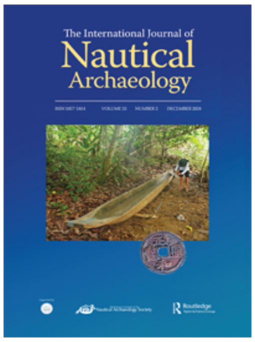

International Journal of Nautical Archaeology

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/rjna20

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To cite this article: Niklas Eriksson, Juha Flinkman, Minna Koivikko, Mia Lempiäinen-Avci, Martijn Manders, Liisa Näsänen, Jouni Polkko, Jirsi Reinders, Edd Stockdale & Ivar Treffner (26 Nov 2024): *Witte Swaen* from 1636. The Discovery and Archaeological Survey of an Intact *Fluit* in the Gulf of Finland, Baltic Sea, International Journal of Nautical Archaeology, DOI: 10.1080/10572414.2024.2413068

To link to this article: https://doi.org/10.1080/10572414.2024.2413068

Published online: 26 Nov 2024.

INTERNATIONAL JOURNAL OF NAUTICAL ARCHAEOLOGY
https://doi.org/10.1080/10572414.2024.2413068

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ABSTRACT

In 2020, the diving group Badewanne discovered an exceptionally well-preserved wreck in the Gulf of Finland, Baltic Sea. Researchers and divers from several different institutions collaborated to survey the wreck with the ambition of gathering as much archaeological information with as little impact on the wreck as possible. This paper summarizes the current state of research and argues that the wreck is the remains of a merchant *fluit* loaded with grain. Archival research has identified the ship as *Witte Swaen*, built in 1636 and sunk in 1638. Besides highlighting the fate of this particular *fluit*, the survey has revealed the characteristic hull shape as well as the sculptural decorations, which diverge from other later archaeologically surveyed *fluits* in the Baltic.

KEYWORDS
Baltic Sea; *fluit*; 17th century; carvings; barley; trade

PALABRAS CLAVE
Mar Báltico; *fluit*; siglo XVII; tallados; cebada; comercio

关键词
波罗的海; 福禄特帆船; 17 世纪; 雕刻图案; 大麦; 贸易

關鍵詞
波羅的海; 福祿特帆船; 17 世紀; 雕刻圖案; 大麥; 貿易

الكلمات الدلالية
بحر البلطيق
الفلوت
القرن السابع عشر
نقوش
شعير
تجارة

Witte Swaen de 1636: descubrimiento y estudio arqueológico de un *fluit* intacto en el golfo de Finlandia, mar Báltico

RESUMEN

En 2020, el grupo de buceo Badewanne descubrió un pecio excepcionalmente preservado en el golfo de Finlandia (mar Báltico). Investigadores y buceadores de varias instituciones colaboraron en el estudio del pecio, con la ambición de reunir la mayor cantidad de información arqueológica con el menor impacto posible sobre el pecio. Este artículo sintetiza el estado actual de la investigación y sostiene que el pecio corresponde a los restos de un filibote *(fluit)* mercante cargado con granos. La investigación de archivo ha identificado a la embarcación como *Witte Swaen*, construida en 1636 y hundida en 1638. Además de poner de relieve el destino de este *fluit* en particular, el estudio reveló la forma característica del casco, así como decoraciones esculturales, que divergen de otros filibotes posteriores investigados arqueológicamente en el Báltico.

1636 年造"白天鹅号"（*Witte Swaen*）：波罗的海芬兰湾一艘保存完好的福禄特帆船的发现与考古调查

摘要

2020年，潜水团体"浴盆"（Badewanne）在波罗的海芬兰湾发现了一艘保存极为完好的沉船。来自多个不同机构的研究员和潜水员共同合作对这艘沉船进行了勘测。其目的在于收集尽可能多的考古信息，同时尽可能减少对沉船产生的影响。本文总结了迄今为止的研究状况，并推断此沉船是一艘装满谷物的福禄特商船残骸。文献研究确认其为建于1636年并于1638年沉没的"白天鹅号"（*Witte Swaen*）。除了标示这艘特殊的福禄特商船的命运外，此次调查还揭示了其独特的船体形状和雕刻装饰，这与之后在波罗的海考古调查发现的其他福禄特帆船有所不同。

1636 年造「白天鵝號」（*Witte Swaen*）：波羅的海芬蘭灣一艘保存完好的福祿特帆船的發現與考古調查

摘要

2020年，潛水團體「浴盆」（Badewanne）在波羅的海芬蘭灣發現了一艘保存極為完好的沉船。來自多個不同機構的研究員和潛水員共同合作對這艘沉船進行了勘測。其目的在於收集盡可能多的考古訊息，同時盡可能減少對沉船產生的影響。本文總結了迄今為止的研究狀況，並推斷此沉船是一艘裝滿穀物的福祿特商船殘骸。文獻研究確認其為建於1636年並於1638年沉沒的「白天鵝號」（Witte Swaen）。除了標示這艘特殊的福祿特商船的命

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This article has been corrected with minor changes. These changes do not impact the academic content of the article.

運外，此次調查還揭示了其獨特的船體形狀和雕刻裝飾，這與之後在波羅的海考古調查發現的其他福祿特帆船有所不同。

ويتي سوين من عام ١٦٣٦: الاكتشاف والمسح الأثري لسفينة كاملة من نوع *الفلوت* في خليج فنلندا في بحر البلطيق

المُستخلص
اكتشفت مجموعة الغوص بادواني في عام ٢٠٢٠ حُطام سفينة محفوظاً بشكلاً استثنائياً في خليج فنلندا، بحر البلطيق. ولقد تعاون باحثون وغواصون من عدة مؤسسات مختلفة للقيام بمسح الحُطام وذلك بهدف جمع أكبر قدراً ممكناً من المعلومات الأثرية مع أقل تأثيراً ممكناً على الحُطام. تُلخص هذه الورقة ما توصلت اليه الابحاث وتُجادل أن الحُطام ما هو إلا بقايا لسفينة تجارية *الفلوت* وانها كانت مُحملة بالقمح. وقد حددت الأبحاث الأرشيفية السفينة بأنها السفينة "ويتي سويز" التي بنيت في عام ١٦٣٦ وغرقت في عام ١٦٨٣. وإلى جانب تسليط الضوء على مصير هذا *الفلوت* على وجه الخصوص، كشف المسح الأثري عن شكل هيكل السفينة المميز وكذلك الزخارف النحتية والتي تختلف عن سفن *الفلوت* الأخرى التي تم مسحها أثرياً في وقت لاحق في بحر البلطيق.

Introduction

The Gulf of Finland is the easternmost part of the Baltic Sea and reaches the estuary of the Neva River and present-day St Petersburg in Russia. In the 17th century, the area was part of the Swedish Kingdom, and Nyenskans, near present day St Petersburg, formed one of the most prominent harbours. The Gulf has a long continuity for trading contacts and exchange as well as for warfare. Over the centuries, it has formed a battleground in several conflicts, which have resulted in many lost vessels. The seabed in the Gulf of Finland thus contains a unique cultural heritage that remains largely unexplored.

The Finnish diving team 'Badewanne' is a voluntary group of divers specializing in documenting First and Second World War wrecks in these waters. This work has resulted in several publications and presentations in various forms in media and conferencies, and the team is also involved in research on the threats of environmentally hazardous oil-containing shipwrecks and derelict fishing gear accumulated on them. The team closely co-operates with Finnish and Estonian civil and military authorities.

In 2006, the Finnish Transport Agency conducted a multibeam survey of an area in the Gulf and came across a wreck anomaly. The Badewanne team believed this anomaly to be either an early World War One minesweeper or a schooner from World War Two, known to have sunk in the area. An inspection dive was made in July 2020. At a depth of 85 m, it turned out to be an old, remarkably intact wooden hull resting on an even keel, with parts of rigging and hull components resting loosely on the seabed (Figures 1 and 2). Already during the first dives, it was clear that the wreck revealed several characteristics typical for 17th-century ships and, in particular, *fluits*. This type of merchant ship was developed in the Netherlands in the late 16th century and became one of the most common bulk carriers in regional Northern European commerce, especially on Baltic routes during the following century. *Fluits* are easily recognisable from the round and pear-shaped stern and relatively long hull designed for carrying cargo (Eriksson, 2014; Hoving, 1995; Jensen, 2018; Unger, 1994; Van Holck, 2021; Wegener, 2003, pp. 37–38).

This paper aims to describe the fieldwork at the site, the ship's architecture, results from analyses of the grain cargo, and the archaeological conclusions drawn so far. During fieldwork, the remains of the ship's transom were discovered intact. It revealed the image of a swan and the year of the ship's construction – 1636. This information has formed the departure for archival research that identified the wreck as *Witte Swaen* ('White Swan' in Dutch). There is always some uncertainty when it comes to identifying shipwrecks in written sources (see discussions in Cederlund, 1997, pp. 92–111; Eriksson, 2018; Harpster, 2013; Martin, 2017, p. 27; Rodgers et al., 2005) but as we regard the connection between the material remains and the written sources as very strong in this case, we have decided to call the ship *Witte Swaen* throughout the article rather than giving the wreck a working name.

Witte Swaen's long and narrow hull differs from other archaeologically-surveyed *fluit* wrecks, which have more box-like hulls. This article argues that *Witte Swaen* represents an early version of the *fluit* design, and that the discovery and the archaeological survey fill a gap in the knowledge of this iconic type of merchant vessel.

Project Organization and Fieldwork Campaigns

The discovery in the Gulf of Finland was made in July 2020 during the annual Badewanne diving camp. Over two days, the site was photographed and filmed, forming the basis for a photogrammetric 3D model of the wreck. The model was built from 4k video footage (frames downscaled 2k for the model) provided by two cameras (Sony A7sII and GoPro 7) from two dives each and from still photos taken with a Canon EOS5D mkIII collected during one dive. The 3D model was processed using Agisoft Metashape software. The model used 12,000 frames, resulting in a

Figure 1. The Baltic Sea area with the borders as they were when *Witte Swaen* sank in the 17th century (Niklas Eriksson).

2k model of the ship, and is under further development (Figure 2).

In 2021, a project plan with two main objectives was formed around the discovery: first, to carry out an archaeological survey and research concerning the wreck in order to learn as much as possible about the ship itself, its societal context, and the trade network it was used in; second, to produce a documentary film about trade, seafaring, and not least the importance of the *fluit* ships in early modern society. The project has included a variety of partners and organizations from several countries. Besides the Badewanne team, representatives from the Finnish Heritage Agency, Estonian Maritime Museum, CEMAS-Centre for Maritime Studies at Stockholm University in Sweden, the Cultural Heritage Agency of the Netherlands, and the University of Leiden were also present. The documentary film '*Fluit*' is produced by Handle Productions and Windmill Films and follows the entire research process. The project has been a collaborative effort, and the film team, researchers, and divers have shared and benefitted from each other's work.

Following the initial work in 2020, a 14-day field campaign was carried out in July 2021 to enhance the 3D model, searching for decorations on the seabed astern of the hull that might provide clues for possible identification of the wreck, as well as identifying potential areas for sampling of the ship's cargo. As the wreck is resting at 85 m depth of water, the adequate diver working time at the site under water is limited to around 20 minutes. The working conditions are dependent on temperature, visibility, and current. Access to the site is further limited by weather conditions, which can change in hours during a day in these waters. In addition, the site is located offshore, in the middle of an active sea route with busy shipping traffic. Every dive event has to start with finding the wreck since no ropes or marking buoys can stay at the site in order to avoid damage to the wreck. The obvious risk is the rope getting entangled in the wreck or a ship's propeller, and subsequently damaging the wreck. Also, uncontrolled diving at the site could create hazards.

Fieldwork has been carried out as non-intrusive as possible. The only artefact recovered during this campaign was a window shutter for one of the stern

Figure 2. 3D model of the hull seen from the stern, the bow, the starboard side and from above (Jouni Polkko/Badewanne).

windows. In total, teams of two to three divers made 15 dives on the wreck in 2021.

Fieldwork continued in July 2022 to examine the ship's structure and create 3D models of the rudder and to gather more general video material from the wreck. One of the main tasks was collecting sediment samples from inside and outside the hull in order to learn more abouth the grain cargo. Weather conditions limited diving to three days with three dive teams a day.

Preservation and Site Formation

Generally, the conditions for preserving organic material are favourable in the Baltic Sea thanks to the darkness, low salinity, cold temperatures and often low oxygen content of the deep-water layers. This leads to very slow physical, chemical, biochemical and biological decaying processes, and most importantly to the absence of *Teredo navalis* – also known generally as shipworm – which consumes wooden structures very rapidly in temperate oceanic environments. This means sunken ships can remain intact for centuries (Eriksson, 2014, pp. 15–16).

The ship rests with no obvious list on a flat seabed consisting of sand and silt. The preserved length of the hull is 32.75 m, and the breadth 6.7 m. The ship originally had three masts. The most visible damage at the wreck site is that it has been struck by a pelagic fishing trawler (Figures 2 and 3). The trawl hit the ship from the direction of bow, pushing the uppermost part of the stem into the hull, removing the lower masts of the fore- and mainmasts. In the bow, some remains of the trawl are stuck between planking, and pull marks left from the fishing gear are visible on the sides of the hull.

The mizzen mast (Figure 3B) has fallen towards the bow, which indicates that it probably fell before the trawl impacted the wreck. Mizzen masts on *fluits* were standing with their lower ends on the lower deck level, whereas the fore- and mainmasts were standing on top of the keelson, a much more robust construction. A similar site formation process – where the mizzen masts fall before the mainmast and foremast – can be observed on other wrecked *fluits* as well (Eriksson, 2012, pp. 21–23, 2014, p. 86; Eriksson & Rönnby, 2012, p. 356).

When the trawl struck the lower masts, the foremast pushed the windlass and the pawl-beam slightly aft, and the mainmast support pulled the deck beam abaft of the main hatch, which resulted in the coaming of the main hatch disintegrating into the hull.

The planking and most of the beams from the quarterdeck are gone. To what extent the trawler has

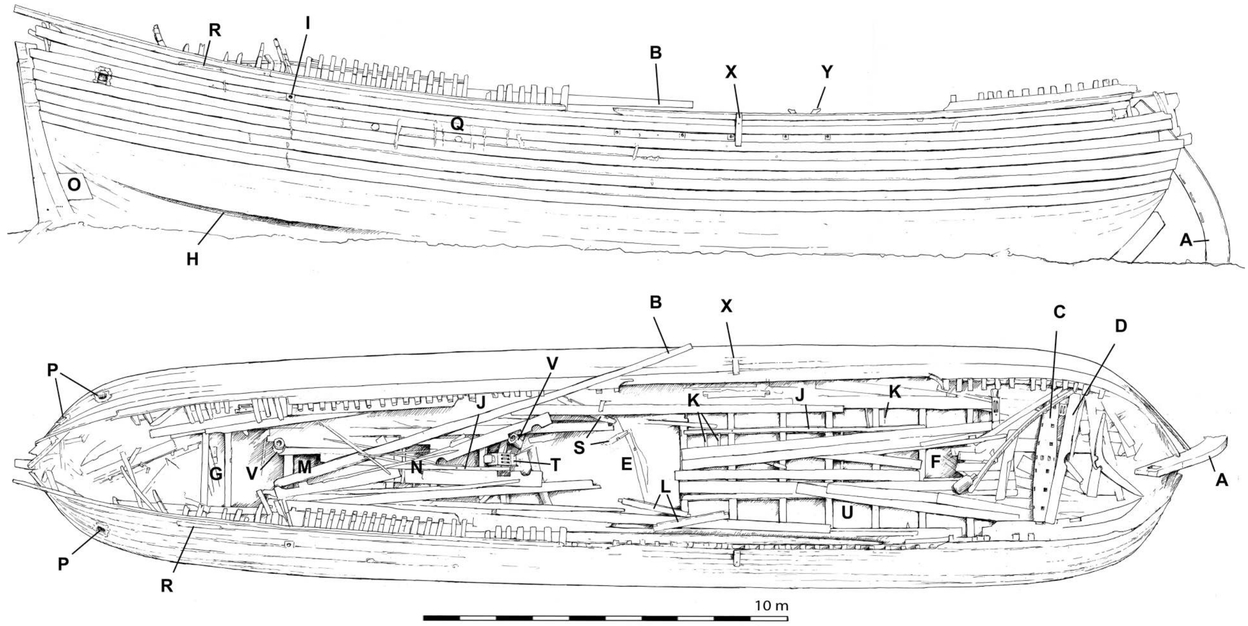

Figure 3. Plan and side view drawing of *Witte Swaen*. A: stem, B: mizzen mast, C: windlass, D: pawlbitt, E: main hatch, F: small hatch for cable tier, G: quarterdeck beams, H: crack in the lower hull, I: pumpdale, J: carlings, K: ledges, L: coaming for the main hatch, M: possible hatch, N: possible hatch, O: loading port, note the depth marks on the sternpost, P: cabin windows, Q: remains of chains, R: chainwale, S: remains of main top, T: main halliard knight, U: spar for main coarse, V: bilge pumps. X: chesstree (drawing by Niklas Eriksson compiled from Jouni Polkkos 3D model and photos).

caused the quarterdeck's disintegration may be disputed as it is a more lightweight construction than the upper deck. The planking of the quarterdeck may have come loose already during the sinking due to air pressure that builds up inside the hull as the ship sinks and fills with water. The stern's flat, uppermost part of the transom has disintegrated, and its components rest on the seabed astern of the wreck. We will return to these below. Otherwise, the hull is intact and still loaded with its cargo of grain.

Along the starboard side, below the waterline, there is a lengthwise crack in the planking in the lower part of the hull (Figure 3H). It is not possible to tell if this is the reason for the sinking, if it occurred when the hull hit the seabed, or if the trawl impact caused it.

Hull and Arrangement of Space

As with other *fluits*, *Witte Swaen's* hull is carvel-built. Research questions that relate to different building methods, construction sequences, and similar are usually difficult to answer from well-preserved Baltic shipwrecks as they tend to 'bounce against the intact hull side' (see discussion in Eriksson, 2014, pp. 34–35). However, the crack along the turn of the bilge reveals that the ship has only one layer of planking.

The hull has five wales, not counting the gunwale, which is slightly lower and has an elegant, planed profile. An interesting detail is that the wales are the only strakes of planking that are rebated into the stem (see Figure 3A).

In the bow and stern, where the hull rises above the gunwale, the sides are panelled in overlapping planks. These planks were attached to the frames with iron nails, which loosened and fell off the hull as the nails corroded.

As will be described more thoroughly below, the shape of *Witte Swaen's* hull diverges from other archaeologically-surveyed *fluits*. Still, the arrangement of decks and rooms inside the ship resembles other examples.

The upper deck is chiefly preserved and runs from the bow to just aft of the pump dale, which forms the main deck's aftermost deck beam. The deck is reinforced with carlings, which run over several deck beams. Before the main hatch, the carlings were in place, but they moved slightly in the area aft of the main hatch (Figure 3J). The deck is further reinforced with thin ledges, some of which are still preserved *in situ*.

The remains of the main hatch's coaming are resting near their original location (Figure 3L). There is also a smaller hatch in the forward part of the main deck, right aft of the windlass. This hatch would allow access to the cable tier (Figure 3F). The aft part of the main deck has disintegrated, and the remains are covered with loose planks and other parts. There seems to be another opening in connection to the pump-dale and a possible another opening some metres further towards the bow (Figure 3M and 3N)

Abaft of the pumps is the break of the quarterdeck. The height of this deck level is indicated by two deck beams preserved *in situ* (Figure 3G). Below the quarter deck in the stern are the rooms accommodating the crew.

An essential advantage of the *fluit*, often put forward as a factor contributing to its success, was that these ships could be sailed and operated with proportionally small crews. Often the *fluits* were sailed with around 12 or 13 men, whereas another vessel of similar size often required more than 17 (Kirby & Hinkkanen, 2000, p. 189; Lucassen & Unger, 2011, pp. 3–44, for discussion regarding ton-to-man ratio, see Van Tielhof & Van Zanden, 2011, p. 49; Van Zanden & Van Tielhof, 2009, pp. 289–403). Well-preserved wrecks of *fluits* have contributed to our understanding of the arrangement of space aboard these ships, and how these small crews occupied the space aboard (see Eriksson, 2014).

On other Baltic Sea *fluit* wrecks, the space under the quarter deck is divided into two rooms separated by a bulkhead. Usually, the hearth of the galley is located in the foremost room under the quarter deck, along the port side. It seems likely that it has also been the case aboard *Witte Swaen*, but no evidence has yet been identified.

Aft is the cabin that has formed the crew's main accommodation area. Parts of the disintegrated quarterdeck have fallen into the cabin, and the components give a slightly chaotic impression at first glance. Several standing stanchions that initially formed the supporting structures for bulkheads are still visible, indicating that there may still be some remarkably intact archaeological contexts in the cabin. Further investigations may shed new light on the division of space under the quarterdeck.

The stern cabin has three openings through the sides in the stern, two on the port side and one on the starboard side (Figure 3P). On the outside of the planking, these are framed by carefully carved window linings (Figure 4). These carvings are more significant than the openings through the hull planking. It is still being determined if the openings housed glass windows. As described below, one hatch, with a rounded upper end that would fit one of the carved openings, was found loose as part of debris on the seabed astern of the ship and recovered (Figure 18).

Below the main deck, hidden under sediments, there is likely a lower deck, which forms the floor of the crew's accommodation area in the stern (Figure 5). Below the lower deck is the large cargo hold. Access to the cargo holds was from above, through the main hatch before the main mast. Long objects like planks, spars, and timber could be loaded into the hold through a nailed-down port in the stern. The port is *ca.* 0.7 m high and 1 m wide (Figures 3O and 6). On the sternpost, just below the lower edge of the port, are depth marks in the form of four holes carved onto the sternpost.

Rig and Fittings

Fluits were ship-rigged with three masts and square sails. Even if the trawl pruned off the lower fore- and mainmasts, several fittings reveal their original position

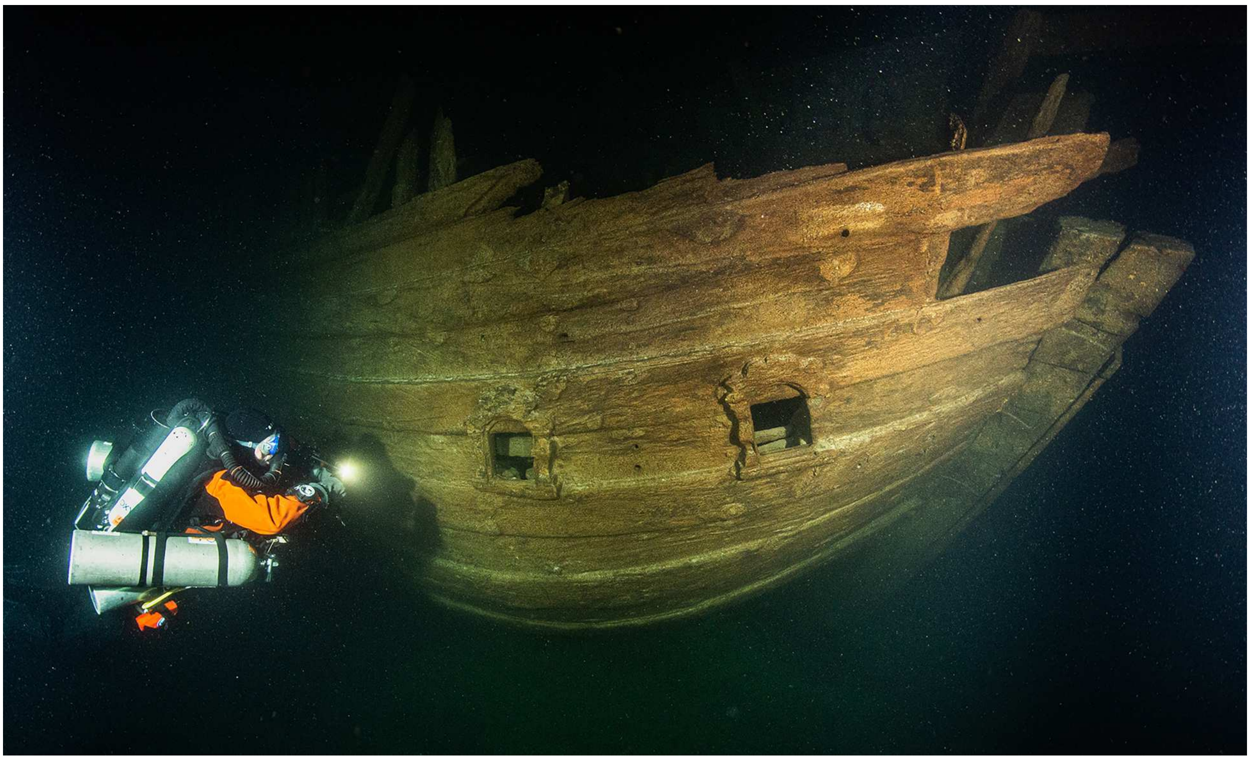

Figure 4. The cabin has two window openings on the port side surrounded by carved window openings (Jouni Polkko/Badewanne).

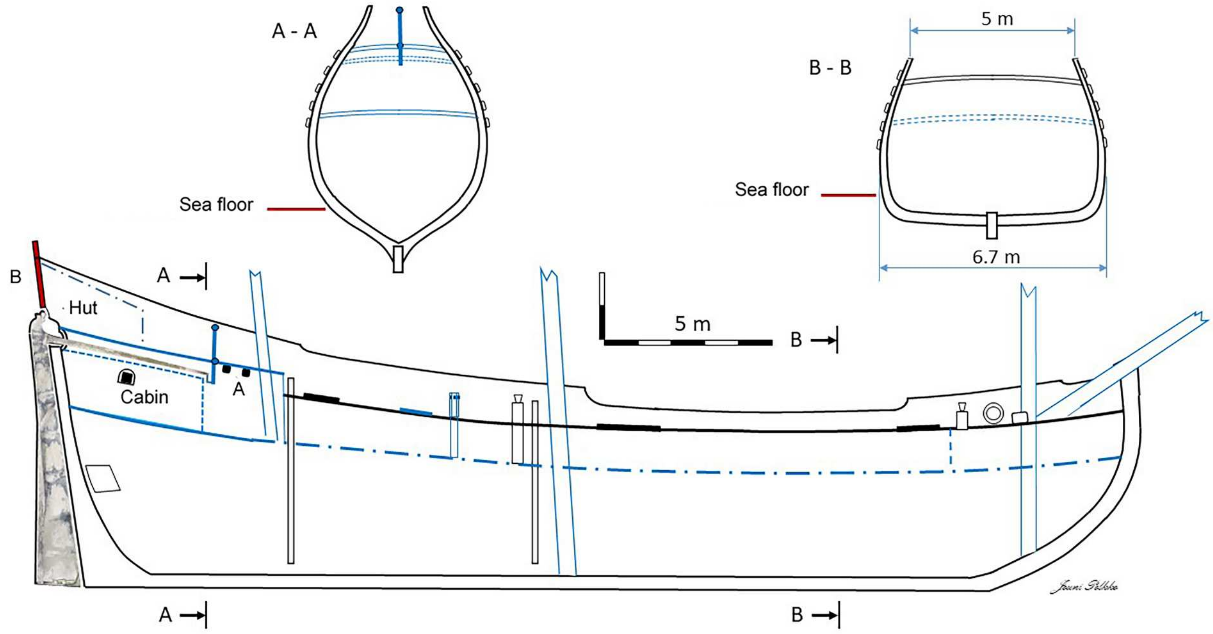

Figure 5. Longitudinal section sketch with the rudder reinserted to give the depth of the keel, whereas the transom (B) gives the height of the stern. Structures in blue are collapsed or below deck and not seen. Beams preserved *in situ* (A) indicate the height of the quarterdeck (the same crossbeams are shown in Figure 3G). Section A–A shows the location of the whipstaff. Tiller slot and cabin are presented as they could had been according to contemporary drawings (F.C. Keyser's *fluit* after Hoving, 1995, *Fluit* Graaf Floris in Sleeswyk, 2003). Level of seabed at the wreck is shown with the cross-sections. The shape of the hull below the seabed is after Witsen's plate XCIII (Hoving, 2012). Location of masts and angles are not known exactly, shown are most propable locations estimated according to knights, pumps and marks of hatches. Whipstaff was not seen or recognized at the wreck (Jouni Polkko/Badewanne).

on the ship. For instance, the pawl bitt just before the windlass (Figures 3D and 7) has a notch to fit the foremast. The fore halliard knight is found loose on the deck towards the port side aft the windlass.

The lower mainmast rests on the seabed along the starboard side of the ship. What appears to be the remains of the main top have fallen into the opening of the main hatch (Figure 3S) together with the knighthead for the halliards (Figures 3T and 8). Other *fluits*, such as the 'Ghost Ship', had a capstan aft of the mainmast to raise the main yard (Eriksson & Rönnby, 2012, p. 354). Semicircular cutaways in the loose deck planks aft of the mainmast might indicate that *Witte Swaen* had a capstan at a similar location. The main yard rests on the deck along the starboard side (Figure 3U). The tack for the main sail was led to chesstrees located on the outside of the hull a few metres before amidships (Figure 3X) (see Hocker, 2023, pp. 39–44, 70–71 for comparisons).

The remains of the chains that attached the shrouds to the hull are visible as rust encrustations on the outside of the hull. The starboard chainwale for the mizzen mast is still in place, whereas the others have come loose and fallen off. Several deadeyes used for adjusting the shrouds have been noticed scattered on the seabed by the wreck, and some are resting on the wales near their original position. One deadeye was discovered stuck on the transom (Figure 14).

The style of deadeyes changes over time, from a triangular shape in the 16th century to a round style during the 17th century. Even if they have not

Figure 6. On the starboard side just above the waterline there is a closed loading port for loading long objects into the hold (Jouni Polkko/Badewanne).

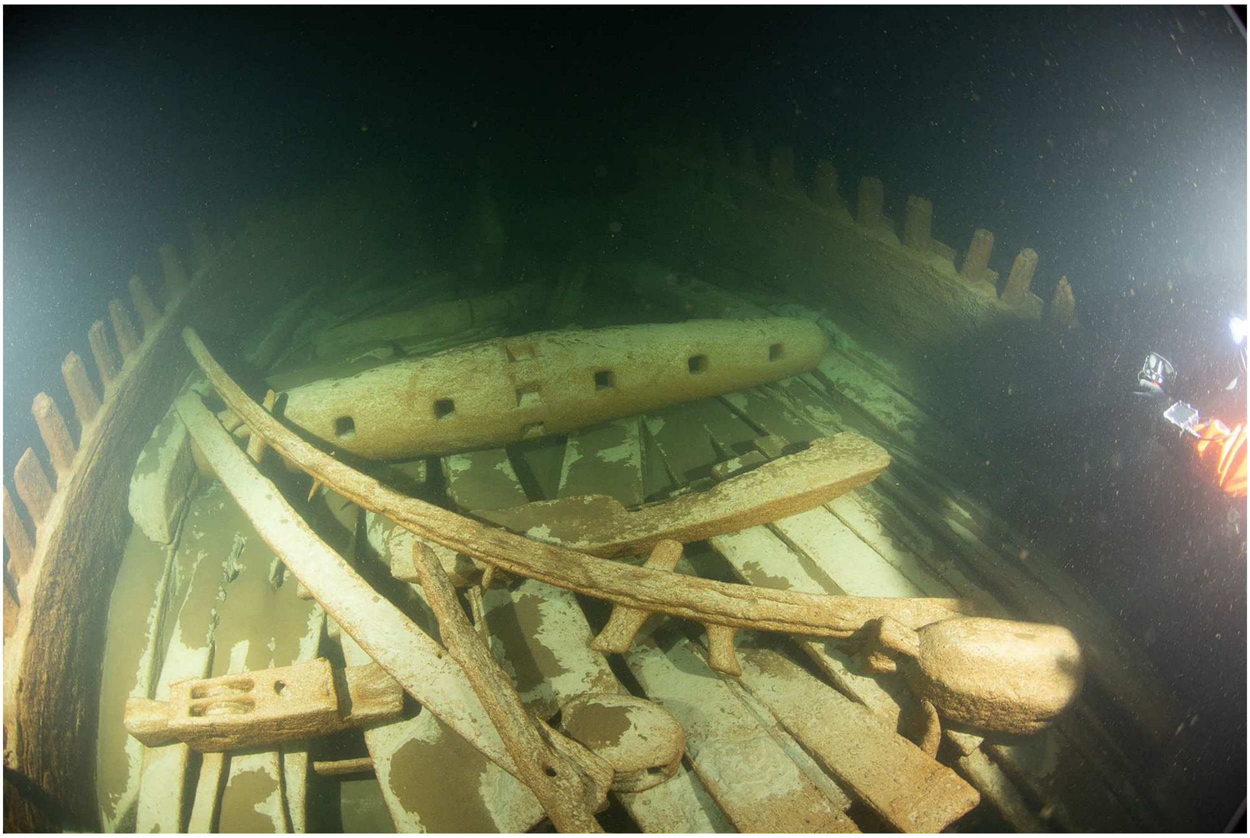

Figure 7. The windlass has moved slightly out of place. Note the beam with the pinrail and kevels as well as the knight (to the left) and an anchor bouy to the right (Jouni Polkko/Badewanne).

been studied in detail, the deadeyes observed on *Witte Swaen* appear to be of the triangular shape that was common on ships during the first decades of the 17th century and similar to those on *Vasa* from 1628 (see, for instance, Howe et al. 2023, pp. 125–140; Tsai, 2022).

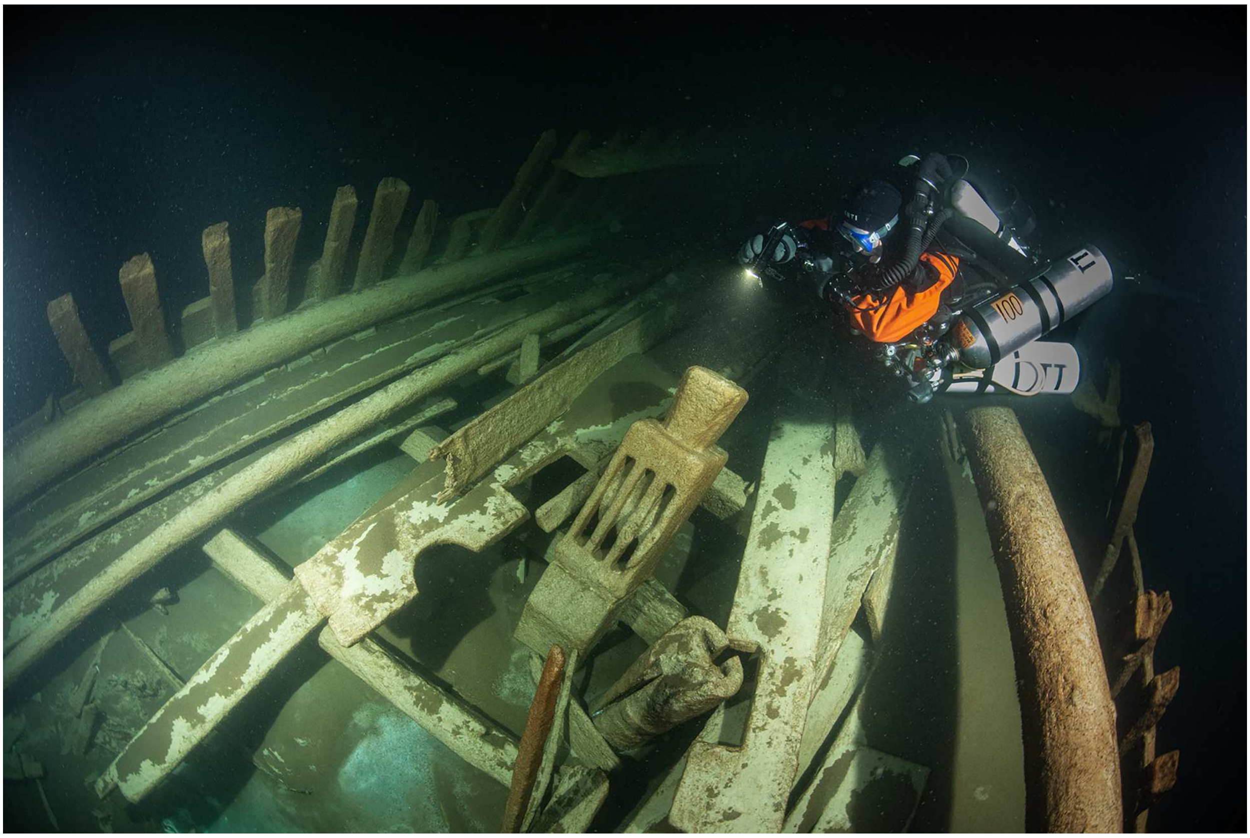

Figure 8. The main halliard knight and a pump tube to the right (Jouni Polkko/Badewanne).

As seen on other *fluit* wrecks the bilge pumps are connected to the aftermost deck beam, which also serve as a pump-dale (see several examples in Eriksson 2014). On *Witte Swaen*, only one pump tube is visibly connected to the pump dale, but as it is placed slightly to the port side, it is likely that there was another pump situated next to it. There is another pump in connection to the now-collapsed main hatch. In his treatise on shipbuilding, *Aeoloude En Hedendaegshe Scheeps-Bouw en Bestier* (Ancient and Modern Shipbuilding and Management), first published in 1671, Nicolaes Witsen writes that large ships have two pumps before the steering stand, and one near the main mast, which is similar to the arrangement on *Witte Swaen* (Hoving, 2012, p. 265).

An Early *Fluit*´s Hull Shape

According to the Dutch city of Hoorns chronicler Theodorus Velius, the *fluit* ship was invented by the merchant Pieter Jansz Liorne in 1595. However, most writers of today agree that the type was the result of gradual improvements over time (De Vries & Van Der Woude, 1997, p. 357; Eriksson, 2014, pp. 9–13; Hoving, 1995, pp. 47–48; Hoving & Emke, 2000, p. 34, Jensen, 2018, pp. 26–27; Ketting, 2006, pp. 9–13; Unger 1978, pp. 36–39; 1994, p. 121; Van Holck, 2021, pp. 37–38; Wegener 2003, p. 20). In any case, the *fluit* was a total success, and from the end of the 16th century to the mid-18th century, they were amongst the most common type of merchant vessels in Northern Europe and the Baltic Sea.

An aspect that has not been studied is how – and to what extent – the original *fluit* design changed over time. This lack of research has to do with the lack of available information. Few sources describe *fluits* in detail regarding their hull shape, internal arrangements, or carvings. Like many other early modern ships, *fluits* were built without constructional drawings. Instead, the hull was shaped using an extensive set of formulas and proportions. It was a complex design and construction method with predictable, repeatable results. The 'same ship' was built repeatedly, over and over again, but in different sizes (Hoving, 2012, pp. 15–18). The few drawings that have survived to the present were produced for the basis of discussion or as illustrations to literature (Eriksson 2014, pp. 12–15; Hoving, 1995, p. 48; Hoving & Emke 2000, p. 45; Rålamb 1943, p. 25, plate G.; Witsen, 1979, p. 160).

During the past decades, several well-preserved *fluit* wrecks have been discovered and archaeologically surveyed in the Baltic Sea as well as in Iceland (see Eriksson 2014 for an overview; Martin, 2022; Treffner & Lätti, 2024), but these ships date from the latter half of the 17th century.

Witte Swaen was built in 1636, so it is a relatively early example and adds important information on the early development of this iconic ship type. Soon after the wreck was discovered, it became clear that the ship differed in several aspects from the *fluit* wrecks of the later 17th century. To begin with, *Witte Swaen* is narrower than these *fluits*, perhaps not that surprising as the *fluits*' length-to-breadth proportions can vary between 4:1 to 6:1 (Unger, 1994, p. 121). Considering that the trawl has moved the stem, the original length between the stem and sternpost has been estimated to 32.75 ± 2% m, and the breadth 6.7 ± 2% m (Figure 9). By dividing the length by the beam, one will receive a ratio that facilitates comparison. *Witte Swaen's* length-to-beam

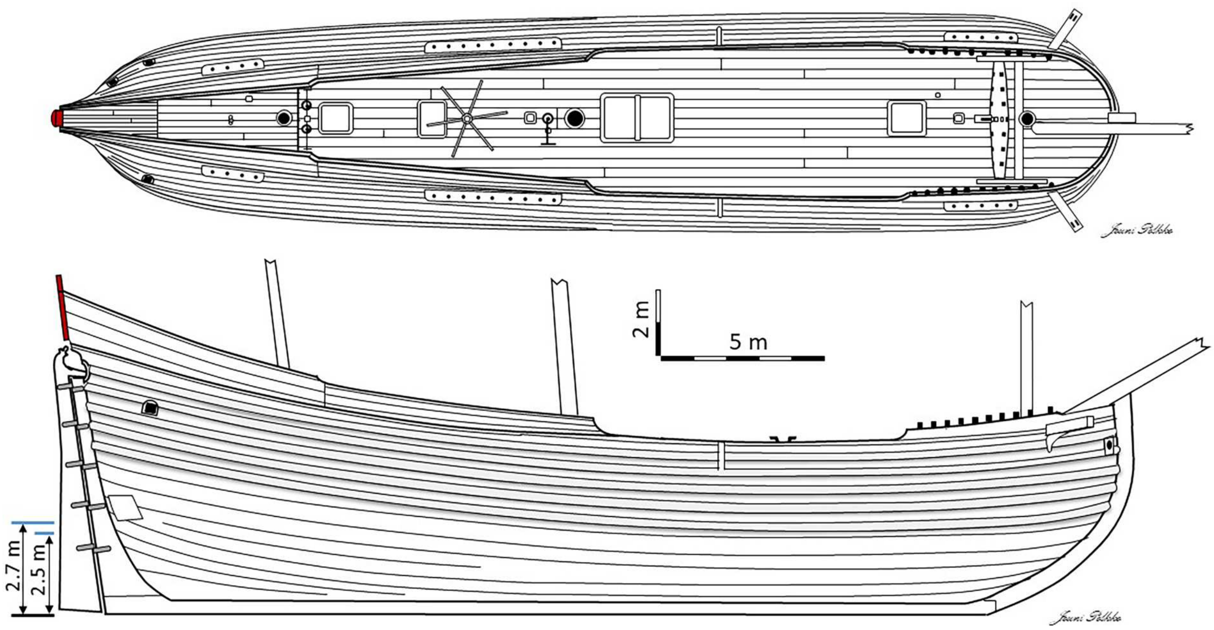

Figure 9. Reconstruction of *Witte Swaen*, its main dimensions and draught (Jouni Polkko/Badewanne).

ratio is approximately 4.88 ± 0.14, whereas the ratio for the above-mentioned 'Ghost Ship' and *Anna Maria* are 4.6 and 3.8, respectively (Eriksson, 2014, pp. 78, 86).

What is more striking than the proportions is that the shape of *Witte Swaen's* hull differs from other archaeologically-surveyed *fluits*. The bow is less blunt than on other, later *fluits*, which are nearly flat in the bow. In contrast to later *fluits*, the hull of *Witte Swaen* narrows from the quarter, making the stern slenderer. Conversely, in later *fluits*, the hull sides run more or less parallel when seen in plan view. The hulls of the 'Ghost Ship', dated through dendrochronology to 1669–93, and *Anna Maria* (Figure 10) from 1694 may be used for comparison (Ahlström, 1997, pp. 87–110; Eriksson, 2014, pp. 77–86; Koehler et al., 2017, pp. 457–459).

There may be a historical explanation for these differences in hull shape between *Witte Swaen* and the more recent *fluit* wrecks, which has to do with the development of ship measuring and the calculation at the Sound Toll when entering or sailing out from the Baltic.

The Sound Toll was calculated based on the size of the ship, but in the 17th century, the size of ships was measured through cargo-carrying capacity rather than displacement. Moreover – which is essential – the cargo-carrying capacity was not measured from the ship itself but from the cargo size. The actual size of a ship—or rather the true cargo capacity—was not revealed until it had sailed fully loaded. Thus, the cargo's size defined the ship's size and – as a consequence – the fee that should be paid at the Sound Toll (Ferreiro, 2007, pp. 191–194; Jensen, 2018).

According to a frequently reproduced historical misinterpretation, the Sound Toll was calculated by measuring the width of the deck (see Jensen, 2018, with references). It has been argued that the *fluits'* characteristic hull with the narrow deck was designed as a response to cut costs. In an important article, Mogens Jensen scrutinized this myth and explained that ships were not measured at all at the Sound but that changing routines for calculating the fees affected the *fluits'* design (Jensen, 2018, pp. 27–30).

Methods and formulas for calculating the cargo capacity from the main dimensions were used in other areas and have existed since the end of the Middle Ages. In the late 1500s, measurements of carrying capacity sprang up more or less simultaneously in different parts of Europe. The calculation formula used the hull's dimensions (keel length x beam x depth). There were other European units; in Italy and the Adriatic, the unit was *botta* and the English *tuns*, whereas in northern Europe, the Dutch and the Baltic Sea area used *lasts* (see overview in Ferreiro 2007, pp. 191–199). Most scholars agree that the *last* term

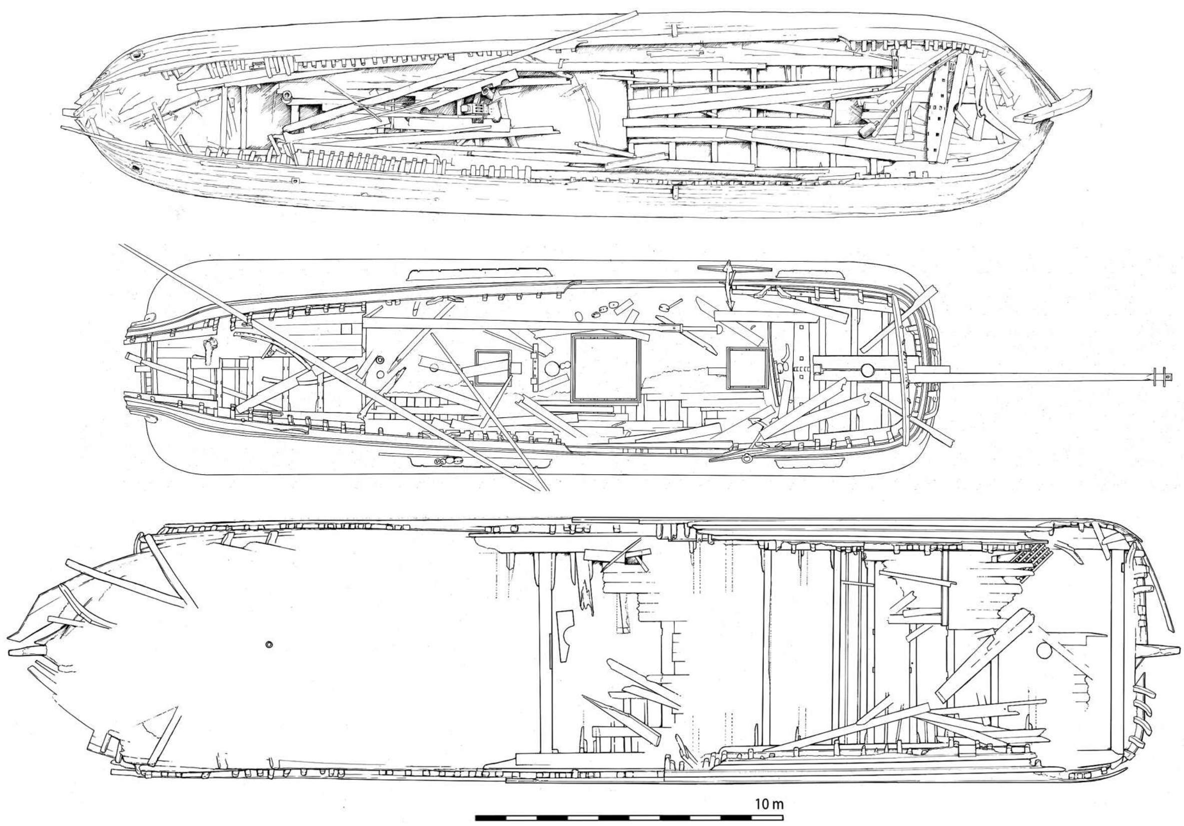

Figure 10. Three *fluit* wrecks seen from above. Note how the long and slender *Witte Swaen* differs from the later, more box-like hulls below here represented by the 'Ghost Ship' (middle) and *Anna Maria* (below). All represented in the same scale (Niklas Eriksson).

means a cartload, roughly equivalent to 12 barrels. However, a *last* could sometimes mean 18 or up to 24 barrels (Jansson, 1946, pp. 29–47, 1950, pp. 46–48).

The first attempt to apply such measurements to calculate the Sound Toll dates from 1632 and was implemented very slowly during the following years (Jensen, 2018, pp. 32–34). In the negotiations after the Torstensson War between Sweden and Denmark-Norway 1643–45, where the Netherlands acted as mediators alongside France, it was concluded that the Sound Toll should be based on measurements of the main hull dimensions (Jensen, 2018, pp. 37–38, 99; Møller, 1974, pp. 16–21).

In response to the new regulations where the rate was calculated from the length, beam, and depth, a new *fluit* hull form was developed; these *fluits* were built broader fore and aft. According to contemporary descriptions, the ships with these new hull forms looked more like warehouses than ships. Despite their looks, the new hull form was said to be able to carry a more significant load than ships of the older design. As discussions arose regarding the relation between the different hull forms, the cargo capacity, and its effect on the toll fees, tests were conducted to reveal how significant the difference was. In 1669, three *fluits* representing different hull forms were measured and compared. The conclusion was that ships of the new form could carry a load of 1/4 to 1/3 heavier than the old form (Jensen, 2018, p. 38).

It is tempting to see the long and slender hull of *Witte Swaen*, with its relatively rounded bow and narrowing stern quarter, as an example of the old hull form. The ship was built in 1636, thus before the ship measuring regulations of 1645. The almost square and box-like 'Ghost Ship' from the 1680s or the *Anna Maria*, built in 1694, should be examples of the later hull form (Eriksson, 2015).

The critical limit for calculating a ship's size when sailing through the Sound and into the Baltic was if the vessel was below 30 *lasts* or above 100 *lasts*, as this would affect the size of the toll fee. According to the Danish Table of Measurement, a ship 100 feet long, 23 feet wide, and 13 feet deep in the hold carried 100 *lasts*. If the hull dimensions measured from the wreck are recalculated using Sjælandske feet (0.314 m), *Witte Swaen* would measure 103 feet long and just above 21 feet wide. It thus seems reasonable that the ship's capacity would be of around 100 *lasts* (Møller, 1974, p. 43; Jensen, 2018, p. 33). There is reason to return to this number of *lasts* below.

Carved Expression of the Ship's Name

Like most early modern ships, *fluits* were decorated and embellished with carvings. Only the largest *fluits* were equipped with beakheads, which means that the majority of the carvings were concentrated on the narrow transom in the stern, the knightheads – the standing timbers with sheaves in their ends aimed for the halliards, topsail sheets and topropes – or the top of the rudder (for an overview, see Eriksson, 2014, pp. 151–180).

Witte Swaen's rudder has come loose from the sternpost and is resting on the seabed astern of the wreck. Its upper end has a carved trefoil, a motif common on *fluit*-rudders (Figures 11 and 12). The motif was still common on the top of the rudder of Dutch vessels at the beginning of the 20th century.

Carved knightheads are found on naval vessels, but archaeological surveys reveal that they were common aboard *fluits* as well, a custom visible on, for instance, the 'Ghost Ship', the 'Lion Wreck', and a recently discovered *fluit* in Tallinn Bay (see Eriksson 2012, 2014; Eriksson & Rönnby, 2012; Treffner & Lätti, 2024). Knightheads with carved motifs have also been discovered on other Dutch-style wrecks of merchant ships,

Figure 11. 3D model of the rudder with its still-attached tiller. Rudder is 8.3 m measured along the line of sternpost from the keel up to the trefoil carving on the top. The tiller is 5.0 m long (Jouni Polkko/Badewanne).

Figure 12. The top of the rudder has a carved trefoil, a common motif on the top of *fluit* rudders and other vessels (Ivar Treffner/Badewanne).

such as the so-called 'Borstö Wreck', previously believed to be *St Michael* (Kaukiainen, 2021). *Witte Swaen* is unusual and differs from this pattern as it lacks decorative carvings on the knightheads, which might again derive from the fact that it is the oldest of the ships mentioned here.

Most carvings on the *fluits* are found on the flat transom on the uppermost part of the stern. These decorations usually follow a very uniform and predictable pattern. Several motifs served a decorative purpose, and some also informed about the vessel, such as communicating the ship's names and the year of launch. The uppermost part of the transom usually had a coat of arms, which revealed the ship's home port, whereas the central motif of the transom was a symbolic representation of the ship's name (Eriksson, 2014, pp. 157–164).

From written sources, it is apparent that *fluits* usually had names that could be expressed through images. They had (translated) names like *The Rose*, *The Crescent*, *The Wine Barrel*, or *The Milkmaid*. Sometimes, the ships had names borrowed from the Bible, such as *Jonah and the Whale*, *The Good Shepherd*, or *King Solomon*. A practical advantage of this custom was that most people familiar with Christianity could decode and understand the names, irrespective of their mother tongue or reading ability. Several contemporary images of *fluits* provide an idea of the appearance of the transom decorations with the coat-of-arms from the home port, the name, and the year of the vessel construction. There are also several archaeological examples where fragments of the motifs have been discovered (Eriksson, 2014, pp. 157–164).

The uppermost parts of *Witte Swaen's* stern probably disintegrated before the trawl struck the wreck, as the parts had come to rest within a limited area on the seabed. Hence, finding parts of the carvings that resembled the ship's name and home port was a potential option.

A 2 m-long and 50 cm-wide plank was of particular interest. It was found at the seabed, just astern of the sternpost. The contour of the plank suggested that it could be the transom, although unusually narrow compared to other, later *fluits*. One of the ends of this plank was rounded, and along this edge, the timber was carved to imitate cordage or rope. As the rest of the plank lacked any visible carved motifs, it was assumed that it rested upside down. Potential motifs could be found on the side of the plank facing down against the seabed. After thorough discussions within the research team and consulting the Finnish Heritage Agency, it was decided to turn the plank over to see if any motifs were on the other side. Before doing so, a photogrammetric 3D model of the area around the potential transom was created, and the area in the vicinity was searched for fragments of carvings (Figure 13).

When the plank was turned over, what was found on the other side exceeded every possible expectation! Not only was the assumption that the plank represented the ship's transom correct, but it also showed that all motifs were carved directly onto this massive piece of wood, most likely oak.

The transom thus reveals the entire composition of the carved motifs in their original order. The central motif is a bird – a swan – depicted from the side with its beak to the left, carved in low relief. Without a doubt, this is a representation of the ship's name. The legs are hidden under a deadeye stuck to the

Figure 13. 3D model of the transom before it was turned around to reveal the carvings. Note the window shutter to the right of the transom (Ivar Treffner/Badewanne).

Figure 14. The inscription with the year of construction 1636 along the lower end of the transom. Note also the deadeye attached to transom (Ivar Treffner/Badewanne).

Figure 15. The main motif on the transom, the swan that represents the ship's name (Ivar Treffner/Badewanne).

Figure 16. The upper end of the transom with its rope-like carving that runs around its edge. The staining centred in the upper end is probably encrustations of iron (Jouni Polkko/Badewanne).

transom due to corrosion. The bird stands on some carved ornaments. Underneath this motif, the year 1636 is carved, which informed us when the ship was launched (Figures 14, 15, 16 and 17B).

The edge around the transom's uppermost end has a carved ornament resembling a rope. Two nail holes centered in the uppermost edge of the transom reveal that an additional part has been attached here. The shape in the field directly below the rope-like ornamentation might be a heavily eroded depiction of a face.

One of the most well-preserved transoms from a *fluit* is found in Søndre Harritslevs church in Denmark. According to tradition, it derived from a ship that foundered on the nearby coast. The 1.75 m-high and 0.93 m-wide transom is made of horizontally-oriented planks. Naturalistically-painted carved figures are attached to these planks. Above the angel and Abraham's sword, we find the arms of Hindeloopen in Friesland. The year of construction, 1639, is carved below the name motif (Eriksson, 2014, pp. 157–159; Hoving & Emke, 2000, p. 9). It seems likely that *Witte Swaen* would have the home port revealed with a coat-of-arms, just like other *fluits* (Figure 17A)

The Window Shutter

A piece of wood measuring 40 cm in length, 25 cm in width, and 3 cm in thickness with a rounded end was discovered at the seabed near the transom timber. As the piece had to be removed to prevent potential damage when turning over the transom, and its shape indicated that it could be a shield with a coat of arms, it was decided to recover it to facilitate a closer examination of possible motifs.

The recovered piece of wood was not a coat-of-arms but a window shutter, which leaves the question about a possible visual representation of the ship's home port open for the time being. The window shutter (Figure 18) derives from one of the window openings on the port side in the stern. After recovery, it was transported to the conservation laboratory at the Collections and Conservation Centre of the Finnish Heritage Agency for treatment. It was cataloged in the collection of the Maritime Museum of Finland (No. SMM22022:1).

Upon analysis, it was determined that the wood was conifer. However, it contained too few growth rings for dendrochronological dating. While made of a single piece of wood, the state of preservation of the hatch on the two faces is entirely different. The outer face is markedly more complex than the inner face, exhibiting a sponge-like texture, exceptionally soft, and easily deformed by pressing. The degree of waterlogging is considerable, presenting challenges for the conservation process.

Iron staining is notable but mainly localized to the lower edge, the curved side, and the outer face. In the latter, possible paint remains are uneven and covered in significant iron staining. Most interestingly, a distinctive pattern is visible on the outer face, initially thought to be bacteria-related staining, but upon closer inspection, it revealed intriguing details of the outlines of two parallel hinges, preserved as iron corrosion products. This is strong evidence, suggesting that the shutter opened like a typical window rather than in an upward fashion, as observed in some scale models of *fluits*. To what extent these openings have been equipped with windowpanes as well is not known, but there are evidence from other, later *fluits* that confirm this (Eriksson, 2014, pp. 59, 74, 91). Otherwise, the shutter was plain, with no decorative carvings, except for the lap at the edges, which was designed to ensure a better fit into the window opening in the hull. Due to the highly informative nature of the hinge outlines, the decision was made to retain this feature.

Before any intervention, the window shutter was 3D imaged and modeled by Ilari Järvinen, the Finnish Heritage Agency photographer. The model was created in RealityCapture from 402 images in 02h:38m:15s. Images 18 A and B show the shutter's outer and inner face sections captured from the 3D model.

The discovery of the hinge outlines presented a unique challenge in developing the conservation protocol. The presence of iron salts in wood is known to develop into post-treatment instability issues in objects treated using poly(ethylene glycol), as has been witnessed with the *Vasa* (1628) (Bjurhager et al., 2012) and, more recently, *Mary Rose* (1545) (Preston et al., 2014), among others. Thus, while the hinge outlines are being intentionally preserved, the removal of other, non-informative staining is being

Figure 17. A: The transom from the ship *Abrahams Offerhande* from 1639, preserved in Søndre Harritslevs church in Denmark. B: The transom from *Witte Swaen* to the right. *Fluits* usually had the coat of arms of the home port in the upper end, *Abrahams Offerhande* was from Hindeloopen in the Netherlands. Note the difference of proportions between the two transoms (Niklas Eriksson).

carried out using localized treatment methods, with the application of 2% diammonium citrate solution with dithionite using agar-gel poultices (Rapti et al., 2021). The hinge outline areas are protected with sprayable cyclododecane $(CH_2)_{12}$ (Rowe & Rozeik, 2008) to minimize direct contact with the treatment solution. Several cycles of this treatment were required, and the results have been encouraging. The desalination and mechanical cleaning phases were completed before the removal of the localized iron staining. The consolidative impregnation process will be carried out with poly(vinyl butyral) in a solvent

Figure 18. 3D image captures of window shutter prior to cleaning A. Hinge outlines on outer face, B. Inner face. The model was created in RealityCapture from 402 images in 02h:38m:15s (Ilari Järvinen, Finnish Heritage Agency).

medium, applied under vacuum to ensure complete impregnation at the cell level (Wang & Schiniewind, 1985). This will be followed by controlled air-drying, with weight being monitored regularly until a level is reached. After the conservation treatment, the hatch will be presented in the new exhibition of the Maritime Museum of Finland.

The Grain Cargo

The ship was loaded with grain, and four samples for botanical analyses were collected during the fieldwork in 2022 to learn more about what species were transported.

It was impossible to take samples through the crack in the hull (Figure 3H) as the sampling probe hit the ceiling, so all samples from inside the hull were taken through the main cargo hatch (Figures 3E, and 19). Samples from outside the wreck were taken from the seabed sediment around the wreck. A 1 m plastic corer, 22 mm in diameter, was used to take samples though the main hatch. The samples were decanted into sample bags once taken except the last sample and returned with divers. Three samples were taken from the cargo hold, but unfortunately, sampling outside the wreck failed because the sediment fell out of the sampling tube.

Botanical material was collected with tube samplers, inserted with seawater into sealable plastic bags, and stored in the cold. Samples were analyzed in the Herbarium at the University of Turku. All samples contained well-preserved grain skins, weed seeds, and shoots of mosses. Over a hundred skins of barley (*Hordeum vulgare* var. *vulgare*) were recovered from the samples. A few seeds from corncockle (*Agrostemma githago*), cornflower (*Centaurea cyanus*), and false cleavers (*Galium spurium*), as well as shoots of a red-stemmed feathermoss (*Pleurozium schreberi*) were identified.

Barley was a prevalent grain in Northern Europe until the 20th century, and it was used for food, beer

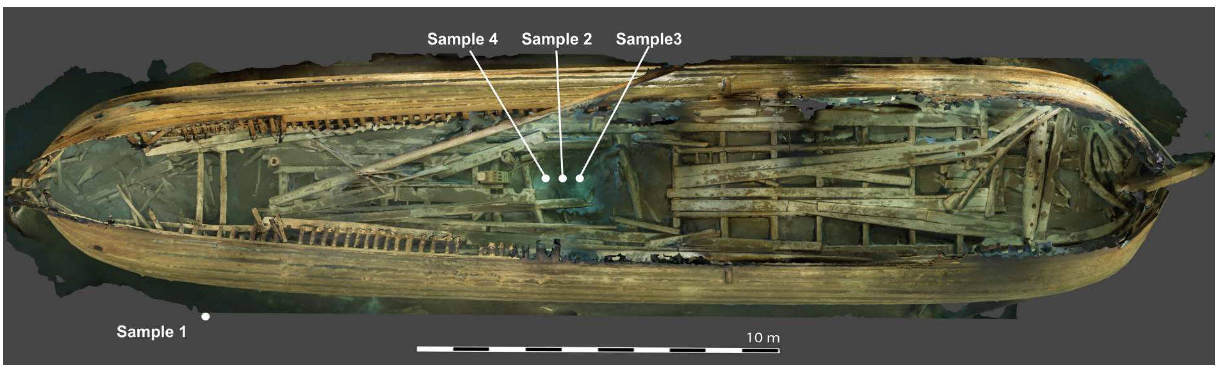

Figure 19. The location of the core samples (Jouni Polkko/Badewanne).

brewing, fodder, and seed. Weeds from the samples are typical species growing together with cultivated crops in fields. Moss from the samples can indicate caulking, as feathermoss is well-known for making log houses, wooden barrels, and boats watertight (Saatkamp et al., 2011).

Previous studies of plant remains found from shipwrecks in the Gulf of Finland have been conducted by a Dutch two-masted merchant ship, *Vrouw Maria* (1771). The research revealed coffee beans, tobacco rolls, and true indigo (Lempiäinen-Avci et al., 2021). Botanical analyses, e.g., in the case of *Vrouw Maria*, added significantly to the knowledge about the traded items and cargo of the ship.

Archival Research and Identification

The wreck site investigation revealed the type of vessel, its main dimensions, and possible cargo capacity – the number of *lasts*. Moreover, the motif on the transom revealed that the ship's name should include the word 'Swan' and that it was built in 1636. The analysis of the cargo revealed that it consists of grain. These parameters form the background for searching the archives for a possible identity of the ship and its original societal context.

In the 17th century, the Swedish empire stretched around both sides of the Baltic Sea, including the shores around the Gulf of Finland in present-day Estonia and Russia. Ports like Reval (Tallinn), Riga, and Nyenskans (St Petersburg) were important Swedish trade ports and possible destinations or departures for the *fluit*. The Dutch Republic was Sweden's leading trading partner and referred to the Baltic trade as the *Moedernegotie* (the Mother of all Trades) (Fahlborg, 1923, p. 206; Fahlström, 1947; Müller, 1998; Noldus, 2002, p. 14, 2005, p. 8; van Tielhof, 2002; van Zanden & van Tielhof, 2009, pp. 389–403), whereas the English, the competing economic superpower, regarded the Baltic as 'the lost trades' (Barbour, 1930, p. 267). *Fluits* formed the tool in this story of economic success in the period later known as *De Gouden Eeuw* (the Golden Age) of the Dutch Republic and *Stormaktstiden* (the Great Power Period) in Sweden.

Since most Dutch skippers sailing into the Baltic were Frisians or Hollanders, the archival research was conducted mainly in the Netherlands. In addition to the already digitized Sound Toll Registers – which registred all passages in and out of the Baltic during 1574–1857 – these seafarers left most of their traces in documents that were signed in Dutch harbors, with great emphasis on the economic flourishing of Amsterdam (Winkelman, 1971–1983).

The wreck's location and the information from the transom formed a starting point for the research. Since the Sound Toll Registers do not mention ship names, it is necessary to look further into the Amsterdam notarial charter contracts first. Although the complete archives of the Amsterdam notaries (1578–1915) have not survived through time, this extensive remaining archive of over 3.5 km of shelf length does provide much information on skippers (mainly from Frisia and Holland) sailing into the Baltic and back.

More importantly, the charter contracts that were signed in front of Amsterdam notaries, in early modern times, always contain information such as the name of the ship and skipper, the size of the ship (mostly in *lasts*), ports of destination, sought for cargo, and additional regulations such as cargo prices and demands for sailing in convoys, etc. First, all possible harbours of the destination in the extension of the waterway where the wreck is currently situated were mapped. Possible harbours are (clockwise around broadly speaking the Gulf of Finland) Rauma, Turku (Åbo), Helsinki (Helsingfors), Porvoo, Vyborg (Viborg), Nyenskans (in Dutch: *Schans Ternij*, a place located near nowadays St Petersburg), Narva and Reval (Tallinn). Next to general remarks concerning the trade in then-Swedish Finland and Estonia, these ports of destination formed the focus point of the archival research. In this research, the notarial archives were entered via all possible further accesses: an old card index on ship names and locations, a new but still incomplete online index, and automatically generated transcriptions of the notarial deeds. Although it was not possible yet to cover the complete notarial archives, it was possible to search over 100,000 scans from 1630–56, covering many of the freighting contracts that were signed in this period (Reinders, 2023).[1]

The timeframe 1630–56 can be considered realistic since the year 1636 was mentioned on the transom, and the lifespan of this kind of merchant ship in the early modern period did not exceed 20 years (Asaert, 1976, p. 182; Unger, 1978, p. 44; Martin, 2022, p. 133; for similar numbers concerning naval vessels, see Probst, 1996, p. 34).

Within this period, there are hundreds of charter contracts for skippers sailing into the Gulf of Finland. Reval (Tallinn) and Vyborg were ports frequently mentioned in Amsterdam sources. Some ships and skippers occur several times in the dataset, indicating that the research covers most of the ship names and skippers active in the Gulf of Finland between 1630–56. When focusing on ship names with a variant of 'swan' in it, they usually appeared with 'crowned', 'flying', 'little', 'young', 'old', 'golden', and 'red' swans. However, only the 'white swans' were active in the 1630s. For instance, another *Witte Swaen*, from Jacob Pietersz from Beets, measured 114 *lasts* and was not active anymore in the second part of the 1630s. In 1633, it sailed to Riga.

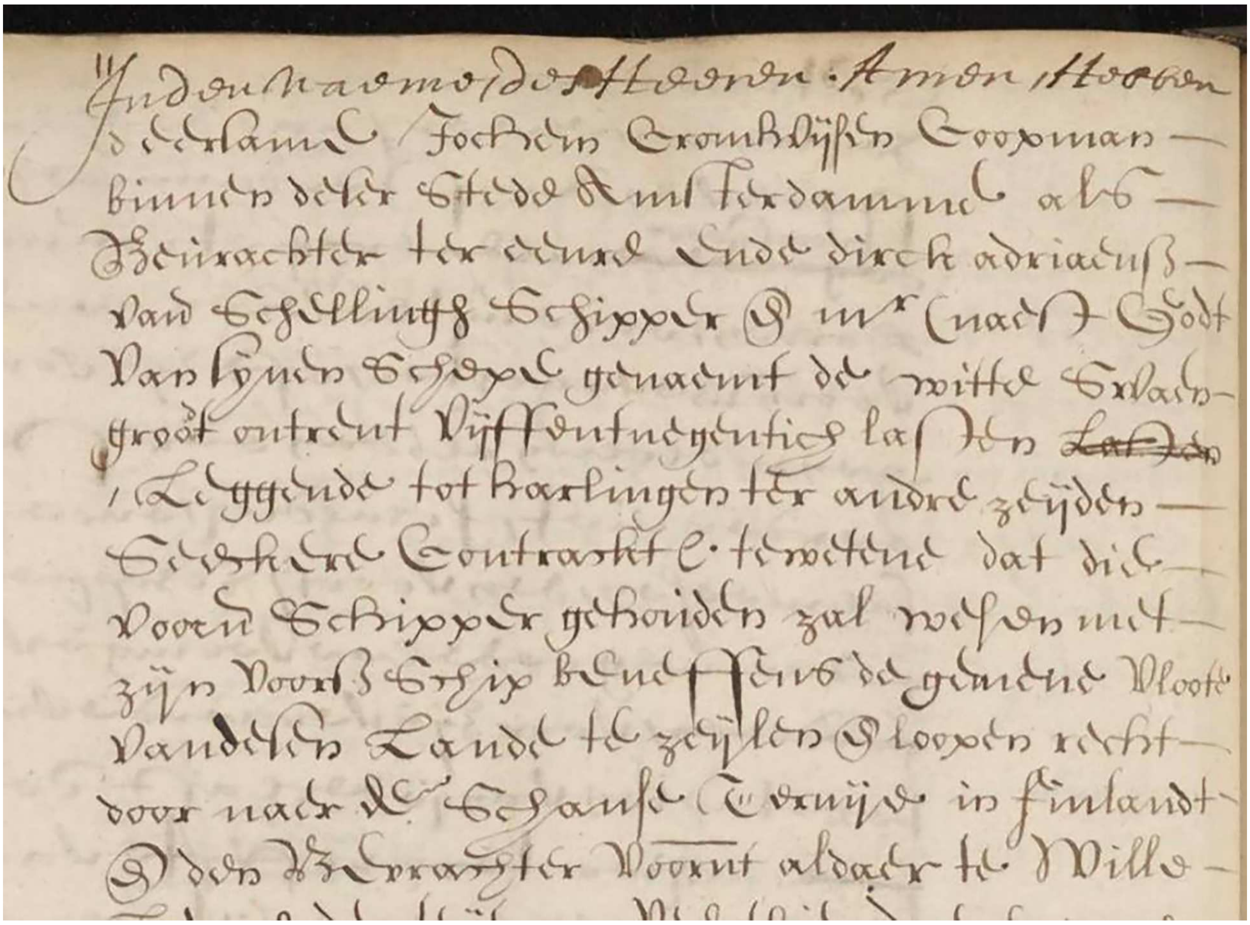

Figure 20. Opening of the charter contract from 31 March 1638. In this first part of the deed merchant Cromhuijsen and skipper Adriaensz agree that *de Witte Swaen* should sail in convoy to 'de Schanse Ternije in Finlandt' (Amsterdam City Archives, Notarial Archives (5075), inv. no. 1407, scan 190, Open Access).

Of all these ships with a variant of 'swan' in their name, only one *Witte Swaen* ('white swan') was active in the Gulf of Finland, which makes it a suitable candidate. The ship, which measured 95 *lasts* and was mastered by skipper Dirck Adriaensz from the Wadden Island Terschelling, was contracted on 31 March 1638 by the Amsterdam ship owner Jochem Cromhuijsen (Figure 20) (Amsterdam City Archives, Notarial Archives (5075), inv. no. 1407, scan 190).

From the archives, it is clear that Cromhuijsen and Adriaensz agreed that *Witte Swaen* would sail to Nyenskans in Ingria – by then a part of Sweden – to be loaded with barley or rye. Although there is a risk of focusing on one ship, the information about the transport of barley in this part of the Baltic by a ship that carried a reference to a swan in its name was considered too attractive to ignore for further historical research. Thus, the Sound Toll Registers were consulted. When researching the passages of Dirck Adriaensz from Terschelling with all possible name variants of both the personal name and the geographical name, it was possible to trace almost all of his passages through the Sound between 1630 and 1638 (see Table 1). All reported entries from the Sound Toll Register derive from the website (https://www.soundtoll.nl/), where the results of the Sound Toll Registers Online (STRO) project are searchable. A source critical remark should be made concerning the year 1634 as this year's administration is not entirely handed down. Although considered quite complete for the rest of the corpus, it is clear that many fewer passages were registered that year: only 1,444 entries of 1634 exist, compared with 1633 (6,333 passages) and 1635 (4,496 passages), a deficient number.

Dirck Adriaensz was registered 32 times in total, having visited present-day Kaliningrad (then Königsberg) at least five times, Riga and Gdansk three times, and Nyenskans twice. In three journeys, he visited other ports in the Baltic region. For reasons that remain unclear, two incoming passages and one returning passage in, respectively, the first half and the second half of the year 1634 are missing in the Sound Toll Registers.

Considering these three journeys and the administration of the Sound Toll to be further complete, 18 incoming passages and 17 returning passages can be counted. However, where is the registration of the 18th and last return passage? This is when the archival research starts to become extremely interesting. The lack of a return passage in the Sound Toll Registers is highly unusual. It can only point to ship wreckage, the death of the skipper, or a form of fraud

Table 1 The passages of Dirck Adriaensz from Terschelling through the Sound between 1630 and 1638. Note how the size of the cargo (the column to the right), in *lasts*, increase after 1636, which indicates that he now is sailing a new larger ship, which coincide with the construction of *Witte Swaen*. Compiled from the Sound Toll Registers Online (STRO) Sound Toll Register (https://www.soundtoll.nl/).

ID	Day	Month	Year	First name	Family name	Place of origin	Departure	Uniform cargo
903127	1	5	1630	Dirich	Arianssen	Schelling	Bayonne	74 + *lasts* salt
910683	28	6	1630	Dirich	Arianssenn	Der Schelling	Kalinigrad	Diverse
899983	5/7	4	1631	Dirich	Arianssen	Der Schelling	Terschelling	Diverse
901203	14	5	1631	Dirich	Ariaenssen	Schelling	Pärnu	Diverse
897040	25	6	1631	Dirich	Ariaanssen	Schelling	Terschelling	Ballast
909740	25	7	1631	Dirich	Arendtsen	Schelling	Kalinigrad	73 + *lasts* rye, ash, hemp
920575	22	2	1633	Dirich	Ariansen	Der Schellingh	?	
900273	2/3	4	1633	Dirich	Ariaenssen	D. Schelling	Gdansk	73 + *lasts* rye, etc.
909690	27	5	1633	Dirich	Adrians	Schellingen	Amsterdam	17 *lasts* salt
904894	2	7	1633	Dirich	Adriannsenn	Der Schelling	Riga	Diverse
885961	14	4	1634	Dirick	Arianssen	der Schellingh	Gdansk	
910264	24	6	1634	Dirich	Arianssen	d. Schelling	Kalinigrad	86 *lasts* rye
897113	28	7	1634	Dirich	Arianssen	der Schellingh	Terschelling	Ballast
903292	20	4	1635	Dirich	Adrianssen	d. Schelling	Terschelling	
895891	14	6	1635	Dirich	Adriansen	der Schelling	Riga	Timber
896660	27	8	1635	Dirick	Ariansen	der Schellingh	Seudre	82 *lasts* salt
883518	16	10	1635	Dirich	Ariansen	d. Schelling	Riga	Timber
870436	18	5	1636	Dirick	Ariansen	Der Schelingh	Terschelling	Diverse
876024	11	6	1636	Dirich	Ariansen	der Schelingh	Kalinigrad	99 *lasts* rye, hemp
852721	25	10	1636	Thierloff	Ariansen	der Schelling	Terschelling	33 + *lasts* salt, sugar, ivory
852562	3	11	1636	Direck	Ariansen	der Skellinge	Gdansk	79 + *lasts* rye, ash
825764	23	2	1637	Dirich	Ariansen	der Schellingh	Terschelling	Diverse
829711	2	4	1637	Sirich	Adriansen	der Schellingh	Landskrona	95 *lasts* malt
830196	10	5	1637	Dirich	Ariaenssen	Schelling	Terschelling	100,000 bricks
831988	27	7	1637	Dirich	Ariansen	der Schelling	Kalinigrad	Timber
819680	16	10	1637	Dirich	Ariansen	der Schelling	Terschelling	
833563	21	11	1637	Dirich	Ariansen	der Schellingh	Præstø	
816829	15	4	1638	Dirck	Ariaensen	Schelling	Terscheling	Ballast
813166	24	5	1638	Dirich	Ariaensen	d. Schelling	Nyenskans	96 *lasts* barley, rye
867086	9	7	1638	Dirich	Arianssen	der Schelling	Terschelling	2 *lasts* salt
863121	13	8	1638	Dirich	Ariansen	der Schelling	Nyenskans	105 *lasts* oats, barley
816122	18	10	1638	Dirich	Ariaensen	De Schelling	Terschelling	Diverse

(Veluwenkamp et al., 2021, p. 154). Although the latter cannot be excluded, the first two scenarios are in line with the assumption that the wreck is *Witte Swaen* from Dirck Adriaensz.

No decisive evidence was found stating that Dirck Adriaensz and a part or all of his crew had a fatal accident with their ship in the Gulf of Finland, but more indications are pointing in this direction. On 25 January 1640, four men appeared in the office of Amsterdam notary Palm Mathijsz, signing a declaration (another notarial deed type) on behalf of merchant Rijckert Gerritsz ter Horst. The witnesses, a Danish merchant from Slagelse in Denmark called Pieter Seurinxsz, two loaders from Kalundborg in Denmark named Willem Lootsman and Jan van Dien, and the Dutch skipper Ariaen Crabbe from the Wadden Sea island Vlieland declared that they met skipper Dirck Adriaensz from Terschelling in 1638 in Kalundborg where he was unloading barley. They declared that after he was unloaded and set sail to Holland, they never heard of him or his men again (Amsterdam City Archives, Notarial Archives, inv. no. 451, scan 37).

This declaration must be clarified because it implies that Adriaensz's ship sunk somewhere between Denmark and the Dutch Republic and not in the Gulf of Finland. To understand this deed correctly, it is necessary to go back to 1638. This year Dirck Adriaensz sailed up and down the Sound five times. On 15 April, he sailed in ballast from Terschelling. Adriaensz calls again in the Sound on 24 May, when he returned from Nyenskans with 46 *lasts* of barley and 50 *lasts* of rye. This is the realization of the contract he had made on 31 March of the same year with merchant Cromhuijsen in Amsterdam. On 9 July, Adriaensz passed the Sound for the third time that year, with only two *lasts* of salt. On 13 August, he returned from Nyenskans with 72 *lasts* oats and 29 *lasts* barley. On 18 October, Adriaensz came from Terschelling with diverse goods through the Sound for the last time. There is a very, very unlikely scenario that Adriaensz did not have to pass the Sound on his last journey back to the Dutch Republic because he used the Great Belt. In practice, however, this sea route was not used by foreigners because it was not as navigable as the Sound, and the same toll amount had to be paid. In the case of coming from Kalundborg, it would have even meant a slight detour. In this very unlikely case that *Witte Swaen* shipwrecked somewhere in the North Sea, this does not coincide with the actual wreck studied in the Gulf of Finland by the Badewanne group (Veluwenkamp et al., 2021, pp. 154–155).

A more plausible explanation of this deed can be made through looking at the dates when one of the witnesses, the Vlielander skipper Crabbe, was active in the Baltic in 1638. This year he is mentioned twice in the

Sound Toll Registers: his outgoing passage on 4 June when he sailed with only 18 bags of hops eastwards and his return voyage on 29 June when his ship came back from Reval (Tallinn) full of rye, hemp and other products (STRO, id 862089 and 875771).

The deed from January 1640 mentioned Crabbe already laying in the port of Kalundborg in 1638 when Adriaensz came in and refers to Adriaensz as returning to Holland afterward, meaning that he was on his way back to the Dutch Republic. Although it is impossible to determine the exact date (not mentioned in the deed), the two Wadden island skippers likely must have met between 25 May and 4 June. This explanation places the notarial declaration of 1640 in another perspective. The witnesses surely met Adriaensz and his crew in 1638, but not on his last trip (even before he started his second to last trip). The declaration more than one and a half years later most likely implies merchant Rijckert Gerritsz ter Horst had financial interests in the last journey of *Witte Swaen* and that he faced difficulties finding witnesses that could testify about the fate of the ship. A notarial declaration could be used as evidence to collect, for instance, an insurance premium for the ship. A declaration of the visit at Kalundborg a few months earlier in 1638 was the best Ter Horst could get in Amsterdam in 1640. This is an indication that almost nobody knew about the fate of Adriaensz and his men nor anybody knew when and where the ship could have wrecked exactly.

The cargo-carrying capacity of the ship can be an essential factor for identification. According to the Sound Toll Registers, Adriaensz sailed from 1630–35 with a ship of around 80 *lasts*. From 1636–38, Adriaensz's ship could carry around 100 *lasts*, implying that from 1636 onwards, he sailed a different, slightly larger ship than before. This would make sense since, on the transom, the year 1636 was carved. In the freighting contract of 1638, it was mentioned that *Witte Swaen* could carry 95 *lasts*. The earlier mentioned 100 *lasts* can be considered an acceptable deviation of this size, especially considering the mariner's portage. As shown elsewhere in this article, this completely corresponds with the size of the wreck (Jensen, 2018, p. 25; for conversion tons into *lasts*, see Leenstra, 2021).

One would expect more archival sources from relatives of the men of *Witte Swaen* in Dutch archives. It is known that Adriaensz came from Terschelling and that the ship was also anchored at Harlingen, a city opposite Terschelling on the Frisian mainland. The 1640 declaration reveals that Adriaensz lived in Nieuwendam (a small place outside Amsterdam). However, in all these places, he or his relatives (or sailors from *Witte Swaen* or their relatives) or his creditors did not leave any traces except those mentioned in this article. Moreover, there is a high probability that other sources have not yet been found. However, one must remember that this period was exciting but challenging to research since many archives did not survive in the early modern period. The archives of Terschelling must have suffered enormously from Holmes's Bonfire (1666), and the Amsterdam City Hall suffered from two big fires (1652 and 1762) that affected the (notarial) archives heavily. A cautious look at the archives of Nieuwendam, Harlingen, and Kalundborg also clarifies that these records are incomplete for this period. Continuing the archeological and archival research, looking for more snippets of information, could give decisive evidence.

Conclusions

The discovery of and the collaborative underwater archaeological survey of the *fluit* wreck laying on the seabed of the Gulf of Finland has provided new hitherto unknown aspects regarding the architecture of early 17th-century *fluit* ships. Even if the interior of the hull, and the division of space, appear to be more or less similar to other archaeologically-surveyed *fluits*, the shape does diverge from these. Compared to later ships, it is slenderer and more streamlined than the more box-like *fluits* built from the mid-17th century and onwards. The wreck is also more sparsely decorated than many later *fluit* wrecks. The carvings are concentrated to the transom which reveal the image of a bird – a visual representation of the ship's name. Analysis of the cargo showed that the ship had been used as many other 17th-century *fluits* transporting grain. In this sense, the wreck forms a representative for the *fluits* used in the Baltic trade and contributes to our general knowledge regarding ships and shipping in this period.

However, the favourable conditions, with the clues collected from the wreck site regarding the size of the ship (around 100 *lasts*), the year of construction (1636), and the depicted swan on the transom also mean that it has been possible to learn more about the particular ship. The archaeological traces fit so well with Dirck Adriaensz's ship *Witte Swaen* mentioned in written sources that we argue that it is the same ship. The link between the material remains on the seabed, and the ship mentioned in the archival sources must thus be considered vital. The discovery and the research around *Witte Swaen* will be presented in a documentary film.

Note

1. Amsterdam City Archives, Archive of S. Hart: (partly) entrance to the Notarial Archives (30452), inv. nos. 297 (Finland), 328 (Reval), 341-342 (St Petersburg), and 546 (Ship names: Swan) were consulted.

Acknowledgments

Former project leader of the Sound Toll Registers Online Jan Willem Veluwenkamp is acknowledged for his elucidation on the matter of completeness of the Sount Toll

Registers and possible missing registrations and Menno Leenstra for his explanation on the calculation of *lasts*. The authors especially would like to thank Hanna Hemila, Beata Harju from Handle Productions, Annemiek van der Hell from Windmill Film and Xavier Picard for a good and creative cooperation on the survey, research and documentary filming. We thank Reijo Green, captain and owner of the diving support vessel Deep Explorer and Mikko Karvonen, captain and owner of the schooner Joanna Saturna with the crew. We also thank the divers Juha Flinkman, Harri Laakso, Tiffany Norberg, Jouni Polkko, Mauro Sacchi, Edd Stockdale, Sam Stäuber, Jani Tattari, Tommi Toivonen and Ivar Treffner who participated on field work. The research has been supported by the Antero and Merja Parma Foundation, Kone Foundation, Samenwerkende Maritieme Fondsen, Spliethoff Foundation, whereas Swedish Television SVT and Creative Europe has supported the filming.

Disclosure Statement

No potential conflict of interest was reported by the authors.

Author Contributions

Niklas Eriksson wrote first draft of the article and the sections which describe the hull, the rig, the decorations and the comparisons with other *fluits*. Juha Flinkman, Jouni Polkko and Ivar Treffner were part of the original Badewanne team that discovered the wreck and planned and organised fieldwork, diving and written those parts of the article. Jouni Polkko built the photogrammetric 3D and calculated dimensions of the ship and contributed in details of the wreck. Minna Koivikko and Liisa Näsänen wrote about the recovery and study of the window shutter. Mia Lempiäinen-Avci analyzed and wrote about the botanical material. Martijn Manders coordinated research in the Netherlands. Jirsi Reinders was responsible for the archival research in the Netherlands, which was conducted mainly in the Amsterdam notarial archives. Edd Stockdale designed the technique/protocol for sampling the hold content in addition to collecting both the window shutter and the grain cores.

Permission Statement

The responsible authority for the fieldwork was the Finnish Heritage Agency. Since the wreck is located in the Economical Zone of Finland, where the Antiquities Act does not apply, official permission was not needed. However, the project has been undertaken with continuous contact with the authorities, who were informed about both the project plans and progress.

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