-European tradition.

The flush hull construction of the younger waterships had the characteristics of the Dutch flush style of shipbuilding. Maarleveld introduced the term *Dutch flush* in relation to shipbuilding developments in sixteenth century Holland (Maarleveld 1992). He refers to large sea-going vessels and not locally operated ship types like the watership. The Dutch flush technique is perceived to be a variation to the Northwest-European tradition of shipbuilding, meaning that the shipwright had the *bottom based* philosophy in mind and used clamps in a *shell first* approach. New is that the Dutch flush ships in general have well integrated flush sides, as opposed to having lap-strake sides. As described in paragraph 4, the VAL₇ wreck actually displayed the features indicating that a *shell first* construction approach was used in a flush built watership (fig. 9). Also the sides were well integrated in the hull.

7 Drivers for change

Waterships in the fifteenth century probably trawled the creeks and lakes in North Holland and occasionally the Zuiderzee, in addition to assembling and transporting fish (Van Dam 1997, 132-136 & 172-173). Around 1520 however the watership started to take possession of the

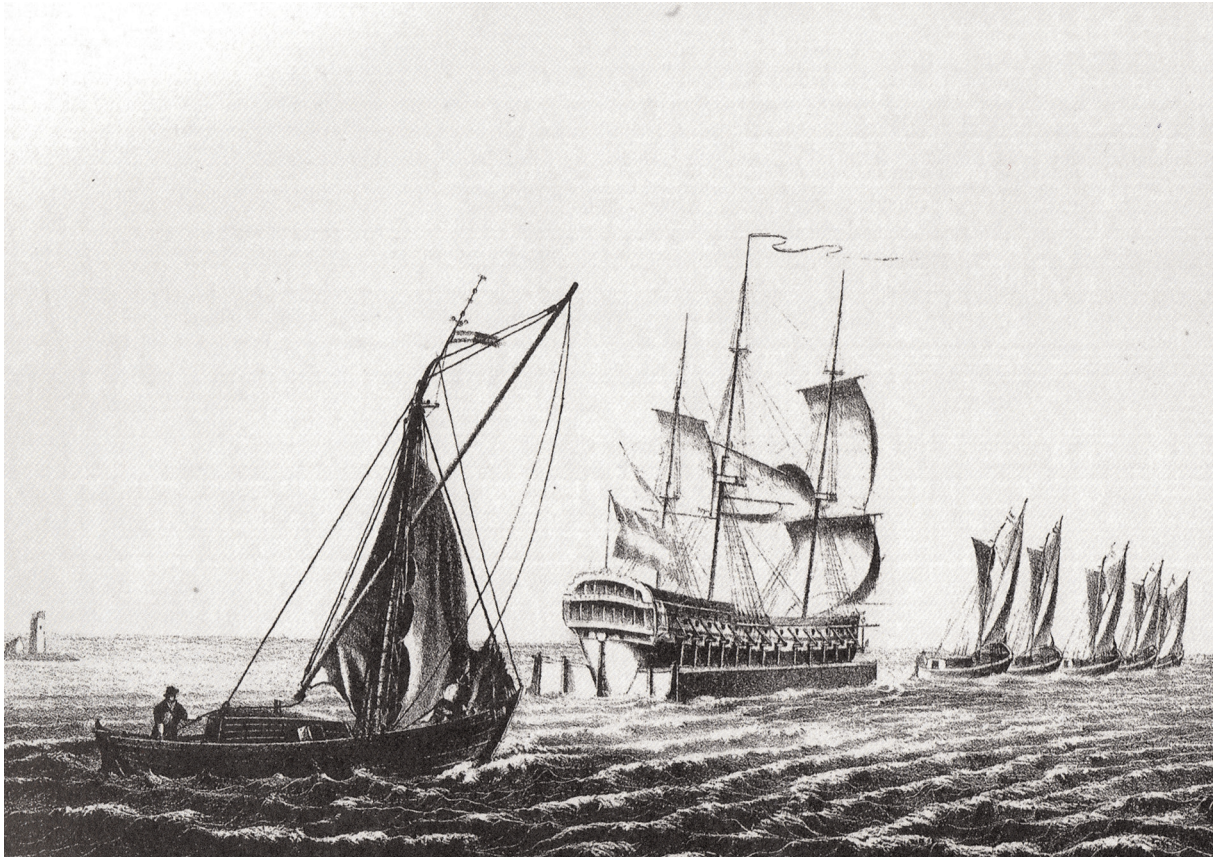


Figure 12: Five waterships towing an ocean-going ship in a shipscamel. The function of the camel was to decrease the draft of the ship. (Boven & Hoving 2009, 42).

Zuiderzee as a fish trawler. The number of waterships being built more than doubled (Van Holk 1994). During the next one hundred and fifty years the ship was at the apex of its functional life. The reason is that population numbers in the ports of Holland went up six-fold within a period of a century and a half (de Vries & Van der Woude 2005, 472-475). As a result there was a fast increasing demand for protein rich food. Also the Zuiderzee ceased to be a pirate-infested environment by 1543 as the surrounding territories became politically united (Sicking 1999).

The timeframe in which the trawling function is scaled up in the early sixteenth century, coincides with the first observed design change in the previous paragraph in which watership dimensions increase with more workspace and fish well volume. However, the watership possibly retains its postulated long distance transport function throughout the sixteenth century. Three wrecks (ZN74-1, NP40, NR13) from this period appear to have their water inlet holes in the fish well plugged thus isolating the inner fish well space from the outside. An explanation is that fresh-water fish, transported in a saline environment, will die in the fish well. The same is true when transporting sea fish in a fresh-water environment. Even eel, adapted to both environments, could die if its skin is damaged. Other explanations exist, like the use of the watership to transport saline water to the salt factories onshore (Van Holk 1994, 4). Early in the seventeenth century the watership lost its long distance transport function. This is indicated by early reports of the *Friesche palingschuit* exporting life eel from the Frisian lakes to London (Haalmeijer & Vuik 207, 59). The year 1616 is mentioned, which coincides with large-scale windmill-driven land reclamation projects in North-Holland (fig. 7) at the expense of the local eel trade.

While the long distance transport function of live fish was lost to Frisia, another function as tug emerged in the archival records. The first report of a watership being used for towing



Figure 13 Detail from a painting made by Hendrick Avercamp between 1600 and 1634. The ship to the left has a flush hull, the other ship is lap-strake constructed. (Museum Boymans van Beuningen, Rotterdam, inv. no. 2482).

operations is made in an East Indiaman logbook from 1598 (Crone 1949, 168). The river IJ was silting up while the Republic founded the East India Company. In order to reach Amsterdam, ocean-going ships had to be towed through a shallow mud-bank in the river entrance called *Pampus* (fig. 12). From this period onwards the watership is employed as tug for big ships until Amsterdam can be reached alternatively via a new canal dug in the early nineteenth century.

The second observed design change in the previous paragraph may be related to the newly identified function as tug, i.e. a better manoeuvring capability, but the data is not fine-grained enough to make this a convincing statement. As the keel length outside the ships hull already increased earlier in the sixteenth century, it is likely that shipwrights improved manoeuvrability earlier in relation to trawl net fishing. VAL 7, still built on a keel plank and an open stringer configuration, may not have been optimised for heavy duty towing. Seventeenth century waterships however have made all the observed changes for better manoeuvrability.

In paragraph 5 it is observed that the functional design change of the watership, resulting in larger dimensions and more fish well volume in the first half of the sixteenth century, also involved the transition from a lap-strake hull to a flush hull. Why was this change in construction technique made? There is no apparent functional or political reason that would justify the abandonment of the proven lap-strake construction technique. For ocean-going ships it was suggested that there are technological limits to the construction of lap-strake vessels. In the fifteenth and sixteenth century economic and political pressures in Europe resulted in increased performance, better adapted hull form and higher weight allowances for oceangoing ships with larger rigs and an increasing number of gun ports. This is not applicable in the case of the watership. An indication that there is no clear functional advantage to lap-strake over flush hulls may be given by figure 13. A flush hull watership is depicted next to a lap-strake watership in wintertime half a century after the transition is made. Suggestion is that the lap-strake technique never disappeared entirely.

The lap-strake construction approach may have lost the competition with flush built ships. It is proposed that economic factors in local circumstances determine whether or not one construction is more viable than another (Hocker 2004a, 80-82). An argument may be that the amount of wood saved in flush over lap-strake construction makes the difference. However the gain is lost again by the higher density of the frame timber needed. This was very likely also true in the case of the watership. The real gain is made in the substantial savings of labour and the amount of iron required, as the strakes do not need to be nailed together. Also flush strake hull repairs are less complicated and therefore less costly.

8 Drivers for continuity

Shipbuilders probably did not like to change a proven design. Ships are structures with a high degree of technical complexity in order to be able to cope with the high risks of sailing. Shipwrights only had their knowledge and experience to work with, a profession well guarded in the egalitarian guild system. It was not until the eighteenth century that geometric methods were introduced in Dutch oceangoing vessels (Hoving 2006).

Shipwrights in the sixteenth and seventeenth century probably had their minds set to local traditions of shipbuilding. It is suggested that social practices of shipbuilding in Holland were different from the practices in England. The Dutch shipbuilding process was more transparent and egalitarian, allowing for a high degree of efficiency, while in England the differentiation in knowledge between the master shipwright and ship carpenter was reinforced. The master shipwright in England already engaged in methods of geometric ship design, while his Dutch colleagues still worked with rules of proportion. (Adams 2003, 190). So socio-cultural factors may partially explain why the watership retained its medieval S-shape all the way to the end of its existence, as opposed to becoming a flat bottomed ship with side-mounted retractable leeboards at an earlier point in time. Rather to the contrary, the keel plank was replaced by a heavy keel beam at the end of the sixteenth century.

An important factor however must have been the unique quality of the watership design in itself, enabling it to absorb new functionalities. The stable and robust design of the watership probably made it the best local candidate for such heavy duty functions as pulling large trawl nets and ocean-going ships in the rough Zuiderzee environment. The S-shape of the underwater hull and the enlarged lateral surface area underwater must have made it a very manoeuvrable ship with a smaller drift component than could be expected from the flat bottomed ship. This was an important quality as for example ships in tow, losing too much headway in the mud of Pampus, would drift towards the sand bank near Muiden.

9 Impact from international trends in shipbuilding

The economic boom of the sixteenth century is reflected in the development of the local maritime infrastructure in North-Holland. There was a strong tendency toward concentration and specialisation of shipyards on a large scale, resulting in five clusters i.e. Haarlem, Amsterdam, Hoorn, Enkhuizen and Edam (Boschma-Aarnoudse 2003, 125-127). Concurrently the maritime infrastructure was quickly growing with a large diversity of specialised trades like storage facilities, timber yards, ropeyards, sail makers, smoke houses, salt factories, cooperies and packers. Although initially waterships must have been built with funds from local families of skippers and sailors in small rural settlements, most of them are built with funds of ship owners in one of these specialised clusters by the time that the sixteenth century has arrived (de Vries & Van der Woude 2005, 294-295). There is solid evidence of waterships being built in Edam and Amsterdam in archival records (Boschma-Aarnoudse 2003, 330-355). Edam, having 21 shipwrights at work in 1462, is harbouring 68 shipyards in 1595 producing small and larger ship types for ship owners. In 1565 Edam launches in three months 47 ships of which 17 are waterships. The evidence for watership construction in Haarlem, Hoorn and Enkhuizen is not conclusive yet, but there is enough indication to make it very likely. So if the watership was included in the dynamic process of a rapidly growing local maritime infrastructure, the question arises whether or not this impacted its design. Was the transition from a lap-strake to a flush hull somehow related to shipbuilding developments on a larger scale?

From the fifteenth century onwards a new technology in shipbuilding increasingly dominates shipbuilding practices in the European Atlantic and Baltic communities, at least at the level of ocean-going ships. It is called the carvel method of ship construction. The associated processes of change in shipbuilding can be correlated with socio-political developments in society, characterized by such keywords as exploration, colonial expansion and state building. In evolutionist and diffusionist models it is argued that improved technologies, like the carvel shipbuilding technology, tend to spread to areas where economic developments accelerate (Gould 2000, 199). According to the chronicler Johan Reygersbergh, shipwrights from the south built the first carvel ships in Zeeland and Holland in 1459 (Haalmeijer & Vuik 2007, 10). In Hoorn the first carvel ships were built around 1460 according to the chronicler Velius, and carvel ships were also being built in Haarlem around 1530. (Boschma-Aarnoudse 2003, 231-232).

The carvel technology is initially associated with the Iberian method of ship construction where strakes were laid flush onto the frame timbers and were fastened to the frames and not to each other. Each frame in this ship design was built up from interlocking pieces and put transversely on the keel. Next the resulting skeleton of frames was planked on the outside to form a watertight hull. The frame pieces were heavy and the skeleton as a whole gave the ship its primary strength. The strength philosophy is therefore *skeleton based* or synonymously *frame first built* (Maarleveld 1992, 157-162). This frame first method of shipbuilding was the first one to employ a predictive basis for its design. This set the design process apart from the assembly process.

If carvel ships were already built in fifteenth century Holland, was then also a predictive method used for the design of the hull shape? The answer must be no, as geometric methods were not introduced in Dutch shipbuilding until the eighteenth century. In Holland the Dutch flush style was employed, based on a shell first collection sequence as opposed to a frame first collection sequence. However in both cases a flush hull resulted, which may have contributed to a definition problem.⁶ There are arguments that in comparison with the frame first assembly sequence the Dutch flush collection sequence is fast, which is an economic advantage to Dutch shipyards (Maarleveld 1992). The shipwright gains tremendous freedom in timber selection and timber conversion when allowed to define the hull shape in the process, and when not restricted by the requirement to build a rigidly applied framing system. The conclusion has

even been drawn that the Dutch flush style of shipbuilding was in part responsible for the success of the Dutch economy resulting in the economic and cultural boom known as the *Golden Age*. Unger refers to the period of the sixteenth and seventeenth centuries in Holland as one in which Dutch shipbuilding is efficient and leading in Europe (Unger 1978, 79).

It is pointed out by Adams that there are many nuances in the degree to which the hull shape is predicted before actually building a ship (Adams 2003, 190-195). From several cases of archaeological research he infers that in fact most of the carvel shipbuilding outside Holland in the sixteenth and seventeenth century was not completely skeleton first. Iberian cases show that frames and strakes were alternately erected using ribbands for control. Even in Holland there was a difference in shipbuilding practice between Amsterdam, as first codified by Witsen,⁷ and Rotterdam as first codified by Van Yk.⁸ (Hoving 1988). Amsterdam used clamps to shape the hull as you go, in the same way as was observed in the VAL7 watership. Rotterdam used ribbands to pre-shape the hull. As opposed to building the ships bottom *shell first*, the process starts with fixing four floor timbers on the keel, subsequently followed by tracing the shape of the hull with ribbands. Then the other frame timbers are built up and strakes are positioned where possible in the process. For this basic method of pre-shaping the hull a pre-design stage was not required and frame pieces were not interlocked as in the frame first assembly method.

In summary it is very likely that trade offs were made by local shipwrights between efficiency demands and performance, space and weight requirements, with a variety of possible outcomes. Each variation and nuance to shipbuilding practice was driven by local socio-political and socio-economic pressures. The shipwright of the sixteenth century had to survive in a tough competitive environment. For example shipyards in Amsterdam still produced only lap-strake ships while Hoorn and Haarlem already built carvel ships (Van Nierop 1955/1956, 28-29). The city was not able to develop a competing infrastructure of shipyards until late in the century, when an infrastructure was developed for the East Indies Company and the Admiralty. Ship owners in Amsterdam even procured ships from shipyards in Danzig for economic reasons.

So was the watership design impacted by trends in shipbuilding developments? The answer must be yes, but not for functional or technological reasons. The ship type transitioned from a lap-strake hull to a flush hull, because specialized shipyards in Holland adopted a Dutch flush style of assembling ships. The influence of the Nordic tradition diminished in Europe, because the ever increasing demand for resources, and not in the least construction wood for ships, put much strain on the economic aspects of shipbuilding. In addition for ocean going ships the lap-strake technique was not the optimum answer to the ocean environment in which the aspirations of maritime nations had to be met. The watership however could have easily retained its lap-strake hull if not local economic circumstances dictated otherwise.

The demand for ships was high after a century of naval battles and colonial expansion. (Adams 180 & 196). By the end of the seventeenth century the steady decline in the availability and quality of timber is dramatic. This forced shipyards to change their procedures in the use of timber which in turn is reflected in the design of ships. An example is that shipwrights increasingly incorporated iron construction elements in their design. Attempts were also made to offset the increasing costs of timber by processes of industrialization and standardization. A good example is the industrialization process of the *Zaanstreek* in North Holland. In the second quarter of the seventeenth century Amsterdam is losing the ability to build competitive ships to a quickly growing industrial complex in the rural region around Zaandam called the *Zaanstreek*, despite protective measures taken by the city council (Van Nierop 1955/1956, 28-29). At the basis of its success is a new invention in windmill technology that allows rotary movement via a crankshaft to be converted into the vertical movement of long saw blades. The advantage of receiving uninterrupted wind for the sawmills in the open rural landscape, the availability of free space in a waterlogged environment, and the low costs of workers not united in guilds,

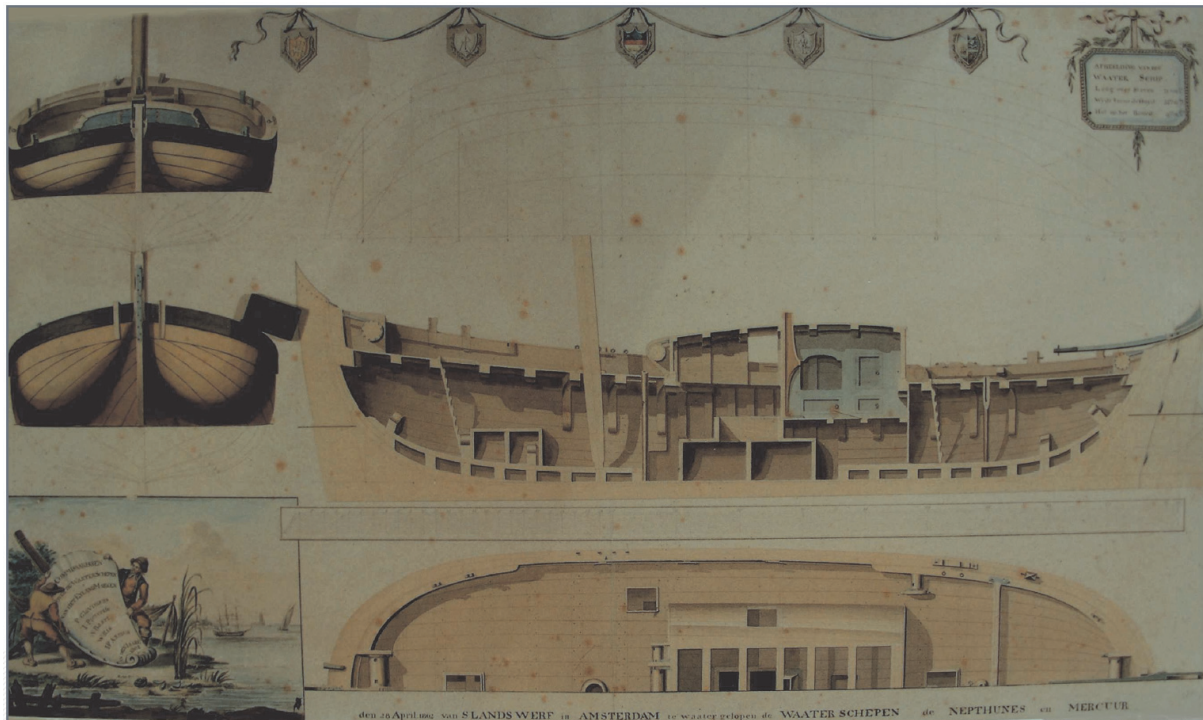


Figure 14 Construction drawing of a watership. More sober drawings of the same design still exist. This drawing probably served as a special issue made when two waterships were launched on 16 april 1802 from the Navy yard in Amsterdam. (Collection Maritime Museum Rotterdam inv. no. T2311).

make the difference. The Zaanstreek is able to produce a large and richly assorted supply of planks and beams in such a short time that it allows for additional standardisation and industrialisation of the ship building process (de Vries & Van der Woude 2005, 352-353). Ships are built in a serialized manner even before being contracted. The majority of hulls under construction are flutes, but also waterships are mentioned in the assortment.

It would be intriguing to know what happened to the watership design in the eighteenth century. Unfortunately there is no archaeological or archival evidence so far revealing the design of a watership built in the *Zaanstreek*, but it is not difficult to imagine that the construction had a more regular planking arrangement than before and that the use of standardised beams and planking sizes may have altered or at least refined the design. A construction drawing made in 1802 of a watership built in the Navy yard in Amsterdam gives some hints to that effect (fig. 14). The keel beam and frame timbers are heavier than their counterparts in any of the measured watership wrecks before. The distance between the frame timbers is double that of VAL7 and quite different from the other watership wrecks analysed. A caveat to this observation is that the drawing may be a simplified version of the reality, even if it indeed was a construction drawing.

10 Conclusion

The watership originated from the area of North Holland and its life trajectory spanned at least four centuries. Its area of operations was the many creeks, lakes and inlets in North Holland and the Zuiderzee. This hypothesis, based on archaeological data and archival records is point of departure in this paper. Clues to the contrary have not been found yet. There is indication however that the watership also sailed the rivers in the Netherlands, and the coastal area's including the North sea and Baltic to export live fish.

The VAL7 watership wreck, lifted from the IJ-river near Amsterdam, is a prime example of a heavy duty trawler in the Zuiderzee for the fish market in Amsterdam in a period of rapid population increase. Its design incorporates increased dimensions and better manoeuvrability, short of a keel beam and a closed stringer system. This may have made it a less capable ship for towing big oceangoing vessels across Pampus than its seventeenth century successors. Its construction is substantially different from the construction of lap-strake ships. The VAL7 wreck is the only archaeological example in the flush hull watership dataset that clearly demonstrates the use of a local style of shipbuilding i.e. the Dutch flush style. The other flush hull waterships were very likely built in the same Dutch flush style considering the strong resemblance in hull form and construction details.

Archaeological data support the perception that there was continuity in the watership design through mechanisms of tradition. However contrary to what can be observed on the surface, major technical and geometric changes were made to the watership design.

The archaeological record uniquely reveals that the life trajectory of the watership as a type in the sixteenth and seventeenth century included at least two design changes involving increased dimensions and better manoeuvrability. This is interpreted on the basis of geometric data and construction details from thirteen wrecks. And there are indications that more changes were made.

Change in design is driven by both changing functional requirements and by developments in shipbuilding economics at a local level. The economic boom of the sixteenth and seventeenth centuries in North-Holland was putting high demands on the watership as vessel for transport, fisherman and tug. Factors behind this drive for change in the case of the watership most likely were:

- the need to feed an fast increasing population;
- the need to tow big ships into Amsterdam (East Indies Company, Admiralty);
- increasing scale of local trade and institutions;
- rapidly growing maritime infrastructure;
- specialization and concentration of shipyards;
- land reclamation projects resulting in loss of eel trade;
- increasing scarcity of resources, timber being the most pressing one.

Although not reflected in the archaeological record yet it is expected that factors could be added to this list like industrialization and standardization when resources get dramatically scarce.

The case of VAL 7 and the watership in general supports the hypothesis that international trends in shipbuilding impact the design of ships, be it not directly but through local pressures of a socio-political and socio-economic nature. Local strategies are pursued to cope with these pressures. The watership followed a general trend to change from lap-strake hull design toward flush hull design, but the selected method was a local one. The shipwrights constructing waterships used a variation to local traditions of bottom-based shipbuilding, the Dutch flush technique.

Acknowledgements

Our thanks are due to several people who were of help in writing this article. In the first place to Alice Overmeer for offering insights in the variability of shipbuilding within existing shipbuilding traditions, and for the useful editorial comments. Secondly ADC, Periplus and Subcom kindly provided the data of the VAL7 excavation. Finally Kelly Fennema and Wesley van Breda kindly checked the translation of the text into English.

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Notes

1. The watership was lifted from the river bottom by ADC ArcheoProjecten in close cooperation with Periplus Archeomare, specialized in hydrographic and marine archaeological survey and data processing, and Subcom, a provider of subsea services. ADC ArcheoProjecten is one of the largest companies in The Netherlands engaged in archaeological research and consultancy, and the first to add maritime archaeology to its list of specialties.
2. Wreck designation numbers refer to the location where a wreck is found. VAL7 means *Vaarweg Amsterdam-Lemmer* (Sailing route from Amsterdam to Lemmer) segment number 7. The designations listed in tables 1 and 2 refer to wreck locations in the land, reclaimed from the Zuiderzee.
3. Article in the Dutch newspaper *NRC handelsblad* dated 10 September 2009 reporting on the excavation of the VAL7 shipwreck.
4. The programme of the Dutch organization for scientific research (NWO) funded the project *Fish and Fortune (The watership floating fishpond and tugboat & the prosperity of Holland in the sixteenth and seventeenth century)*. In this project all the available archaeological watership data was gathered for analysis purposes. This data is stored in the maritime archaeology archive of the Netherlands Cultural Heritage Agency located in Lelystad. Project manager Prof. Van Holk kindly made the dataset available for a master thesis and subsequently for this paper.
5. All measurements involving length have been taken at keel level, since it is only the lower part of a wreck that is generally found. The sample size is too small to be statistically significant. Nevertheless there is a central tendency in the measurements, represented in the tables by the middle number in a range of measured numbers. The implied variability is interpreted to be the result of two factors, i.e. measurement inaccuracy and variability in shipbuilding. Standardisation and industrialisation in shipbuilding occurs after the construction date of the wrecks listed in the tables, therefore no two ships are exactly the same. The term *first* bulkhead refers to the most forward bulkhead in a ship.
6. Today scholars define the term carvel ship only to mean a ship with a flush hull, not necessarily pre-designed. So the construction of carvel ships may have been based on the frame first approach (pre-designed hull) as well as on the shell first approach without a pre design stage.
7. Nicolaes Witsen (1641- 1717) was mayor of Amsterdam, East India Company administrator, ambassador, cartographer, maritime writer, and an authority on shipbuilding. His standard work on Dutch shipbuilding in the seventeenth century is called "*Aeloude and hedendaegsche Scheepsbouw en Bestier*". It was published in 1671.
8. The seventeenth century ship carpenter Cornelis van Yk made a career as Master shipwright in Delfshaven (today part of Rotterdam). He wrote a book in 1697 on shipbuilding named *De Nederlandsche Scheeps-Bouw-Konst open gestelt*.

Glossary

Bitt (*beting*)

A heavy post rising above the deck for either the belaying of heavy lines or to carry gear such as a windlass.

Bulkhead (*schot, scheidingswand*)

An internal wall for extra lateral strength and water tightness of the construction.

Carvel (*karveel*)

A term believed to derive from the Portuguese ship *Caravela* that has come to mean the method of

ship construction where the hull planks are laid flush onto the frame timbers and are fastened to the frames, not to each other.

Caulk (*breeuwen*)

To render a hull watertight by forcing compressible material, such as moss or oakum, into the seam. Oakum is a mix of rope-like fibres and tar.

Ceiling (*wegering*)

Planking over the inboard surface of the frames.

Chine (turn of the bilge) (*kim*)

The area of transition from bottom to side. A sharp transition is called a chine, a rounded transition is called a turn of the bilge. The bilge is the lowest part in the hold of a ship or the flattest part upon which the ships rests when aground.

Clamp (*klamp*)

A general term for off-cuts or small pieces of wood used for temporary fastenings. In the context of the Dutch shipbuilding tradition, particularly those pieces used to fasten hull planking during construction, prior to fitting the frames.

Compass timber (*krommer*)

Naturally curved wood used for correspondingly curved elements in ship construction. In the water-ship it is positioned in the chine as a frame component to increase lateral strength of the hull.

Cutwater (*loefbijter*)

Most outward extension from the stem forward to improve course stability, cutting through the water when the ship is moving forward.

Deadrise (*vlaktilting*)

A term referring to the upward angle of the floor timbers as they run out from the keel towards the turn of the bilge.

Fife rail (*nagelbank*)

Plank with a row of fifes or fife bank used for belaying the ropes of running rig and other working gear.

Floor timber (*vlakgang*)

The lowest component of a ship's frame running across the keel.

Flush built (*gladboordig*)

Planking of the hull laid flush, edge to edge, rather than lap-strake.

Frame (*spant*)

A transverse structural member made up of one or more components fastened to the interior surface of the hull planking and often the keel. Together the frame timbers form the framework or skeleton that gives the hull its lateral strength. The frame is made from several pieces each of which has a specific name i.e. floors or floor timbers, futtocks and top timbers.

Frame first (*spant eerst*)

A boat or ship built in such a manner that the frames are placed first to determine the shape of the hull as opposed to a shell first building sequence. Strakes are added later to the skeleton of frames.

Futtock (*oplanger*)

The timber between a floor and a top timber forming a frame.

Garboard (*zandstrook*)

The outboard plank next to the keel (garboard strake, the lowest strake of planking).

Hold (*ruim*)

The lowest space within the body of a ship.

Hull (*scheepsromp*)

The total ship construction without rudder, mast, rigging and other movable elements.

Keel or keel beam (*kiel*)

Central backbone timber of sufficient cross sectional area to offer longitudinal strength to the hull. In most cases a portion of it projects below the bottom planking and offers lateral resistance.

Keel plank (*kielplank*)

Centerline strake, often thicker than the adjoining garboards, but not sufficiently stiff to be considered a true keel.

King plank (*schaarstok*)

A heavy deck plank, often inlet for other timbers.

Knee (*knie*)

An angled or curved piece of wood used to connect various elements of the hull that lie in different planes. Knees set with one arm running down from the side, and the other running underneath deck supporting beams, are referred to as hanging knees.

Lap-strake (*overnaads*)

Strakes that overlap at the seams typically with the lower edge of the upper plank outboard. The planks are fastened together in the overlap area.

Luting (*breeuwen*)

As in caulking the purpose is to render a hull watertight, however the material (moss, animal hair, rope-like fibres) is not forced but laid into the seams. In lap-strake seams the material can be laid, but in between flush-plank seams it must be forced.

Metacentric height (*metacenterhoogte*)

The vertical distance between a ship's centre of gravity and its metacenter, for transverse or longitudinal inclinations. The height of the metacenter above the centre of gravity serves as a measure of the stability of a vessel. More metacentric height means more stability.

Rabbet (*sponning*)

A recessed channel cut in a timber to accommodate another, such as the V-shaped rabbet cut into the side of a keel into which the garboard is fitted or rabbetted.

Ribbands (*sent, strooklat*)

Length of timber (usually softwood such as pine) nailed along the outside of the frames at specific heights both to bind and support them during construction. As the ribband was carefully worked it would take up an even curvature as it passed over the standing timbers, effectively acting as a spline. It thus defined hull curvature for the insertion of the intermediate timbers.

Rider beam (on deck) (*dekligger*)

A heavy beam above the deck beam, with the deck planking in between. The rider beam and deck beam are both transverse timbers fastened to opposite ends of the hull.

Rig (*Tuigage*)

A term referring to the configuration of masts and sails where this accords to more or less standard patterns.

Scarf-joint (*las*)

A method of joining two pieces of timber end to end with a tapering overlap, generally so that the width and thickness of the timber is not altered.

Shell (*scheepshuid*)

The outside of the hull built up with strakes.

Shell first (*huid eerst*)

A boat or ship built in such a manner that the shell is built up first, thus forming an integral, watertight unit. Further stiffening or strengthening frame elements may be added later.

Sintel (*sintel*)

An iron staple with broadened head used to hold caulking materials covered with a lath into a seam. It is originally a Dutch and German word, but it now used by English speaking archaeologists and ship historians.

Skeg (*scheg*)

Stiffening timber positioned in the triangular areas between keel and sternpost or keel and stem. Skegs extend forward and aftward to increase the lateral surface area of stern and bow for better manoeuvring.

Spike plug (*spijkerpen*)

A small wooden dowel fitting in a hole, previously occupied by a square-shanked metal nail or spike used for general fastening purposes.

Stem (*voorsteven*)

The large timber scarfed onto the keel that largely determines the shape of the bow of a ship and into which the ends of the outer shell planking are rabbetted.

Stern (*achtersteven*)

The large timber set on the upper face end of the keel to which it is joined. It can be variously formed depending on the type of vessel, but commonly the ends of the outer shell planking are rabbetted into it in a similar fashion as with the stem, and the rudder is hung on its aft side.

Strake (*gang*)

A run of outer shell planking. The ship's shell is made out of several parallel runs of planks either overlapping each other or edge joined side to side to one another.

Stringer (*weger*)

A thick internal plank running longitudinally along the hull. They can be either alternate with the ceiling planks or they are placed where extra strength is required, such as over a line of joints or under deck beams.

Treenail (*houten pen*)

Wooden dowel used for fastening timbers together.

Turn of the bilge (*kim*)

See *chine*.

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