University of Tartu

Faculty of Arts and Humanities

Institute of History and Archaeology

Department of Archaeology

Ivar Treffner

A 17TH CENTURY FLUIT WRECK IN GULF OF FINLAND

MA dissertation

Supervisors: Marge Konsa

Maili Roio

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CONTENTS

1. Introduction

Since the dawn of times the Baltic Sea has been an important trade route between East and West. It has seen ships in all shapes and sizes. Countless numbers of vessels perished in the treacherous waters of the Baltic Sea but even more reached safely their destination. Trade was the catalyst for economic growth, technological advancement, and the cultural exchange. Shipping was fundamental for the economic development of Western Europe in the late middle and early modern age. With shipping more distant markets became available to merchants that would have been unreachable or economically unviable by road. Because the ships could hold more cargo, the amount and variety of the goods rose. In addition to trade, with long-distance contacts the spread of information, customs and culture set scene for development and innovation. Amongst all ship types that sailed the Baltic Sea, one type stands out – no other ship type was so dominant and contributed so much to economic advancement. This ship type was the Dutch *fluit* (also *fluyt* or *flute*) which became to be the prevalent merchant vessel during 17th and early 18th century. Thousands of *fluits* passed through the Danish Sounds to the Baltic Sea and back. Being so numerous it's curious that today we know so little about the *fluit's* architecture, inner layout and everyday life on board. It is here where the maritime archaeology has an important role to play.

Although the wrecks of *fluits* have been found almost all around the world, none of them are as well-preserved or complete as the wrecks in the Baltic Sea. This is the main reason why this thesis concentrates mainly on the Baltic Sea wrecks. With newly found wrecks the first question usually is: what type of ship it was? Where did she come from and where was she going? What was the purpose of the journey – to wage war, to do business or both? Those well-preserved wrecks that never reached their destination and now lie under the cold waters of the Baltic Sea are invaluable sources of information to marine archaeologists.

When the new wreck is found it's up to the archaeologists to put it into context, to fit it into the current understanding. Or, if it doesn't fit, reassess that part of the understanding. Eriksson (2014) has pointed out that, although a lot of research can be done through written historic accounts, there are still many aspects that can only be accessed by archaeological work on the wrecks. And these aspects can help us to understand the social hierarchy and everyday life on board. Even if the facts about the building place and time of the vessel are known, the wreck can shed light to many aspects on maritime industry. One aspect is the vessel herself and the contemporary mariner – where did the crew come from, how was the life organised on board, to name just a few questions. In addition to the sailing and everyday life on board, another aspect can be an insight to the shipbuilding as industry, which was closely related to the socio-economic and political background at the time (Castro 2008). How the shipbuilders organised their material supply, how they selected the timbers, what methods and tools where used. Third aspect is the maritime trade – which trade routes were used, what cargo was carried, how information was exchanged and what developments this brought on.

The author of this thesis has been a member of Badewanne research team since 2011 and actively participated in the fieldwork on the *fluit* wreck discussed in this work in 2020 (as a diver/cameraman) and 2021 (as a field work leader and a diver/cameraman). Every season Badewanne team spends at least three weeks researching and documenting different deep wrecks in the Baltic Sea. Other activities where the author has participated include different field works and research conducted by Estonian National Heritage Board and Estonian Maritime Museum (starting from 2003, still ongoing), "Vrouw Maria" (Finland) fieldwork in 2012 and various environmental evaluations of different wrecks in Estonian waters for the Ministry of Environment over the past six years. Since 2021 the author is a maritime archaeology researcher in Estonian Maritime Museum.

The aim of this thesis is to explore and interpret the information collected during 2020 and 2021 fieldworks on a *fluit* wreck found in 2020 in Gulf of Finland. The wreck is well-preserved, making it an excellent source of information for the researchers. The main objectives are:

1. To analyse the information available about the wreck to see how it fits with the current knowledge about the *fluits*.

2. To offer possible explanations to the new finds that do not fit with the current knowledge.

3. To show the challenges of deep-water archaeology and to explain possible methods to overcome them.

4. To offer a written account of the wreck for future research – even though fragmented and imperfect, gained knowledge from the two fieldworks covered here can be a source for further interpretations.

This thesis is divided into two main parts, followed by discussion. The first part sets a historical scene for the *fluit* to enter. The focus is on the role of the Netherlands in the European trade, concentrating on the trade between the Baltics and the West. Furthermore, the advances in the Dutch shipbuilding will be discussed, along with the social, economic and political factors that enabled those advances. It will be explained how those advances brought the *fluit* to life and what did the *fluit* look like and why she looked like she did. The advantages that the *fluit* had, played important role in the success of the Dutch merchants not only in the Baltic Sea, but also in the Mediterranean trade and on other routes. Although the *fluits* were built in different variations – for whaling, for trading with the East and the Mediterranean, for Norwegian timber trade and so on, in this paper the focus is on the *fluits* that sailed in the Baltic Sea. Part two concentrates on the fieldwork. The subchapters give a short overview of other well-preserved *fluit* wrecks in the Baltic Sea, explain the methodology used in maritime (deep water) archaeology, describe the wreck and try to put information learned into context. Finally, there's a discussion about the possible interpretations of the new finds and challenges faced with future research of the wreck.

Even though there are a few other well-preserved *fluit* wrecks, and there are the contemporary paintings depicting *fluits* and even some literature about the *fluits* in general and about the wrecks, our knowledge about *fluits* is far from complete. Every new *fluit* wreck that is found, be it just a fragment or a whole ship, gives us additional information and better understanding about these vessels that shaped the economy and trade during their era. Research into the wreck discussed here has already shown that maybe our current understanding about the *fluits* and the philosophy behind their construction is not as clear as we thought it was.

I would like to thank my supervisors Marge Konsa and Maili Roio for their advice and guidance. Also, big thanks goes out to Minna Koivikko for trusting our team with the research and Niklas Eriksson for all the work he has done on the subject. Last but not the least I would like to thank the whole Badewanne team for the dives and the contribution to the research, especially Jouni Polkko for being the "engine" behind our team and providing excellent 3D models and Roope Flinkman for the surface support during the dives, for being a bottomless well of useful (and sometimes useless but funny) knowledge and for "Dark'n'Stormy"!

2. The Dutch "Golden Era"

The era that has been described as "The Golden Age" or "*Gouden Eeuw*" of the Netherlands started in the end of the 16th century and lasted approximately hundred years. Compared to the rest of the Europe, the Dutch Republic had very high population density and a lot of the population lived in the cities. Often these cities offered favourable conditions for economic development by acting as so-called information exchanges that were vital for successful local and international trade (Lesger 2008). The lack of local resources (except maybe the cheese) forced the Hollanders to develop their skills in trade as middlemen and handlers of logistics (Hocker 1991). Also, Dutch Republic did not have a strong central government, all the provinces and cities exercised a great deal of autonomy. The cities were governed by elected council of elders and magistracy, whose members were known as regents. These regents were most often from middle class or "*burgerij*", unlike the rest of the Europe that was mostly ruled by aristocracy. If for example German or French noblemen were looking for personal glory in battlefield, Dutch regents favoured other virtues and were more concerned with favourable economic conditions and networks, thus ensuring the blooming of local economy (de Jong 2011). Unlike Sweden, a major trade partner to the Dutch, which was built up on feudal system and privileges, the Netherlands merchant class was very influential and strong in its home country (Eriksson 2012, 25). It is worth to note that shipping was one of the most important sectors in early modern Europe's economy and even more so in the Netherlands, where merchant marine employed most of the seafarers (Tamaki 2010, Vanneste 2019). The Dutch had the largest cargo fleet in Europe during most of the early modern times (Van Tielhof and Van Zanden 2011, 47).

Dutch merchant elite was heavily involved in maritime trade and shared interest between different economic actors like merchants, bankers, insurers, shippers and so on. The main source of their wealth was interchange of bulk commodities between two main regions: Western Europe and the Mediterranean on one side and the Scandinavia and Baltic countries on the other side (Jones 1988; Rommelse 2007; Tamaki 2010; Ormrod 2011). The location of the country contributed to that significantly. Like a spider, the Dutch were sitting in the middle of a trade network, thus enabling them to engage in multilateral trade. During the summer months the Dutch merchants would sail in the Baltic Sea, buying up raw materials in bulk like grain, timber, iron, hemp, tar and limestone. Come winter, the ships left the Baltic Sea and moved to the ice-free regions. Southern and Western Europe had immense need for such bulk imports that the Baltic had to offer. The goods were shipped to Mediterranean countries, to Portugal and Spanish and French Atlantic coast ports (Van Zanden and Van Tielhof 2009; Eriksson 2014). The ships were then loaded with wine, salt, spices, cloth, and herring, which in turn was in high demand in the Nordic and Baltic countries. In the first half of 17th century, Baltic market accounted for about 40 percent of Dutch herring production (Unger 1980). Important advantage of this system was that the ships, after they had delivered their cargo, did not sail back in ballast which would have doubled the cargo rates because the shipping cost of goods would have had also to cover the return journey. This kind of multilateral trade network was easily managed from the centre of the network but not from the ends of those routes (Van Zanden and Van Tielhof 2009; Rönnby 2013). Also, this network allowed the Dutch to extend their shipping season. Other ships in Baltic trade who were not able to leave the Baltic before winter (for example, they were waiting for cargo or had no connections in the South), had to stay there until the ice melted in the spring (Van Tielhof and Van Zanden, 2011). Dutch merchants became valued trade partners – they bought in large quantities during the season when the prices were lowest, always paid punctually in cash or in goods and offered generous credit to the local merchants.

The Baltic trade was such a lucrative business that it was called the "mother of trade" for the Dutch, who had established their supremacy in these waters already in the beginning of 16th century (Ressel 2013). During the second half of the 16th century and the first half of 17th century many periods with food shortage plagued Europe and the Baltic grain which the Dutch carried helped to relieve those. Already by the end of 16th century Danzig (Gdansk), Riga and Reval (Tallinn) had become major grain (mostly rye) exporting ports and that grain was mainly moved by Dutch ships (Brand 2007). However, grain and timber were large volume but low value cargo, suitable for large number of small merchants and skippers. There was yet no wealthy merchant elite like in the Hanseatic cities until the end of the 16th century, when the Dutch were able to penetrate the "rich trades" of silk, cloth, spices and other high value, low bulk goods. During 1590s they challenged the English in the Baltic trade of cloth and in 1613–1614 Amsterdam took over the Swedish copper trade from Lübeck (Israel 1995). To achieve that the Dutch experimented in the years between 1560–1640 with different vessel types and sizes to find out the optimal size for the Baltic route (Van Tielhof and Van Zanden 2011).

By the start of the 17th century, Amsterdam had emerged as the most important centre of shipping easily overshadowing the Hanseatic cities. In 1640s Sweden had become the most important trade partner to the Dutch and about 50 percent of Sweden's imports came from Amsterdam (Brand 2007). Building, purchase, chartering and freighting a ship were combined into fast-spreading joint business ventures called *rederji*, so that the different know-how and capital supported each other (Özveren 2000). The risks were minimised by merchants having shares in multiple ships, so the loss of one ship would not ruin them. In the middle of 17th century, most investors in Hoorn held 6.25 or 12.5 percent of vessel's shares and some held shares in as many as 20 different vessels (Rommelse 2007, 147). The Dutch set up a system where sailors were given by legislation a permission to *voering* - a right to conduct private trade. The seamen had the right to take on board a certain amount of merchandise to be traded for personal profit. Of course, the main cargo always had the priority and at least the outgoing *voering* was subject to tax, but this allowed the wages to be kept lower and that reduced the operating costs (Vanneste 2019). The Dutch were able to offer the lowest freight rates in Europe. This is further illustrated by the historic account of the shipowners from Lübeck complaining in 1612 that they could not get return freights from Spain because the Dutch were underbidding them (Barbour 1930).

2.1. Dutch trade through the Danish Sound

The Danish Sound Toll Register Online (STRO)[1] had digitised the complete Sound Toll Registers, containing information about almost all the ships and their cargoes that sailed to and from the Baltic Sea through the Sound from 1497 to 1857. In the 16th and 17th centuries more than half of the recorded passages were made by ships under Dutch flag (Gøbel 2010). For example, during 1636 - 1686[2], according to STRO, 632 ships that declared their destination to be Estonia departed from the Dutch Republic. Most popular destination for the Dutch was Tallinn[3] (570 ships) with rest of the cities far behind. 60 ships were heading to Saaremaa Island and two to Haapsalu. Of 632 ships bound to Estonia, 595 ships had a home port in the Dutch Republic with Amsterdam being the main port of departure (452 voyages). The cargo that was mentioned most in the toll register is wine (approximately 375 mentions), which is followed

[1] www.soundtoll.nl
[2]The period of 1636 - 1686 was selected because this would coincide at least in part with the operating time of the fluit discussed in this paper. Estonia was selected because it is a probable destination/point of departure for the fluit. 50-year period should be well over an average lifespan of a 17th century vessel, although this is very difficult to establish. Koivikko (2017, 149) mentions the results of a study conducted by Hjulhammar in 2010 about the age of Swedish vessels from 1600–1850. The average age of those vessels was 23.5 years.
[3] Present town names are used in this chapter, because in STRO different spellings and versions were used (Tallinn was named Reval at the time, but spelled in STRO "Reffuell", "Restuell", "Roffell", "Reffell" and so on).

by sugar (158), cloth (148), herring (119) and rice (111). Interestingly, 167 times the ships sailed to Estonia in ballast. This indicates that the Dutch did not always sail with cargo. Total of 3557 cargo entries were recorded. The cargo numbers can't be taken as absolutes, because in many cases one entry could include combined cargo that in other entries are recorded separately – for example "sugar and anis" ("Sucher och Anis") or "sugar, almonds and raisins, cumin and anis" ("Sucher mandler och rosiner comin och anniess"). Also, different spellings are used (see "Anis" vs "anniess") and for some items old names are used which meaning has been lost in time (Gøbel 2010). These numbers here are just for the illustration of the goods distribution and direction of movement.

During the same period total of 803 ships departed from Estonia, of which 800 were heading to Dutch Republic. Again, Tallinn was most popular port of departure (721 ships), followed by Saaremaa Island (76). Majority (730) ships declared their destination as Amsterdam, which was the centre of European grain trade (Vanamölder 2011). Rye was the biggest cargo (mentioned 901 times, in many instances same type of cargo was registered in the same load with different units or with a remark "Swedish goods"), hemp and flax (sometimes together, 384 times), barley (177).

There are, of course, some concerns about the reliability of STRO. In the 1650s only destination and port of departure are noted, but no information about cargo is available. And not all ships used the Sound, some traffic may have used the Great of the Little Belt. This could not have been significant amount though, because of the guard ship in the Great Belt and difficult navigation conditions together with a longer voyage to and from the Baltic through the Little Belt. Fraud was not difficult as ships were seldom boarded, and clearance was given based on the cargo manifests and ship documents. Some goods were exempt from tax and thus not recorded. Minor errors and omissions in the database itself are also a possibility (Rönnbäck 2010; Veluwenkamp *et al*. 2021). However, the data still shows the nature of the trade between Dutch Republic and, in this case, Estonia, so these inconsistencies are negligible. And the *fluits* had an important role to play in this. In the 1630s about 70 percent of the ships passing the Sound were *fluits* and around ten years later the *fluits* accounted for 90 percent of the total traffic (Cederlund 1995).

There's no consensus when exactly did the economic growth in the Dutch Republic end. In the 1650s the decline started in fishing and production industry, but it wasn't so pronounced in the trading (Ressel 2013). The decline in the fishing industry (namely herring) was not a result of decreasing demand or competition, but it was due to the Spanish disrupting Dutch salt trade from the Caribbean and Portugal which was vital for herring processing (Israel 1995). Dutch shipping continued to be a major business even throughout the 18th century, but it wasn't fuelling the economic growth anymore (Ressel 2013). The Dutch were unable to improve the shipping efficiency after the first quarter of 17th century and the competition began to catch up. However, it seems that they were so far ahead of everybody else that the English were still complaining about the low Dutch freight rates in the last decades of 17th century (Van Tielhof and Van Zanden 2011, 79). The main decline in European trade volume happened in the Baltic Sea and from 1680s goods from the colonies accounted for the main volume of Dutch shipping (de Wit 2008). Baltic trade was taken over mostly by Swedish and Livonian ships. The trade routes were also changing - Danzig began to lose its importance. Vessels started to sail more often to Livonian ports. In the last quarter of 17th century Riga exported twice as much goods as Danzig. A lot of this was a result of Swedish protective policies which aimed to oust the Dutch from the market (Brand 2007). The Dutch did manage to hold on to the grain trade monopoly until late 18th century, but by the 1740s Dutch economic, cultural and political influence in the Baltic had almost vanished (Israel 1995; Granqvist 2020).

2.2. Dutch supremacy in shipbuilding

The success of Dutch shipping is generally attributed to the technological progress of shipbuilding, but also to effective logistics in procuring building materials for ships and creating extensive route plans connecting the demand with suppliers in different ends of Europe. Unger (1975, 56) notes that by the 17th century Dutch shipbuilders had established themselves as technologically most advanced in Europe. Their supremacy was such that the French minister of finance to Louis XIV, Jean-Baptiste Colbert had to engage in industrial espionage and sent spies to Dutch shipyards (Unger 2011a, 77). Overall, ships were the most expensive investments during early modern times. Owning a ship needed a long-term investment, and extensive logistical planning was necessary from the shipwright for procurement of materials and manpower. Technological advancements such as the sawmill helped to drive design improvements and lower the production costs (Unger 1994; Kyriazis 2006; Gelderblom 2010; Eriksson 2014). Also, using sawmill meant faster production of construction materials and thus the ships were completed much more quickly. Daly *et al.* (2021) notes that sawmills could process 60 beams of timber in 4–5 days while processing the same amount of timber by hand took 120 days. This lowered manual labour costs because the period necessary to hire carpenters and other manual labour became considerably shorter. Shipbuilding that had previously been handicraft work, became more of a factory-like industry. Shipyards started to specialise and concentrate into specific locations (for example Hoorn, Amsterdam etc.). In the 17th century at least 10 000 men were employed in the shipyards of Holland. Combining and concentrating specialised labour was also an incentive for the development of the subcontractors in maritime trade like timber yards, ropeyards, sail makers and others whose business was also growing at an unprecedented pace (Jacks 2000, 22; Verweij *et al*. 2012, 85). After 1600 the ships were not only built by contract – to keep the workers occupied between repair jobs shipbuilders started to speculatively build more or less standardised ships in hopes that if a buyer emerges, he would be prepared to pay extra for quick delivery (Unger 1975, 62). It's easy to see the effect that the specialisation and industrialisation of shipbuilding had on the Dutch merchant fleet – Van Zanden (1993, 8) estimates that in the 150 years since the beginning of 16th century the merchant fleet increased ten times and the biggest growth happened onward from 1585.

2.3. The *fluit*

There's a report by Hoorn's chronicler D. Velius that the first *fluit* was built in 1595 in Hoorn by Pieter Jansz Liorne. Because the story is mentioned by just one chronicler, Unger (1994, 121) claims that the story about the invention of the *fluit* by Mr. Liorne is not accurate. There's no contestation about the fact that Pieter Jansz Liorne lived in Hoorn and launched a ship in 1595 that incorporated the technological improvements of a *fluit* (more on these later), but rather if he was the inventor of those features and if that was really the first time the world saw those advancements. During fourteenth and fifteenth century ship design experienced many dramatic changes. One of the most significant ones was the adoption of full rig in late fourteenth century (Unger 2011b). Greater length to breath ratio was used on cargo ships already in the second half of sixteenth century (Unger 1994; Van Zanden and Van Thielhof 2009). A hulk depicted by Dutch artist Pieter Bruegel the Elder in 1564[4] already displays many of the characteristics of the *fluit* (Van Beylen 1977, 28). The continuous search and experimentation to find better and, in terms of cost, more efficient ship designs that led to the

[4] The engraving "A Dutch Hulk and a Boeier" can be accessed: https://www.nga.gov/collection/art-object-page.47637.html (22.03.2022)

creation of the *fluit* started already in the end of 15th century. It took the Dutch around one hundred years to finally develop the first *fluit*, a ship "that represented the recent differentiation between ships of violence and ships of trade" (Jacks 2000, 23). The *fluit* wasn't a technological breakthrough but an efficient vessel that came to be by incorporating many different advancements made over time into one ship design.

Considering that the *fluits* were the most common merchant vessels in the Baltic trade during 17th century it is surprising how little is actually known about the vessel type. Two contemporary works describing *fluits* that have survived to this day are works by Nicholaes Witsen (1671) and Cornelis Van Yk (1697), and they were not specifically about *fluits* but of shipbuilding in general (Unger 2011a). It's possible that because *fluits* were so common, nobody thought of describing them in detail, especially those who were very familiar with the ships. They might have become invisible to the contemporary people, like today nobody pays any attention or spares another thought at a passing truck. Because *fluits* were usually built free-hand based on experiences from previous ships, there were no constructional drawings. And those few drawings that have survived to present time were produced to be used for discussion or illustration in literature, not as schematics for a shipbuilding (Eriksson 2012; Eriksson 2015a). The contracts between the buyers and the builders of a ship concentrated on the interests of the future owners and included details about cost, cargo capacity, material quality and other details, but not enough for even a naval architect to reconstruct the vessel (Reid 2017b, 192).

One can find the easily recognisable shape of the *fluit* in paintings by such masters as Reiner Nooms, Ludolf Bakhuysen, Willem van der Velde and other contemporary Dutch artists. However, these pictures were usually made in celebration of Dutch naval victories and mostly concentrate in greater detail to East Indiamen or men-of-war, leaving *fluits* to a role of background players. Compared to the "superstars" on the pictures, *fluits* received much less attention on detail and were not painted with such care (Eriksson 2012, 25). From the paintings and few drawings and from the wrecks, we have pretty good idea how the *fluits* looked from the outside. She had a long and narrow hull with a blunt bow. Looking from above the *fluits* looked like rectangular box with slightly rounded corners. However, the most distinctive feature of the *fluit* is her pear-shaped hull with the sides sloping inwards creating an unusually narrow deck that rises considerably towards the stern. This hull shape resulted in a spacious cargo hold for bulk goods. It has been a popular conception in the past that Danish Sound Toll was calculated from the breadth of the upper deck, so sometimes it has been assumed that *fluits* were designed with a large hold and narrow deck to keep the toll as low as possible (Unger 1994, 126; Peters 2013, 183; Thomas 2018, 6). There is no concrete evidence on that, though and it seems rather unlikely as *fluits* were not used exclusively in the Baltic Sea. In fact, Jensen (2018) argues that this was not the case at all as there is no evidence of any measuring devices or measurements made when collecting the toll before 1632. Instead, toll-officers used the bills of lading to calculate the toll and the deck measurements did not have any effect on the amount of toll collected.

One possible reason for such a hull shape could have been the desire to keep the centre of gravity low and hold as much cargo as possible (Eriksson 2014, 10). This peculiar hull shape resulted in almost flat bottom and shallow draft. Lengthening the hull from medieval 3–3,5:1 length-to-width ratios to 4–5:1 and more removed the long and deep keel but allowed for the ship to still sail close into the wind for easy manoeuvring (Voertman 1954, 85). Shallow draft may have been desirable due to the shallow coastal waters in Netherlands but also in some parts of the Baltic Sea (Petrejus 1967; Bellamy 2006). It would make the navigation in coastal waters easier and safer. Also, the vessel would be able to get closer to the shore in places where there are no ports with suitable depth, to make loading and unloading faster and easier. If necessary, they could even beach safely on shallow sandy coasts. There was another upside to this – visiting smaller ports enabled the merchants to buy bulk goods directly from landowners, thus cutting out the middlemen and avoiding tax collectors which would result in lowest possible purchase price (Brand 2007).

This hull shape made the vessels more stable in the longitudinal axis, but the downside of the shallow draft is heavy rolling in rough weather, especially when sailing in ballast. Having cargo on board would lower the centre of gravity thus making the vessel more stable and less prone to heavy rolling. Considering this from the perspective of seaworthiness and safety, one could say that Dutch sailors were almost forced to get return cargo to sail the seas more safely and comfortably. It was usual and in fact necessary to get combined cargo because a ship laden with only timber would be too light and float too high in the water, affecting the sailing abilities. On the other hand, taking aboard only heavy cargo like metal products would mean that a lot of cargo space would be left empty. Thus, it was common that *fluits* carried a combined cargo of timber and metal products on their return from the Baltic Sea (Eriksson 2014).

The *fluit* was a complete success for many reasons. She was the most standardised vessel of her time. She was built in different sizes, usually varying between around 90 to 140 Amsterdam feet (about 24 to just over 39 meters), though the concept was almost the same, only the scale differed (Eriksson 2014). As mentioned above, the shipyards and associated craftsmen and businesses started to specialise and consolidate. However, it didn't stop there. The specialisation occurred even between shipyards – for example, in the Schiedam shipyards smaller *fluits* of 70 to 80 *lasts*[5] were built, while larger *fluits* were mostly built in the shipyards of Zaanse, Rotterdam and Amsterdam (de Wit 2008, 37). Thanks to the standardisation, *fluits* as specialised cargo vessels were easy and cheap to build (Reid 2017a, 19).

Peaceful times made it possible to reduce, or as in most cases in Eastern trade, to exclude cannons and other weaponry on board ships, thus cutting both capital and labour costs. The space made available could be used to carry more goods (Van Zanden and Van Thielhof 2009; Duran 2011). That does not mean that all *fluits* sailing the Eastern route were without armament. Some *fluits* carried cannons and some were built with the possibility to add weaponry should the need arise. In Sweden the motivation behind this option was the reduction of tax offered for merchant vessels if they could be armed with at least 14 cannons and be used by the crown in times of need (Müller 2009, 32; Eriksson 2015a, 181). Another proof of the success of the new vessel type was that over the next eight years since the "first" *fluit* was built, 80 of these ships were produced in Hoorn and sailed under Hoorn flag, earning considerable profits for their owners. Other merchants had but no choice to replace their older vessels with *fluits* in fear of losing their competitiveness on the market (Petrejus 1967).

An important contributing factor to the success of the *fluit* was the reduced cost of ship-building material. Dutch shipwrights were dependent of the imported raw materials, because from already onwards the year 1200, the Dutch indigenous oak forests were depleted (van Daalen and van der Beek 2003). The supply lines for timber had to be reliable and plentiful, because almost no local timber was available (Maarleveld 2013, 356). Wood, iron and tar necessary to build a ship was mostly imported from Scandinavia and the Baltic area (Eriksson and Rönnby 2012, 360). In 1670s the Dutch–Norwegian timber trade started to rapidly decline, so Eastern Baltic and the Rhineland took Norway's place as supply regions (Ormrod 2011). Timber was

[5] One *last* equals roughly 2 metric tons (Bowman 1936, 339)

initially exported mostly through Danzig, Königberg and later via Elbing. Because of the Dutch trade, in the end of the second half of 17th century Riga became the largest timber exporting port in Swedish overseas provinces (Vunk 2016). These ports became main actors in the trade because they were well connected by navigable river systems to large, forested areas (Kumar 2018). Timber exported through Riga was not cut only from the immediate area around the town – dendrochronological evidence shows that the timber was cut from the forests in Dniepr basin as far away as today's Belarus and brought to Riga via Daugava River (Wazny 2002). Same can be said about Narva and Nyen, whose importance in timber export also increased in the last decades of the 17th century. Narva's reach extended to the sawmills in Ivangorod and Jama, while Nyen was supplied from the rich forests of the northern corner of Ingria (Åström 1975).

Construction costs were further lowered by using fir and pine instead of the usually preferred oak. Pine was also cheaper than oak and more readily available. And since pine was much easier to work than oak, shipwrights spent less hours in working the wood. The downside, of course, was that the *fluit* made of pine was not as durable as a ship made of oak and she needed more maintenance (Unger 1994). Because fir or pine are considerably lighter than oak, the displacement of the *fluit* became much less, thus making it easier to handle. Combined with simple rigging, smaller sails, narrow deck and the lack of armament, it meant that the fluit could be operated with relatively small crew. Compared to other traditional merchant vessels, a fluit required about half the crew to sail, decreasing the operational labour costs considerably (Brand 2007; Van Zanden and Van Thielhof 2009). Richard Unger (1994, 144) claims that in Norwegian trade a *fluit* of 150 tons could be handled by seven men and a boy. That gives a ton-to-man ratio of about 20:1, while at the same time the English could only manage a ratio of about 7:1 and the Germans about 11:1 (Lucassen and Unger 2000, 130). Though the bigger was not always the better. The Dutch were able to build ships of 400 *lasts* and more, but they knowingly used much smaller ships in the Baltic trade that required relatively few men (Van Tielhof and Van Zanden 2011). Average size of a Dutch ship in the Baltic trade in 1634 was 120 *lasts* (ca 240 tons), with only few ships under 75 *lasts* or over 400 *lasts* (Bowman 1936).

The speed of the shipping can be crudely calculated as the time spent on the voyage and the loading/unloading time in the ports. Speed affects shipping costs directly – the longer the voyage and turnaround time in port, the higher the labour costs (Rönnbäck 2012). If goods were purchased on credit, longer shipping time would mean longer payback times and higher interest costs. Some authors (Van Beylen 1977; Veen 2000; Sleeswyk 2003) contribute the success of the *fluit* also to increased speed of the vessel, though this is highly unlikely. The masts were shorter and carried less canvas (making the rigging cheaper) and with the bulky hull, the *fluit* was likely a rather slow ship (Barbour 1930; Unger 1994; VanHorn 2004; Van Tielhof and Van Zanden 2011; Guy 2012). There were other factors affecting the number of voyages a ship could perform during a season. Two of these were covered earlier – the possibility to extend the shipping season in ice-free regions and better and faster information exchange. Advancements in cartography made the Netherlands a leading mapmaker in the 17th century Europe. They produced accurate high-quality maps giving sailing instructions and combining them with visual expressions of the collected data which would help the shipmasters get to their destination safer and faster (Israel 1995; Okhuizen 1995; Unger 2011a).

Also, the state subsidised shipbuilding – low customs tariffs were assured for the imported materials used by shipwrights (Barbour 1930, 273). In additions to low tariffs by the state, towns had their own incentive schemes in place to make their town an attractive place for a shipyard. For example, the beer which was offered to the builders by their employer was received tax free (Unger 1975, 61). This well-structured system and beneficial-to-all cooperation between state, local municipality and private sector meant that Dutch were able to build good quality vessels with much lesser cost than anywhere else in Europe. Unger (*ibid*, 56) claims that late 17th century Dutch-built ship cost one-third to one-half as much as ships of equivalent size built in England. That is supported by Barbour (1930, 275): in 1669 production cost of a *fluit* in Holland would have been GBP800 compared to GBP1300 in England. However, the Dutch did not build the *fluits* exclusively for Dutch merchants. Ships and shipwrights were often imported to other countries around the Baltic Sea (Hocker 1991, 179; Eriksson 2012, 25). Supposedly almost half of the merchant vessels in Sweden and Denmark in the last decade of seventeenth century was built by the Dutch (Barbour 1930, 287). And even though the Dutch dominance in the Baltic trade declined during 18th century, being replaced by English and Swedish merchant ships, the Dutch merchant fleet was still largest in Europe at least until 1780 (Tamaki 2020, 357).

3. The fieldwork

3.1. Known well-preserved *fluit* wrecks in the Baltic Sea

Fluit wrecks have been found all around the world, but none of those wrecks are as well preserved and complete as the ones in the Baltic Sea. Dutch-built ships from 17th–18th century have been found in the Netherlands (Maarleveld 2013), Iceland (Lucas *et al*. 2021), Malaysia (Green 1986), the Caribbean (Antczak *et al*. 2015) and elsewhere. In some cases, there has not been sufficient remains left to identify the vessel type, so they cannot be confirmed as fluits with absolute certainty. To understand the difference in the meaning of "well-preserved", one can just compare the "*Melckmeyt*" in Iceland, which is considered a well-preserved wreck[6], to the *fluit* wrecks in the Baltic Sea. Often there are only fragments of the wreck or even just the cargo or ballast left on the wreck site. There is no possibility to accurately reconstruct the vessel – it can only be a guesswork which in best cases relies on previous knowledge, but in many cases this knowledge does not exist or is very limited. Intact wrecks offer a much more complete view into the history. Unlike paintings or drawings, they make it possible to go on board and experience the architecture first-hand. Space distribution, personal items, furniture and tools onboard enable researchers to study the everyday practices carried out onboard (Eriksson and Höglund 2012).

Most of the well-preserved *fluit* wrecks in the Baltic Sea have been so far found in Swedish waters. A comprehensive overview of those wrecks along with drawings and photos can be found in the works of Niklas Eriksson, with most notable being his doctoral dissertation "Urbanism Under Sail" (2014). Below are the best-preserved examples that are also used in this paper as a comparison material. All the descriptions below (except Nimetu-45) are based on abovementioned work by Eriksson.

"Jutholmen wreck"

Found in 1965, she lies in 15 meters of water. Major excavations were carried out in the 70s by the Swedish National Maritime Museum. She is believed to be sunk around 1700 while carrying a cargo of typical Swedish export – tar and iron ore. The wreck is 25 meters long and

[6] See McCarthy and Martin 2019

6.6 meters wide. This gives her a bit wider length-to-breath ratio than what was considered normal for *fluits*. She does not have a lower deck that the *fluits* usually had. She had a forecastle and quarterdeck with living quarters beneath in the stern. "Jutholmen wreck" is not one of the best preserved *fluits*, there are traces of salvage and also the shallow depth has made the wreck more susceptible to the environmental factors than deeper wrecks. Still, considering the depth, the wreck has preserved remarkably well (*ibid*., 53–77).

"Anna Maria"

This is another shallow wreck at 18 meters that is quite intact considering the depth. She lies in Dalarö harbour not far from the "Jutholmen wreck". Excavations in the 1980s revealed her to be a larger *fluit* with a length of 37,24 meters. Dendrochronological samples taken from the timber in the cargo revealed that the trees were felled 1707-1708, so it was estimated that the ship sank probably quite close to those dates. Fortunately, it turns out that the story of "Anna Maria's" sinking is quite well documented. As many other *fluits* she was carrying raw materials like tar, timber and iron out of Sweden and bringing back salt and wine. In the autumn of 1708, she took on board a cargo wood and metal that was destined for Lisbon, Portugal. During their stop in Dalarö she became icebound and eventually burned down probably due to unsupervised fire in the galley while the remaining crew went to the local inn for a beer. She had the regular features of a *fluit*. Her lower deck was built so that in need it could be armed with cannons (because she was owned by a group of Stockholmers, that would have meant a tax reduction). In the forecastle remains of gunports are visible. Even though the fire started in the stern there is still enough left to determine the length of a quarterdeck and the arrangement of rooms under it (*ibid*., 77-85).

The "Ghost Ship"

Found in 2003 at the depth of around 130 meters 30 nautical miles east of Gotska Sandön island in the Baltic Proper, the "Ghost Ship" is one of the best preserved *fluit* wrecks. The conditions have been so good that even her fore and mainmast are still standing. She has not been identified, but according to dendrochronological analysis the timber used on the vessel came from the trees felled somewhere between 1669 and 1693. Her length is 27 meters and width around 7 meters. The wreck displays a typical 17th century Dutch merchant ship shape with hourglass shaped carvel-built hull and a narrow deck. The foredeck is partly survived, the quarterdeck is almost intact and the upper cabin on top of the quarterdeck is clearly identifiable. Under the quarterdeck there is a cabin with furniture inside. In the stern corners there were two *hoekmen* depicting contemporary merchants or townsfolk, one of which was recovered during the research. Several carved knightheads were observed on board. The decorations on the wreck are consistent with the common style at the time. However, they are still impressive (*ibid*., 85-92; Eriksson and Rönnby 2012).

"The Lion Wreck"

The wreck of an unknown 17th-century *fluit* that was found in Stockholm Archipelago in 2009 featured a carved lion on top of her rudder giving the wreck her working name "The Lion Wreck". She lies at 50 meters in Stockholm archipelago. The length of the wreck is 21.8 meters and as the "Ghost Ship" she is remarkably well-preserved. Another thing in common with the "Ghost Ship" is that the fore and mainmast are still standing. Even though the ship was smaller, she had all the characteristics of bigger *fluits* like the round carvel-built hull, layout and rigging. The hold is full of sediment, so it is impossible to see what's inside. She had three masts making her also a full-rigged ship. In the stern there is a main cabin under the quarterdeck with probably a galley in front of the main cabin. There was also an upper cabin above the main cabin. "The Lion Wreck" is also decorated with many carvings. Abaft the mainmast is a carved knighthead where the main halyard was fastened. Some of the ornaments that used to decorate the stern have fallen off and lie on the seabed. Two *hoekmen* flanked the stern, one of which was identified on the bottom next to the stern (Eriksson 2014, 92-96; Eriksson 2012).

Nimetu-45

There is a wreck off the northern tip of Naissaar island near Tallinn, Estonia that was found in 2013 by the Estonian Maritime Museum. In the Estonian Transportation Agency's hydrographical database HIS, the wreck is tentatively named Nimetu-45. It's a wooden sailing vessel about 25 meters of length and 5 meters in width. The wreck lies in 64 meters of water and is quite well preserved. This wreck has not been thoroughly researched and has not been identified undisputedly as a *fluit*, but she does have many of the characteristics of a *fluit* – the hull shape and building method, carved knightheads and other decorations. In 2013 when the author of this paper dived the wreck to document her condition for Estonian National Heritage

Board (photos were taken), no attention was paid on the details that could identify her as a *fluit*. However, further research, should it happen, could very well confirm this suspicion.

3.2. Methods

Global cultural exchange and inter-connectivity has been facilitated by the advancement of sea shipping since the Stone Age (Kahlow 2018, 15). Wrecks in general can be seen not only as evidence of technological advancement, but also as connections between different societies. Different vessels from simple log boats to large sailing ships were the medium through which customs and culture from one area arrived in a different area and influenced the lives of the persons they reached. The remains of the sunken vessels help us to understand these connections and the effects maritime transportation had on the societies (Adams 2001). Surveying wrecks can give researchers and the public a possibility to see and understand where and how the people on board the vessel lived and worked, and how the structure or layout of the vessel affected their actions (Eriksson 2014). In that sense all wrecks can be considered a cultural heritage even if according to UNESCO 2001 Convention on the Protection of Underwater Cultural Heritage, a wreck becomes underwater cultural heritage after being underwater for at least 100 years. Though ships have been found also on land (for example as grave finds in Scandinavian countries, Estonia and even in Egypt[7]), in the scope of this work we concentrate only on the wrecks found underwater.

In deciding which methods to use for researching the wreck one important factor to consider is what is left of the vessel, which in most cases of wooden wrecks is not much. However, it is common understanding that the Baltic Sea has excellent conditions for preservation of wrecks (Rönnby 2013, Fors and Björdal, 2013, Eriksson 2014, Lempiäinen-Avci *et al*. 2021). Over the decades hundreds of well-preserved wrecks have been found all around the Baltic Sea at various depths. It has been attributed to the prevalent conditions of the Baltic – cold brackish water with low oxygen content and salinity. Due to the latter, the "shipworm", *teredo navalis*, which is capable of boring through and decomposing a wreck in a decade, cannot survive in our waters and this is essential for the preservation of wooden wrecks. Natural light can't penetrate the Baltic Sea water to reach deep wrecks (50+ meters) which further decreases the deterioration speed (Drap *et al*. 2015). However, none of the wrecks are indefinite - even

[7] For discussion see Černý 1955, Bonde and Christensen 1993, Price *et al*. 2020

though the conditions are favourable for their preservation, they are still at risk from man-made hazards like trawling, and natural hazards like bacteria. Submerged wood is gradually degraded by the microbial activity which is affected by the availability of oxygen. In deeper water, where oxygen levels are lower, the microbial activity is slower. Preliminary research carried out on the "Ghost Ship" confirmed degradation by erosion bacteria which result in structural modifications, contamination and successive degradation of wood (Fors and Björdal, 2013; Fors *et al*. 2014). It is safe to say that sooner or later all the wrecks will vanish, removing the opportunity for the maritime archaeologists to study them. Intact wrecks will collapse, making it harder or even impossible to understand their inner layout, hiding vital clues to the identity of the vessel or severely limiting the options for preservation. Considering this it is vital to document and research a newly found wreck as quickly and as thoroughly as possible to ensure sufficient data for further analysis.

Some wrecks are like time capsules that offer researchers a unique view into the past. However, unlike land-based sites that normally are culturally related to the people who either lived in the immediate area or were passing through there, wrecks are not necessarily connected to the coastal state where they have been found. Vessels may have a home port and destination in a faraway geographical location, the origin of the cargo can be from multiple regions, as can be the origin of the crew. Ownership of the vessel or the cargo it carried may not have any direct relationship with the area where the wreck is found (Farrell and Baillie 1976; Adams 2001; Smith and Couper 2003; Staniforth *et al*. 2009). On-site underwater research alone is usually not enough to answer all the questions about the identity, origin, destination, type of the vessel and many other questions that may arise. Multidisciplinary approach is needed to answer these questions – laboratory skills (dendrochronology, radiocarbon method etc.), archival or historical work (from historical accounts of shipwrecks to different shipbuilding methods to trade routes and cargoes), technical knowledge of how to operate different equipment like remotely operated vehicles (ROVs), sonars, magnetometers. Conservation skills are necessary to conserve the artefacts brought to surface. And because according to UNESCO 2001 Convention *in situ* preservation should be preferred, diving skills become relevant. It's unlikely that a single person is an expert in all those fields. Collaboration between experts in different areas is necessary. It gives a view of the same subject from different perspectives, adding layers of interpretations that either support or contradict each other. This leads to creating a complete picture of the research subject or if this is not reached, it stimulates discussion and further research (Rich et. al. 2017).

Recording and measuring the remains of a sunken vessel, cargo and artefacts found on or around the site is one of the main methods of researching underwater cultural heritage (Smith and Couper 2003). Measuring can be done manually using measuring tapes or sticks or if a 3D model is available, the measurements can be taken from there, assuming the model is to the scale. In the past recording was mainly done by written reports and hand-drawn sketches, but today it's more common to use digital photos and videos. However, sketching is still used in many cases (see, for example, sketches made by Eriksson in 2012a; 2012b; 2014 and in this paper). Sketching is not 100% accurate and must be used mainly for discussing major features of the wreck (Eriksson and Höglund 2012). Photos and videos capture much more information than human eyes and they offer us a possibility to revisit the site again and again. Seemingly trivial details like size and number of nails or direction of the tool strokes can easily be missed underwater, but they can give a researcher valuable information about where and how the builders of the vessel lived and why they used such methods of shipbuilding as they did (Hocker 1991).

3.2.1. Advantages of photogrammetry in deep-water archaeology

Limited visibility underwater means that a researcher can only see a small portion of the object on the seabed and comprehensive understanding of the dimensions and features of the object is difficult to achieve. A precise 3D model can be very useful for understanding and interpreting wrecks and determining their current structural state (Nornes *et al*. 2015). Also, 3D model can be used to plan further research on the surface, where there is no time pressure and thus taking out the most from the time on the bottom on next dives, which is especially important in deep water archaeology. However, the main motivation behind using photogrammetry is cost. It helps to reduce the time underwater (also a safety issue) and decreases the amount of equipment deployed on survey (Drap *et al*. 2015). Using photogrammetry is in fact nothing new in marine archaeology. It was used successfully already in the 1960s by George Bass (1966) in excavations of the Yassi Ada 2 wreck. Over time the technology has advanced tremendously and today it is possible to extract photos for the 3D model from a video, assuming the video has been shot at a right angle to the wreck and enough overlapping of images has been achieved. Following a pattern while shooting a video is imperative to ensure full coverage of the object with necessary overlapping for the alignment of photos and avoiding gaps between swimming transects. Experiments carried out also by Badewanne team have shown that the best results are achieved by shooting at a 90-degree angle to the wreck from the distance of 1–3 meters depending on the visibility while aiming for at least 70% overlap. Slight deviations from the angel are allowed – during their work on Dalarö wrecks in Sweden it was observed that a maximum of 45-degree angle to the object was acceptable for creating a 3D model (Hansson 2019). The information above is presented to illustrate the difference in regular underwater photography or video filming for documentation – different perspectives must be considered. With the limited time available to research the wreck, 3D model has proved to be the best way to document the wreck and use the model for later analysis of the site. Main risk in creating a 3D model is the uncertainty if the whole wreck can be covered sufficiently in the limited time available underwater to create the model without "blind" areas or gaps. It may mean that additional dives are necessary to complete the model. Cameraman will concentrate solely on the swimming pattern and keeping the camera at the right angle and distance, basically seeing the world only through the camera's lenses, a diver(s) with the light(s) must anticipate the movements of the cameraman, be a few meters ahead and make sure that the light is in such position that it doesn't throw any shadows into the camera's field of view or reflections of light into camera housing dome. Safety diver must make sure that the other divers do not swim into any danger like hanging fishnets or ropes.

Yamafune *et al*. (2017) argues that first object to capture should be cargo distribution "because it is key to the understanding of the ship size, its internal divisions, and the site formation process". This is true if the hull is badly damaged or disintegrated totally and only elements of the ship remain. It does not apply to well-preserved wrecks as then the measurements can be taken from the 3D model, cargo distribution is often not visible because the cargo is in the hold(s) and sometimes covered with a thick layer of sediment. In case of well-preserved or intact wrecks covering the hull, deck and superstructure would be the first task. To be able to cover more of the hull in one go, camera can be used in portrait orientation (tilted 90 degrees sideways). This method was tested by Badewanne team during 2020 research of the fluit. It was unclear if the model will align with portrait-oriented photos, but the risk paid off. Since the visibility was rather good – around 7–8 meters, it was possible to capture almost the whole vertical height of the hull.

3.2.2. Dendrochronology

Dendrochronology is a useful tool when researching wooden ships. Most trees growing in temperate or continental climate zones grow a ring under the bark each year. The trees from the same species and same location growing at the same time have similar ring patterns. They respond similarly to different environmental changes like rainfall, temperature, changes in the atmosphere etc. which will be identifiable in the rings – wider ring indicates more favourable growing conditions than a thinner ring. These patterns make it possible to create reference chronologies for specific species in specific areas (Daly and Nymoen 2008; Dominguez-Delmas *et al*. 2019). That data is used for crossmatching – a procedure of matching tree-rings and other characteristics of rings among the reference chronologies allowing to identify the exact year the ring was formed (Haneca *et al*. 2009). Best results will be achieved with samples taken from timbers with long ring sequences with last ring below the bark visible. If the last ring is not visible, the year when the tree was felled can only be estimated (*ibid.*; Läänelaid *et al*. 2019).

Dendrochronology can help to identify the construction period and area where the vessel was built. The latter may be misleading in case of fluits (but not only), because the timber used in fluits came mostly from other regions than Netherlands. However, dendrochronology can help to identify the original timbers used in the construction from the later refitting or repair jobs (Loewen 1998). This could give a hint about the vessel's working life, which would probably be greater than the difference between the two felling dates (Farrell and Baillie 1976). The wood species used for building, repairs or in cargo can hint on the building place of the vessel or a route she was used on. A ship built of mainly Mediterranean wood but repaired with tropical wood may indicate a shipping route between Mediterranean and a tropical region (Dominguez-Delmas *et al*. 2019).

Choosing the right sampling strategy may determine the success of the research. It is important to select the right places to take samples for dendrochronology. The easiest and least invasive way of taking samples is collecting loose wooden details from the wreck site. The main risk is that those may not have sufficient tree rings and probably do not have any sapwood or waney edge to accurately determine the felling date. Sapwood is not as durable as heartwood and biodegrades more quickly and shipwrights removed it while processing the wood. Also, loose objects may not be in their original positions or may not belong to the wreck at all. If the construction period is the main goal of dendrochronology, the samples should be taken from structural elements like frames, beams and hull planks. To ensure that the results can be placed in the context of the shipwreck, the position of the timber must be recorded, and samples labelled prior to cutting. Size does not always matter – bigger timbers are not necessarily better than smaller ones. this comes down to the growth rate of the trees. Typically, at least 80 growth rings are necessary for reliable match in dendrochronology. For the ship structures tense wood with higher stiffness and bending strength was preferred. Depending on the type of the wood, this could be either a fast-growing tree (like oak) or a slow-grown tree (like pine). If the selected sample happens to be cut from the fast-growing tree, there might not be enough tree-rings available (*ibid*.).

Number of visible tree-rings is further affected by the method of cutting the wood. In case of planks, radial cutting exposes more rings than tangential cutting of the wood. There is also the question of damage to the wood by woodborers. In case of Baltic wrecks this is not a major concern if samples are taken from beams or frames. However, if the ship had spent considerable amount of time in the seas outside the Baltic Sea, damage to the outer hull planking from the wood borers like *teredo navalis* is possible. Quantity of the samples has also important role. More samples mean more information and better rate of success. To ensure this, samples must be taken from different locations in the wreck. Domingues-Delmas *et al*. (2019) suggest that "20–50 samples should be removed from an archaeological ship-timber assemblage, each from different structural timber group with entire assemblage being represented" (for detailed explanations about sampling timbers and additional research methods like DNA or ^{14}C, see also Rich *et al*. 2017).

Downside of dendrochronology is of course the fact that it is invasive research method. This method takes time – previous reconnaissance is required for selecting samples and cutting the samples can be very time consuming and difficult. It is possible that even tens of samples do not yield a reliable result. 23 samples were taken from the "Bellevue" wreck, but it was not possible to date them through dendrochronology (Eriksson 2021). What must be considered, is the feasibility and safety of retrieval operation – the time underwater is limited, the access to the site may be difficult due to the distance, weather and/or depth. Cutting by handsaw can be done in shallow water using open-circuit system, but it will be very time-consuming and labour-intensive, especially in case of bigger timbers. On deeper wrecks only hydraulic tools and surface-supplied scuba systems must be used for sample retrieval operations. With open-circuit systems physical labour will increase the breathing rate which will lead to faster breathing gas consumption and a risk of running out of breathing gas. Where rebreathers are used, any physically strenuous labour is unthinkable because of the risk of getting carbon dioxide poisoning which can lead to death.

3.3. Overview of the fieldworks in 2020 and 2021

In July 2020, Badewanne[8] – a multinational voluntary dive team with more than 20 years of experience in researching and documenting wrecks in the Gulf of Finland and Baltic Proper, dived a well-preserved wooden wreck at the depth of 84–85 meters. The wreck is situated in Finnish Exclusive Economic Zone about half-way between Tahkuna Peninsula on Estonian island Hiiumaa and Hanko Peninsula in Finland. The wreck was found by Finnish Maritime Administration (now Finnish Transport and Communications Agency) during regular seafloor mapping activities in 2006. It was assumed that the wreck could be a Russian minesweeper "Provodnik" from the World War I. However, upon surfacing, the first dive team reported the wreck not to be a Russian WWI minesweeper but a wooden sailing vessel in very good condition. After considering this information the decision was made to continue with taking still photos and shooting video for the purposes of documenting and possibly identifying at least the type of the vessel. By the end of the day, it was evident due to the characteristic shape of the hull that the discovered wreck was most likely a *fluit*. The decision was made to return to the site as soon as weather allows and try to get enough material for photogrammetric model[9] of the wreck. The working name of "Swan" was given to the wreck to identify and separate material related to this wreck.

Unfortunately, 2020 fieldworks are not thoroughly documented because the original plan included different target and objectives. There was only two days for diving the wreck, so the team concentrated on getting enough footage to create a 3D model of the *fluit*. Cameras used for recording the material for 3D model were Sony a7s II with fisheye (day 1) and 12–24mm (day 2) lenses and GoPro Hero 7 (used by the author). Additional still photos were shot with Canon EOS 5DmkIII with Tokina 10–17mm lenses. Some of those photos were also used in 3D model. The model was created with Agisoft Metashape.

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[8] For more info, see www.badewanne.fi
[9] Also, the term "3D model" is used and from here on it will be used in this paper.

2021 fieldwork took place 10.–24.07.2021. During the two weeks when the research was done, the team got five dive days on the *fluit* wreck. Total of 15 dives was made and 2252 minutes of dive time was accumulated (see table 1). Dives were made on 12., 13., 15., 17. and 24.07.21. Rest of the days were either too windy to go out to the sea or were needed for rest after consecutive dive days. Two vessels were used for the support of the operations. Divers and the support staff were accommodated on "Joanna Saturna" (FIN) which was moored in Port of Dirhami, Estonia. Dives were done from aboard "Deep Explorer" (FIN), a specialised diving vessel. It took "Deep Explorer" roughly 2 hours to reach the wreck from Dirhami.

Total of 9 divers plus one surface supervisor participated in the fieldwork. Due to the depth of the wreck, the team was split into three sub teams, that entered water in different times to avoid crowding at decompression stops and to make getting divers in and out of the water easier and safer. All divers were experienced technical (mixed gas) rebreather divers. Teams entered the water according to their tasks that were assigned to each team during morning planning sessions. First team (the author was the dive leader of this team) was always the one to locate the wreck, because the descent line with the buoy had to be removed after each dive day. This was necessary because the wreck lies on a very busy shipping lane entering the Gulf of Finland and the likelihood of a vessel running over the buoy and removing it was considered high. Thus, the buoy with descent line had to be removed after day's dives.

Depending on where the descent line was in relation to the wreck, the first team located the wreck using a reel if necessary. The reel was attached to the descent line about 4–5 meters higher than the bottom and was usually left lying next to the wreck or on the deck of the wreck. The reel was never attached to the wreck or any part of it. Every dive day the first team also attached a strobe light to the descent line. This made it easier to locate and navigate back to the descent line. All the measurements of the wreck that were taken underwater were taken by the first team. Additional task for the first team was to document separate objects like the rudder and shoot material for the 3D model of the transom. The second and third team's tasks depended on the results of previous dives and overall research plan, mainly shooting additional footage to enhance the 3D model and for a documentary.

Table 1. Dives, depths, bottom times (time spent descending + on the bottom), total dive time (bottom time + ascent/decompression time).

Dive no.	Date	Max depth (m)	Bottom time (minutes)	Total dive time (minutes)
1	12.07.21	83	27	151
2	12.07.21	81	32	180
3	12.07.21	cancelled due to leak in camera housing		
4	13.07.21	84	26	173
5	13.07.21	83	33	193
6	13.07.21	83	25	127
7	15.07.21	84	27	161
8	15.07.21	81	25	140
9	15.07.21	84	30	141
10	17.07.21	83	26	161
11	17.07.21	82	36	200
12	17.07.21	84	28	175
13	24.07.21	85	22	138
14	24.07.21	85	32	196
15	24.07.21	84	18	116
		Total:	387	2252

Following photo and video equipment was used for documentation in 2021:

Sony a7sII with Sony 12-24mm lens (fixed at 12mm – this was used for photogrammetry footage).

Canon 5D MKIII with 14mm/F2.8 lens for cinematic footage.

Both cameras had 2 x Northern Light Scuba 100W led lights, but after first day Sony set was changed to 2 x Keldan Video 8X 15000lm lights.

Additional lights used by lightmen – Northern Light Scuba 300W led light (for photogrammetry footage), 2 x Keldan Video 18XR 30000lm lights mounted together and remotely controlled by the cameraman and Keldan Video 24XR 35000lm, remotely controlled by the cameraman (for cinematic footage).

GoPro Hero 7 Black with 2 x Keldan Video 8X 13000lm lights - for additional video, also for checking and identifying objects.

Lumix GH-5 with Keldan 8X 15000lm lights and GoPro Hero 8 Black mounted on top of the housing – only for 24.07.2021.

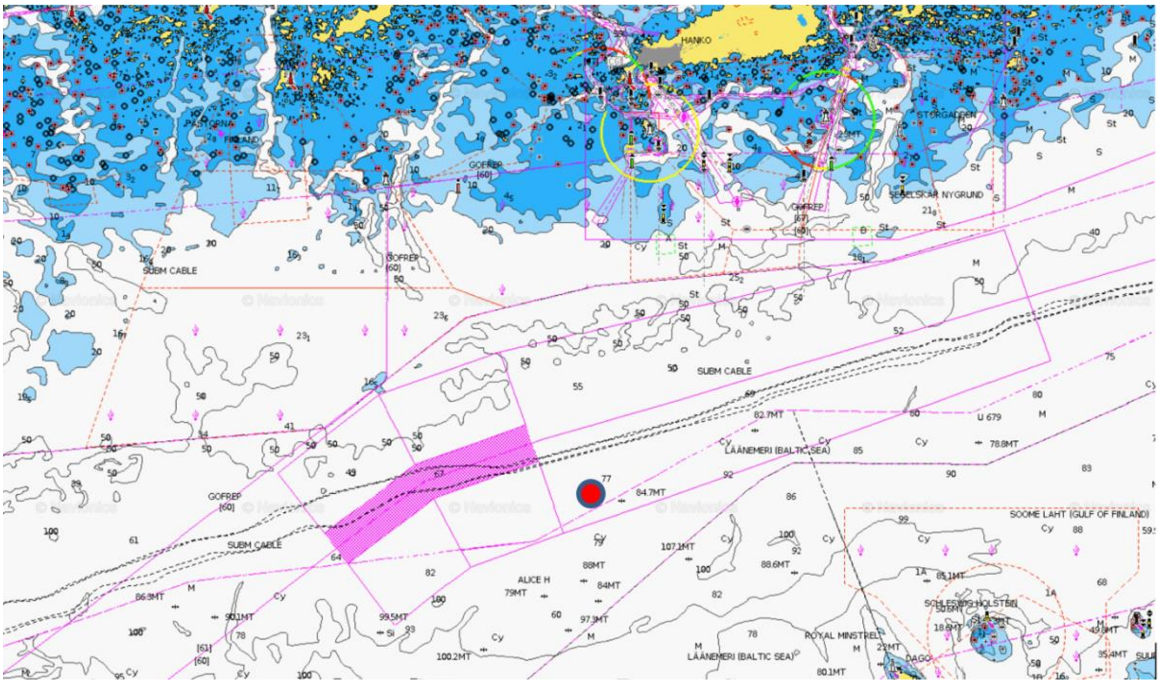

Figure 1. Location of the wreck (source map by Navionics S.r.l.).

3.4. Description of the site

The bottom is mostly made of clay and sediment, though some patches with rocks can be seen around the wreck and it's mostly flat. During the dives only mild current was observed. The visibility differed from day to day and was better in 2020 than in 2021. Average estimated visibility in 2020 was over 10 meters and in 2021 7–8 meters. Water temperature was 5–6 degrees Celsius on the bottom. The wreck is sitting upright on her keel, with a slight list to port side, which is quite usual because of the almost-flat bottom of *fluits*. The wreck has suffered damage from trawling. This is evident from the dislocated elements of the wreck that could not fall into their current position during the sinking like the masts and yards that lie 10–15 meters in front of the bow perpendicular to the wreck, rudder that is 7–8 meters from the aft with a clear drag mark through the sediment (abovementioned distances are visual estimates by the divers), stempost in an unnatural position that could have not resulted from the sinking. However, the most obvious evidence is the remains of a trawl in the bow. The dislocated elements will be discussed in more detail later.

3.4.1. The hull

"Swan" has the signature wide-hipped hull and a narrow taffrail of a *fluit*. The stern rises and narrows considerably, creating the pear-shaped look from the aft. She's long and narrow with a low blunt bow. When assessing the newly found wreck, the first thing to find out is whether the hull is carvel or clinker built (Eriksson 2010). In simple terms, if a hull is carvel-built, the planks are fixed to the frame so that they are side-by-side to one another creating a smooth and more streamlined hull. In clinker-built hulls the upper plank's lower edge overlaps the lower plank's upper edge. Carvel-built ships were built skeleton-first, so the planks were fastened to a completed frame, while clinker-built ships were built shell-first and the frames were inserted afterwards. Several building techniques were used simultaneously onwards from 16th century. However, the ships built in carvel and clinker technique had a different social status. In Low Countries clinker technique was considered less prestigious and clinker-built ships were usually peasant ships, while carvel-built ships were built for merchants and noblemen (Hocker 1991, 12; Eriksson 2010, 77). In "Swan's" case, the hull is carvel-built. On the upper hull there are five wales that are much thicker than regular planking. Wales are horizontal external strakes that increase hull's stiffness and strength and as such they were an important element in ship hull design. Above them, a bulwark runs around the vessel.

The size of the vessel is an important factor when researching a wreck. For example, measurements can be compared against historical data to determine the ship type. According to Unger (1994, 126) *fluits* that were built for the Baltic trade had mostly length-to-breadth ratio of 5:1 or 6:1 and length of the vessel was between 30–40 meters though it is now known that smaller *fluits* were also used (ie. "Jutholmen Wreck", "The Lion Wreck" and the "Ghost Ship"). 5:1 ratio of a 30-meter ship has a beam of about 6 meters and in case of 6:1 ratio about 5 meters. Since *fluits* had a characteristic tumblehome, the deck is considerably narrower than the beam. To take the measurements from the 3D model, it was necessary to establish a reference point. For that, two measurements were taken from the same predetermined place on the deck to decrease the possibility of error. The measurements were taken from the place where there are two "rope guides" on the outside of the hull (see figure 2). On both times a measuring tape on a roll was used and the result was 480 cm both times. From the cross-sections of the hull (figure 2), the pear-shape (sometimes also called a champagne glass shape) of a *fluit* is clearly visible.

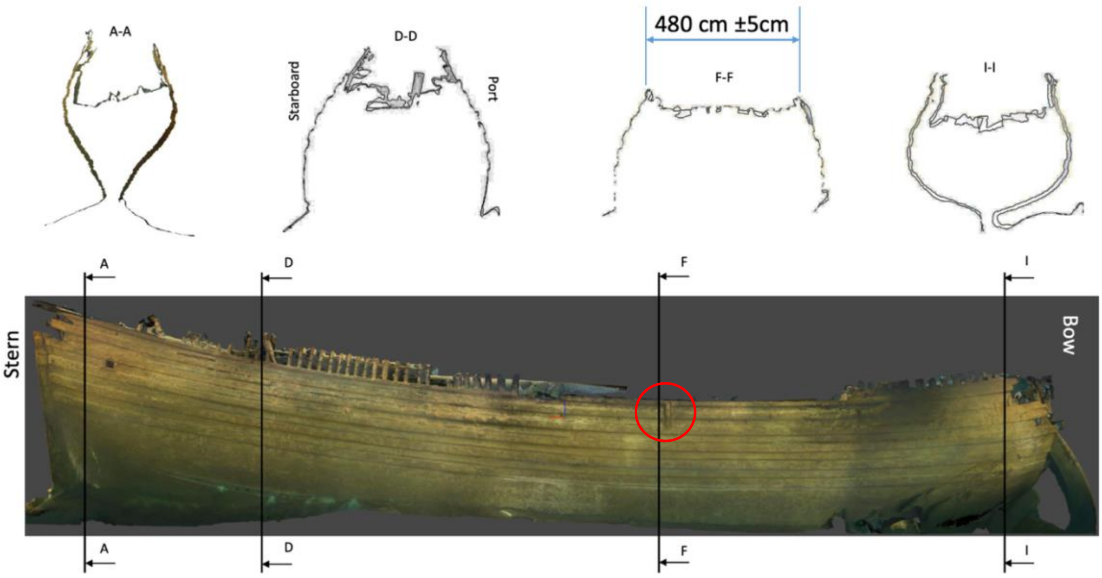

Figure 2. The place where the measurement was taken is marked with red circle (Jouni Polkko 2021).

Another hull width measurement was taken from further to the bow, just below the front cargo hatch (figure 3, location G). Result – 490 cm. From these measurements it is possible to calculate other dimensions of the wreck.

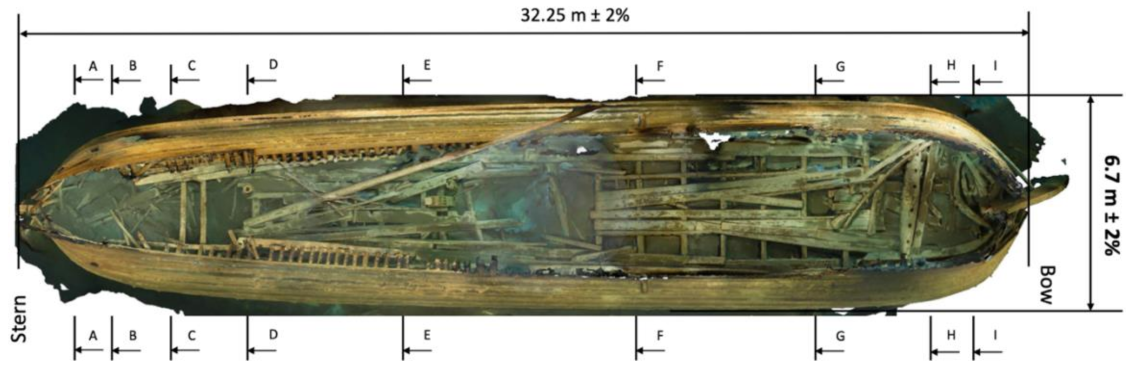

Figure 3. Measurements of the wreck (Jouni Polkko 2021).

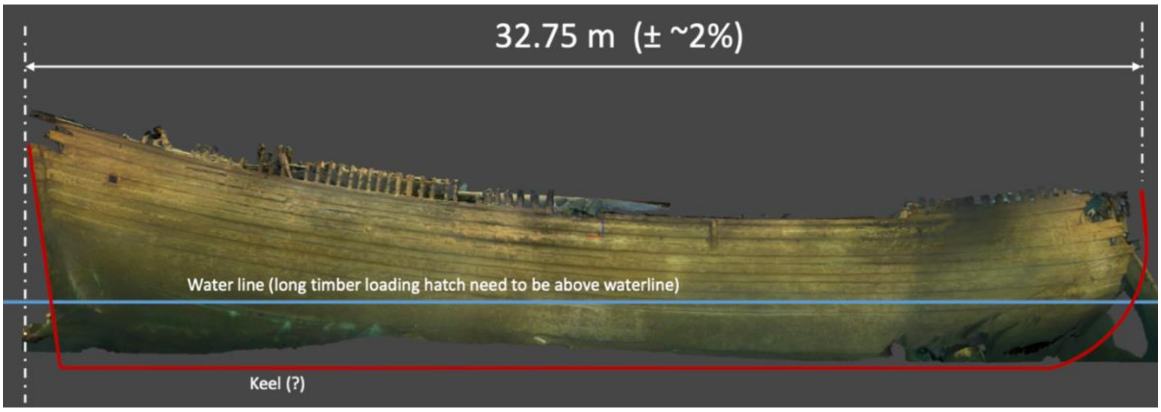

Figure 4. Stem post to stern post reconstruction and measurement (Jouni Polkko 2021).

The beam of the ship is 6.7 meters. These measurements give the length-to-breadth ratio of 5:1 which is a standard ratio for *fluits*. These vessels were usually rated between 200 – 500 tons (Barbour 1930, 280). According to Nicholaes Witsen (cited in Unger 1994, 122) a *fluit* of 32.5m in length and 6.65m in breadth would be rated to 300 tons. These measurements correspond almost exactly to the measurements of the *fluit* discussed in this paper, so it is safe to assume she was also rated to about 300 tons.

The hull has three windows in the stern. What is peculiar is that the positioning of windows is not symmetrical – there are two windows on the port side and one window on the starboard side. When discussing openings in the stern, Eriksson (2014, 91) suggests that the cabin of "Ghost Ship" has a "seemingly standardised arrangement of openings in the stern". The ship has two windows that are placed on the rounding on the stern, each on one side. The same applies to the "The Lion Wreck" (see a sketch of the wreck in *ibid.*, 114). This means that all other known well-preserved *fluit* wrecks from the Baltic Sea have equal number of windows on both sides. For some reason the "Swan" differs from the usual layout. Window frames and panes have not survived in their original position. Windows have a carving around them, but the carvings will be discussed in more detail below. Windows were covered with wooden hatches that were fixed to the outside with iron hinges. None of the hatches are in their original position and have either fallen off due to corrosion or been dislocated by the trawl. One of the hatches will also be discussed in more detail later.

Next to the sternpost on starboard side there is a cargo hatch that could be used for loading long timbers or other tall objects (Van Beylen 1977, 31; Eriksson 2014, 56). The lower edge of the hatch had to be just above the waterline for the ease of loading of timbers, so it gives an indication of the approximate freeboard the vessel had. Sitting so close to the water meant that the opening must be as watertight as possible, so after covering the hatch it was heavily caulked (Unger 1994, 126). Dimensions of the hatch were measured underwater with measuring tape and the height of the hatch is 70 cm and the width is 100 cm (figure 5). The hull has a crack between the planks on the starboard side running abaft from the last third of the hull. It is unlikely that this is the reason for sinking thought at this stage it cannot be dismissed. It is more likely that the crack is a result of aging and/or from the tensions that may run through the wreck when she was caught in the trawl. There must have been considerable forces at play if the stempost has been broken in two and it has fallen inward. This shows that the force applied to the stempost was dragging it towards the stern. This would mean that the bow would become lighter during the drag, and the centre of mass would move towards the stern. Such mass redistribution may cause the planking to curve outwards and possibly resulting in a crack, especially after being hundreds of years underwater. Even when not disturbed, old wrecks tend to reshape on the seabed (Eriksson 2012, 19). It may be another reason for the crack. At this stage it is impossible to say with any certainty what has caused the crack. Also, it must be noted that some of the elements of the ship are most likely irrevocably lost because of the trawling.

There are no other bigger man-made openings in hull (of course, there are scuppers through the bulwark to drain water from the deck, a single remaining hawse hole in the bow etc., but here larger openings are considered, like gunports), so "Swan" was not armed below deck. This doesn't rule out the possibility that she had a few cannons on the deck, but since cannons add considerable weight, they would make the ship even more susceptible to rolling by lifting the centre of the gravity.

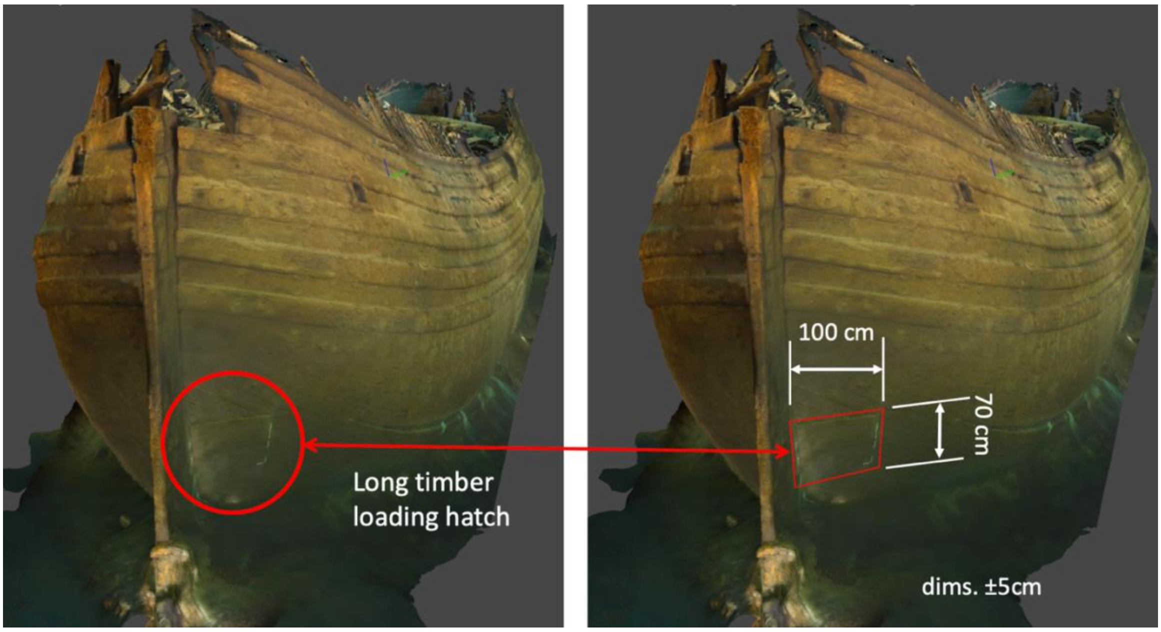

Figure 5. Location and measurements of the hatch for loading tall objects (Jouni Polkko 2021).

Figure 6. Broken stempost, remains of the trawl and clear drag marks from the trawl on the bow (Jouni Polkko 2020).

Figure 7. The stempost resting on debris from the wreck. Notice the cut-in in the lower part of the post for connecting two parts of the post (Jouni Polkko 2020).

The stempost is made of several timbers and has a gammoning hole on top of it. The bowsprit rested on the top of stempost, and the hole was used for lashing the bowsprit to the post. The bowsprit and the prow are both missing. As mentioned earlier, the stempost has been broken in two from one of the joints between timbers because of a trawl. This is evident from the fact that the broken part of stempost rests on top of some wooden debris from the wreck. The length of the broken part is about 510 cm. The method for joining two parts of the stempost is clearly visible on figure 6. The break is two planks lower than the lowest wale. In front of the windlass there's a plank with a cut-in for the foremast. The windlass barrel is made of a large log and the windlass system is almost identical to the one on the "Ghost Ship" (see Eriksson and Rönnby 2012, 353). The barrel was rotated by hand levers that were inserted into the square holes in the barrel. As on the "Ghost Ship", the bearings for the windlass are made of two horizontal timbers attached to the inside of the bulwark. On the "Swan", the port side timbers for bearings are still intact and the barrel sits inside, but on the starboard side the barrel has been dislocated and the top horizontal timber securing the barrel is missing. The difference with the "Ghost Ship" is that on "Swan" the plank with a cut-in for the foremast is fixed to its place with the same horizontal timbers as the windlass. And the foremast is further towards the bow from the windlass on the "Ghost Ship". Considering the distance between the windlass and the foremast, much smaller "The Lion Wreck" is more similar to the "Swan" (for reference, see Eriksson 2014, figure 4.10). This may illustrate the suggestion that *fluits* were built the same way but in different scales. Catheads that were used for lifting anchors have not been found.

The foredeck and forecastle have disintegrated. Though some of the *fluits* did not have a forecastle (like "The Lion Wreck"), on "Swan" it is evident because of the extra rows of planking and the extended stanchions rising above remaining planking in the bow. The prevalent suggestion, that stems from the 19th-century ship architecture, is that the crew were housed in the forecastle, away from the captain. No archaeological evidence has been found on the Swedish *fluit* wrecks to support this. In fact, the evidence points to the contrary – the crew were lodged in the stern (Eriksson and Rönnby 2012; Eriksson 2014; Eriksson 2015b). The evidence from at least three of the wrecks suggest that the forecastle was most likely used as storage space (Eriksson 2014, 99). On "Swan" no tools or ropes have been found in this part of the wreck.

The main deck extends the whole way from the stempost to just behind the bilge pump. Abaft of the windlass barrel there is a small hatch, right in the midship there's a main cargo hatch and it looks like there are two small hatches abaft main cargo hatch. Because the deck planking has been dislocated and now lies in disarray, the existence of two small hatches abaft the mainmast needs to be confirmed. However, there is one small hatch right in front of the intact bilge pump and it looks like the edges and cut ins in the deck planking of a little bit larger hatch few meters in front of the last hatch (see figure 8).

Compared to the Swedish *fluit* wrecks four cargo hatches would make this vessel unique as none of the other *fluits* in the Baltic Sea had four hatches. "The Lion Wreck" and the " Ghost Ship" had A, B and C hatch, but lacked the D hatch (Eriksson 2014). All the hatches have lost their coverings, probably already during sinking. Eriksson (*ibid.*) claims that decks, hatches and bulkheads on *fluits* were following a standardised pattern. It raises a question what was the purpose of the fourth hatch? Where did it lead and why was it necessary?

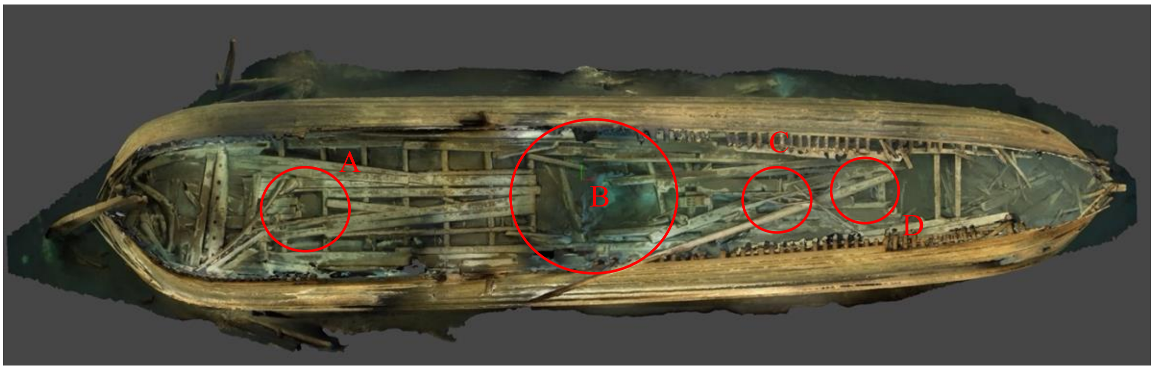

Figure 8. Hatches: A – small hatch in the bow, B – main cargo hatch, C – another possible hatch, D – small hatch in front of the bilge pump (Jouni Polkko 2021).

It is unclear if the hold is full or not, because only a thick layer of sediment is visible. However, since the sediment layer starts just below the deck level it stands to reason that the vessel was not in ballast when she sank. The thickness of the sediment layer was measured using a measuring stick in the main cargo hatch (see figure 9). The results were between 22 and 40 cm in four different measuring locations. Something solid was felt underneath. It is possible that the measuring stick hit a lower deck (also called orlop deck) – a deck between the main deck and the cargo hold. Lower deck had a height of 1,2–1,5 meters and was used for storing loose or lighter items like barrels or crates and items that were supposed to stay dry (Hoving 1995, 48; Eriksson 2015b, 52). Lower deck did not necessarily stretch out the whole length of the ship, it could start just abaft the main cargo hatch and some *fluits* like the "Jutholmen Wreck" did not have a lower deck at all (Eriksson 2015b). Considering the size of the "Swan" she probably had a lower deck, but this yet needs to be proven. Another possibility is that the stick hit the cargo. Removal of the sediment can give an answer to that. The distance between the beams under the main deck from forward small hatch to main cargo hatch is approximately 132 cm (measured from the model). Two of the beams have fallen into the hold and the deck planking is in disarray so the exact position of the main hatch is difficult to establish from the 3D model.

Another distinctive feature is the location of the bilge pumps. Usually, two pumps are in the aft section in front of the quarterdeck (see "The Lion Wreck", the "Ghost Ship", also "Nimetu-45"). "Swan" has only one pump in that location, although the position on the port side suggests that there might have been another pump on the starboard side as well. However, there is another single pump that is just abaft the mainmast and in front of the bitt. Cut-ins in the planks show its original location that was on the central axis of the hull. Positioning of a pump amid-

Figure 9. Measuring the sediment layer in the main cargo hatch (Ivar Treffner 2021).

ship is not something unheard of, because a lot of 15–16th century ships had pumps in such locations (Bendig 2016). Also, later vessels had bilge pumps in midsection and even in the bow part – a good example is "Kasuunihylky" in Finland that is tentatively dated to 18th century (see Polkko and Peltokorpi 2021). Two factors that determine the position of the pumps are the design of the hull and the trim. The pumps are positioned at the lowest point of the hull, which usually is in the aft section (Bendig 2016; 2020). However, the other *fluit* wrecks from the Baltic Sea do not display such layout as "Swan". Could it be because "Swan" is larger than most of the other preserved *fluits* and she needed an additional pump in the midsection? Or is this just a feature loaned from older or other ship types? With current information available, there is no way to tell.

Just abaft of the remaining bilge pump there seem to be remains of a bulkhead, which would indicate the outer limit of the stern cabin and quarterdeck. It was quite common that the aft-most beam of the main deck served as a pump dale and the quarterdeck started right behind the pump dale (Eriksson 2015b). These remains are 620 centimetres from the sternpost, which correspond to Eriksson's (*ibid.*) estimate that on "Anna Maria", a *fluit* of 37.24 meters, the break of the quarterdeck was 8 meters from the stern. Roughly 130 centimetres (measured from the model) towards the stern from the aft bilge pump two slightly curved beams remain, with the first beam missing. The distance between the beams is about 75 cm, so if the first beam would be replaced towards the bow, it would support the supposed bulkhead behind the pump. The beams are about the same level as sternpost, so that indicates the height of the quarterdeck. The height of the beams from the main deck is between 150–160 cm. Considering the height of the quarterdeck and space necessary for the tiller (see below), the floor of this room would have to be lower than the main deck. This is further supported by the height of the windows that are well below the quarterdeck level. Usually, two rooms were under the quarterdeck – the galley and the main cabin. The first room when stepping below quarterdeck would have been the galley where the hearth was located (same layout is on "Jutholmen Wreck", the "Ghost Ship" and "Anna Maria"). To enter the galley, one would need to enter through a door in the bulkhead and descend the stairs to the level of the lower deck. This setting was common in *fluits* and is visible in other *fluit* wrecks, ship models and paintings (Eriksson 2014, 73). Access to the main cabin would be through the galley. To interpret everyday life on board the *fluit*, it seems that eating and sleeping in the main cabin was the standard arrangement on board *fluits*. On larger *fluits* there could have been smaller spaces divided by bulkheads. It is known from the Danish Sound Toll register that most of the men on board Dutch merchant vessels came from the same geographical region and social environment where the shipmasters were located (Eriksson 2013, 106–107). There's no doubt about the chain-of-command on board, but it's highly likely that the rest of the life on board the *fluit* was not so segregated as, for example, on warships or vessels with larger crew[10]. The fact that the small crew often came from the same area and possibly even knew each other and the captain, could mean that the atmosphere on board was much more informal. The research into other Baltic Sea *fluit* wrecks has provided proof that the whole crew was lodged in the stern of the ship and not spread out along the ship according to rank (Eriksson and Rönnby 2012; Eriksson 2012; 2014). It is impossible to determine the layout of the main cabin of the "Swan" and possible division with bulkheads, because the roof of the cabin has fallen in, there are a lot of loose planks, sticks and other debris and everything is covered with a thick layer of sediment. In fact, the debris and sediment layer is so thick that it reaches almost to the lower edge of the windows. Because of this, no furniture, utensils or personal belongings have been found so far – that would require removal of at least the sediment layer.

[10] For descriptions of spacial solutions on warships and larger merchant vessels, see "Interpreting Shipwrecks – Maritime Archaeological Approaches" (2013) Edited by J. Adams and J. Rönnby

3.4.2. The whipstaff and the *hennegat*

Above the cabin was a low space called the *hennegat,* where the tiller ran. The *fluits* were steered with a steering system called a whipstaff, a mechanism used possibly already from the late Middle Ages until the beginning of eighteenth century (Pipping 2000, 19). In very simplified terms a whipstaff was a vertical lever that moved perpendicular to the deck and was connected to the horizontal tiller via rowle (also "roll", "roller", "rowel"). Tiller was connected to the rudder and moving the whipstaff left or right caused the rudder to turn accordingly (for more detailed explanation on whipstaff mechanism, see Harland 2011). The stanchions and planking above the quarterdeck give reason to believe that there was another structure, an upper cabin, on top of the quarterdeck. However, the strongest evidence of this is the transom. On the bottom, close to the sternpost ship's transom was found. As is typical for *fluits*, the transom is tall and narrow. The transom, measuring 200cm in height would be located above the narrow opening to the *hennegat* where the tiller comes out of the hull and is connected to the rudder. This opening would have been right above the sternpost as the bearing where the tiller was fixed was sitting on top of the post. The transom would add well over 2 meters (height of the transom plus the height of the *hennegat*) to the overall stern heigh over the sternpost. Since the top of the transom has a carving around it which has been carved from both sides, it's safe to assume that this part extended over the roof of the upper cabin. That would give the height of the upper cabin of around 150–160 cm. The height of the similar cabin on board "the "Ghost Ship" was estimated to be 140 cm at the highest point (Eriksson 2014, 91). Unfortunately, it is impossible to estimate the length of the upper cabin from the available data. However, on board the *fluits* the helmsman steering the ship using the whipstaff was on the open quarterdeck (Eriksson and Rönnby 2012, 356; Eriksson 2014, 91). That would mean the upper cabin must have been considerably shorter than the space under the quarterdeck. The volume of the upper cabin must be relatively smaller compared to the deck area because of the very pronounced tumblehome. It could have been a captain's cabin as Eriksson (2012, 22) has suggested for "The Lion Wreck".

3.4.3. The anchors

There are total of four anchors on the bottom, two on both sides of the wreck. All the anchors are typical "traditional" or Old Admiralty-type anchors with their large, heavy stocks (see photo 2). This type of anchor was used from 16th century and was the most popular type until 19th century (Marlowe 2017). It appears that one of the port side anchor's shank is broken (figure 11). Originally these anchors would have been tied to the hull. Either the binds holding the anchors have rotten and broken or the anchors have been dislocated by a trawl (which could explain the broken shank). However, the former seems more likely than the latter, considering the position of the anchors. If caught in the trawl while still attached to the hull, the anchors should be further away from the hull and their current positions, or they would be completely missing. Also, parts of the rigging have fallen over the anchors, suggesting that the anchors were on the seabed when the masts fell or were trawled down. It is possible that a yard that fell on the anchor broke the shank.

Figure 11. Stock and broken shank (highlighted with red circle) of the second port-side anchor (Ivar Treffner 2021).

3.4.4. Rig

Fluits were mostly three-masted vessels (also called full-rigged) – they had a foremast, a mainmast and a mizzenmast. Compared to the earlier cargo vessels, the rigging on a *fluit* was more simple and easier to handle, because she carried less canvas than other vessels. The rigging included blocks and tackles to help with the handling and thus required smaller crew to operate. Usually, the foremast and mainmast had one square sail and on bigger *fluits* the mainmast could have two sails. However, in case of two sails on a mainmast the topsail was relatively small compared to the main sail. Smaller *fluits* carried a lateen sail on mizzenmast but larger vessels had square top sail. Also, under the bowsprit was the spritsail (Unger 1994; Eriksson 2014). "Swan" was also a full-rigged *fluit* – she had three masts. Some of the masts and yards lie on the port side of wreck on the bottom, some in front of the wreck (most likely the foremast) and the mizzen mast has fallen diagonally on the deck towards port. Masts and yards have not been studied in detail nor filmed with any purpose yet. Only the original position of the foremast can be determined from the plank with a cut-in in front of the windlass. Foremast and mainmast have been removed so that no visible stubs remain above sediment layer, so it is possible that such force was applied to the masts that they came out of the mast steps. That could have been the result of trawling. Of course, they could have broken beneath the current sediment layer. The mizzen mast is not broken, but that is not surprising because mizzen mast was not so robust and was not keel-stepped but deck-stepped on the deck beneath the galley (Eriksson and Rönnby 2012). On starboard right next to a bulwark lies a mast, that was probably for emergency repairs and not part of the rig.

Three bitts were found on the deck – one on the port side just abaft the windlass barrel, one is standing amidship on the central axis and third one lies in the aftmost small cargo hatch. Bitts are posts with sheaves for the rigging that are fixed through the deck. The bitt amidship has three sheaves while the others have two sheaves. The bitt with three sheaves was originally fixed along the same line behind the single bilge pump behind the mainmast. This is evident from their current location and two planks that have mirroring cut-ins fitting both the pump tube and the bitt. These planks have another circular cut-in towards the stern that could have housed the capstan, which has not been found. The location of capstan would have corresponded with other *fluits*. On the forecastle the *fluits* had two curved beams in front and behind the foremast. Inside those beams there were holes for pins to secure the lines from the running rigging. One such beam with two fixed and four removable pins lies in the bow part of the wreck. A lot of deadeyes and blocks lie scattered on and around the wreck.

3.4.5. Carvings

"Dutch ships had always been highly decorated, with the design of even their modest inland trading vessels incorporating a wonderful balance of practicality and artistic ornamentation."

– Andrew Peters (2013)

Before the 17th century the ship hulls and sails were decorated with painted designs. However, since these paintings tended to fade over time, in the beginning of the 17th century ornamental carvings started to replace the paintings. This development can be witnessed from the paintings, prints and model of contemporary ships. Decorations express the growing pretentions and high status of owners and nations, starting in the beginning with borders, edging, gallery arches and heraldic shields and gradually growing into larger and smaller figurative sculptures (Soop 1986, 9). By 1630 overdecorated prows and sterns, figureheads and statues were a norm on ships[11] and the *fluit* was no exception (Petrejus 1967). Although not as lavish as carvings on men-of-war or Dutch East India Company ships, the *fluit* had carvings on her transom, taffrail and on other parts of the ship. Bitts usually featured carvings as well and they were known as knightheads because the tops of the bitts were carved in a shape of a nobleman or soldier's head. However, in contrast to warships, the knightheads onboard *fluits* did not depict knights or soldiers – instead of military themes, the heads were possibly familiar characters of the time associated with trade or other similar reference. Also, top of the rudder usually featured carvings (Eriksson 2014). *Fluits* used the same arrangement as smaller Dutch barges that had traditionally a human or an animal head carved on top of the rudder stock. Sometimes it could even feature a whole animal climbing up to the tiller. This form of decoration was called *roerkoppen* (Peters 2013, 183). A good example is "The Lion Wreck" with her carved lion head on top of the rudder. So, the standardisation of the *fluit* did not stop with the structure and a layout of the ship – also the composition of carvings followed same rules (*ibid.*, 151).

Ship's transom was full of carvings. In fact, this was due to practical reasons. *Fluits* sailed in an era where most of the population could not spell their own name, let alone read. It was useless to write the ship's name or home port on the stern. Instead, carvings or paintings were used to depict ship name and a town's coat of arms used to identify home port. Obviously, this

[11] Probably one of the most famous and well preserved example is the Swedish warship "Vasa" (see Soop 1986)

limited the selection of usable names – common names were those that were easy to depict like The Sun, The Wine Cask, The Gray Wolf, The Golden Phoenix, The White Swan and so on. Quite popular were the motifs from the Bible like The Good Shepherd or Noah's Ark (Eriksson 2014). Many transoms that have survived feature direct interpretations of the Biblical scenes engraved by artists like Pieter Hendrickz Schut and Claes Jansen Visscher (Peters 2013, 183). Also, the year the vessel was built could be carved on the transom. One very distinctive feature that the *fluit* had, was the *hoekman* (the corner-man). Those were carved figures on both sides of the ship flanking the transom. In par with the overall theme on board the *fluit*, the *hoekmen* were figures whose appearance was much like any merchant or a burgher of the time. It is believed that the *hoekman* represented a class or a part of society rather than a concrete individual (i.e., the owner of the vessel, though in some cases it could be possible) since a lot of the vessels were co-owned by groups of people (Eriksson 2014; 2015b). The *hoekman* raised from the "Ghost Ship" wreck supports this theory rather nicely. It was carved wearing a dress fashionable in the Netherlands and in style favoured by businessmen between 1665 and 1675 AD (Koehler *et al*. 2012). *Hoekmen* were positioned with their backs against the corner of the hull where transom meets the ports. Commonly, *hoekmen's* heads were turned so that they were looking almost to the direction where the vessel came (Eriksson 2014). The carvings could send another important message. More lavish and higher quality carvings meant that more money had been spend on creating them thus showing the wealth of the owner or owners (Peters 2013)

Surprisingly, the only surviving ornaments on the "Swan" are the carvings around the windows (see figure 11), on the rudder and the transom (the latter will be discussed separately). The carvings around the windows follow the common flower-like motif which was typical for Holland (Eriksson and Rönnby 2012). No carved ornaments were found in the bow section. All three of the bitts found on board the "Swan" do not feature any carvings – usually the tops of the bitts were carved with heads of merchants or military figures in case of warships. This is highly unusual for a *fluit* – both "The Lion Wreck" and the "Ghost Ship" featured carved knightheads and lavish carvings in the stern (see Eriksson 2012, Eriksson and Rönnby 2012). No *hoekmen* were found in the stern. This does not necessarily mean that there were no *hoekmen*. Carvings were fixed to the ship's hull with iron nails which will rust, and the wood gets soft over time (Arrison 1994, 160, Eriksson 2014, 86). Considering this, it's possible that the *hoekmen* have just fallen off their original position or have been removed by the trawl. There is a large debris field all around the wreck which is still waiting for research. Divers (including the author) have mentioned seeing two objects on the seabed next to the stern that could possibly be *hoekmen*, but at the moment there is only a limited video footage of these potential objects that does not allow any definite conclusions. Rudder, with the tiller still attached to it, has been torn off the wreck and now lies some distance away on the starboard side near the stern. Clear and deep drag mark in the sediment follows it from the stern to its current location. The rudder features a simple carving that seems to follow the same motif as the windows (figure 12). Similar carving of three flowers can be observed on the rudder of the "Ghost Ship".

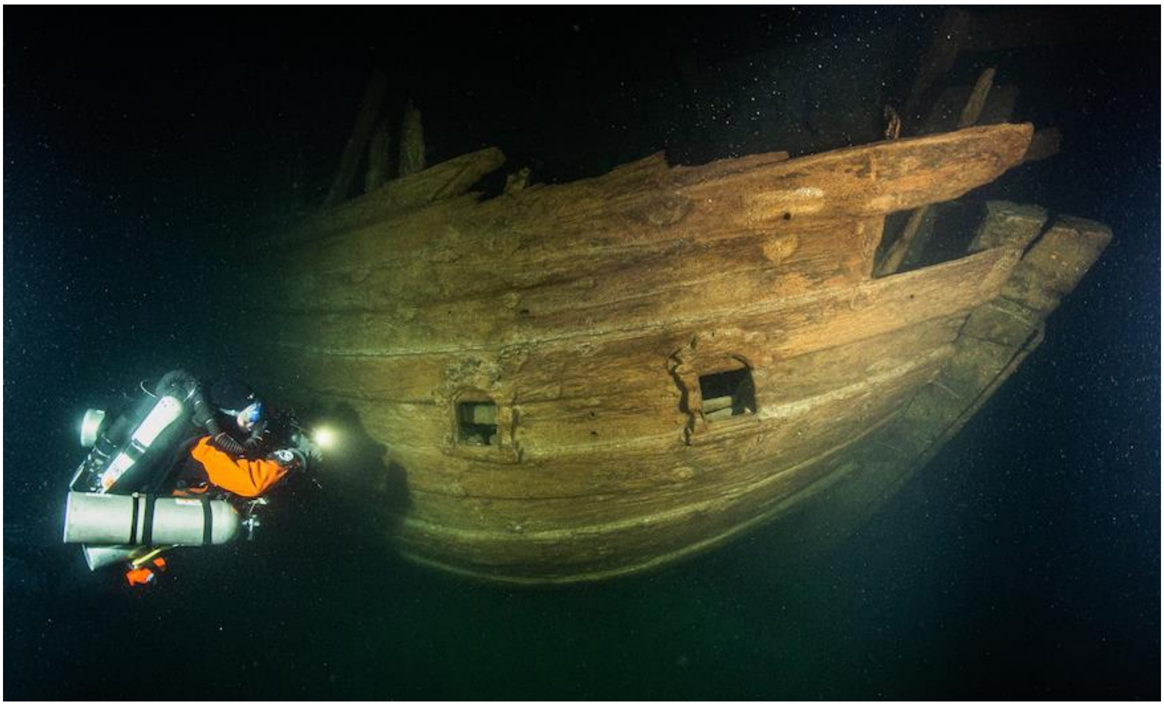

Figure 11. Carvings around the windows. Note the two holes between the windows that were probably used for opening and fixing the window hatches (Jouni Polkko 2020).

Figure 12. Carving on top of the rudder (Ivar Treffner 2021).

3.4.6. The transom

The stern of the *fluit* had a narrow flat transom high above the lower hull. The shape of the transom closely resembles the transom of a *fluit* depicted on a painting "View of the Hoorn" by Abraham de Verwer (ca 1650)[12]. The "Swan's" transom has fallen down and lies on the bottom a few meters from the stern. It was first identified as a possible transom from the videos shot in 2020, because of its peculiar shape. The plank on the videos was long and narrow and around the top part there seemed to be a carved ornament. Because no other carvings were visible, it was believed to be upside down. Flipping the possible transom around became one of the goals of 2021 field works. The transom and area around it were thoroughly documented before the operation. Another smaller piece of wood with unusual shape was identified next to the transom. The flipping operation was carried out manually by two divers holding the transom from both ends. When the water cleared after the flipping it was clear that this was indeed the transom. Length of the transom is approximately 200 cm and the width in the middle ca 40cm. A swan (hence the working name of the vessel) and a figure 1636 were carved on the transom along with some decorations. 1636 represents the year the vessel was built, making her older

[12] The painting can be seen online at https://www.nga.gov/collection/art-object-page.140376.html (accessed 21.04.2022)

than the estimates for other well-preserved *fluits*. The swan depicts the name of the vessel. "Swan"-themed names were quite common on *fluits*. The "Ghost Ship" could have also been named similarly, because a sculpture of a bird resembling a swan was found on the seabed next to the stern (Eriksson 2014, 156). Under and above the swan figure spiral decorations can be seen. Under the swan carving a two-holed deadeye is stuck to the transom. Two-holed deadeyes were not as common as three-holed deadeyes and were mostly used on parrel rope for the mizzen yard, making it possible to control the yard from the deck. It makes sense to find this type of the deadeye in the stern area. The deadeye had probably fallen to the seabed when the ship sank or when the rigging rotted away and once the nails holding the transom rusted, it fell upon the deadeye. Or it could have happened when the trawl damaged the wreck, but that probably did not happen so long ago for the deadeye to get fixed on the transom. Immediate inspection of the transom did not reveal the coat-of-arms of the home port and so it was assumed that the smaller wooden plank close to the transom may be the coat-of-arms. The author does not consider himself an expert on wooden carvings, but even to an untrained eye the carvings on the transom seem rather simplistic and not too elaborate.

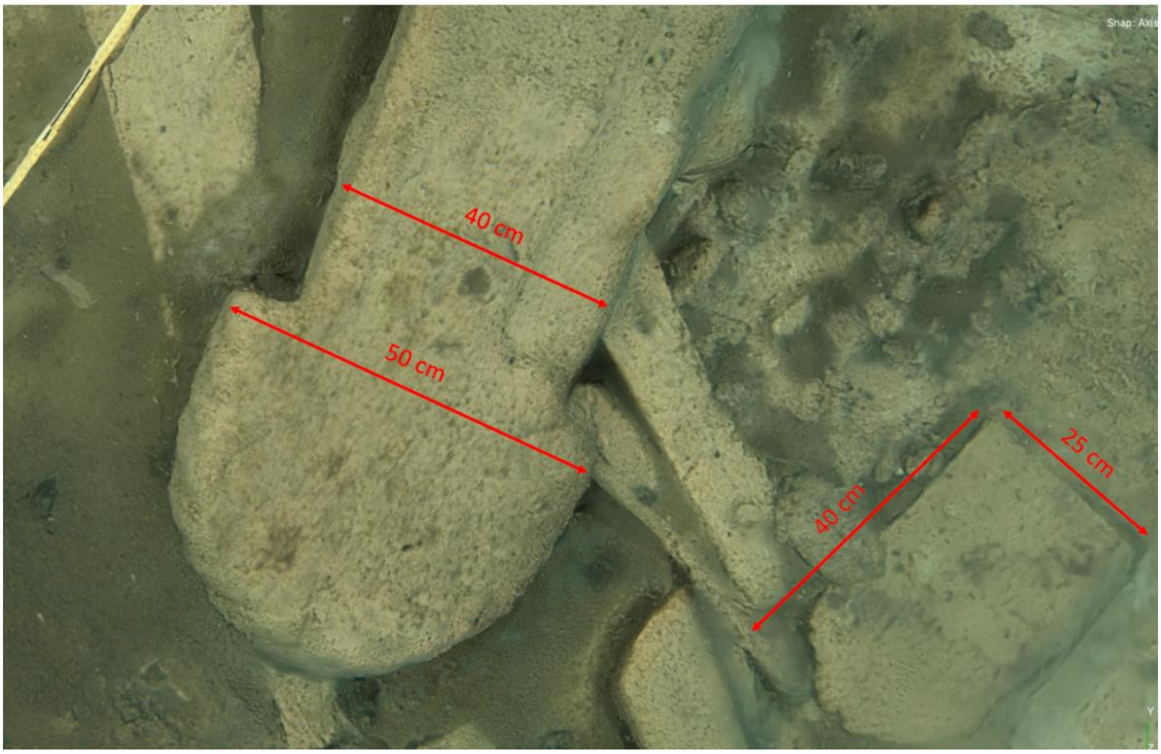

Figure 13. The transom in its original position, presumed coat-of-arms and its dimensions on the lower right corner (Jouni Polkko 2021).

Figure 14. The transom after being flipped around (Jouni Polkko 2021).

Figure 15. Carvings on the transom – the swan (left) and 1636 (right) (Jouni Polkko 2021).

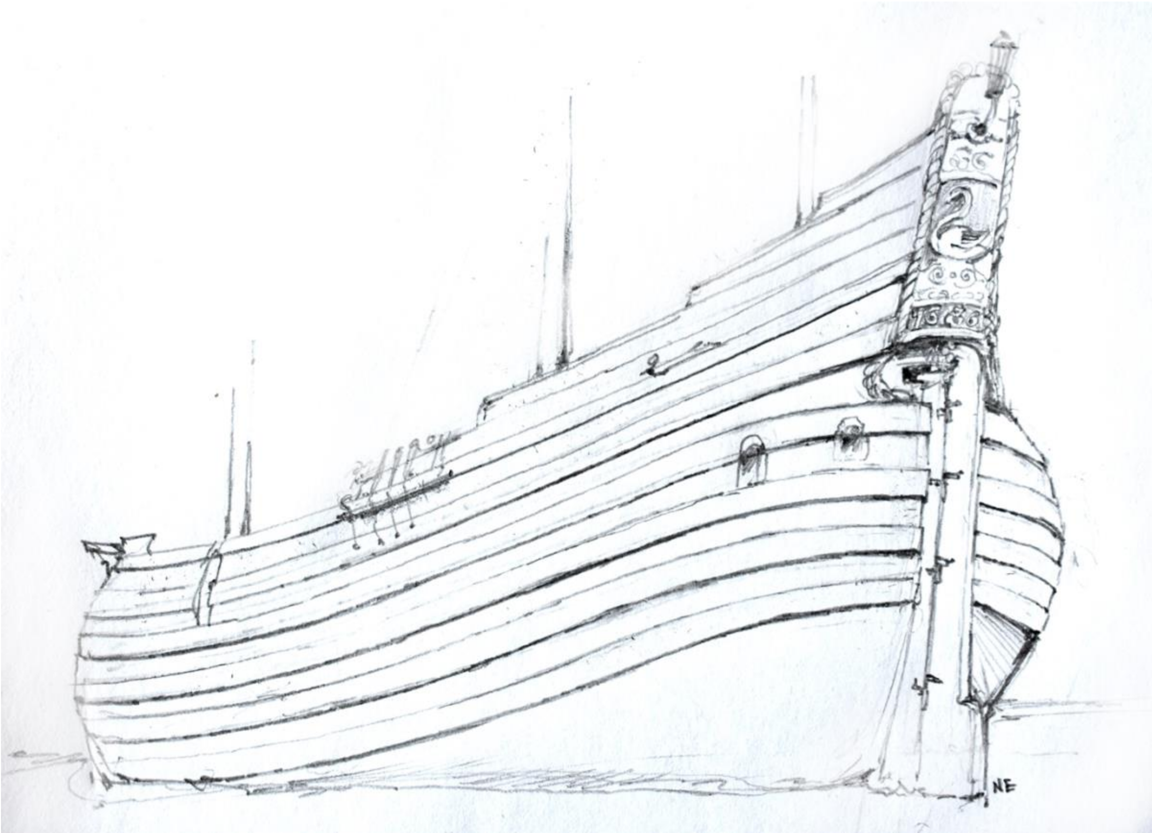

Figure 16. Artist's interpretation of the "Swan's" stern (drawing by Niklas Eriksson 2021).

3.4.7. Window hatch

Since no coat-of-arms was found on the transom, it was decided in consultation with Finnish Heritage Agency representative during the fieldwork to recover the wooden plate thought to be the coat-of-arms. Because of the small size and lightness of the object a mesh bag was used for recovery. Once surfaced the object was immediately put to protective plastic box filled with seawater. However, it was clear that the plate was not the coat-of-arms, but a window hatch. Judging by its location it probably used to cover one of the port side windows. The hatch has a cut-in on two sides on the inner side of the plate to fit snugly into the window opening. On the outer side clear marks from the hinges are still visible. Hinges have rusted away. A 3D model of the window hatch has been created and it can be viewed in Sketchfab[13]. The hatch itself is now in Finnish Heritage Agency's Collection and Conservation Centre. Samples for

[13] See https://sketchfab.com/3d-models/floitti-luukku-c41c99a7dd8a442d8875d697f032c476 (accessed 13.04.2022)

XRF-analysis[14] have been taken from the hatch on 30.03.2022, but the results are not yet in (personal communication with Minna Koivikko, 2022).

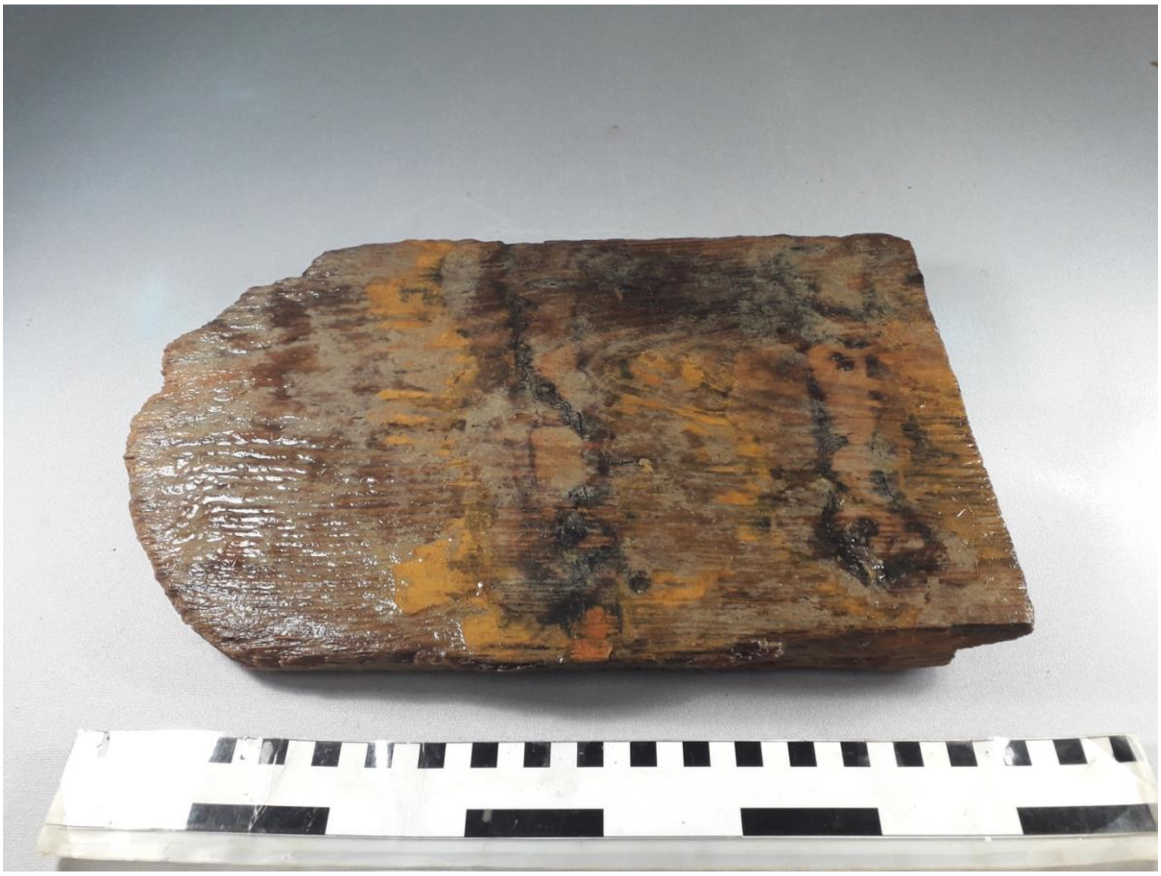

Figure 17. Recovered window hatch, outer side with marks left by hinges (Liisa Näsänen, Kansallismuseo 2021).

[14] For more information on XRF-analysis, see Szökefalvi-Nagy *et al*., 2004, Löwemark *et al*. 2019

Figure 18. Recovered window hatch, inner side (Liisa Näsänen, Kansallismuseo 2021).

4. Discussion

The "Swan" is a curious wreck that on one hand it proves many of the theories and today's knowledge about the *fluits* and on the other hand it raises quite a few questions. The length-to-breath ratio, peculiar hull shape and rigging are just a few examples that correspond well with what is known today about *fluits*. The wreck confirms some of the theories that have been formed about the *fluit* based on the findings in the literature, art and other *fluit* wrecks. However, what about the differences – are those significant enough to rethink some of the theories we know? It is obvious that the "Swan" was a workhorse, a true "Baltic grain-carrier" that was also called *Oostervaerder* (see Unger 1994) and the first well-preserved wreck of this type of *fluit* found. She was large ship designed to maximise the profits. But there are some differences from the "regular" *fluits* that make her special. For example – if further research proves that there are four cargo hatches on the deck, then this would be highly irregular. One reason for an additional hatch would be that the orlop deck was divided by a bulkhead somewhere and additional entry from the deck would make it easier to load and unload that space. Even if that was the case, the question remains – why divide the orlop deck and what was the purpose of the extra space?

As it was pointed out the Dutch ships were all highly decorated with carvings. It was also a symbol of status. So why did the "Swan" have only a few carvings? None of the bitts featured standard head figures and only had conical wooden stumps. It could be argued that maybe first *fluits* didn't have so many carvings and maybe it was not yet popular at the time. However, the "Swan" was built in 1636, so around 40 years later than the first *fluits* appeared. And lavish decorations were already a norm at that time. So why not decorate this ship according to the contemporary standards? As *fluits* were built to maximise profits, it could be possible that the owners were not rich or yet well-established in the business and ordered a "blank" version of the vessel to save money, but that seems a bit far-fetched. Let's consider another possibility. It would make sense that the ships sailing to Western Europe's cities or even to Stockholm would be highly decorated. It would demonstrate the status and wealth of the owners. This could even be considered as a contemporary business card – the decorations show that the owners are wealthy merchants and probably trustworthy partners. The owners could have afforded a "properly" decorated ship but decided to go with the cheapest option for this size of a ship. Why? The wreck lies in the mouth of Gulf of Finland, so it's quite safe to assume she was on her way to or from one of the ports by the Gulf. It doesn't matter which side of the Gulf those ports were because this would have been anyway a periphery of the Swedish empire and in the beginning of 17th century Sweden itself was considered a periphery of European economy (Müller 2009, 30; Edvinsson 2009, 3). If the ship-owners bought the "Swan" to be purely a raw material carrier from the outer edges of modern Europe, from lands that just mere centuries ago were full of pagans – could they opted for a cheaper "blank" version of the vessel because showing their wealth or having the "right" image in the eyes of the locals just did not matter to them? Maximising return from the investment could have been a factor. What if the simple composition and minimal standard decorations reflect the common cargo of raw materials she was built to carry? From the Sound Toll Register we know that some vessels sailed to Estonia in ballast (see page 8) – could the "Swan" be one of those vessels mainly carrying raw materials from the Gulf of Finland ports to, for example, Amsterdam?

There's yet another possibility – the ship was not built in the Netherlands and maybe even not owned by the Dutch. It's possible that she was built by a Dutch shipwright employed somewhere else outside The Netherlands. The role Dutch shipwrights played in Swedish shipbuilding is well documented, although it mostly concentrates on the area covered by Sweden today (see Jakobsson 2021). Less is known about the Swedish overseas regions. However, it is not unreasonable to assume that Dutch shipwrights found their way to the Swedish lands on the eastern side of the Baltic Sea. Riga was the biggest Sweden's Baltic port both in import and export accounting for over a three-quarters of total export value of Baltic ports under Swedish rule (Attman 1981, 181). During 1630s Riga had a Dutch mint master and a burgher named Martin Wulff, from whom in 1631 the Swedish Admiralty ordered three ships. To ensure necessary shipbuilding expertise, twelve experienced Dutch ship carpenters were sent to Riga (Jakobsson 2021, 130–131). It's possible that after completing those three ships the carpenters built more ships in Riga and it would stand to reason that other Dutch shipwrights might have found their way to the shipyards in Finland or in the Baltics. If, in fact, it will be confirmed that the "Swan" was built on the eastern shores of the Baltic Sea or in Finland, it would offer a unique view into Dutch-influenced shipbuilding tradition and methods in the region.

Courland with its large oak forests had shipyards in Goldingen (Kuldiga) already in the end of the 16th century. Even though during 1630s–1640s the main product was a two-masted galliot, it's possible that other types of ships were built there too. Ships were built also for export (Anderson 1959, 264). By 1658 there were 18 Dutch shipwrights employed in Vindau

(Ventspils). The third bigger shipyard was established in Libau (Liepaja), and local shipwrights used the Dutch vessels as examples in ship design (Vunk 2016, 21–22).

Turku in Finland had large shipyard and shipbuilding started there in the first half of 16th century (Ratilainen 2012, 9). Another important shipbuilding area in Finland was Ostrobothnia, where large-scale shipbuilding is recorded already in the end of 16th century. In mid-1580s Pedersöre shipyard in Ostrobothnia employed 480 men to handle logistics for shipbuilding material along with 60 peasants who were involved in shipbuilding (Huhtamies 2021). And by the end of 17th century around 20 brand new merchant ships were built and sold to Stockholm in Kokkola alone (Ojala 1997). These and other shipyards in Finland could have produced also *fluits*.

The situation in Estonia is not so clear as there is little to no information about shipyards from the first half of 17th century that would have been capable of building such a vessel. Vunk (2016) believes that bigger merchant vessels were not built in Estonia until the end of 17th century. Smaller vessels were built in Reval (Tallinn), Hiiumaa and probably other places. Reval was an important trade centre in Swedish areas around Gulf of Finland, especially for Russian imports. For a period of time, Reval along with Vyborg were the only ports where foreign ships were allowed to trade (Kotilainen 2005). Kotilainen (*ibid*., 174) writes that "(i)n 1680, Reval citizens still owned some 30 ships" indicating that the number had been greater. Unfortunately, there is no information where these ships were built and what type they were. Considering that the *fluit* was by far the most numerous vessel type in the Baltic trade, it would be safe to assume that at least some of the ships owned by Revalers were *fluits*.

In Narva, wood industry emerged in the 1670s and it became a locally significant shipbuilding centre (Soom 1963, 212). The Dutch and English merchants residing in Narva built around a dozen ships of 100–200 *lasts* between 1689–1697 (Küng 2011a; Vunk 2016). However, the shipbuilding "boom" in Narva happened a lot later than the "Swan" was built. On the other hand, with the 1617 Sailing Ordinance Swedish Crown gave the citizens of Narva the right to overseas trade using their own vessels (Kotilainen 2005). This means that already at that time there must have been a considerable number of vessels owned by the citizens of Narva for this clause to be added to the Ordinance. By 1690s there were more than 10 Narva-controlled vessels of 40–280 *lasts* (80–560 tons) that were active in long distance trade through the Danish Sound (*ibid*.). Some of these or earlier vessels could have been *fluits*.

There's statistical evidence of timber trade out of Pärnu since 1652. On that year all the timber was shipped out by the Dutch, and it wasn't the only export article. Other raw materials like grain, flax and hemp were exported too (Küng 2011b). As is the case of Narva, the timber industry was established only in the second half of the 17th century. And, unlike Narva, there is no evidence of a large-scale shipbuilding in Pärnu during that period. However, these ports could have been visited by the "Swan" to pick up raw materials.

If the "Swan" was locally built on the eastern side of the Baltic Sea, she was most probably built in either Riga, Courland or Turku, although other locations can't be ruled out completely. It is possible that the owners were not Dutch, and they may not have had the same affection for decorations as did the Dutch. Maybe they even viewed those as an unnecessary expense for a simple grain carrier. It could also be that there was a shortage of skilled carvers in local shipyards at the time of the building. That could be the reason for the difference in the carving pattern. And the motivation to build the *fluit* in Swedish shipyard could come from the fact that Sweden-built and Swedish-owned merchant vessels received tax reduction even if they were not able to carry guns (Müller 2009).

These theories can be proven or disproven with further research into the living quarters of the crew and the cargo. Of course, it is possible that none of theories offered above are true or the truth is a combination of some or all of them. Further research is necessary to document the area and objects around the wreck. A side-scan sonar survey with a radius of 50–100 meters around the wreck would be enough to identify bigger details that have either fallen off the ship during sinking or were removed by the trawl. The objects found should be documented and recorded. The main aim of this would be to identify characteristic elements that could help identifying the vessel. One of the greatest challenges in deep water archaeology is how to perform necessary tasks safely and within budget. These two things go hand-in-hand. The use of divers is always limited in deep water archaeology, mostly due to the short bottom times, long decompression and associated risks. It may be feasible to use divers recording the objects close to the wreck, but for objects further away using a ROV is safer and better option. There are some limitations, of course. If the object needs to be cleaned of the sediment or if it needs to be turned like the transom, it may be difficult or impossible to do with a ROV. Yes, there are ROVs that can do that, but here comes into play one of the biggest limitations in deep water archaeology – the budget. Is there such a ROV available and is there enough budget to rent it? Bigger and more advanced ROVs are considerably more expensive and need more equipment or even bigger support vessels on the surface (i.e., due to the weight a crane may be needed to get the ROV into and hoist it out of the water). And would this cost be justified, if these objects turn out to be nothing more than nondescript bits and pieces of planking or similar? Even is there would be enough budget for that, maybe this money could be used more efficiently to do something else? It may be more feasible to record the objects with simpler (cheaper) ROV and then have divers to check out the objects that are most promising and need physical manipulation. The risks of this need to be weighted thoroughly against the possible benefits.

Both cargo-hold and the living quarters in the stern need to be included in future research plans. If it is possible to remove the sediment in the cargo hold to the level that the cargo is visible, it will be possible to visually identify the type of cargo (at least the part that is visible) and take samples if that is necessary (for example, to identify the type and origin of the grain). The cargo could indicate the last port of call Removing sediments from the stern might reveal personal items of the crew or table/kitchenware. These may offer insight about the origins of the crew or at least the route the vessel was mainly sailing. This needs to be well planned to assure the safety of the divers. Using ejectors and other surface-supplied equipment is possible, but again – it is very expensive and needs extensive surface-support. Removal of sediment manually (by fanning) may prove to be ineffective and is potentially dangerous for the divers (over-exertion and loss of visibility). In deep water, there is no time for the diver to wait for the visibility to clear to see the results of the sediment removal, unless there is strong current that quickly carries away the particles flowing in the water (strong current can be another risk factor – for example inability of a diver to make it back to the ascent line and then drifting away from the operation area while in decompression that can last up to 3 hours). One option would be to divide the tasks between teams. One team will install guideline, perform the removal, and then leave the area using the guideline. Another team records and studies the results if there are any. Again, it comes down to the feasibility and risk assessment. Bulkheads and furniture could shed light into the internal layout of the living quarters and the arrangement of living space. Finnish Heritage Agency is planning to recover the transom to conserve it (personal communication with Minna Koivikko, 2022). An XRF-analysis is planned to be carried out on the transom to identify possible paint remains. It is possible that the coat-of-arms of the home port of the vessel was not carved but painted on the transom which could shed light on the origin of the vessel. What must be considered, is that once the object is recovered it is irreversible action. The challenge is not just to get the object to the surface, but also getting it out of the water and transporting it to the land without damaging the object. The recovery of the window hatch showed that the uppermost layers of the wood are extremely fragile and can disintegrate even at a slightest touch. Fragile artifacts need to be reinforced and packed before any recovery operation (Chen *et al*. 2022). It will be a challenge to recover a large object like the transom. First, a suitable lifting frame or box must be built, where the transom will be put during the lifting and subsequent transport. The device must be light enough to be handled without heavy machinery on the surface. It must be closed enough to limit the water movement inside while lifting (to preserve the fragile wood) and keep the water in during the transport to the conservation facility. This means the weight of the water inside the device must be taken into consideration when lifting the device out of the water. Next challenge would be to decide on the suitable lifting method from the surface. Lifting bags are the simplest option however it would be an uncontrolled ascent. Main risk here is the possibility of a lift bag spill on the surface and the resulting loss of the artefact. This risk increases with depth. One consideration could be using a ROV for the recovery operation or a winch/crane from the surface. The lifting device and the wire from the surface can be taken to the transom on the bottom by ROV. The divers will carefully lift the transom into the lifting device and attach the wire for the crane. The whole lifting operation can then be monitored by ROV ascending with the device.

There are probably many more possibilities to perform the above-mentioned operations, those are just a few possible challenges and solutions to them. It is almost guaranteed that all the challenges can't be foreseen and many of them need to be overcome on-site. That's why deep-water archaeology needs a creative but always conservative approach.

5. Summary

This thesis summarises the results of the fieldwork carried out on a well-preserved *fluit* wreck which was found in Finnish waters between the island of Hiiumaa in Estonia and peninsula of Hanko in Finland in 2020. Curiously, this wreck confirms some of the knowledge already known about the *fluits*, but also displays some new features and raises questions that need to be answered.

The first part of this thesis discusses the historical and economic environment of the 17th century Europe with a focus on the Netherlands and the Baltic trade – the "mother of trade" for the Dutch. It was the time when the *fluits* ruled the seas and not only in the Baltic Sea and contributed significantly to the economic growth of the Low Countries. Of course, it wasn't only the *fluit* and the maritime trade that fuelled the growth. Other factors like political situation, technological advancements and urbanisation played their part in it too. However, when it came to maritime trade the cheap and easy-to-handle *fluit* outnumbered all the other merchant vessels combined in the Baltic Sea. She wasn't a fast ship, with her bulky hull, pear-shaped stern, short masts and simple rigging, but she could carry a lot of cargo and could be handled with fewer men than any other vessel. Because of the trade network that the Dutch had set up between the East and the West Europe, the *fluits* were able to sail year-round, supplying Baltic raw materials to Western and Southern Europe and bringing back high-value commodities to the Baltic Sea. All this enabled the Dutch to offer the lowest freight rates in the Europe.

The second part of the thesis concentrates on the fieldwork done on the wreck in 2020 and 2021. This thesis analyses the information gathered from the dives and from the 3D model and describes the wreck in detail. This information is then compared against our current knowledge about the *fluits*. It is important, because so well-preserved "Baltic grain-carrier"-type of *fluits* have not been found before and the information presented in this thesis offers the first detailed view of the construction and layout specifics of a "Baltic grain-carrier" giving the researchers an opportunity to study this wreck further without actually going underwater. Researchers can use the description of the wreck and the images from the wreck and 3D model as a basis for future research, interpretations and discussions.

In the fieldwork part also the similarities and differences have been pointed out that the "Swan" has compared to the information known about the *fluits*. She has the typical shape, size and proportions of a typical *Oostervaerder* – 5:1 length-to-breadth ratio, just above-the-average capacity (300 tons vs average 240 tons), low bow and a high stern. She was carvel-built and full-rigged, also a standard for the *fluits*. The forecastle, quarterdeck, top cabin - all those are according to the knowledge of how the *fluits* were built in general. This confirms the claim that *fluits* were standardised vessels that were just built in different sizes and the "Baltic grain-carrier" followed these patterns.

However, it's the differences that may change or add to the current understanding about the *fluits*. The differences are pointed out in the chapter 3.4 and its sub-chapters. And there are many which make this wreck unique. The window layout, the carvings, the cargo-hatches – to name just a few. It is possible, that these may have been a standard for the *Oostervaerder*, especially if the vessel was built outside the Netherlands. These deviations from the current knowledge about the *fluits* can also come from the fact that this vessel could have been built somewhere in the Eastern Baltic shores or Finland or owned by local merchants in the same area. The owners may have had a different perspective on how the ship should look like or, in case of carvings, it could have just as easily be that not enough skilled carvers were available. In this case the wreck would be a unique example of Dutch-influenced shipbuilding in the Northern Baltic Sea region. To confirm this, further research is necessary.

The "Swan" is a deep wreck at 85 meters. With depth come different challenges in research methods but also in safety. These are discussed in chapter 3.2 and in chapter 4. Photogrammetry helps to bring the wreck to the surface, eliminating the constraints imposed by the underwater environment. Dendrochronology can place the building or sinking of the ship into specific time or place (latter only applies to the building, obviously). In deep water, the same methods as in shallow water do not apply. In this thesis the main challenges are listed and some possible solutions are offered, but it must be kept in mind that there never is just one "right method". There are a lot of variables that need to be taken into account and that can't be planned for. So deep water archaeology is about creativity and flexibility, but also about conservatism when it comes to safety.

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