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Inland Cargo Vessels at the Mouth of the Oder River from the Early-Modern Times to the Beginning of the 20th Century: An Archaeological Perspective from the Bay of Greifswald

Abstract

This paper focuses on the construction of inland river vessels used at the mouth of the Oder River. As one of the most important communication arteries in Central Europe, the Oder has undergone extensive regulation over the past several centuries. These changes have led to the development of distinct vessel types, designed to navigate both narrow canals and numerous locks, as well as the semi-open waters of the Szczecin Lagoon and Bay of Greifswald. While the general types and distinctive features of these vessels are well-documented in historical and iconographic sources, many construction details and characteristics remain unexplored and poorly understood. Recent marine investment projects in the Bay of Greifswald, however, have enabled the identification and study of several shipwreck sites of river transport vessels dating from the 18th to 20th centuries. These discoveries have provided valuable insights, significantly enhancing our understanding of the design, construction and exploitation of this category of vessels.

Keywords: underwater archaeology, shipwrecks, Bay of Greifswald, inland navigation

Introduction

The construction and exploitation of inland barges have received relatively little attention in maritime history, often overshadowed by the large-scale seafaring. This oversight is partly understandable. Throughout the ages, the presence of bulk-carrying barges on waterways was so ubiquitous that it went almost virtually unnoticed in historical narratives. In the Age of Industrialization, once-prominent and mass-produced 'workhorses' of inland transportation were gradually eclipsed by the expansion of railways, followed by the rise of road transport. In recent years, however, the situation has begun to shift, with growing attention being paid not only to the economic significance of these vessels but also to the regional diversity of their construction, tailored to the unique and specific navigation conditions of individual rivers and canals.[1] This change could not have been possible without a broader shift in the approach to preserving maritime heritage, which increasingly includes artefacts from relatively recent periods.

An example of a region where specific navigational conditions influenced the development of unique vessel designs is the mouth of the Oder River. The peculiar challenges of this area – requiring navigation through the heavily canalized inland waterways of the Oder, transitioning to the wide and partially sheltered waters of the Szczecin Lagoon and the Bay of Greifswald, as well as the open waters Pomeranian Bay – led to the creation of distinctively designed watercraft. These vessels were characterized by unique regional construction features, tailored to meet the diverse and demanding conditions of this complex

[1] E.g. Litwin 2019; Moortel 2011; Ossowski 2010; Reszka 2012; Sohn 2013.

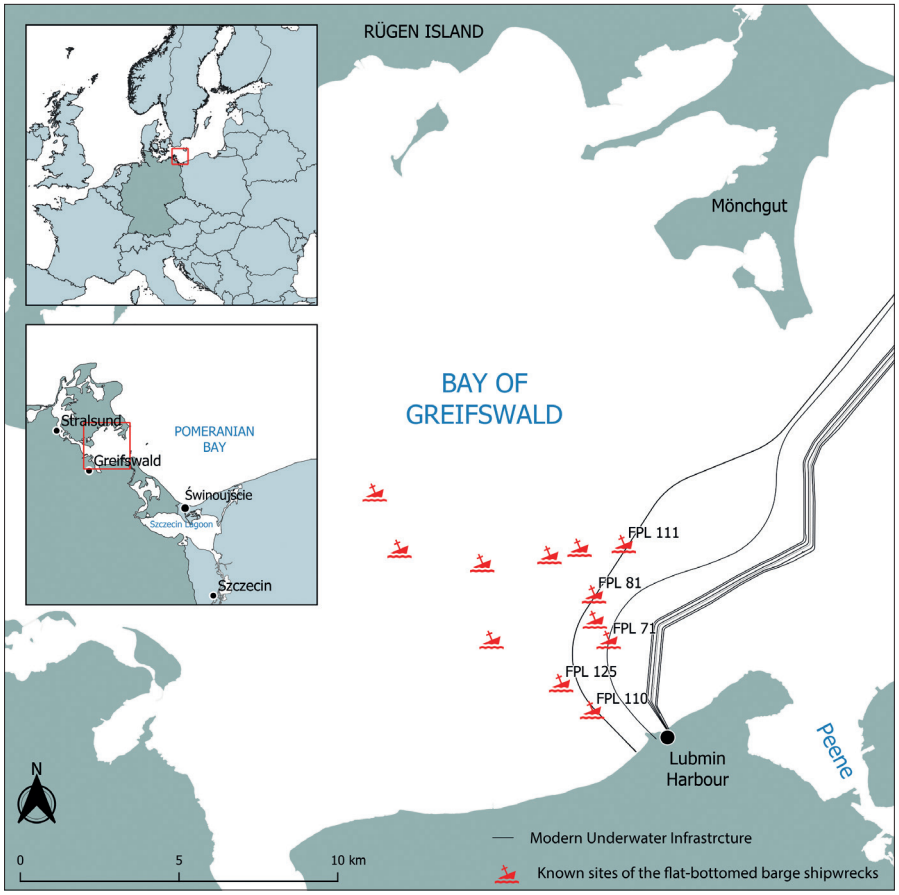

Fig. 1. Location of the shipwreck sites identified as remains of inland and coastal barges within the Bay of Greifswald (compiled by M. Grabowski).

navigational environment – both inland and coastal. The following article focuses on the area of the Bay of Greifswald, where approximately a dozen shipwreck sites have been identified as the remains of the local inland and coastal barges (Fig. 1). Between 2011 and 2019, five of these sites were the focus of archaeological diving operations as part of various offshore and nearshore construction projects.[2] Due to their state of preservation and unique structural features, three of these sites have been selected for a more detailed discussion in the following paper.

The Bay of Greifswald (German: *Greifswalder Bodden*) is a semi-enclosed lagoon in the south-western corner of the Baltic Sea. Bordered to the south and west by the coast of Mecklenburg-Western Pomerania and to the north by the island of Rügen, it has provided favourable conditions for settlement and maritime activity since prehistoric times. Despite its relatively small size, with an area less than 600 km^2, the Bay played a significant role in the regional economy. Here intersected significant communication routes, enabling a vital north-south connection between the rural region of Greater Poland, industrial Silesia, and the Baltic coast with its overseas harbours. Additionally, it facilitated east-west communication among pivotal early-medieval ports-of-trade, such as Ralswiek, Usedom, Menzlin, Wolin and the later Hanseatic harbour towns of Stralsund, Greifswald and Szczecin, along with their immediate economic hinterlands.[3] From medieval times until the mid-19th century, the Bay served as an entrance to the main navigational route of the Oder River. This route extended through the Peene Strait (German: *Peenestrom*) into the Szczecin Lagoon and onward to the harbour of Szczecin, effectively linking the Baltic Sea with the Oder River basin. For centuries, the Peene Strait maintained a significantly deeper and more stable channel compared to the other two straits, Świna and Dziwna, making it less susceptible to sedimentation, meandering and backflows caused by the open waters of the Baltic Sea.

[2] Auer, Grabowski 2017; Grabowski, Auer 2017; Grabowski, Sommer 2019; Sommer 2018.

[3] Gaziński 1993; Hermann 1978; Jöns 2010; Kowalenko 1954; Urliksen 2006.

Fig. 2. A – pictorial representation of the Oder vessel, so-called *Schale*, with broad hull and flat, transom aft. Detail of the *Alten Stettin*, created by Heinrich Kote in 1625 (Copyright: Archiwum Państwowe w Szczecinie / signature: PL-65-46-0-357); B – elongated vessels on the Oder River can be associated with the early *Kahn*-type. Detail of the coloured edition of *Alten Stettin* published in *Civitates orbis terrarum,* vol. IV by Georg Braun and Frans Hogenberg, circa 1600 (Public domain).

Inland Navigation in the Pomeranian Region in the Preindustrial Era

Source data on shipping in the estuary of the Oder River before the 18th century is scarce. During the Medieval period, most vessels, including inland crafts, were generally referred to by the broad Latin term *navis* – the ship.[4] Although a few written sources provide examples of various types of ships used on the Oder River, such as those mentioned in the taxation tariff issued by Prince Barnim I for the town of Szczecin in 1278, these documents are often ambiguous and difficult to correlate with other accounts.[5] Contemporary archaeological findings from this era are still limited and are typically associated with relatively small watercraft types, like fishing vessels or coastal traders designed to transport modest quantities of cargo.[6] More evidence of inland ships comes from iconographic representations dating to the 16th and 17th centuries. Among the most commonly depicted are two types: the so-called *Schale*, a broad vessel with a distinctive stempost and transom aft; and a narrow, elongated vessel called *Kahn* (plural *Kähne*), with a characteristic deadrise at both ends of the hull (Fig. 2).[7] The latter, in particular, was destined to play a significant role in the development of Pomeranian seafaring for centuries to come.

At the beginning of the 18th century, the Lower Oder region found itself in an unfavourable geopolitical situation. After the Thirty Years' War (1618–1648), most of the land along the Oder River was incorporated into Brandenburg-Prussia, a predecessor to the Kingdom of Prussia. However, under the terms of the Peace of Westphalia, the northern part of Pomerania, including the river mouth and its main harbour in Szczecin, remained under Swedish control.[8] For the expanding Prussian Empire, a key priority was to gain access to the mineral-rich and resource-abundant region of Silesia. Due to the economic conflict between Sweden and Prussia, the Prussians relied on the Elbe River and its port in Hamburg as their primary route to the open sea. Shipping from the south to the north was directed through the heart of the Prussian Kingdom, passing through Berlin and Hamburg, and further to the North Sea, via canals connecting the upper Oder to the Spree and Elbe Rivers. As a result, the Swedish-controlled part of Pomerania became isolated from its natural southern hinterland and suffered from the high tolls imposed by the Prussian administration.

This situation began to change soon after Szczecin was incorporated into the Kingdom of Prussia in 1720 and the bulk trade on the waterways slowly revived. A breakthrough occurred during the reign of Frederick II 'the Great' von Hohenzollern (1740–1786), an ambitious monarch, who saw the Oder River as the lifeblood of his kingdom and Szczecin as its primary harbour.

[4] Gaziński 1994.
[5] Prümers 1881, 386–387.
[6] Filipowiak 1994.
[7] Ossowski 2010, 132–133.
[8] Rabb 1962.

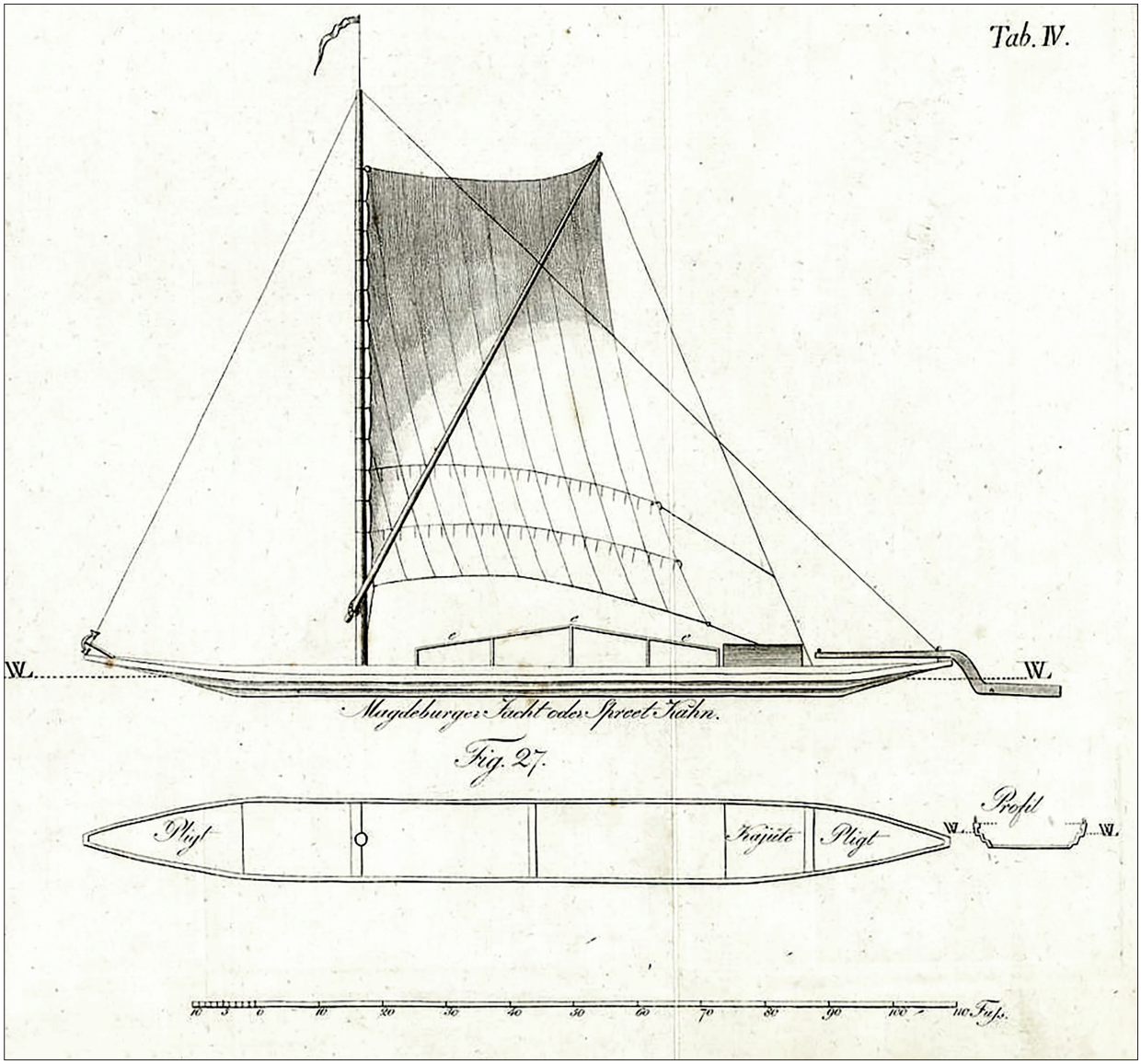

Fig. 3. *Spreetkahn* or *Magdeburger Jacht,* circa 1800 (after: Woltman 1802, tab. IV).

To ensure unimpeded access to the Baltic Sea, the old route through the Świna Strait was deepened and its entrance secured by establishing a port in Świnoujście (German: *Swinemünde*). Furthermore, a series of investments were made along the Oder River to improve its navigability. The riverbed was straightened, with old dams and structures either modified or completely removed. The construction of new canals and the reconstruction of older ones enabled the Oder to connect to the broader network of European waterways. Another significant development during this time was the abolition of outdated customs fees and staple rights, some of which had been in place since the 13th century.[9]

Nevertheless, all these efforts to develop inland navigation would have been unsuccessful without the appropriate vessels. Over the course of the 18th century, the narrow and elongated *Kahn* gained widespread popularity, eventually superseding other vessel types on the rivers of Central Europe.[10] Its success lay in its innovative construction: the flat-bottomed, slender hull made it ideally suited for navigating narrow locks and canals. The overall size of the hull varied by region and was adapted to the

[9] Sohn 2013, 10; Uhlemann 1996.

[10] Litwin 2019, 211; Mielcarek 1970, 379.

Fig. 4. Photogrammetric plan of the Peenemündung, Ostsee Bereich VII, Fpl.125 shipwreck site (compiled by P. Stencel in 2019; copyright: Landesamt für Kultur- und Denkmalpflege Mecklenburg-Vorpommern).

specific conditions of particular waterways, from which their names were derived, such as the Oder-*kahn*, Havel-*kahn* or Elbe-*kahn* (Fig. 3).

The late 18th century *Kahn*-type vessel from the Oder River (*Oderkahn*) measured approximately 30–45 m in length and 4–5 m in width, with the height at midship reaching 1.3–1.5 m.[11] Oak timber was the preferred material for the wooden hull construction, although it was common practice to mix various wood species. Frequently, the sides were constructed from oak, while the bottom was made of pine or spruce. This combination significantly reduced the hull's weight and, consequently, its draft.[12] The vessel was keel-less, featuring a flat-bottomed floor made of edge-to-edge joined planks. The sides were built using the mixed clinker and carvel fashion, with the two lowest strakes fastened in the clinker manner and the remaining upper ones, typically two or three, in the carvel technique.

A distinctive feature of the early *Kahn*-type vessel was its specially designed bow and stern. Until the second half of the 19th century, most of these ships featured a structure known as the *Kaffe*, created by bending the bottom planks firmly upwards. These elevated sections provided enhanced protection for the vessel's ends, particularly when navigating shallow waters or stranding along the shoreline. In some designs, the upward-curved *Kaffe* was constructed as a separate element, attached to the rest of the bottom by a transverse crossbeam. However, this solution introduced a structural weakness in the hull, leaving it particularly vulnerable to impacts from obstacles on the riverbed.[13] A more sophisticated solution involved interconnecting the planks in a herringbone pattern, which provided greater durability and resilience. By the 18th century, both the bow and aft end shared similar shapes and proportions, collectively accounting for as much as 33% of the total hull length.[14] Most *Kahn*-type ships during the 18th century were equipped with a single mast and a sprit-sail positioned about one-third of the hull's length from the bow. The crew typically consisted of three to four men. At the stern of the vessel, there was a small cabin (so-called *Bude*) for the skipper and his family. Additional accommodations for the remaining crew members might have been located at the bow, beneath the forward half-deck. The rest of the hull was allocated for cargo, giving these vessels an average capacity of 30–50 t.[15] The lifespan of a vessel was largely determined by the quality of timber used in its construction. Hulls made entirely of oak had an average lifespan of 10 to 12 years, while those constructed from pine lasted only 5 to 6 years.[16]

The Shipwreck of Peenemündung, Ostsee Bereich VII, Fpl. 125: An Example of the Late 18th – Early 19th Century Kaffenkahn

The site is located approximately 3 km northwest of the Lubmin Harbour at a depth of 8 m, on a relatively compact seabed of marine sand. Only a small portion of the original hull structure has been preserved, consisting of bottom planking and 27 partially intact frames. The total length of the wreck was measured at 27.5 m, with a maximum width of 3.6 m (Fig. 4).

Although the wreck was discovered relatively close to the shoreline, the missing upper parts of the hull and

[11] Hoyer 1793, 148.
[12] Kostecki 1826, 123.
[13] Sohn 2013, 41.
[14] Mielcarek 1986, 24.
[15] Mielcarek 1970, 387.
[16] Kostecki 1826, 121–123.

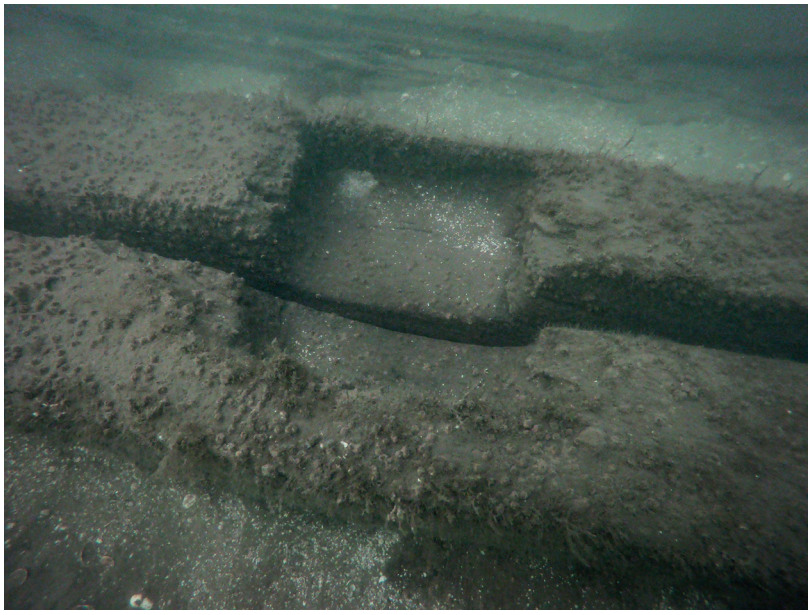

Fig. 5. Shallow mast step cut on top of two adjoining frames (photo by J. Ulrich 2019; copyright: Landesamt für Kultur- und Denkmalpflege Mecklenburg-Vorpommern).

the absence of cargo make it impossible to determine the cause of the vessel's loss or its intended destination. A few loose fragments of side planking found near the wreck suggest that the rest of the structure either deteriorated and was carried away by currents or that the whole preserved section was moved by waves from a more distant, unknown location.

The nearly complete bottom of the hull consists of ten strakes of edge-to-edge joined oak planks, each measuring between 28 and 32 cm in width and approximately 4 cm in thickness. Characteristic transverse straight cuts at both ends of the wreck indicate that the bow and stern were originally equipped with separate sections, shaped into elongated, triangular forms of *Kaffen*.

Each frame station consisted of two adjacent L-shaped frames. The shorter arms of these frames extended upward on either the port or starboard side, while the longer, horizontal arms tapered toward the opposite ends. This configuration created a scarf-like joint between adjacent elements, allowing the frames to span the entire width of the hull. In contrast, the shorter, vertical arms of the frames were preserved only in small fragments, covering just two to three strakes of side planking. At the bottom, each shorter arm was fitted with a rectangular joggle, designed to accommodate the overlapping connection between the two lowermost strakes. A single square mast step, located at the third frame station from the forward end of the vessel, measures approximately 40 × 40 cm with a shallow depth of 19 cm. It is carved into the top of two adjacent frames (Fig. 5).

A brief examination of the shipwreck site revealed only a small number of minor artefacts potentially related to the vessel's equipment and cargo. These included a small-sized anchor with four flukes and a single brick found near the mast step. Although it is difficult to identify the specific cargo based on these individual items, the presence of the brick might suggest the transportation of building materials.

Despite the shipwreck's state of preservation, certain visible structural features allow for an attempt at preliminary reconstruction of the ship's original appearance and dimensions (Fig. 6). Based on available records of Oder vessel classifications from the 18th century, the overall dimensions of the vessel can be estimated at approximately 40–42 m in length and 4.5–5 m in maximum width.[17] This suggests the use of relatively elongated bow and stern sections, with estimated lengths of 7.5 m and 6.5 m, respectively. Such dimensions align with the placement of a single mast, typically positioned at one-third of the hull's length. With a total of five strakes along the sides, the hull's depth can be estimated at approximately 1.5 m. These dimensions indicate a relatively large inland vessel, possibly of the Oder-*Kaffenkahn* size and type, with an estimated cargo capacity of about 70 t.

The *Kaffenkahn* ship was designed as an efficient and low-cost bulk carrier. Until the end of the 18th century,

[17] Mielcarek 1986, 25; Sohn 2013, 14–15.

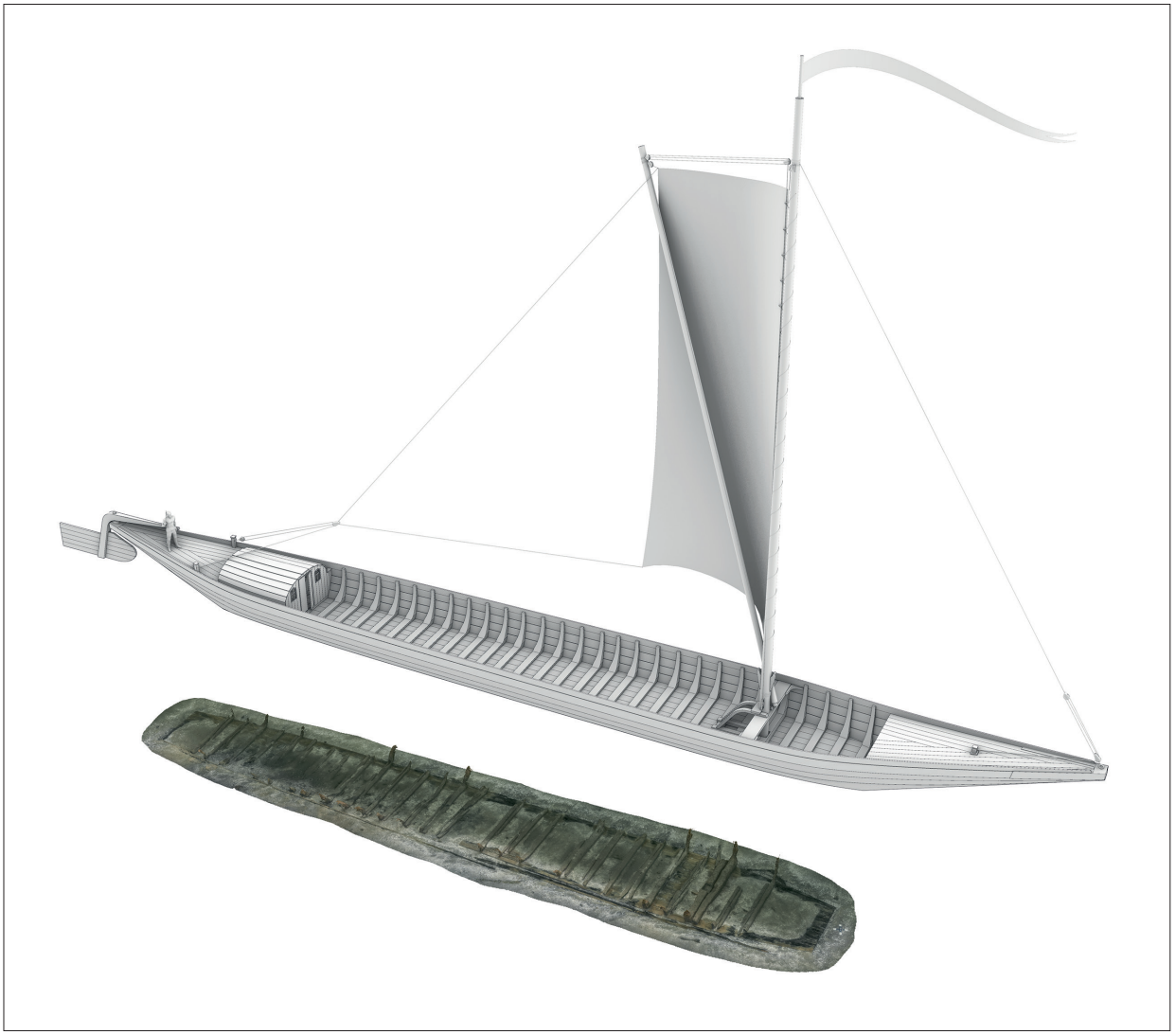

Fig. 6. Attempt at the digital reconstruction of the Peenemündung, Ostsee Bereich VII, Fpl.125 (compiled by M. Grabowski).

grain was the most commonly shipped cargo on the Oder River, exported from the hinterland, primarily the Greater Poland district, and later delivered to Western and Scandinavian countries.[18] Alongside grain, oak was another key export product. As a fundamental material for shipbuilding, oak timber was in high demand, particularly in Scandinavian countries, which lacked sufficient high-quality timber and relied on imports from the southern Baltic coast.[19] Although no archaeological evidence has been discovered to confirm long-distance timber trade on the *Kahn*-type ships, the presence of shipwrecks like Fpl. 125 proves that these vessels, with their large cargo capacity, could be used for transporting bulk goods within the sheltered coastal waters of the south-western Baltic.

On the Threshold of Industrialization – Challenges and Opportunities for the Pomeranian Inland Shipping

The unification of Germany in the second half of the 19th century laid a solid foundation for economic expansion, resulting in nearly uninterrupted growth until the World War I. The development of a unified system of weights and measures, a single currency, and standardized

[18] Chojnacka 2007; Szultka 2015, 190.

[19] Ressel 2012, 84.

administrative procedures greatly stimulated trade and strengthened the domestic market. This economic momentum was further enhanced by the technological innovations of the Industrial Revolution. The introduction of steel and iron, along with significant advancements in transportation – such as the emergence of railways – and the mechanization of various sectors of the economy, propelled Germany's transformation from a predominantly agrarian society into a modern industrial nation with a robust agricultural sector.[20]

The harbour cities of Bremen and Hamburg benefited the most from the new economic circumstances. Both had convenient connections to Germany's industrial heartland in the south (via the Weser and Elbe rivers), which allowed them to play a significant role in maritime trade. During the Industrial Revolution, the burden of this trade shifted increasingly toward the North Sea. For the Pomerania region, particularly Szczecin, this shift meant even fiercer competition in the shipping market compared to previous decades. A severe blow was dealt with the introduction of the railway. Between 1871 and 1914, Germany's railway network nearly tripled in length, establishing vital connections between the country's pivotal economic centres.[21]

Nevertheless, the Pomerania's natural resources supported the development of a locally based economy, supplying nearby regions with the necessary raw materials and semi-finished goods. One of the key local products, mass-exported not only to neighbouring areas but also to other German and Danish ports on the Baltic Sea, were bricks. Torgelow, located near the mouth of the Uecker River into the Szczecin Lagoon, was a well-known brick production hub. By the turn of the 19th and 20th centuries, approximately 50 brick factories operated in the area, producing 180 million bricks a year. Simultaneously, the region became a significant centre for cement production and distribution. The first cement factory in Szczecin was established as early as 1850, marking the beginning of the industry's growth. The abundant deposits of limestone and chalk in Pomerania, especially on the Rügen Island, were essential to this development. The growth of the cement industry in Szczecin led to a surge in demand for chalk, which was imported from Rügen, with inland transport playing a crucial role in efficiently distributing cement throughout the coastal harbours.[22]

To meet the increasing demands for transportation, extensive regulations and modernizations were required for the waterways on the Oder River. The main route to the open sea through the Peene Strait became insufficient and unprofitable due to the growing tonnage of maritime shipping. As a result, the shorter and less winding route through the Świna River was considered more feasible. In 1880, after six years of work, the construction of the new shipping route – *Kaiserfahrt* was completed, and the entire waterway from Świnoujście to Szczecin was deepened to 7–8 m.[23]

At the same time, the inland canals connecting the Oder River with other waterways were either modernized or newly constructed. In 1891, the *Oder-Spree* Canal was completed, and in 1914, the *Oder-Havel* Canal was finished, replacing the old *Finow* Canal, which had been in use since the 17th century.[24] By the end of the 19th century, the Oder River was regulated and canalized all the way to the industrial region of Silesia. In 1853, the so-called *Finow-Mass* was established by law as the upper limit for the length and width of vessels for use in the *Friedrich-Wilhelms* Canal, Finow Canal, as well as on the Havel River, from Liebenwalde to the estuary of the Spree near Spandau.[25] However, as economic development continued to grow and demands for inland transportation increased, even this restriction became incompatible with the dynamic changes in the industry.

All these changes also impacted the fleet of inland ships. In the relatively short period of 1872–1912, the total number of registered vessels on the Oder River increased from 2,289 to 4,432, while the average tonnage of a single ship grew from 65 to nearly 240 BRT.[26] To maximize the ships' capacity, their sides began to be arranged more vertically. Also, the length of the *Kaffe* (both, aft and bow) began to decrease and were finally replaced by a straight timber of the stern- and stempost, making the vessels more suitable for towing by steam-powered tugs. As a result, the specialization of inland vessels became more pronounced and associated with particular canals or even locks. For example, an *Oderkahn* capable of passing through the Finow Canal was referred to as a *Finowmässige Oderkahn*, while vessels travelling between Szczecin and Frankfurt (Oder) were known as *Frankfurter Oderkähne*.

During that time, vessels known as *Haff-* or *Pommernkahn* became popular on the Lower Oder and its estuary. These were larger variants of the *Oderkahn*, better suited for navigation on the open waters of the Szczecin Lagoon (Fig. 7). The average length of

[20] Abrams 2006, 17–18; Feuchtwanger 2001, 67–69.
[21] Łuczak 1984, 38.
[22] Sohn 2022, 9–11, 16–20.
[23] Kotla 2008, 141–143.
[24] Keweloh 2005; Miłkowski 2003, 20, 22–23.
[25] Sohn 2013, 10.
[26] Mielcarek 1986, 28.

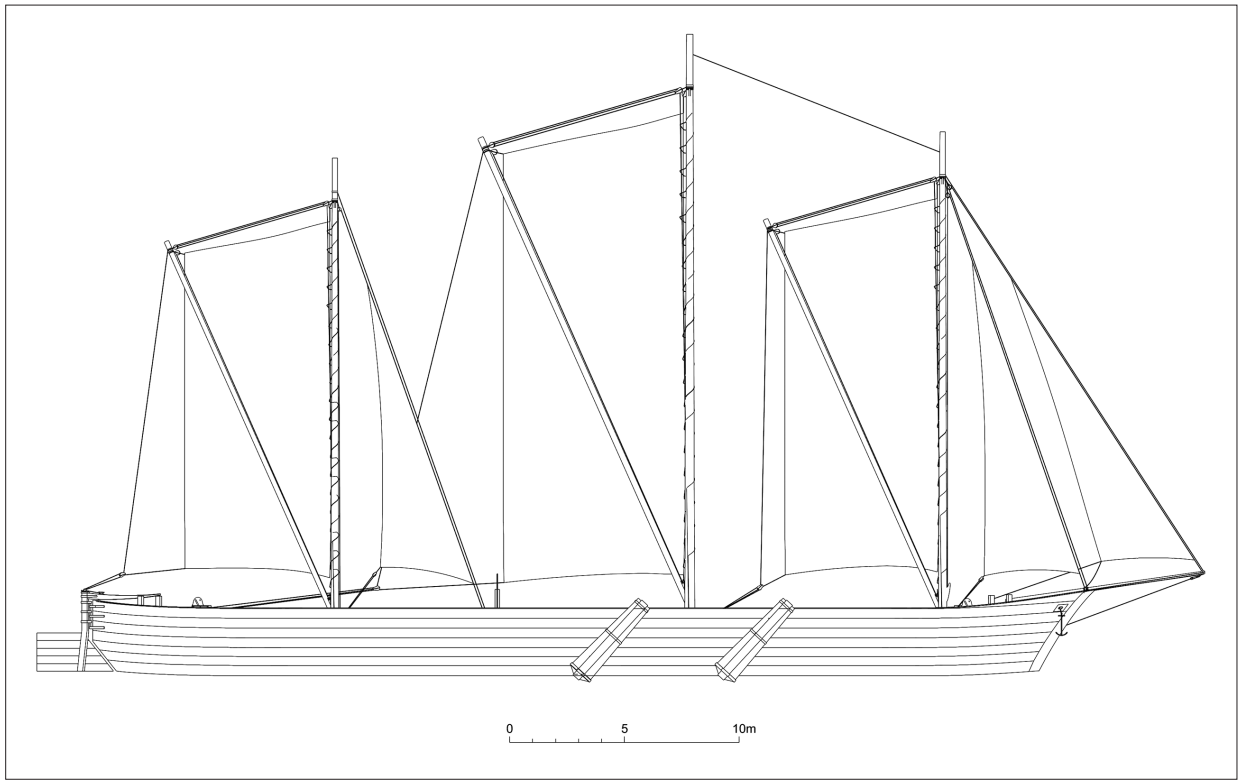

Fig. 7. Profile plan of a typical *Haffkahn*-Type vessel (compiled by M. Grabowski).

their hulls reached up to 44 m, with a width of 5 m. The growing demand for increased vessel capacity also influenced the design of the *Haffkahn*'s ends. By the end of the 19th century, these vessels were being equipped with sharp stemposts, resembling the curved bows of the popular schooners of that era. Also, the stern of the vessel underwent significant modifications. In older constructions, the rudder was mounted at the tip of the sternpost with a massive iron bolt. However, this led to frequent breakage of the fastening.[27] In later constructions, the aft of the vessel was shortened and the centrally located bolt was replaced with several gudgeons spread along the vertical sternpost, to accommodate a hinged rudder (Fig. 8). This change not only improved manoeuvrability but also expanded the cargo capacity of the hull without affecting its overall length.

Like the other *Kahn*-type vessels, *Haffkahn* was designed as a flat-bottomed vessel without a keel or keel plank. To improve seaworthiness during coastal voyages on the Szczecin Lagoon and the open sea, the sides of the hull were raised with additional outer planking strakes. The ships were also equipped with two to four wooden leeboards mounted on the midship.[28] Another improvement was made to the rigging. Starting in the 1840s, larger types of *Haffkahn* were outfitted with two, and soon after, with three sprit-rigged masts.[29]

Shipwreck Peenemündung, Ostsee Bereich VII, Fpl. 81 Shipwreck Site – Early 20th Century Coal Barge of the Haffkahn Type

The shipwreck is located approximately 5 km northeast of the entrance to Lubmin Harbour, at an average depth of 8.6 m. The elements of the wreck were widely scattered, with some found more than 100 m away from the main site. Despite several archaeological campaigns conducted between 2016 and 2019, the investigation of the main wreck site was limited to only a few dives. Therefore, only a short examination of the hull construction was possible at that time.

From the original construction of the vessel, the bottom of the hull survived almost intact, measuring ap-

[27] Teubert 1912, 401–403.
[28] Sohn 2013, 27.
[29] Sohn 2022, 106.

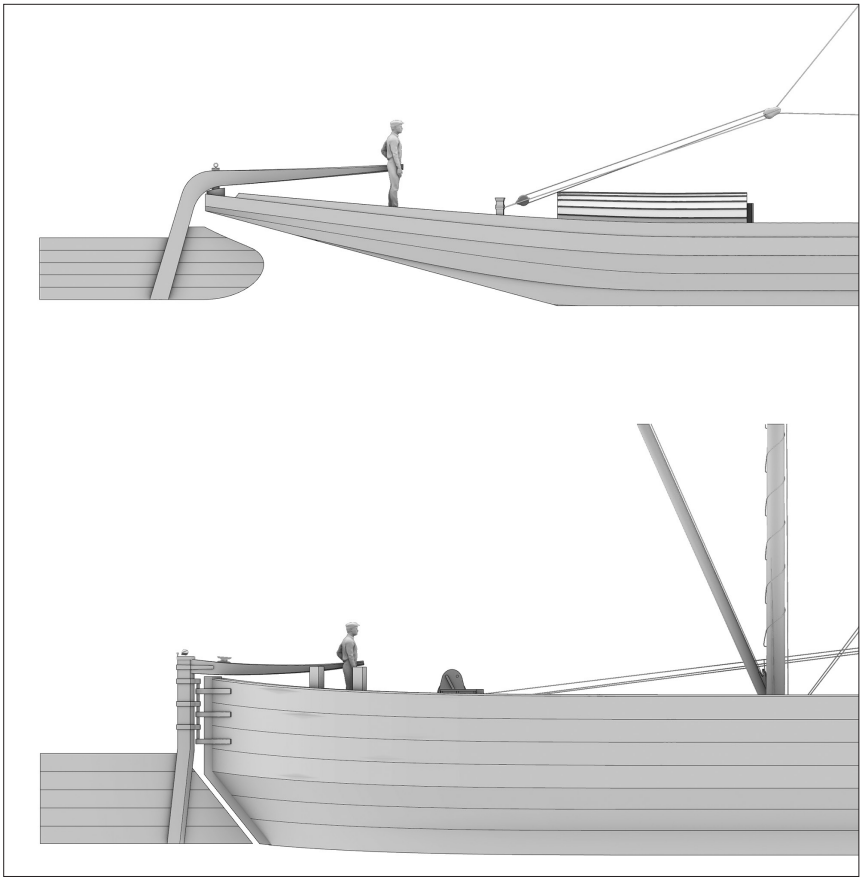

Fig. 8. Comparison between the late 18th century *Kaffenkahn* rudder mounting (above) and early 20th century hinged rudder on the *Haffkahn* (below); (compiled by M. Grabowski).

proximately 38 m in length and 5 m in width (Fig. 9). Apart from the protruding ends of the frame stations, most elements of the upper hull structure were washed away and scattered across the site. These scattered components include parts of the side planking, fragments of frames, and remnants of the main cargo – coal briquettes that covered the whole ship's bottom. It is very likely that the floor was flat and consisted of edge-to-edge joined planks, with no keel or keel plank present.

The framing system consists of wooden frame stations spaced approximately 80 cm apart. Each station includes a flat oak floor timber that spans the entire bottom of the vessel and is secured with trenails. Aft of each long floor timber, shorter L-shaped timbers are attached to the floor planks and extend upward to form the sides of the barge. These futtocks were not directly connected to the floor timbers. Continuations of the futtocks were observed abutting the ends of the initial futtocks and running along the floor across the bottom of the vessel (Fig. 10).

All the investigated outer planks were sawn from oak and measured approximately 8 cm in thickness. Their width was estimated to range between 30 and 42 cm. While none of the investigated planks of the side construction appeared to be preserved in their full length, planks measuring 10 m or more were observed on site and in the vicinity of the hull. A distinctive feature of this shipwreck is the method used to connect neighbouring planking strakes. These were joined using oblique iron nails driven diagonally from the inside of the upper planks into the lower planks. On the outboard side, a rabbet or notch measuring 3 cm wide and 1.5 cm deep was cut along the edges where the planks adjoined. This was covered with a wooden lath 1.5 cm thick and 6 cm wide. The purpose of the lath was to secure a waterproofing material applied between the strakes.

Despite the vessel's poor state of preservation, an examination of both ends provided some insights into the construction of the stern and bow sections. The close proximity of the outer planks on both sides suggests that, instead of a *Kaffe*, the vessel was equipped with posts at both ends. Near the northern end, fragments of chamotte tiles were discovered. These may have been part of the inner lining of an oven, a basic feature typically found in the aft cabin.[30] It is also possible that another

[30] Sohn 2013, 134.

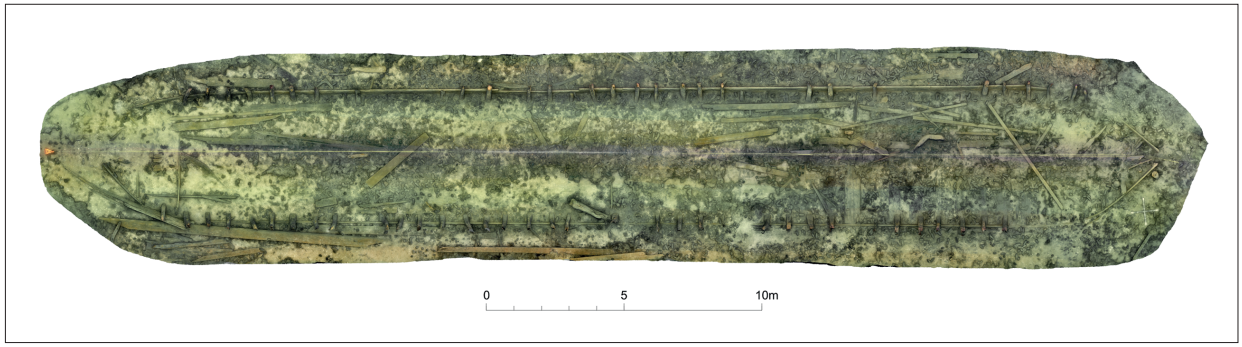

Fig. 9. Photogrammetric plan of the Peenemündung, Ostsee Bereich VII, Fpl.81 shipwreck site (compiled by P. Stencel in 2017; copyright: Landesamt für Kultur- und Denkmalpflege Mecklenburg-Vorpommern).

Fig. 10. Bottom of the shipwreck hull and the exposed components of frame stations – futtocks and floor timbers (photo by M. Grabowski; copyright: Landesamt für Kultur- und Denkmalpflege Mecklenburg-Vorpommern).

smaller cabin was located at the bow, under the half deck, as indicated by other small artefacts uncovered in the forward section.

One of the largest elements of the shipwreck is the rudder. Its construction features a 3.4 m long asymmetric oak stock and a curved tiller. Originally, the stock was attached to the gudgeons on the sternpost using three iron pintles, which were secured with metal bands. Several pine planks found near the rudder may have been part of the blade. The diagonal endings observed on two of these planks are characteristic of the inner structure of a rudder blade. The rudder exemplifies the so-called balance rudder (*Wippruder*), a design typical of Pomeranian *Kahn*-type vessels.[31] In this type of rudder,

[31] Sohn 2013, 50.

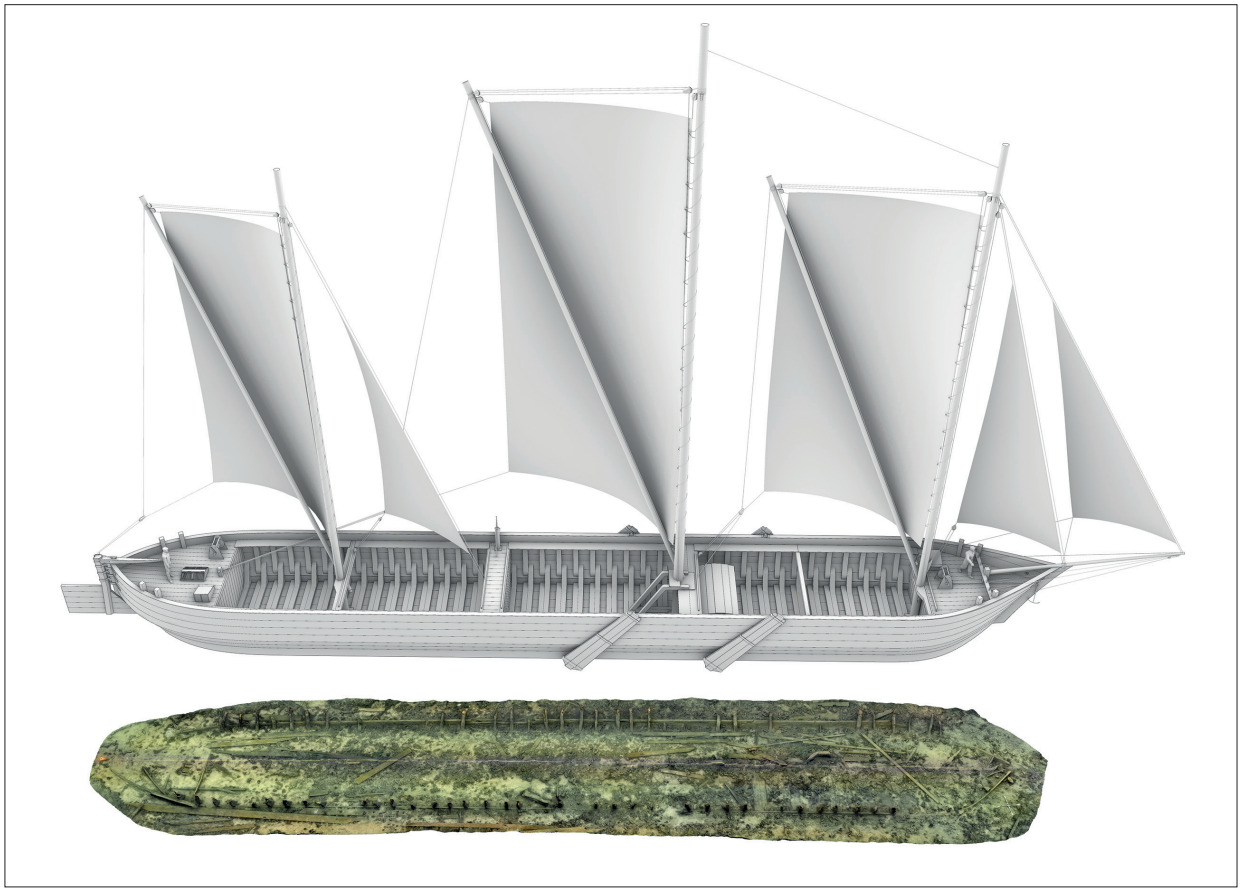

Fig. 11. Attempt at the digital reconstruction of the Peenemündung, Ostsee Bereich VII, Fpl.81 (compiled by M. Grabowski).

the blade extends beneath the sternpost to enhance hydrodynamic efficiency without increasing the vessel's overall length – an important feature for navigating narrow canals and locks. Additionally, the blade extension improved handling by balancing the water pressure on both sides of the blade as the vessel moved, reducing the effort required to steer.

The Peenemündung Fpl. 81 shipwreck can be conclusively classified as representative of the *Haffkahn* or *Pommernkahn* type. Based on the preserved hull remains, its length is estimated to approximately 40–41 m, with a beam of 5–5.6 m. Considering the size of the rudder, the vessel's height could have between 2.5–3 m. Evidence from the rudder and rigging suggests that the vessel was self-propelled, likely using one or more sails (Fig. 11). A significant feature of the site that aids in identifying the wreck is the cargo of coal briquettes. These briquettes were found both within the wreck and scattered throughout the surrounding debris field. All of them are uniform in size and shape, representing the so-called *Salon-briquettes* or *Hausbrand*, used for domestic purposes.[32] The briquettes are marked with the names of their manufacturers or brands: *KAISER* and *Ilse Bergbau ActGes*, alongside a decorative motif of the moon and stars (Fig. 12). Those briquettes were produced by *Ilse Bergbau Actiengesellschaft*, a company founded in 1888 as the successor to *Kunheim & Co.*, a Berlin-based chemical production firm that had established a coal mine in the Lausitz region to reduce fuel costs. The company expanded rapidly as demand for coal briquettes surged in the early 20th century. The size and decorative features of the *Ilse Bergbau ActGes* briquettes suggest their production at the *Marga I* or *Marga II* facilities in Brieske near Senftenberg. Most briquettes produced by *Ilse Bergbau Actiengesellschaft* were sold in Berlin and transported there by train. Szczecin, the nearest export harbour to Berlin, was accessible via both train and inland waterways. Briquettes were also transported directly by train from Senftenberg to Szczecin.[33]

[32] Keilhack 1913, 90.

[33] Keilhack 1913, 112

Fig. 12. Two types of coal briquette recovered from the site (photo by M. Grabowski; copyright: Landesamt für Kultur- und Denkmalpflege Mecklenburg-Vorpommern).

The vessel could, therefore, have been loaded in Berlin or Szczecin and may have been bound for Greifswald or Stralsund when it was lost in the Bay of Greifswald. Some insight into the fate of the wreck may be provided by a brief anonymous note found in the archives of the State Heritage Authority of Mecklenburg-Vorpommern (German: Landesamt für Kultur- und Denkmalpflege Mecklenburg-Vorpommern). This note describes events from 1924 when a *Haffkahn* carrying a cargo of coal briquettes sank in the Bay of Greifswald at a depth of 8.5 m. The coordinates and depth of the sunken vessel match the location of the Fpl. 81 shipwreck. However, beyond its location, cargo description, and mention of rigging still visible at the surface, the note provides no further details about the wreck or the events leading to its loss.

The Introduction of New Materials in the Construction of Pomeranian Inland Vessels

It is widely acknowledged that the first iron-built ship was the barge *Trial*, constructed by John Wilkinson in 1787, measuring 21 m in length. The construction of its hull incorporated wooden beams, posts, and a gunwale covered with iron plates fastened together using iron rivets.[34] By the first half of the 19th century, iron ships gained significant popularity on British waterways, marking a steady rise in their adoption. This trend expanded into large-scale seafaring in 1853 with the launch of the fully iron-hulled steamship *SS Great Britain*.[35]

The introduction of iron into Pomeranian shipbuilding, however, was a more gradual and long-term process. The first recorded mention of iron barges in this region dates to 1877. By the final decade of the 19th century, iron was increasingly used in constructing frames, sides, half-decks, and cabins, while the bottoms of vessels were still made entirely of wood.[36] In 1912, only 40% of registered *Oderkahn* vessels were constructed from iron. This slower adoption was primarily due to the technological limitations of local shipyards, which were small and ill-equipped to meet the demands of the industrial revolution. Although Germany was the world's largest producer of steel and iron before the World War I, wooden rivercrafts remained more cost-effective to produce than their iron counterparts.[37]

Despite these economic constraints, the advantages of the new materials were clear. Steel and iron were lighter, more durable, and could be shaped more flexibly than timber. These qualities were particularly advantageous for inland vessels navigating shallow riverine waterways. However, thin iron plates were less rigid and required additional longitudinal reinforcements. Moreover, iron-bottomed hulls were more susceptible to mechanical damage from underwater obstacles. These limitations likely led to the development of mixed wood-and-iron structures, which became typical for inland vessels from the late 19th century through the first half of the 20th century.

An example of such hybrid construction is a 21 m long wreck recovered in 2011 from the Oder River in the harbour of Szczecin.[38] Its bottom, including the planks and floor timbers, was made entirely of oak, whereas the vessel's sides were composed of riveted iron plates supported by iron futtocks (Fig. 13). A marking plate on the cabin's wall provided information about the

[34] McCarthy 2005, 143.
[35] Farr 1965.
[36] Teubert 1912, 274.
[37] Łuczak 1984, 25; Mielcarek 1986, 28–29.
[38] Grabowski, Ostasz 2016, 118–120.

Fig. 13. Detail shot on the hull's bottom of a barge shipwreck recovered from the Oder River in Szczecin in 2014 (photo by M. Grabowski).

vessel's origin, revealing that it was built in 1902 by *Johs. Thormählen & Co.*, a small family-operated shipyard in Elmshorn, Schleswig-Holstein. Bullet holes visible in the wooden bottom suggest that the vessel may have been sunk during an air attack in the World War II.

A mixed construction of Peenemündung, Ostsee Bereich VII, Fpl. 111

Another example of the early 20th-century mixed iron-and-wood Pomeranian rivercraft is the shipwreck Peenemündung, Ostsee Bereich VII, Fpl. 111. The site is located in the Bay of Greifswald, approximately 6 km north of Lubmin Harbour at an average depth of 6 m. This shipwreck site was also surveyed as part of several archaeological campaigns conducted between 2016 and 2019.

The wreck consists of a relatively small fragment of the hull, measuring 16 m in length and 2.2 m in maximum width (Fig. 14). The remains are almost entirely exposed on the seabed; however, the state of preservation prevents a definitive identification. It is unclear whether the structure visible on the seabed represents the bottom or the side of the vessel. The hull consists of five edge-to-edge joined strakes of oak planks, each with an average width of 27–37 cm and a thickness of 7 cm. The planks within each strake are connected by Z-shaped scarfs. As both ends of the hull are damaged and missing, the original length of the vessel cannot be determined. Nineteen frame stations are attached inboard of the planking, spaced approximately 50 cm apart. The frames are L-shaped, with the longer arm connected to the planking. The shorter arms, visible only from the northern side of the wreck, are bent upwards, indicating the turn of the bilge. All frames are secured to the planking with round metal bolts.

The wreck's width appears too narrow for the typical beam of an *Oderkahn* from this period. Additionally, the frames with upward arms on only one side suggest that this structure may belong to the side of the vessel rather than its bottom. Unfortunately, an examination of the immediate surroundings of the wreck did not reveal any additional components of its construction. This suggests

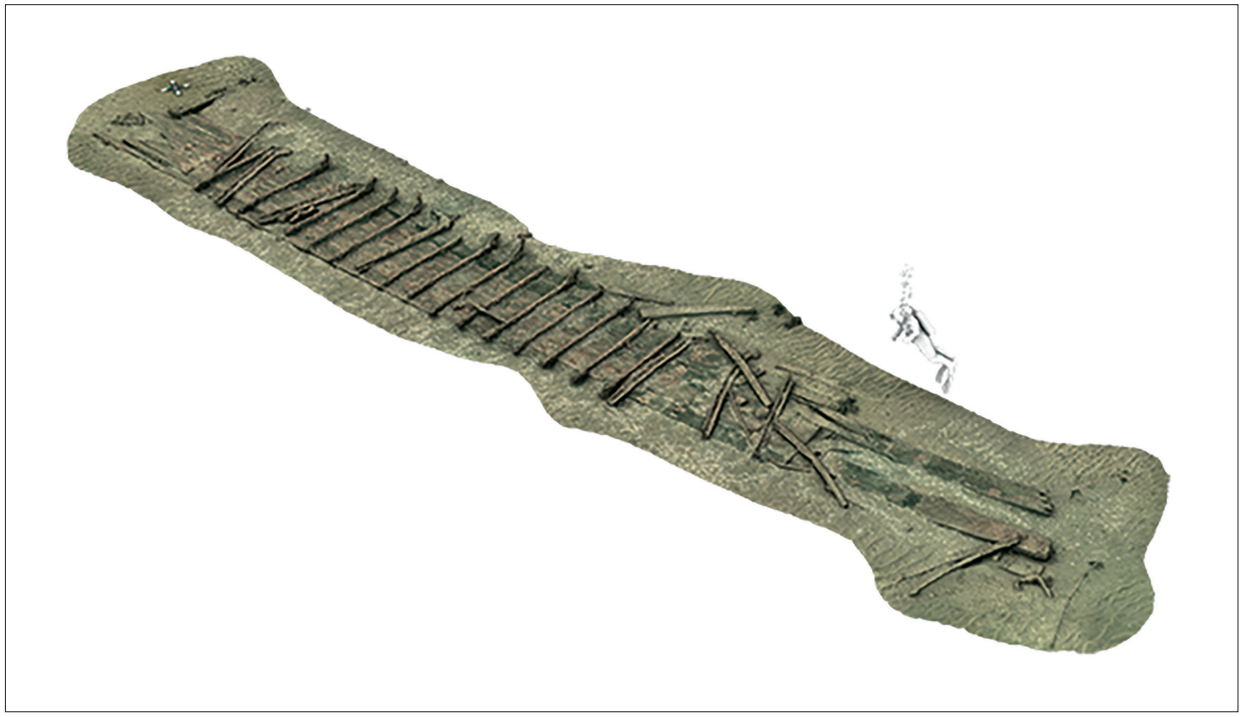

Fig. 14. Photogrammetry of Peenemündung, Ostsee Breich VII, Fpl.111 shipwreck site (compiled by P. Stencel in 2019; copyright: Landesamt für Kultur- und Denkmalpflege Mecklenburg-Vorpommern).

that the fragment may have been dislodged from its original, unidentified, location and carried away.

The Decline of the Sailing Ships on Pomeranian Waterways

Another innovation introduced during the Industrial Revolution that radically transformed navigation was steam engine. The advantages of this new propulsion method were evident, enabling the establishment of regular connections between inland harbours, which became largely independent of weather conditions, such as wind direction and seasonal strong river currents. However, the high costs associated with this technological change – including coal supplies, skilled specialists, and engine operators – meant it was initially accessible only to the wealthiest entrepreneurs. Thus, the first steamships appeared on the Oder River and in the Szczecin Lagoon during the 1830s.[39]

In response to these challenges, a common practice in the mid-19th century was the formation of shareholding companies. These companies were able to pool resources and provide fleets of steam-propelled ships and tugs to meet the growing demands of the market.[40] Gradually, masts and sails on river vessels were replaced with towing bitts, and eventually, diesel engines became the primary propulsion for self-propelled ships.

The World War II significantly accelerated changes in the Oder River fleet, affecting both the nature and scale of river transport. In 1945, the majority of the Oder vessels had been either sunk or destroyed. Most of the surviving ships were seized and relocated to the East by the Soviets. After the war, river transport technology underwent a fundamental shift. A more economical pushing system, utilizing entirely new types of barges and tugboats, began to replace traditional towing methods. This new method was significantly more efficient, as towing required greater power to pull barges against river currents, making it less energy-efficient. The pushing technique allowed for better control over the units and more efficient use of propulsion power.[41] By the 1950s, pushing had become the dominant method of river transport, surpassing traditional towing and driving further advancements in the field.

One of the last remaining examples of traditional Pomeranian-type vessels is the *Haffkahn Emma*, constructed between 1928 and 1929 in one of the lo-

[39] Miłkowski 2003, 20.
[40] Zawadka 1999, 136–137.
[41] Kulczyk, Winter 2003, 105; Reszka 2012, 54–56.

cal shipyards in Pölitz (now Police, near Szczecin). The hull of *Emma* was built entirely from riveted steel plates. Although it retained the traditional three-masted rigging characteristic of *Haffkahn* vessels, navigation through canals was assisted by a tug or motorboat. The vessel remained in use for several years after the war. In 1994, it was handed over to the Maritime Museum in Bremerhaven, where it is currently exhibited.[42]

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[42] Stölting 2004.

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