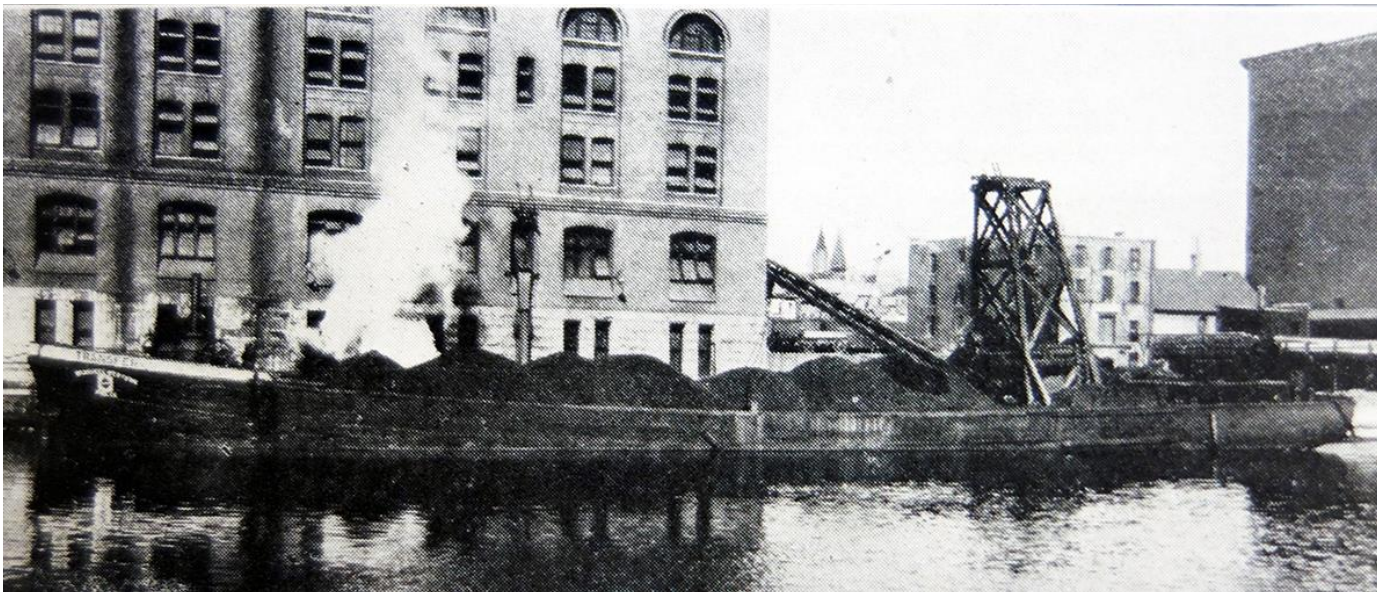
Self-Unloading Schooner Barges:
A Great Lakes Regional Context



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NATIONAL PARK SERVICE

Cover Photo: *Transfer* unloading coal in the Milwaukee River following its conversion to a self-unloader (Milwaukee Electric Railway & Light Co. 1916)

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ABSTRACT

Self-unloading vessels developed out of a need for faster, less labor intensive loading and unloading techniques in the Great Lakes region at the turn of the twentieth century (Lafferty and van Heest 2009:63). Self-unloaders were uniquely adapted to carry and unload small diameter bulk cargos (primarily crushed limestone, sand, or coal). Self-unloading machinery was primarily designed after mining equipment, and most early designs were developed by mining equipment manufacturers. The vessels were equipped with iron hoppers, conveyor and elevator systems, and an unloading boom designed to unload their bulk cargos with little to no manual labor (Lafferty and van Heest 2009:55-56). Early self-unloading designs were simple in construction and had many similar characteristics, although they were not uniform in design or construction. While many self-unloaders built later in the twentieth century were purpose built iron or steel-hulled vessels, it was common practice throughout the Great Lakes region to convert old wooden schooners, schooner-barges, and steam barges into self-unloading vessels (Zant 2015:63-64).

The following regional historic context discusses the characteristics of converted self-unloading schooner-barges, attempts to determine their significance within a regional framework, and serves as a detailed guide for site identification and significance assessment. It also offers a discussion of the historical and archaeological significance of converted self-unloading schooner-barges, and places the vessel type within its larger regional and historical context.

SECTION ONE
Introduction

Rather than looking at ships merely as vessels for the transportation of goods and people, ships can also be studied as cultural materials themselves, greatly representative of the environments, cultures, and regions in which they were built. The construction techniques and technology used aboard vessels can shed light on the development and economics of maritime communities (Adams 2001). Throughout the history of the Great Lakes region, ships remained the primary method of trade and transport, not only of goods, but of people and information as well. The study of the evolution of specialized shipbuilding techniques and shipboard technology in different regions can create an understanding of unique and remote microcosms of maritime heritage (Adams 2001). This is particularly true of the development of self-unloading schooner-barges in the early twentieth century, which reflected and enhanced the economic development of the Great Lakes region.

At the turn of the twentieth century, the Great Lakes were at the center of rapid technological advancement in shipping and shipbuilding. Industrial demands of the era necessitated the development of highly specialized modes of transportation that had high profitability at a relatively low cost of operation. The emergence of converted wooden self-unloaders was a unique solution to technological and economic issues facing maritime industries and transportation needs in the early twentieth century. Technological developments in shipbuilding mechanics and design were established to meet demands of a growing maritime industrial culture. As a relatively simple and inexpensive solution to the needs of bulk cargo transportation, converted wooden self-unloaders were an important link between modern mechanized shipping and traditional methods of waterborne transport, helping propel maritime industry into the modern era.

As a whole, converted wooden self-unloaders were vital to the economy of the Midwest, and the region’s transportation infrastructure prior to the development of road and rail networks. Before rail lines connected many smaller maritime communities along the Great Lakes to the larger industrial centers of the Midwest, these vessels played an important role in the economic development of the Great Lakes region. The mid to late nineteenth century demands for trade, and unique geographic characteristics of the Great Lakes created the necessity for specialized vessel designs and unique shipboard technologies not found anywhere else in the world. This progress is reflected in the development and use of self-unloading schooner-barges, exemplifying the distinctive design of these vessels.

The particular use of schooner-barges in conversions to self-unloaders was a unique addition to the development of self-unloading technology. Schooner-barges developed out of a need to transport large quantities of bulk material economically after the Civil War (Carrell 1985:14-16). With their reduced schooner rigs, these wooden vessels were the auxiliary workhorses of the coal, ore, wheat and stone trades throughout the region. Towed by tugs or steam barges in a consort system and almost never under their own power, schooner-barges were efficiently able to carry large quantities of bulk cargo to ports across the Great Lakes. Schooner-barges needed fewer crew members for their operation than did fully-rigged schooners, thus reducing costs.

Purpose built schooner-barges were also usually constructed with more boxy hulls, with a flatter bottom, sharper turn of the bilge, and flatter sides than schooners renovated into barges. Although most shipping companies were converting to stronger iron and steel hulls, the design and construction of schooner-barges allowed these vessels to compete effectively with larger metal vessels into the twentieth century. The unique hull design of purpose built schooner-barges made them extremely well suited for the implementation of self-unloading machinery (Cooper and Kriesa 1992:37).

Self-unloading vessels developed out of a need for faster, less labor intensive loading and unloading techniques in the Great Lakes region at the turn of the twentieth century (Lafferty and van Heest 2009:63). Self-unloaders were uniquely adapted to carry and unload small diameter bulk cargos (primarily crushed limestone, sand, or coal). Using methods developed for mining, self-unloading technology allowed vessels to unload up to 25 times faster than the latest unloading technologies of the day.

The following sections of this Context focus on the construction and development of schooner-barges and self-unloaders, their use in Great Lakes trade, and the unique mechanisms employed to create the greatest economic benefit in transporting bulk cargos. This is facilitated by the study and analysis of the archaeological remains of known self-unloading schooner-barges: *Adriatic*, *Transfer*, and *EMBA*, along with other converted Great Lakes self-unloaders. Likewise, the very development and construction of these specialized technologies for trade and transport can help in the overall understanding of maritime industrial commerce in the Great Lakes region.

Though examples of this type of vessel construction are no longer available above the water, the archaeological remains of known self-unloading schooner-barges in Wisconsin waters, along with the remains of multiple other vessels located on the bottom of the Great Lakes, provide an opportunity to study maritime innovation and the role these vessels played in the development of the region's unique maritime industrial context. Early converted wooden self-unloading schooner barges in the Great Lakes were incredibly unique and varied widely in their construction and design, but had many similar characteristics and equipment that remain identifiable in the historical and archaeological record. These sites allow for an analysis of evolving unique shipboard mechanisms and technology that would continue to define innovations in Great Lakes shipbuilding well into the modern era.

This Context stands to define the characteristics of converted self-unloading schooner-barges, attempts to determine their significance within a regional framework, and serves as a detailed guide for site identification and significance assessment. The following sections highlight the historical significance of converted wooden self-unloaders in the Great Lakes, outline common features and variations in self-unloading machinery designs, and offer an analysis of known converted wooden self-unloader wreck sites. Additionally, a final section offers a discussion the historical and archaeological significance of converted wooden self-unloaders, and places the vessel type within its larger historical context.

SECTION TWO
Schooner-Barges, Trade, and Technology in the Great Lakes

Throughout the mid-nineteenth and into the early twentieth century, ships remained the primary method of trade and transport, not only of goods, but of people and information as well, across the Great Lakes region. Although other methods of transportation were beginning to become commonplace in the mid to late nineteenth century, waterborne transportation remained the most reliable and cost effective way to move goods and people throughout the Great Lakes. Portions of the Great Lakes region remained unreached by rail and roads until well into the twentieth century, leaving waterborne transportation routes as the primary method of transportation for these areas. As railways began to develop and become the primary transportation system of moving goods westward in the 1870s and 1880s, schooners and consort systems remained the most efficient and economical system of transportation for bulk goods on the Great Lakes.

As demands for goods from these regions continued to grow throughout the late nineteenth century, new, more effective methods of waterborne transportation began to develop and evolve, particularly in the bulk cargo trade. As demand for these bulk cargos increased, so did the demand for faster, more efficient transportation methods to move the cargos. The evolution of specialized shipbuilding techniques and shipboard technology in various regions can create an understanding of unique and remote microcosms of maritime heritage (Adams 2001:300). This is particularly true of schooner-barge construction and self-unloaders, which reflect and enhance the economic development of the Great Lakes region.

The late nineteenth and early twentieth century demands for trade, and unique geographic characteristics of the Great Lakes created the necessity for the development of highly specialized vessels and technologies not found anywhere else in the world. This progress is reflected in the use of schooner-barges and their conversion to self-unloaders, and exemplifies the unique design of these vessels. The very development and construction of these specialized technologies for trade and transport can help in the understanding of these Great Lakes maritime industrial communities.

Schooner-barges primarily developed out of a need to transport large quantities of bulk material economically after the Civil War (Carrell 1985:14-16). One of the largest, and most profitable, industries in the Great Lakes was the stone trade. The transportation of stone to large cities, for harbors, docks, roads, railroad beds, and wharves, helped propel the shipping industries of towns like Sturgeon Bay, Wisconsin. By the early 1880s, Sturgeon Bay had developed into a thriving hinterland port, and its prevalence in the Great Lakes shipping industry continued well into the 20th century (Hotchkiss and Steidtmann 1914:38). On either side of Sturgeon Bay, steep bluffs, rich in limestone, created an ideal location for stone quarries close to the water’s edge (Rodgers 2003:4-5). Waterborne transport was the main vehicle of trade throughout northeastern Wisconsin without extensive rail lines reaching the area until the early 1920s.

The proximity of many of Wisconsin’s industrial centers to the water made the development of barges essential to the state’s trade. With no close access to rail lines, the use of these barges allowed these industrial regions of northern Wisconsin to service remote ports, as well as larger cities connected by rail lines, quickly and effectively. These barges were the vehicles for Sturgeon Bay's success in stone production, and important components of trade in industries up and down Wisconsin's coast in the late 19th and early 20th century. This need for rapid transport expedited the development of maritime technological innovation in the region (Martin 1881:12).

The development and design of schooner-barges is attributed to the Great Lakes region, and represents the culmination of early developments in large capacity wooden vessel design. As a cross between a schooner and a bulk carrier, schooner-barges were highly specialized to carry bulk cargos of wheat, coal, iron, lumber, ore, and stone across the Great Lakes (Morris 1984:1-3). Schooner-barges included schooners converted into barges, or purpose built schooner-barges. The height of construction for these purpose built schooner-barges occurred in the late 1880s and into the 1890s, and the vessel type was commonly seen throughout the Great Lakes region towed by a steamer in a consort system. The hull design of purpose built schooner-barges closely resembled that of bulk carrier steamers as they were built to carry large quantities of this bulk cargo. Unlike traditional sailing and grain schooners, schooner-barges were built for capacity, not for speed. Constructed with a very sharp turn of the bilge and a flat bottom, schooner-barges did not have to rely upon sleek lines for propulsion through the water as they were usually towed by steam powered vessels (Cooper and Jensen 1995:56).

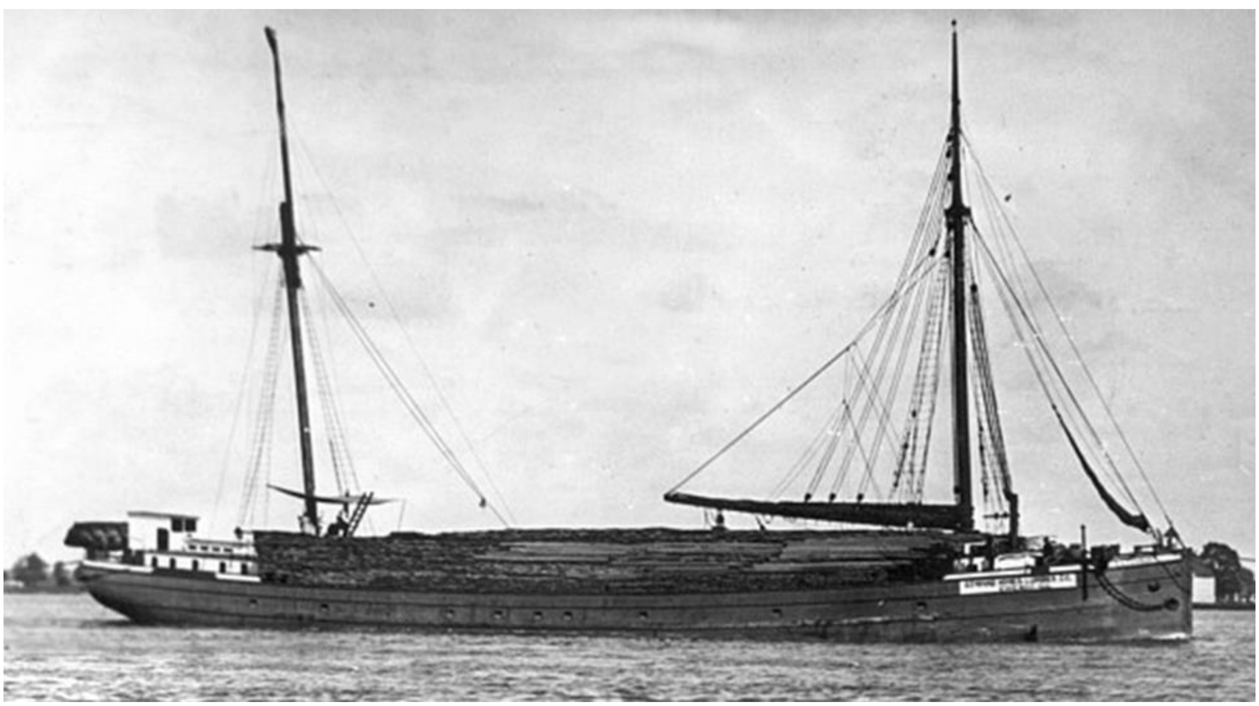


Figure 1. *A.C. Tuxbury*, later *EMBA*, as a schooner-barge in a consort system (Bowling Green State University)

Schooner-barges were also equipped with a reduced schooner rig, which generally had the mainmast removed to facilitate the loading and unloading of cargo, adding to the vessel's profitability with less time spent in harbor. The rig was best implemented on schooner-barges that were towed for most of their passage. Additionally, the vessel's sails were reduced, usually consisting only of two boom and gaff-rigged sails to help maneuver the vessel if necessary. One less mast and fewer sails meant easier handling, which reduced the need for a large crew (Karamanski 2000:40, 42).

It is speculated that this design was transported to the Great Lakes by Scandinavian immigrants who proliferated in the Great Lakes shipping industry in the late 19th century. In the North Sea, vessels that were two masted, fore-and-aft rigged with masts set far apart were called a "ketch", and were used in earnest throughout the region. Though profitable, these vessels were not known for their speed. Because schooner-barges were largely towed as consorts, only using their sails in storms and when tow lines broke, this reduced rigging design helped these vessels remain economical and profitable in an era when larger and faster steamships were plying the Lakes (Karamanski 2000:40).

A wooden steamer towing a consort could carry between 7,500 and 8,000 tons. Despite this, unloading times remained slow, costing shipping companies time and money. In order to combat lengthy stops in port, various methods of unloading bulk cargo were developed throughout the nineteenth and early twentieth centuries, but none as innovative as the evolution of self-unloading technology. Though many semi-manual methods for unloading developed during the early twentieth century, none were as effective as the belt conveyor self-unloading system, which debuted in 1902. The development of self-unloading vessels ushered in a new era of shipping in the Great Lakes, and paved the way for the development of modern unloading techniques (Penton and Sadler 1924:57-58; Devendorf 1995:30).

Figure 2. A schooner in port being unloaded (C. Patrick Labadie Collection)

By the turn of the 20th century, the U.S. economy had fully recovered from the Panic of 1893, and demand for raw materials for industry was on the rise (Timberlake 1997:516-518). Due to this demand, technological innovations in shipbuilding were prioritized to alleviate the high labor costs of maritime transportation. Bulk cargos made up the largest portion of Great Lakes cargos by this time, and the need for faster, less labor intensive loading and unloading techniques became a priority. This was particularly true of the limestone industry in northeastern Wisconsin, where new technologies were necessary to compete with growing demands for stone (Lafferty and van Heest 2009:63). Hinterland communities were growing rapidly, and demanded increasing amounts of raw materials and products to support their development. This demand for more materials meant larger cargos of materials needed to be transported at a faster rate. Unfortunately, unloading times for traditional schooners and schooner-barges remained painfully slow (Lafferty 1998:155-156). Manual and semi-manual unloading techniques usually took 48 hours, or longer, costing the shipping companies great amounts of time and money, and greatly influenced wharf and dock construction. To accommodate the large amounts of cargo needing transport, dockside implementations also required a large amount of space, time, and labor (Lafferty 1998:156-157).

The most common methods of loading bulk cargo included rail carts filled with the cargo upended by a derrick mounted on the dock. Another method of loading was a process involved attaching two logs, outfitted with rails, to the end of a wharf, extending over the barges. A manned cart rode the rails out over the hold of the barge, and a crane tipped the cart, dumping the bulk cargo into the hold (Rogers and Green 2003:10). While these dockside improvements helped facilitate more efficient loading and unloading techniques, the process remained arduous and expensive.

Out of the necessity for speed and economical transportation developed the vessel type that would come to define shipping in the Great Lakes: self-unloaders. Self-unloaders were uniquely adapted to carry and unload bulk cargos broken into small fragments such as crushed limestone, sand, or coal. The earliest self-unloader designs developed in 1902, and were largely influenced by mining equipment, and most early designs were developed by mining equipment manufacturers. With the development of Leathem and Smith's stone crusher in 1905 at the Leathem and Smith Stone Quarry in Sturgeon Bay, Wisconsin, the need for these vessels increased exponentially (Sturgeon Bay Advocate 1912:1).

Though early designs were simple in construction and had many similar characteristics, self-unloading vessels were not uniform in design or building material. While many self-unloaders built later in the 20th century were purpose built iron or steel-hulled vessels, it was common practice throughout the Great Lakes to convert old schooners and steam barges into self-unloading vessels. These cheap, experimental conversions of old wooden sailing vessels, steam barges, and bulk carriers led the way in the development of self-unloading technology. Although similar in design, there were distinct differences in construction techniques that distinguished converted wooden self-unloaders from those purpose built out of iron and steel, with the steam barges *Hennepin* and *Wyandotte* serving as the two earliest examples of each (Lafferty and van Heest 2009:43-44).

SECTION THREE
Self-Unloading Schooner-Barge Typology

The advent of self-unloading vessels was a turning point in labor-saving shipboard unloading technology. The original, early designs of converted wooden self-unloaders paved the way for the development of modern self-unloading vessels, and are an incredibly unique vessel type prevalent for only a short period. While only one of multiple different vessel types used in self-unloading conversions purpose built schooner-barges proved to be extremely well suited for conversion to self-unloaders due to their distinctive construction. The flat bottom, flat hull sides, and sharp turn of the bilge left plenty of space in the hold in which to install machinery, and kept the center of gravity of the vessels lower than in other converted vessel types, such as traditional schooners and wooden steamers.

With little surviving historical documentation illustrating varying designs in schooner-barge construction and self-unloading technology, only research, investigations, and documentation of archaeological sites can answer questions specific to early self-unloader construction, design, and use. Most components of self-unloading technology were influenced by mining equipment design and many of the early converted self-unloaders were equipped with modified mining rigs designed by mining equipment manufacturing companies. While some of these companies used their foray into shipboard labor-saving technologies as advertisements for their prowess in the industry, many others did not, resulting in a lack of documentation on the specifications of these early self-unloader conversions.

Research into various contemporary mining equipment manufacturing companies, along with documentation of known converted self-unloader wreck sites offers the potential to answer questions about this vessel type and the design of self-unloading machinery. Analysis of construction features specific to purpose built schooner-barges, such as construction of the turn of the bilge, and hull lines offers significant opportunities to add to our knowledge of the vessels as well, adding to the knowledge and understanding of this distinctive vessel type. Nineteenth-century wooden vessels were rarely built to drawn plans. Early converted wooden self-unloading schooner barges in the Great Lakes were incredibly unique and varied widely in their construction and design. No two conversions were the same. Several noted features specific to schooner-barges, self-unloaders, and common conveyor systems are noted in the following sections.

Schooner-Barge Hull Construction

While the term “schooner-barge” includes traditional schooners that were renovated into barges, this analysis primarily focuses on purpose built schooner-barges of the late 1880s and 1890s. The hull shape of purpose built schooner-barges were simple in design, but allowed the vessels to carry a maximum amount of cargo while forgoing the sleek aesthetics of traditional sailing vessels. Schooner-barges were built for capacity, not for speed, and did not usually have to sail under their own power. Though the hulls of these vessels largely resembled traditional schooners above the water, below the waterline, schooner-barges resembled modern bulk carriers, which allowed the maximum carrying capacity. The sharp turn of the bilge and flat bottom also contributed to schooner-barges shallow drafts. These features allowed schooner-barges to enter many smaller, unimproved ports that vessel's with larger drafts could not enter (Rogers 2003:28).

It was this unique combination of features that distinguished schooner-barges from contemporary vessels, and adapted them to the diverse demands of late nineteenth century commerce. The unique hull design of schooner-barges made them extremely well suited for conversion to self-unloaders. Their boxy, rectangular cross section left plenty of space in the hold in which to install machinery. This kept the center of gravity of converted schooner-barges lower than with traditional schooners and steamers after conversion, allowing for maximum carrying capacity.

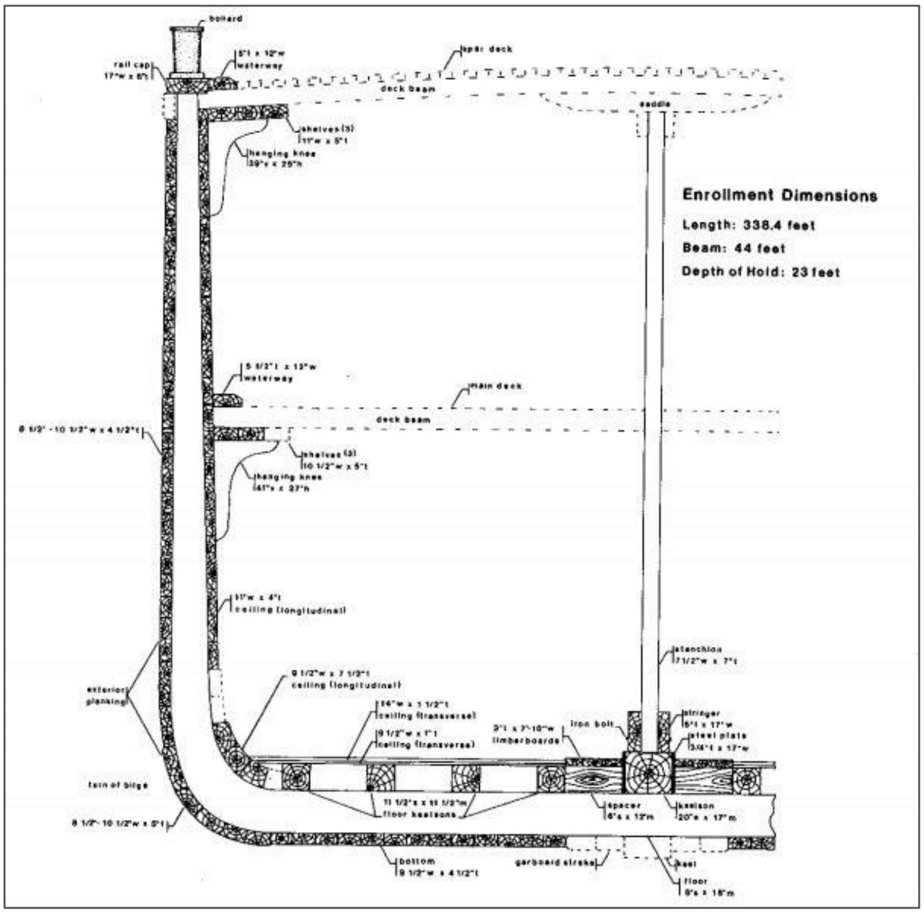


Figure 3. Cross section of the Davidson-built schooner-barge *Pretoria* (Cooper and Jensen 1995)

One of the main difference between schooner-barges and schooners was the reduction in the sail and rigging area. The masts of schooner-barges were shorter, with the vessel's topmasts and sails removed, and usually totaled only two, sometimes three in number. Schooner-barges primarily operated with a reduced schooner rig, known as a "Grand Haven" rig (Karamanski 2000:42). A vessel with a Grand Haven rig characteristically had the mainmast removed to facilitate the loading and unloading of cargo more quickly and easily, but with a significant decrease in speed. The rig was best implemented on schooner-barges due to the fact that they were towed for most of their passage, and did not have to rely upon the wind for speed. Additionally, the vessel's topsails were removed, and two boom and gaff-rigged sails were installed on the foremast and mizzenmast to help maneuver the vessel in inclement weather, or could be used if a vessel's towline broke. The vessel's booms and gaffs could easily be swung out of the way to load and unload cargo.

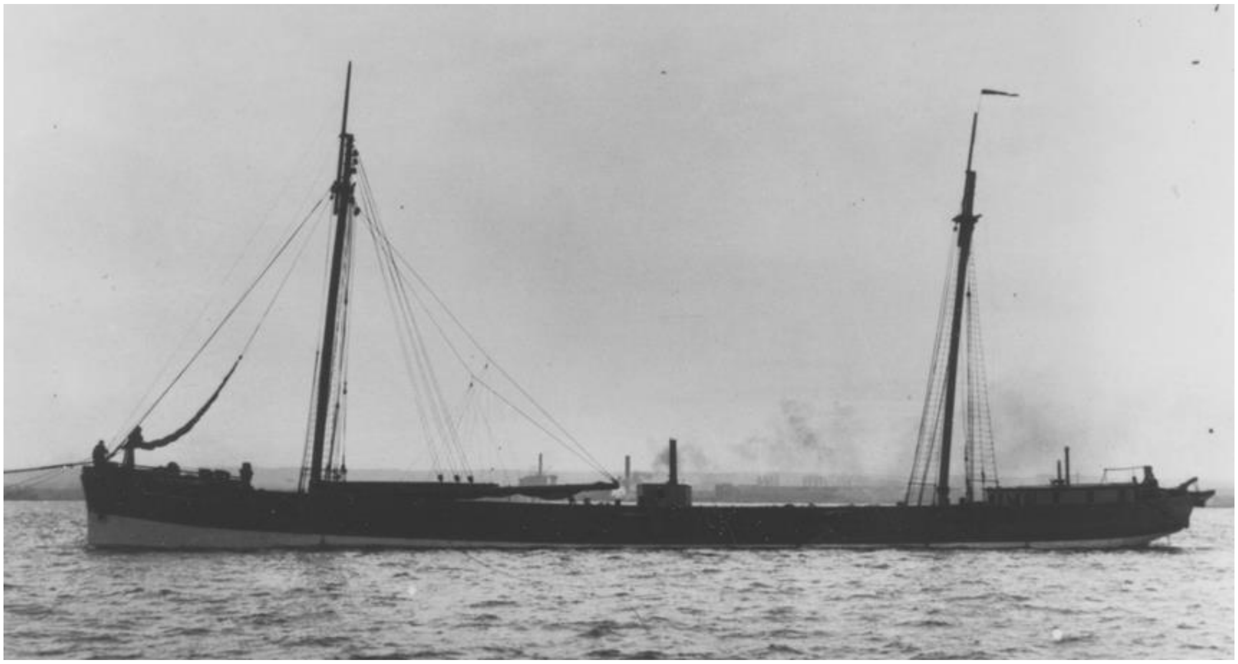


Figure 4. *William McGregor*, later *Transfer*, with a Grand Haven rig under tow in consort (C. Patrick Labadie Collection)

Deck housing was usually removed from converted schooners, and additional hatches were added. A pilothouse was sometimes added to provide the pilot with a clear view, and a small steam-engine was often used to hoist anchors, work pumps, and load and unload cargo. Schooner-barges needed fewer crew members for their operation than did fully-rigged schooners, which reduced the cost of operation. Most schooner-barges of this era sailed with a crew of only eight to ten (Karamanski 2000:40, 42). Purpose built schooner-barges were also generally constructed with more boxy hulls, with a flatter bottom, sharper turn of the bilge, and flatter sides than traditional schooners renovated into barges.

Self-Unloading Mechanisms

The design and use of early self-unloading technology developed simultaneously in multiple areas of the Great Lakes, resulting in a wide variety of adaptations and methods of implementation. With an increasing demand for fast, economical transportation of bulk commodities, companies needed to quickly develop new technologies in loading and unloading methods. Though transportation speeds were greatly assisted by the development of dockside steam powered machinery for unloading cargo, these large apparatuses were often complicated, and still required 48 hours, or more, to unload. Although faster than manual unloading, this time in port cost companies a considerable amount of money. This led directly to the development of shipboard unloading machinery.

The general concept was not new. Shipping companies needed a semi-automated method of moving small diameter bulk cargo from one place to another, generally including a steep incline: a process which had already been utilized by mining companies throughout the mid to late nineteenth century. Due to this, most early converted self-unloading technology was a modified version of mining equipment, specially designed to fit within the confines of a ship's hull.

As the name implies, self-unloaders were equipped with elevator and conveyor systems designed to unload small diameter bulk cargos (primarily limestone, sand, and coal) with little to no manual labor. Instead of the cargo being loosely contained in the vessel's hold, self-unloaders were equipped with parallel hoppers beneath each cargo opening running the length of the vessel. These hoppers would funnel the cargo down to the bottom of the hull where it was deposited through small doors onto conveyor systems designed to transport the cargo to athwartship conveyors located at either the bow or the stern of the vessel, and then to an inclined conveyor or elevator. This conveyor/elevator then carried the cargo up to an unloading boom, equipped with another conveyor located on the vessel's deck. The boom could then be swung over the side of the vessel to deposit the cargo onto the dock. The entire mechanism was steam powered and operated by a series of gears, belts, and wheels, necessitating the installation of a small boiler in converted sailing vessels (Lafferty and van Heest 2009:55-56).

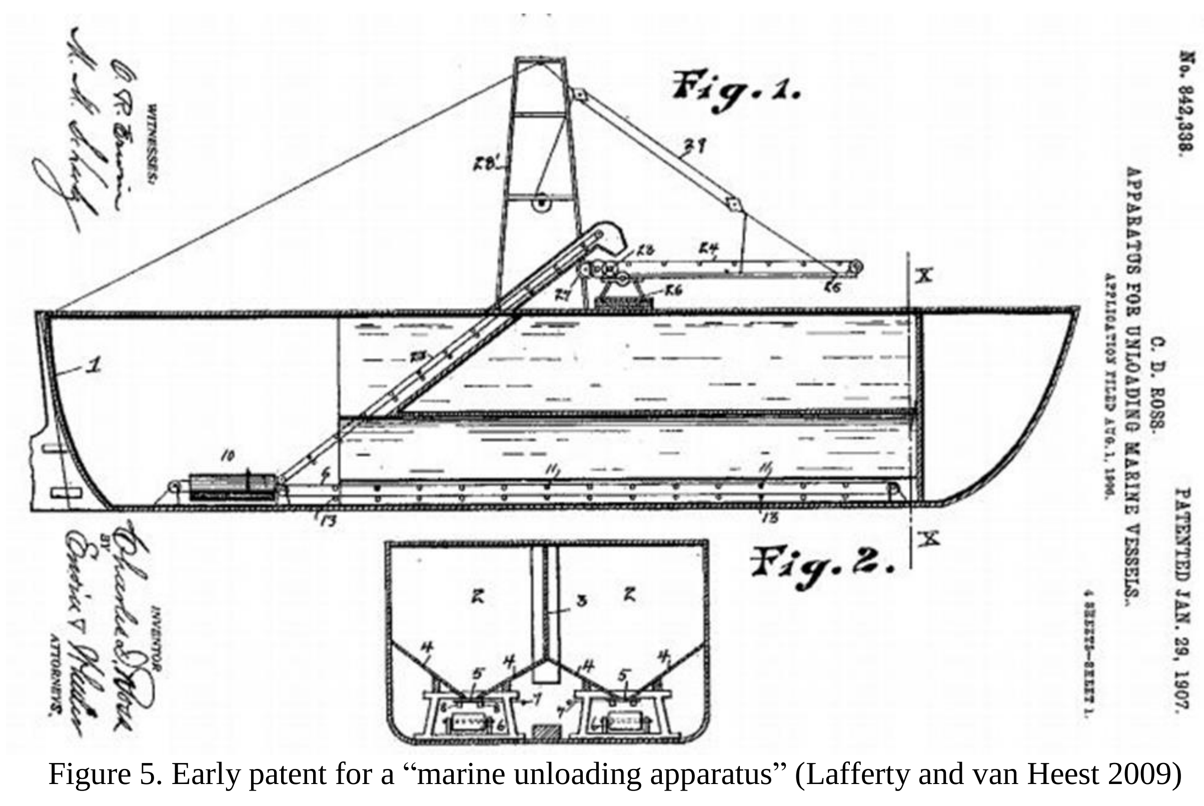


Figure 5. Early patent for a "marine unloading apparatus" (Lafferty and van Heest 2009)

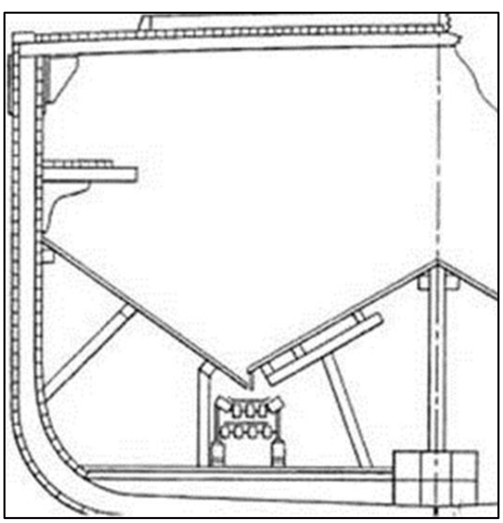
Though early designs were simple in construction and had many similar characteristics, self-unloading vessels were not uniform in design or building material. While many self-unloaders built later in the 20th century were purpose built iron or steel-hulled vessels, it was common practice throughout the Great Lakes to convert old schooners and steam barges into self-unloading vessels. These early, inexpensive conversions of old wooden sailing vessels, steam barges, and bulk carriers led the way in the development of self-unloading technology, paving the way for an evolution of the modern maritime industrial landscape of the Great Lakes. Modern bulk carriers on the Great Lakes still use a slightly modified and advanced version of the early unloading technology developed just after the turn of the 20th century.

Conveyor Systems

Conversions of wooden vessels into self-unloaders varied widely in design and installation. While the general components of the self-unloading machinery were the same (belts, buckets, conveyors, elevators, gears, and wheels), few conveyor systems were the same. At the start of the twentieth century, this technology was changing and advancing rapidly and there was no single method of development. Most self-unloading implements were modified versions of mining or logging equipment already in use. Because mining was such a large industry in the late nineteenth and early twentieth century, there was no shortage of mining equipment manufacturers, contributing to the wide array of shipboard self-unloading systems.

<u>Hoppers</u>

The hoppers installed in converted self-unloading vessels were largely the same: two parallel sets of hoppers lined the inside of the vessel's hull and would funnel cargo onto a conveyor system below. Most hoppers were constructed of wood, built with thick timbers and lined with thinner sacrificial wood planks, however, other vessels were equipped with iron with sacrificial wood planning lining their interiors to protect the metal. The rate the cargo dropped onto the conveyor below was regulated by hopper doors, which varied in design and operation. Some hopper doors were metal and operated by running along tracks which were manually opened by crew members, while others operated more like chutes that were opened and closed with ratchet bars and chains, which were manually operated (Lafferty and van Heest 2009:55-56; Zant and Thomson 2013:6; James, Lafferty, et all 2019:152).



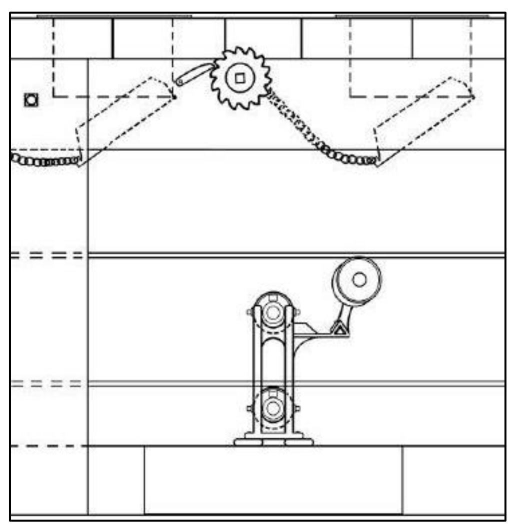


Figure 6. Cross section of hopper doors on *Hennepin* (left) and an illustration of *Adriatic*'s hopper chute doors (right) (Lafferty and van Heest 2009; PanAmerican Consultants, Inc.)

Belt Conveyors

Belt conveyors were a commonly used type of conveyor system in self-unloading vessels, both for inside the hull and on the unloading boom. The belt conveyors inside the hull were located beneath each line of hoppers in the hold. They were relatively simple to operate and had the capacity to move large amounts of small diameter bulk cargo efficiently. Belt conveyor systems consisted of wooden supports, and a belt that was advanced by a series of rollers, and two larger rollers which served as the end points of the belt conveyor, allowing it to continually move in a single direction.

Figure 7. Stephens-Adamson belt conveyor variations for crushed stone (Stephens-Adamson Manufacturing Company 1916)

The belt sat atop rollers situated on angles to the belt, effectively cradling it and the cargo being released from the hoppers. Below these top rollers were two or three additional rollers situated parallel to the belt on a metal bar. These served to support the belt along the bottom as it completed its return along the length of the hold. Each set of rollers was attached to metal rods, which were buttressed by two metal supports that acted as the base for the rollers. Multiple roller mechanisms were fastened along two wooden timbers running the length of the ship (Stephens-Adamson Manufacturing Company 1916:91; James, Lafferty, et. all 2019:164-165).

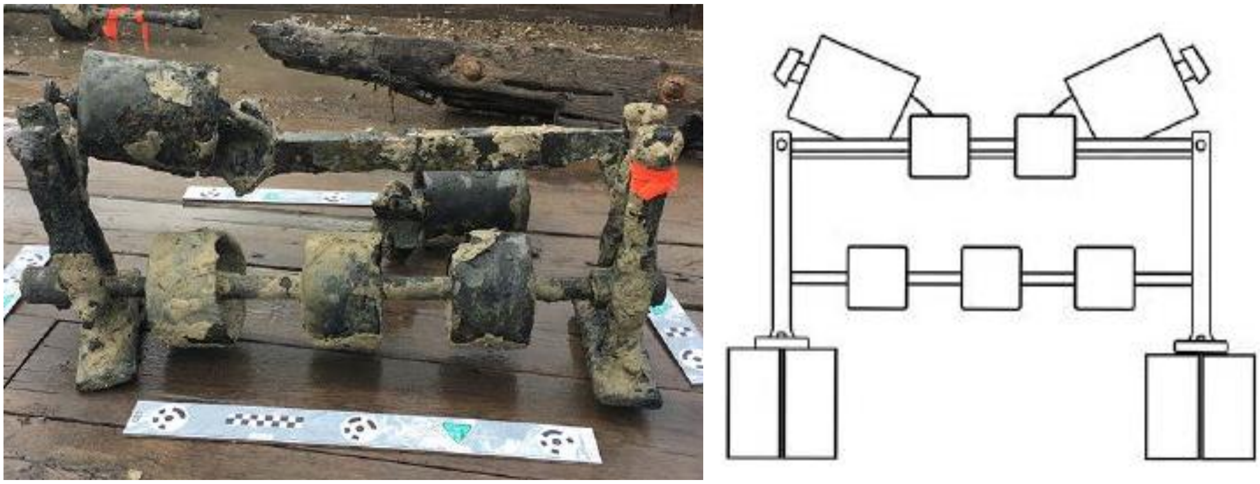


Figure 8. Belt conveyor base and rollers recovered from *Adriatic* (left) and reconstruction schematic of the same belt conveyor base and rollers (right) (James, Lafferty, et. all 2019)

At the ends of each belt conveyor was a large roller attached to a tensioner. These served as the turning points for the belt and also helped keep the belt tensioned. As the belts (generally made out of a rubberized material) were worn more and more from each use, they would begin to loosen and stretch out. The tensioners were used to move the end rollers longitudinally so the belts could be tightened, elongating their use (James, Lafferty, et. all 2019:164).

Figure 9. Two large belt conveyor rollers and a tensioner recovered from the *Adriatic* shipwreck (PanAmerican Consultants, Inc.)

Cable Conveyors

Cable conveyors were less commonly used in self-unloading vessels, and were known for being extremely simple and efficient at hauling loose bulk materials long distances. The speed of cable conveyer systems was slightly lower than belt conveyors, however, cable conveyors tended to need less maintenance than belt conveyors. Cable conveyor systems consisted of a series of circular disks mounted at intervals on a cable, a curved trough, and gapped sheave wheels located at each end of the conveyor, allowing it to continually move in a single direction (Jeffery Manufacturing Co. 1922:334; Kiefer, Zant, et all 2020:5-6).

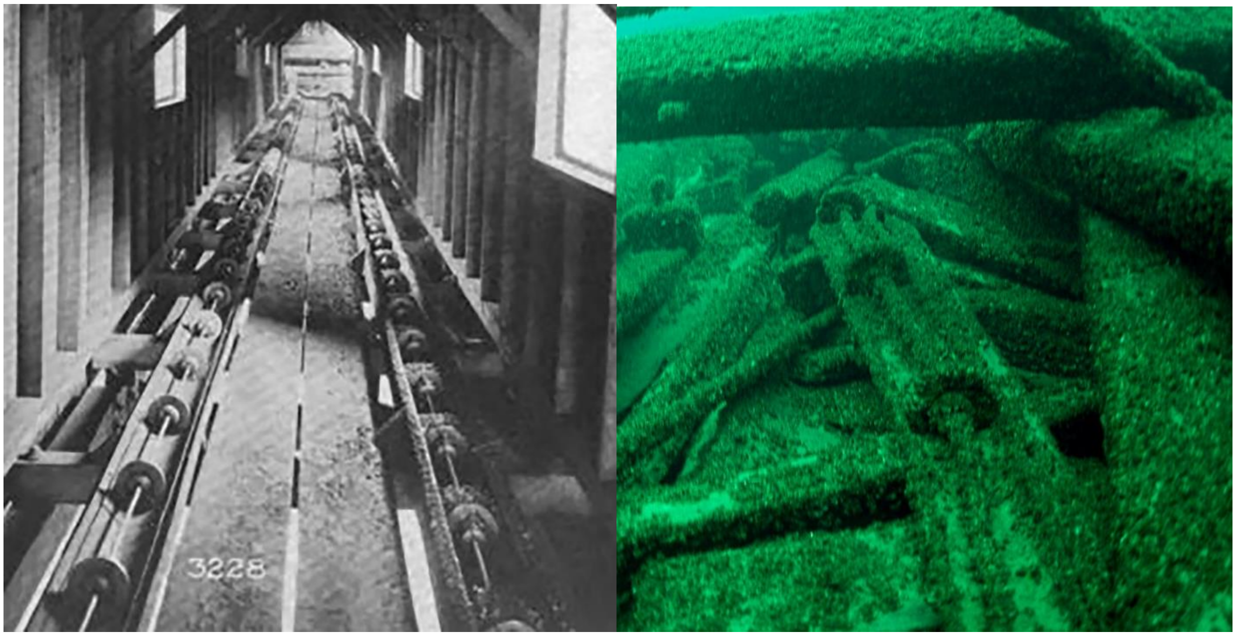


Figure 10. Jeffery Manufacturing Co. cable conveyor layout (left) and cable conveyor system, *Transfer* shipwreck site (right) (Jeffery Manufacturing Co. 1922; Wisconsin Historical Society)

The cable of the cable conveyors was generally made of steel, and measured around 0.2 inches in diameter. Circular steel discs or blocks were attached to the cable at equal intervals, in order to capture and move the material funneled from the hoppers. This disc and cable system ran through a curved, steel or steel-lined wooden trough that sat beneath the hopper doors, collecting whatever material came through. Rotated by a series of beveled gears, the ends of the conveyor were marked by large gapped sheave wheels. The sheave wheels operated similarly to regular gears, but they had gaps cut out for the circular disks to align in order to turn the cable conveyor at its end and keep the conveyor rotating (Jeffery Manufacturing Co. 1922:239; Kiefer, Zant, et all 2020:5-6).

Figure 11. Two gapped sheave wheel designs (left) and a broken gapped sheave wheel from the *Transfer* shipwreck site (right) (Jeffery Manufacturing Co. 1922; Wisconsin Historical Society)

Unlike belt conveyor systems, cable conveyors had no need for tensioners, and the thick steel cables and discs used were highly durable. Cable conveyors came in many sizes and had various disc and block attachments for different types of bulk materials. Additionally, various shapes of steel troughs were used for different material types. "U" shaped troughs were generally used for smaller sized bulk materials such as coal, saw dust, and shavings, while "V" shaped troughs were generally used for large size bulk materials such as wood blocks, mine coal, and other refuse (Jeffery Manufacturing Co. 1922:336).

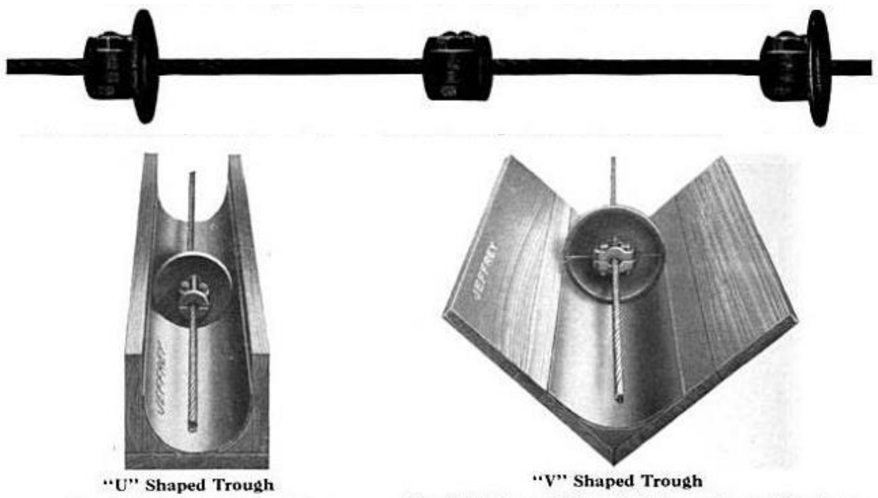


Figure 12. Cable and disc/block layout and the "U" vs. "V" shaped trough style of cable conveyor troughs (Jeffery Manufacturing Co. 1922)

Flight/Scraper Conveyors

Flight or scraper conveyors were even less commonly used on self-unloading vessels to maneuver bulk cargoes. Generally they were not recommended for abrasive materials, and were not well suited to a cargo such as crushed stone. Flight/scrapper conveyor systems consist of a series of flights attached to one or two strands of roller chain, a square or rectangular trough, and sprocket gears located at each end, allowing the chain and flights to continually move in a single direction (Chain Belt Co. 1911:7, 1923; 386, 390).

Figure 13. Illustration of a double strand wooden flight conveyor (left) and image of a Rex Scraper conveyor (right) (Chain Belt Co. 1911, 1923)

The flights were made of metal or wood and attached to the one or two strands of chain at equal intervals, which allowed the movement of the flights along a wooden or metal trough. The roller chains would interlock around the teeth of the sprockets at each end of the trough (similarly to a modern bicycle chain and gear), keeping the conveyor rotating. The flights moved bulk material along the trough similarly to the action of the discs in the cable conveyor system. Like the cable conveyor system, flight/scraper conveyor systems had no need of tensioners due to the rigidity of the roller chains (Chain Belt Co. 1911:7, 1923:386, 390; Jeffery Manufacturing Co. 1922:157).

Bucket Elevators and Pan Conveyors

Bucket elevators and pan conveyors were a commonly used bucket conveyor systems that allowed vessel's to handle larger pieces of bulk material better than the rubber belt conveyors. While some later metal self-unloaders used pan conveyors and other bucket conveyor systems as the primary longitudinal conveyors in the hold, early self-unloaders made use of them as inclined conveyors to get cargo out of the hold. Many of the earliest self-unloaders were designed with an inclined belt conveyor to transport cargo from the vessel's hold to the self-unloading boom; however, these could not operate at a very steep incline, taking up additional room and cargo space in the vessel's hold. Inclined pan conveyors could operate at up to a 45-degree angle and bucket elevators could operate almost completely vertically. These inclined and upright bucket conveyor systems took up much less space in the hold, increasing cargo capacity (Lafferty and van Heest 2009:66; Zant and Thomsen 2013:4, 6).

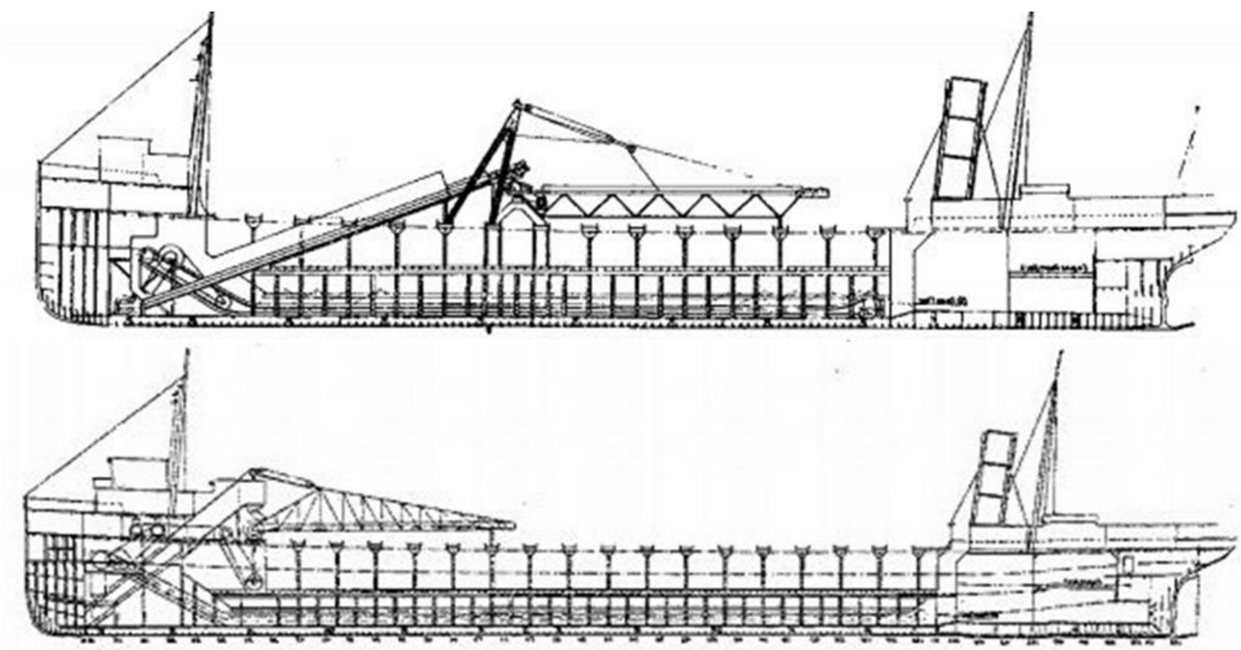


Figure 14. Purpose built self-unloader *Wyandotte* with its original inclined belt conveyor and after its replacement by an inclined bucket elevator (Lafferty and van Heest 2009)

Bucket elevators were made up of a series of buckets which could vary in shape (round bottom, V-shaped, square, pan, etc.) depending on the primary cargo that a vessel primarily transported. These buckets were spaced at equal intervals along chains, which would interlock with large sprocket wheels located at the top and bottom of the elevator, which powered the elevator, allowing the buckets to continually move in a single direction. Bucket elevators were specifically marketed for coal, ashes, and crushed stone (Jeffery Manufacturing Co. 1922:252, 364-366).

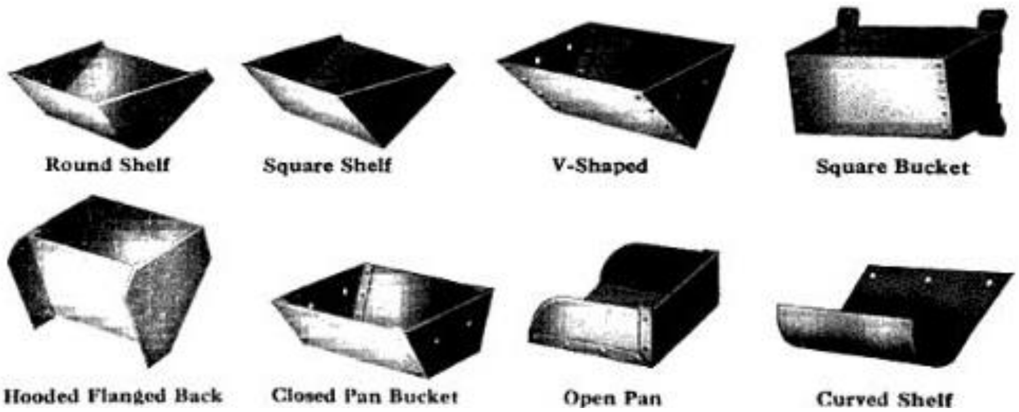


Figure 15. Various bucket shapes for elevators offered by the Jeffery Manufacturing Co. (Jeffery Manufacturing Co. 1922)

Pan conveyors, a specific type of bucket elevator system, were made up of a series of flat bottomed buckets made out of steel, connected by a series of rollers and links/bars. The rollers moved along a narrow gauge rail track, which also acted as the main longitudinal support for the pan conveyor The rollers and bars interlocked with large sprocket wheels at each end of the pan conveyor (or at the top and bottom for inclined pan conveyors), which powered the conveyor, allowing the buckets to continually move in a single direction (Stephens-Adamson Manufacturing Co. 1913:3; 1914:11; James, Lafferty, et. all 2018:79-80, 85-86).

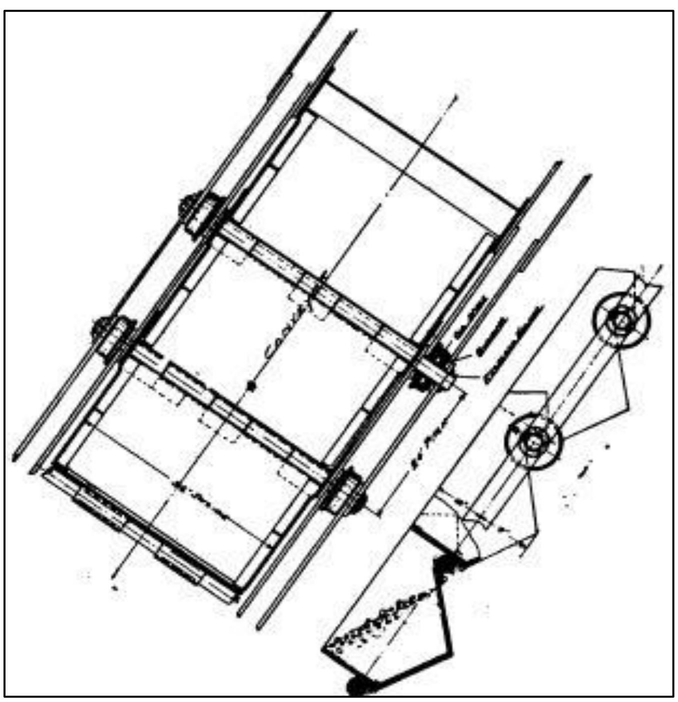


Figure 16. Illustration of the S-A Manufacturing Co.'s pan-conveyor (Stephens-Adamson Manufacturing Company 1913)

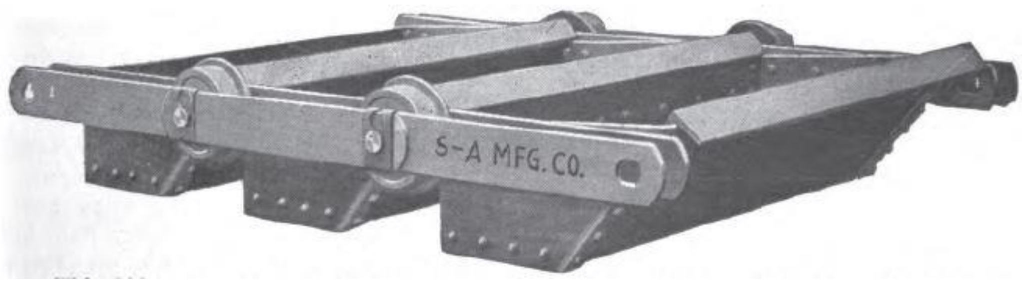


Figure 17. Image of the S-A Manufacturing Co.'s pan-conveyor (Stephens-Adamson Manufacturing Company 1913)

Inclined bucket elevators and pan conveyors also allowed for larger capacities of bulk materials to be transferred from the hold to the self-unloading boom. Two small athwartship conveyors, located on either side of the bucket elevator or pan conveyor would transport the cargo to a small elevator boot or footshaft where it could be picked up by the ascending conveyor buckets. These boots generally were designed with upright sides and a curved middle section that followed the curve of the bucket elevator. At the top of the inclined conveyor, the buckets would be overturned as they spun around the upper sprocket wheel, and its contents dumped into a chute, which would funnel the bulk materials onto the conveyor on the self-unloading boom, and effectively off the ship (Jeffery Manufacturing Co. 1922:364, 369, 390; Stephens-Adamson Manufacturing Co. 1913:3-5; 1914:11; 1916:773-774; Kiefer, Zant, et all 2020:7).

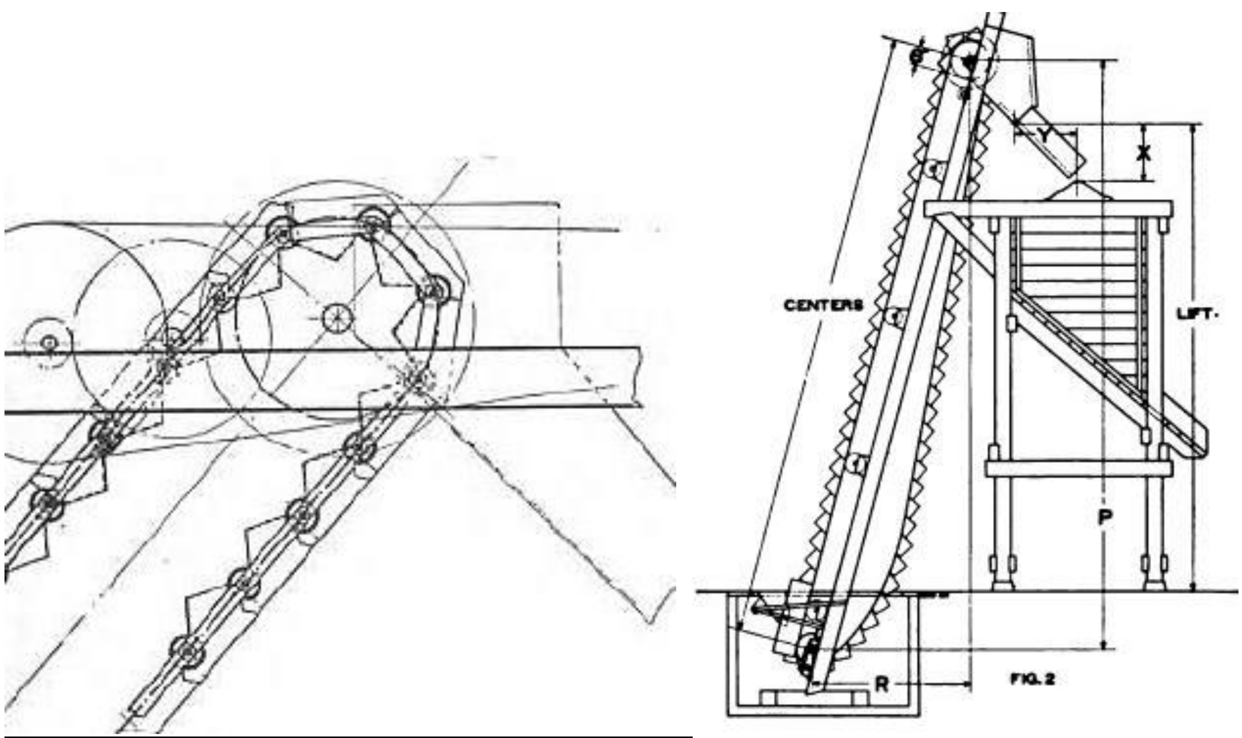


Figure 18. Image of the S-A Manufacturing Co.'s pan-conveyor (left) and an inclined bucket elevator design by the Jeffery Manufacturing Co. (right) (Stephens-Adamson Manufacturing Company 1913; Jeffery Manufacturing Co. 1922)

SECTION FOUR
Comparison of Converted Self-Unloader Designs

Examples of early self-unloading systems represent only a small chapter in the development of self-unloading technology as a whole, but their effect on the development of shipboard technology cannot be overlooked. Self-unloaders built in the first decade of the twentieth century served as the forerunners of more advanced self-unloading vessels that developed later in the century. The design and construction of these vessels demonstrated the distinct differences between converted and purpose built self-unloading vessels.

Early Converted Self-Unloaders

Although similar in design, there were distinct differences in construction techniques that distinguished converted wooden self-unloaders from those purpose built out of iron and steel, with the steam barges, with *Hennepin* and *Wyandotte* serving as the two earliest examples. While innovative, the space occupied by boilers and engines within the hull did not allow the same carrying capacity as converted sailing vessels; however it was the development and success of these earlier vessels that paved the way for the development of self-unloading schooner-barges.

<u>*Hennepin*</u>

Built in 1888 by the Wolf and Davidson shipyard of Milwaukee, Wisconsin, *Hennepin* originated as the steam barge *George H. Dyer*, and served in the grain and coal trades, transporting cargo to ports throughout the Great Lakes. In 1898, the vessel's name changed to *Hennepin*, and it began to serve as a part of the Soo Line, transporting cargo to ports on the coast of Lake Superior. *Hennepin* served in this capacity until 1901 when the vessel caught fire and was purchased by the Lake Shore Stone Company of Milwaukee. By 1902, the company had outfit *Hennepin* with self-unloading equipment, and the vessel began to carry cargos of limestone across Lake Michigan (Door County Advocate 1901:1).

The original design for *Hennepin*'s self-unloading apparatus was conceptualized for loading crushed stone onto awaiting vessels, and was not originally intended for use onboard a vessel. Designed by the Webster Manufacturing Company, the Lake Shore Stone Company's belt conveyor system allowed pieces of limestone to be transported from the walls of the quarry, to a 50-foot pier built out into Lake Michigan for loading vessels. The success of this conveyor system convinced the Lake Shore Stone Company install a similar system on *Hennepin*, making the unloading of limestone much quicker and easier (Lafferty and van Heest 2009:48).

Two iron hoppers were installed running above two parallel belt conveyors made of series of wheels or rollers suspended between two wooden timbers running the length of the hold. On these rollers ran a single rubber belt that ran toward the vessel's stern. Here the belts deposited stone into another hopper which funneled the cargo onto an inclined conveyor which then transferred it up to the main deck. Another smaller hopper collected the stone and deposited it onto a belt which was mounted on a swinging boom, supported by an A-frame, which would deposit the cargo onshore (Marine Review 1902: 20; Marine Record 1902:27).

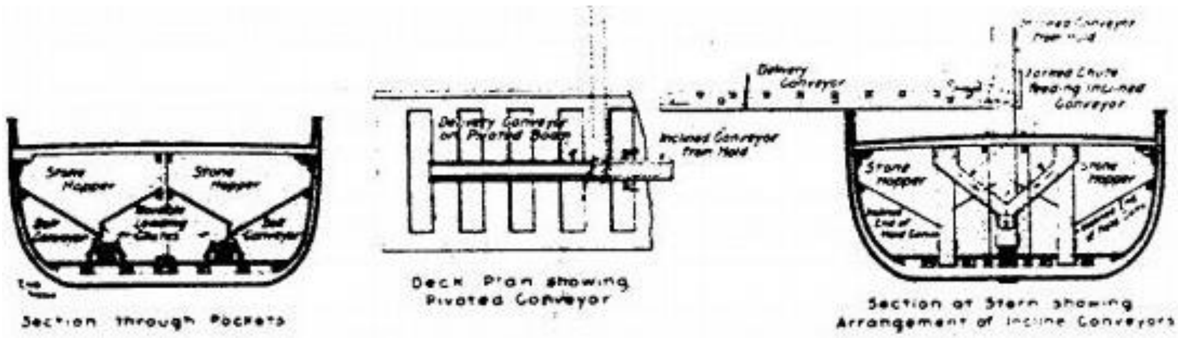


Figure 19. Schematics of *Hennepin*'s self-unloading system (Lafferty and van Heest 2009).

To accommodate this machinery, *Hennepin*'s second deck was removed, which significantly lowered the vessel's cargo capacity. Despite this, the vessel continued to remain profitable for the Lake Shore Stone Company throughout the following decade, with another vessel, *Topeka*, undergoing conversion a few years later. Though the vessel remained profitable, the amount of cargo space lost in conversion was an issue that would plague designers of self-unloaders, both converted and purpose built, for many years (Lafferty and van Heest 2009:62).

<u>*Wyandotte*</u>

In comparison to the converted *Hennepin*, the steel hulled *Wyandotte* holds the honor of being the first purpose built self-unloader on the Great Lakes. Built by the Michigan Alkali Company in Wyandotte, Michigan in 1907, the vessel was also equipped with double hoppers that funneled cargo onto a conveyor system located at the bottom of the hull designed by the Stephens-Adamson Manufacturing Company out of Aurora, Illinois (Lafferty 1998:158-159). Though similar in design, *Wyandotte* was equipped with steel pan-conveyors, not belt conveyors. The addition of a conveyor made entirely of steel allowed the vessel to handle large pieces of limestone better than the rubber and wood belt conveyors found on *Hennepin* and *Topeka* (Lafferty and van Heest 2009:64).

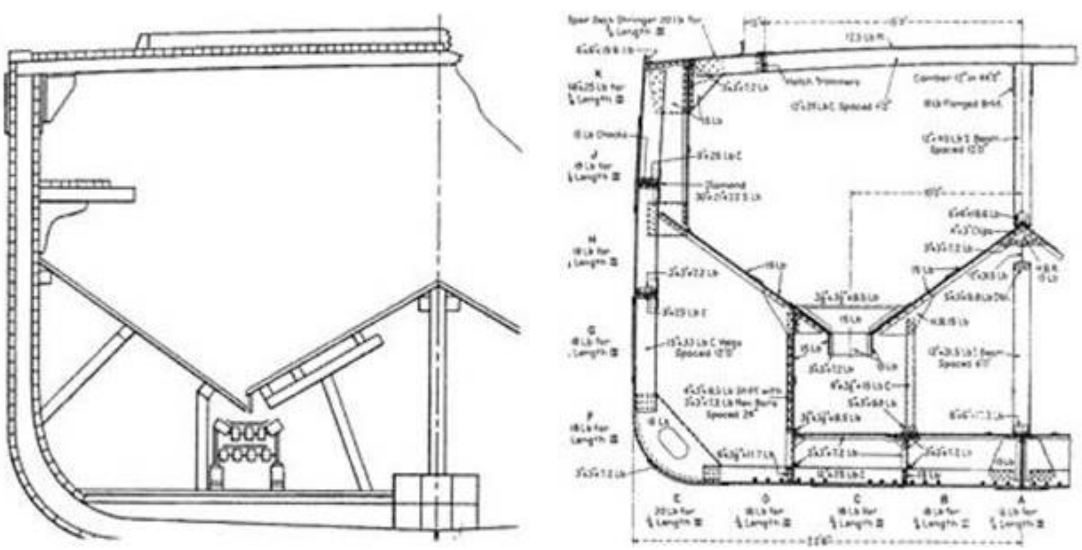


Figure 20. Cross sections of *Hennepin* (left) and *Wyandotte* (right) (Lafferty and van Heest 2009)

Wyandotte was equipped with an inclined belt conveyor, located in the bow, to load the cargo onto the self-unloading boom. It is likely that this configuration was due to the location of the power source for *Wyandotte*'s machinery; two electric motors housed in the vessel's bow though it is unknown if this had an effect on the efficiency of the equipment or the vessel's stability. *Hennepin*'s unloading apparatus was powered by the vessel's steam engine, located in the stern. Despite these differences, the self-unloading apparatus still consumed a considerable amount of cargo space in *Wyandotte*. It was not until the construction of *Alpena* in 1910, the Michigan Alkali Company's second self-unloader, that a bucket conveyor replaced *Wyandotte*'s inclined belt conveyor. Since this conveyor only needed a 45-degree angle to operate effectively, it took up less space in the vessel's hold and greatly increased cargo capacity (Lafferty and van Heest 2009:66).

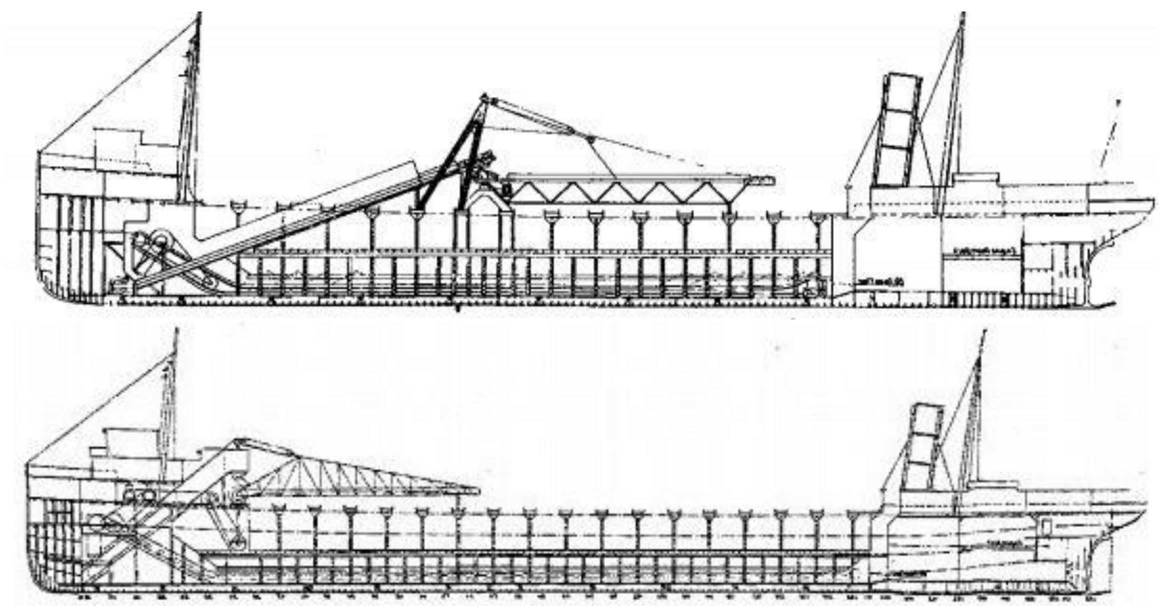


Figure 21. *Wyandotte* before and after bucket elevator instillation (Lafferty and van Heest 2009)

Converted Schooner-Barges

As wooden schooner-barges, *Adriatic*, *Transfer*, and *EMBA* represent a unique vessel type that remains largely unstudied in the historical and archaeological record. Already specialized for increased capacity in the transport of bulk cargos, the installation of self-unloading machinery in their holds further adapted the vessels to the growing demand for the faster, more economical, transport of stone.

<u>*Adriatic*</u>

Built in 1889 at the Davidson Shipyard, by master shipbuilder James Davidson in West Bay City, Michigan, the 202-foot long *Adriatic* was launched as a schooner-barge intended to carry bulk cargoes in a consort system. In addition to the typical schooner-barge boxy hull construction, Davidson took this a step further with his vessels. While many of his early vessels were traditional schooners, *Adriatic*'s construction corresponded with a turning point in his designs. *Adriatic*, and later Davidson vessels were constructed with an incredibly sharp turn of the bilge, and flat bottoms (Bureau of Navigation 1889; Cooper and Jensen 1995:28-29; Zant and Thomsen 2013:1, 8).

In addition to this, Davidson made use of floor keelsons to add longitudinal strength, instead of a traditional keelson, sister and rider keelson system, leaving the interior a vessel's hull more open, increasing its cargo capacity. This particular construction component made *Adriatic* especially well-suited for conversion to a self-unloader. With the extra space in the hold, following its conversion, *Adriatic*'s center of gravity remained lower and its cargo capacity higher than other converted self-unloaders. Davidson also used iron strapping throughout his vessels to further add to their strength and longevity. *Adriatic* was equipped with two iron hogging trusses, iron strapping, and thick iron plating on either side of the vessel's keelson (Cooper and Jensen 1995:28-29; Rodgers 2003:29; Zant and Thomsen 2013:2, 8).

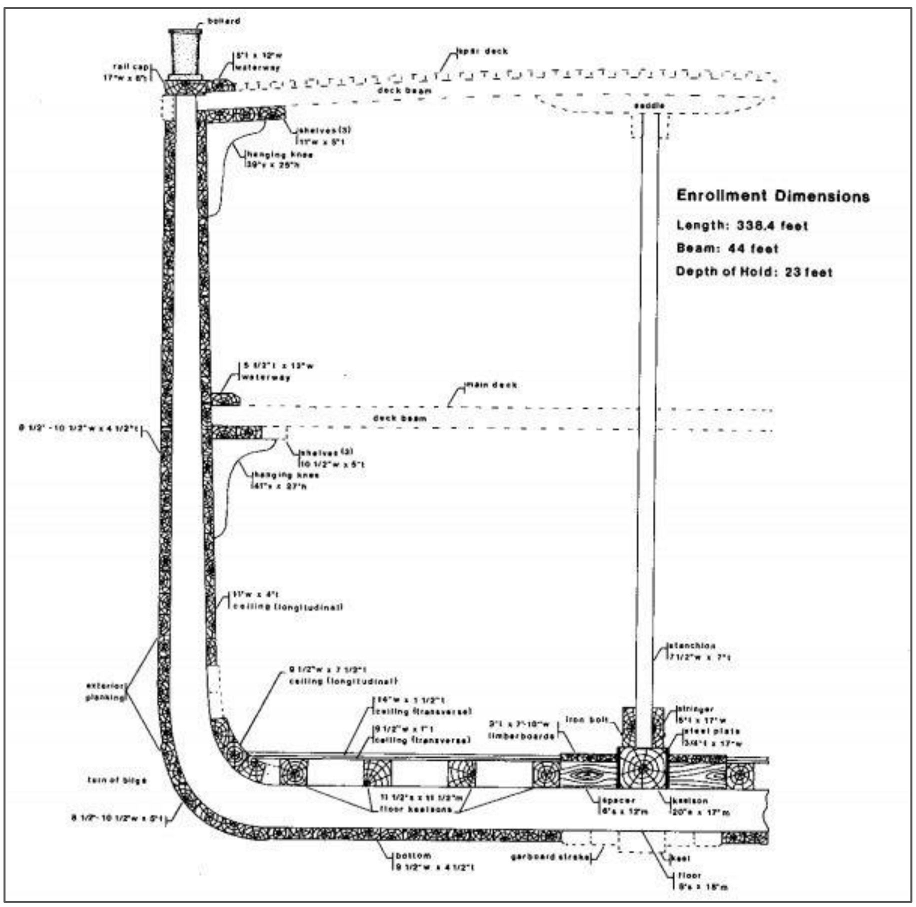


Figure 22. Cross section of the Davidson-built schooner-barge *Pretoria* (Cooper and Jensen 1995)

Like most other contemporary schooner-barges, *Adriatic* resembled a traditional schooner above the waterline; below, the sharp turn of the bilge and flat bottom made the vessel incredibly versatile when it came to entering shallow, unimproved ports, due to the vessel's shallow draft.

Adriatic also featured a reduced schooner rig, appearing with shortened masts, and its main or mizzenmast removed at various points throughout its career. As with most purpose built schooner-barges, *Adriatic* was not meant to sail under its own power, spending its entire early career being towed as a barge in consort (Zant and Thomsen 2013:8-11).

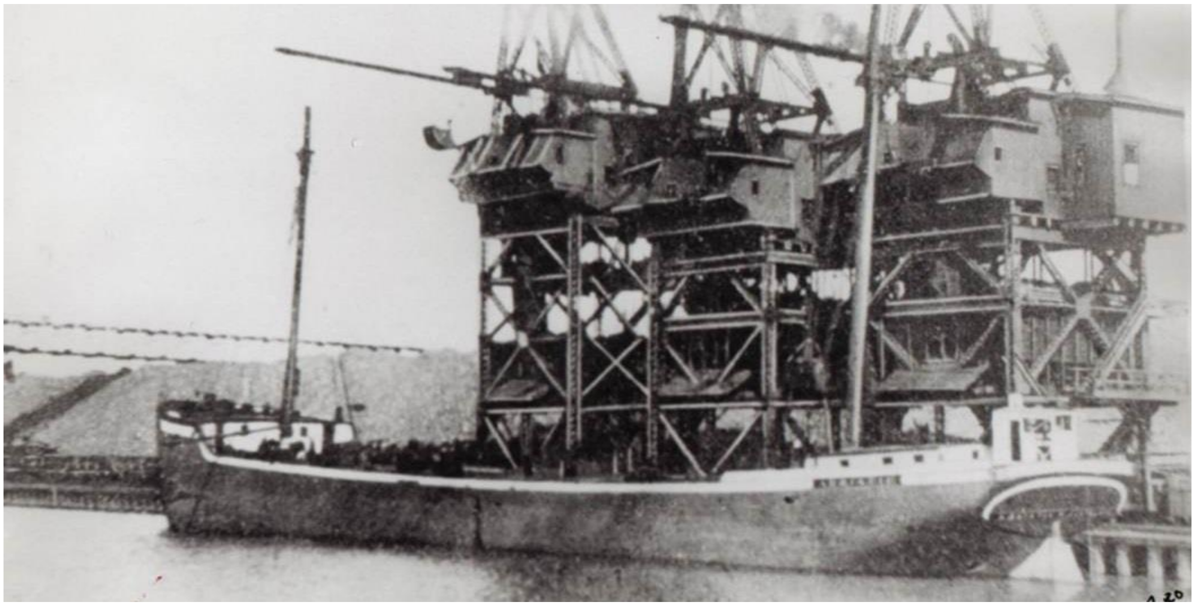


Figure 23. An early photograph of *Adriatic* with its mainmast removed (University of Michigan, Great Lakes Maritime Database)

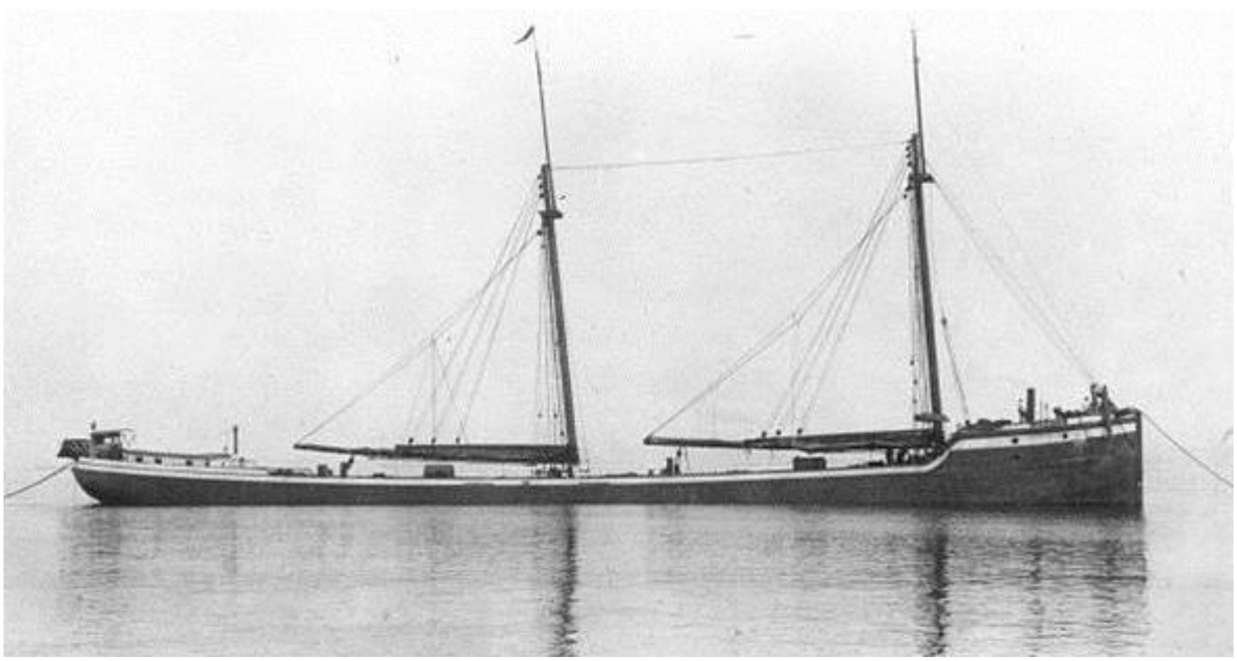


Figure 24. *Adriatic* towed, with its mizzenmast removed (Bowling Green State University)

For the first 22 years of service, *Adriatic* efficiently carried bulk cargoes for M.A. Bradley, of Cleveland, Ohio, between ports on the Great Lakes as a consort of various steamers owned by the Bradley Line. In 1912, the Leathem and Smith Stone Company of Sturgeon Bay, Wisconsin, purchased *Adriatic*, and began its conversion to a self-unloading schooner-barge. The vessel spent its final seventeen years hauling cargoes of crushed stone from Sturgeon Bay across Lake Michigan (Zant and Thomsen 2013:8).

Like *Wyandotte*, *Adriatic*'s specific self-unloading equipment was designed by the Stephens-Adamson (S-A) Manufacturing Company. Following the success of these two vessels, the manufacturing company went on to develop self-unloading apparatuses for numerous other vessels (Stephens-Adamson Manufacturing Company 1916:772-773). Having originally established themselves in the mining industry, the S-A Manufacturing Company were forerunners in the development of belt and bucket conveyor technology. *Adriatic*'s design was the S-A Manufacturing Company's first attempt at designing equipment for a converted wooden vessel, and the design of its self-unloader remained innovative for its use of an inclined pan-conveyor to carry its cargo to the unloading boom; the first use of an inclined pan-conveyor in a converted wooden vessel (Zant and Thomson 2013:15).

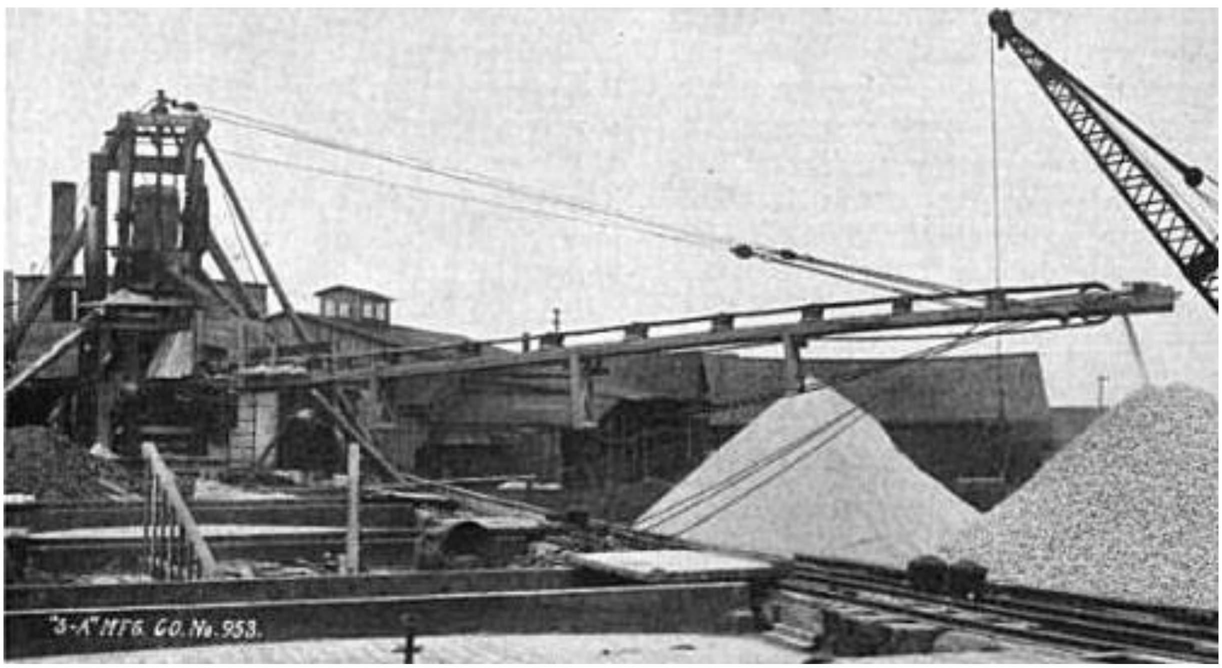


Figure 25. *Adriatic* unloading stone after its conversion to a self-unloader (Stephens-Adamson Manufacturing Company 1914)

As with the earlier self-unloaders, *Adriatic* was equipped with two parallel iron hoppers, extending almost the entire length of the ship's hold. Beneath each line of hoppers ran a 20 in. x 150 ft. wood and rubber belt conveyor that transported cargo from the vessel's stern to bow. *Adriatic* made use of the belt conveyor system, but included an inclined pan-conveyor to effectively transfer the cargo of crushed stone up onto the deck. The belt conveyors would discharge the cargo on to the pan-conveyor in the bow, where it was deposited onto another 55-foot belt conveyor located on the vessel's swinging boom, which could then discharge the cargo onshore (Stephens-Adamson Manufacturing Company 1914:11).

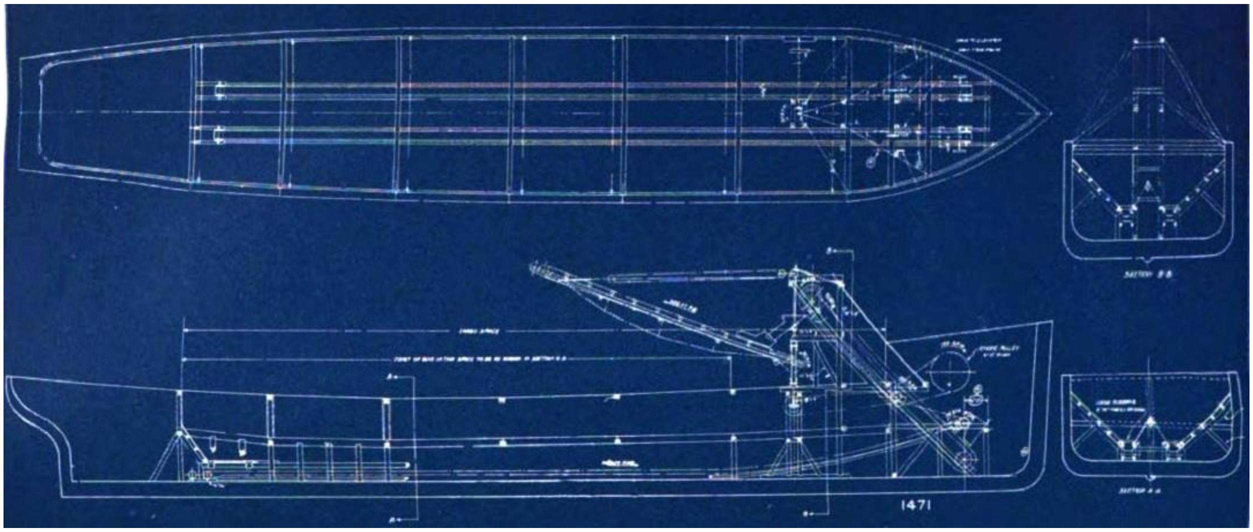


Figure 26. Schematics of *Adriatic*'s self-unloading machinery (Stephens-Adamson Manufacturing Company 1916)

<u>*Transfer*</u>

The 200-foot long schooner-barge *William McGregor* was built at the Linn & Craig Shipyard in Gibraltar, Michigan in 1872 for the Northwestern Transportation Company of Detroit. The vessel spent the first 39 years of its career as a consort, towed by the bulk freighter *R.J. Hackett*, hauling cargos of ore and coal from ports on the eastern Great Lakes to the ports of Chicago, Illinois, and Escanaba and Marquette, Michigan (Bureau of Navigation 1872; *Detroit Free Press* 1883a, 1883b, 1895a, 1895b, 1900, 1905a, 1905b, 1905c, 1905d; Cooper and Kriesa 1992).

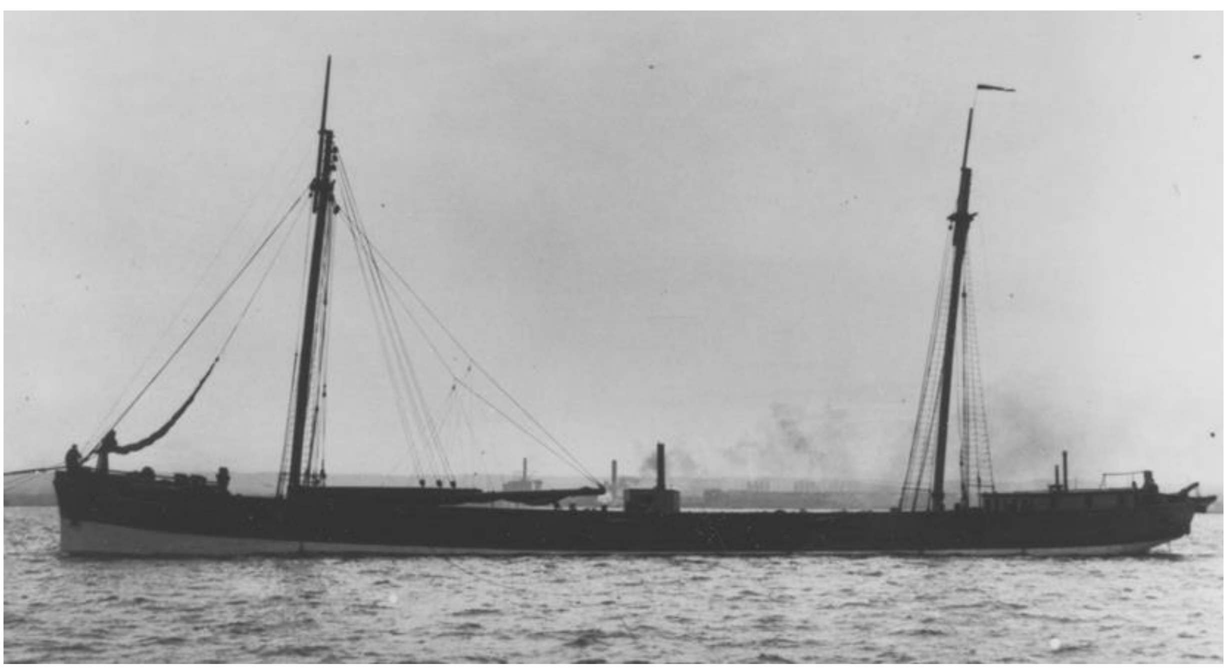


Figure 27. *William McGregor*, later *Transfer*, towed in consort, with a Grand Haven rig (C. Patrick Labadie Collection)

As with other purpose-built schooner-barges meant to spend their career towed in consort, *William McGregor* featured a reduced schooner rig, appearing with shortened masts and its mainmast removed. As a schooner-barge the vessel would have also been built with a sharp turn of the bilge and flat bottom, allowing it a higher cargo capacity to traditional schooners. Unlike *Adriatic* however, *William McGregor* was not built by James Davidson, and therefore had more traditional longitudinal strength, with a keelson, sister and rider keelsons. Built in 1872, *William McGregor* was also built without iron strapping for strengthening. The vessel did, however, have two wooden hogging arches (Kiefer, Zant, et all 2020:2, 9-10).

After serving in this capacity for nearly four decades, the Milwaukee Electric Railway and Light Company purchased the vessel in 1911 for use in the Milwaukee River, renaming it *Transfer*. Following its purchase, the cabin structure, rigging implements deck works, and deck planking were cut down and the vessel was used as a scow transporting coal from the K.K. Coal Yard to the Milwaukee Western Power Plant. After a few years of service, the company converted *Transfer* into a self-unloading barge to increase productivity, and the vessel was used to transfer coal directly into bins connected to the city's powerhouses (Milwaukee Electric Railway and Light Company 1923:21, 1924:24).

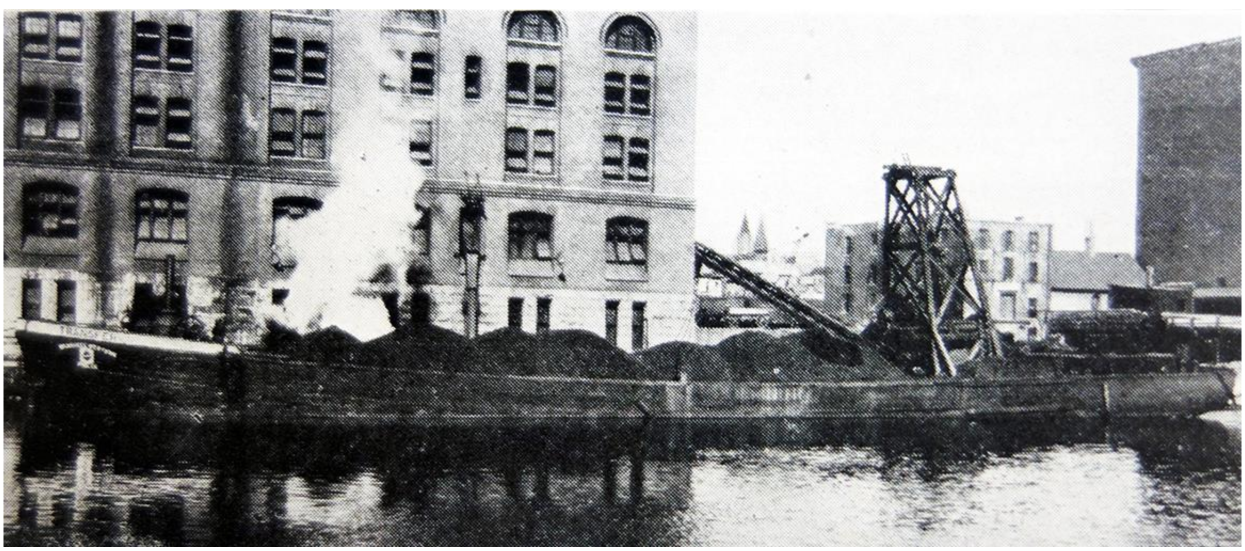


Figure 28. *Transfer* unloading coal in the Milwaukee River (Milwaukee Electric Railway & Light Co. 1916)

The self-unloading machinery installed in *Transfer* was unique in that it was equipped with a cable conveyor system beneath parallel hoppers. These cable conveyors transported the coal to an athwartship conveyor and elevator boot at the stern of the vessel. The self-unloading tower and inclined bucket elevator were located at the stern, just forward of the removed cabin structure. A conveyor on the unloading boom transported the coal into a dockside hopper, which funneled into a steel box located on shore at each of the Milwaukee Electric Railway and Light Company's three powerhouses along the Milwaukee River (Milwaukee Electric Railway and Light Company 1915:36, 1924:24).

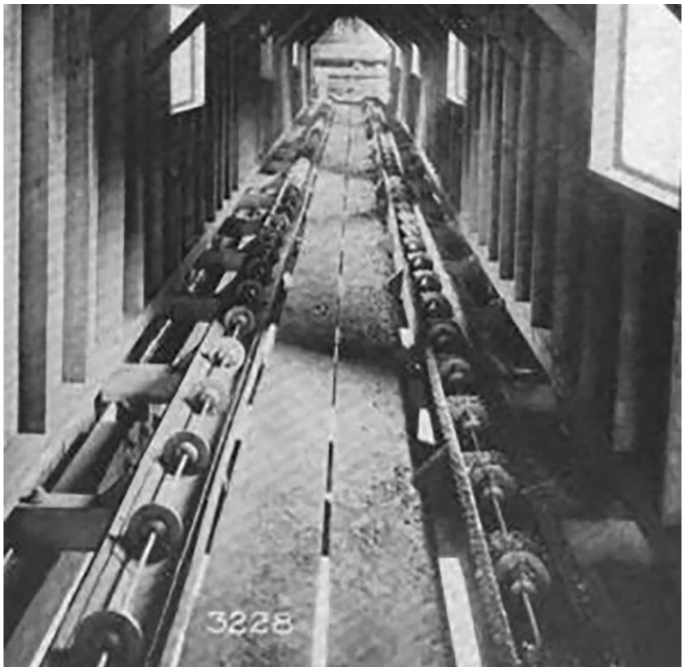


Figure 29. Jeffery Manufacturing Co. cable conveyor layout (Jeffery Manufacturing Co. 1922)

EMBA

A.C. Tuxbury was built as a 181-foot long schooner-barge by master shipbuilder Frank W. Wheeler at the West Bay City Shipyard in West Bay City, Michigan in 1890. Like Davidson, Wheeler was known for building massive wooden ships strengthened by iron strapping. The vessel was towed as a consort of *R.H. Sawyer* for much of its career. For its first 33 years of service, *A.C. Tuxbury* operated in the coal and grain trades, transporting cargos between ports in the eastern Great Lakes and Lake Michigan (Thomson and Meverden 2012:8).

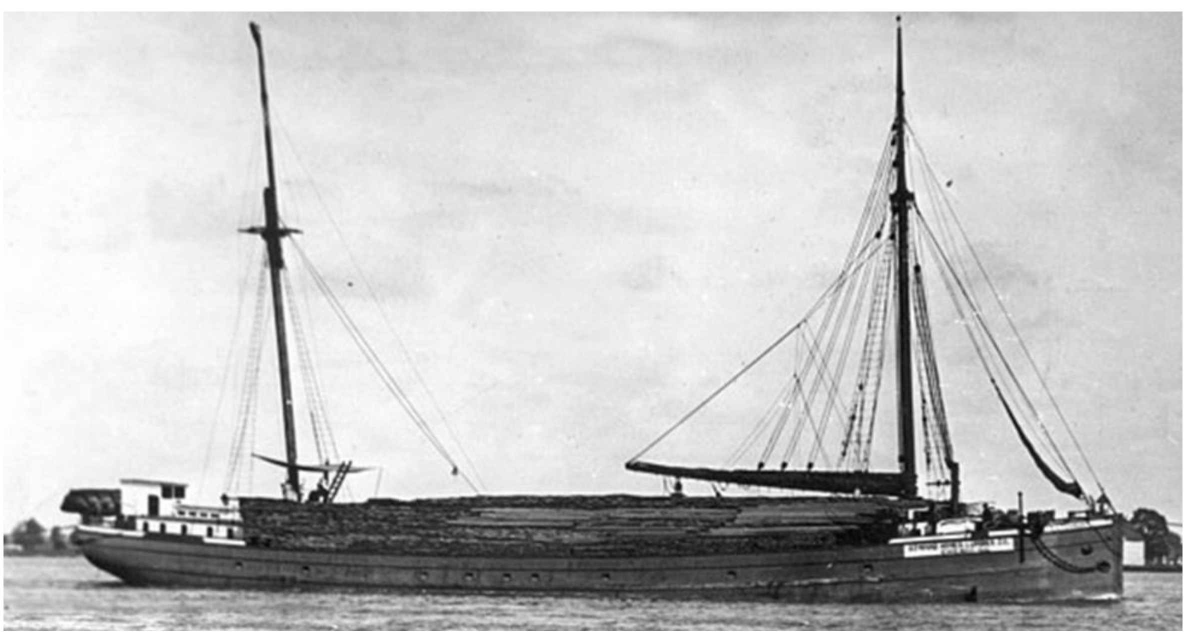


Figure 30. *A.C. Tuxbury* with a reduced schooner rig (Bowling Green State University)

As with *Adriatic* and other contemporary self-unloaders, *A.C. Tuxbury* had a sharp turn of the bilge and flat bottom. Throughout its career as a barge towed in consort, *A.C. Tuxbury* featured a "Grand Haven" rig, appearing with a reduced number of sails, and its mainmast removed. The sails would only be raised to stabilize the vessel in heavy winds or as an emergency propulsion method (Thomson and Meverden 2012:8).

Following its lengthy career, the Milwaukee Electric Railway and Light Company, purchased *A.C. Tuxbury* in 1923, renamed it *EMBA*, and converted the vessel into a self-unloading barge to carry coal up the Milwaukee River (*Door County Advocate* 1923a, 1923b). It is noted in company newsletters that *EMBA* was purchased and converted into a self-unloader to replace the aging *Transfer*. It is speculated that the inclined bucket elevator removed from *Transfer* before its abandonment was used on *EMBA*, but this has not been proven (Bureau of Navigation 1890; *Port Huron Daily Times* 1890; *Buffalo Morning Express* 1890a, 1890b, 1890c, 1890d; Thomson and Meverden 2012:18).

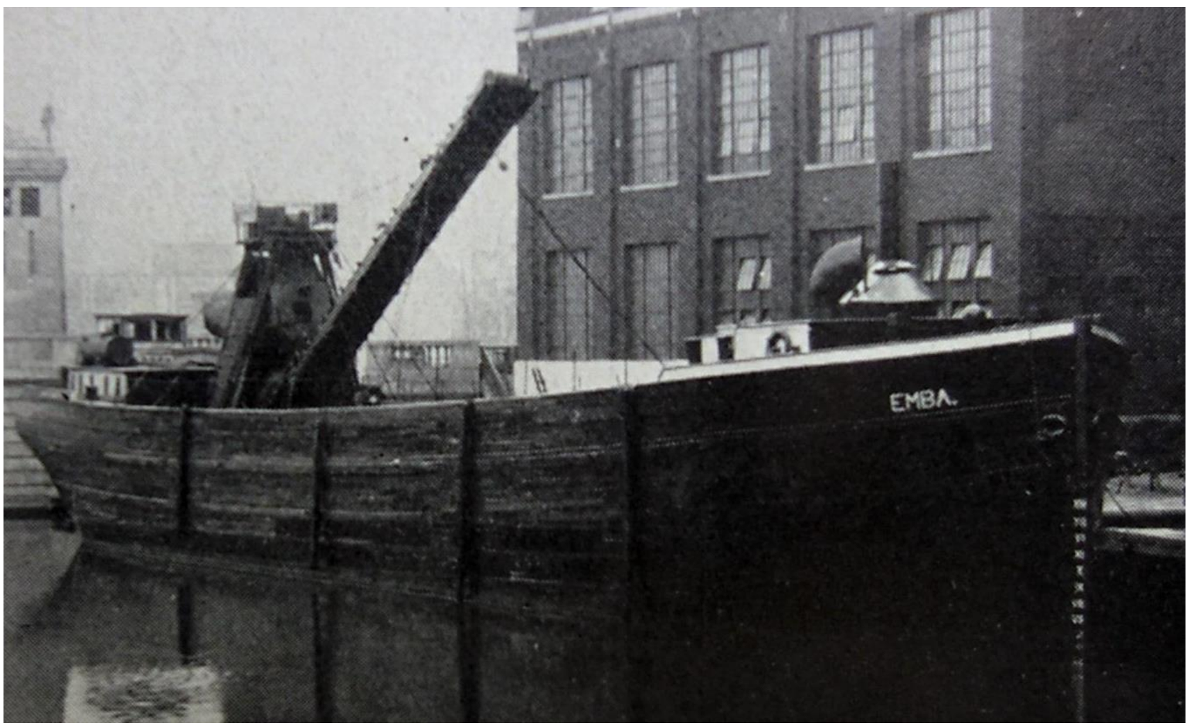


Figure 31. *EMBA* on the Milwaukee River next to the Oneida (Wells) Street Powerhouse (Milwaukee Electric Railway & Light Co. 1930)

The configuration of *EMBA*'s self-unloading machinery closely resembled *Adriatic*'s in design, with two parallel belt conveyors, located beneath parallel hoppers running the length of the vessel. The vessel was equipped with an inclined continuous bucket elevator (pan conveyor) at its stern, made up of buckets connected to one another with a chain on either end, and driven by an upper drive gear. The buckets dumped cargo into a large iron hopper as they reached the top of the unloading tower, and then were cycled down to the elevator boot below. The iron hopper funneled the cargo onto another belt conveyor located on the self-unloading boom.

The unloading boom was rotated by a large gear fastened to a wooden mount atop the deck beams just forward of the unloading tower. This large gear facilitated the operation of the self-unloading boom, and allowed it to swing over either side of the vessel to unload cargo into the awaiting shore-side bins at each powerhouse. Although it is unknown which specific manufacturing company designed *EMBA*'s specific self-unloading equipment, it appears similar to the inclined bucket elevators manufactured by Jeffery Manufacturing Co. (Meverden and Thomson 2012:10).

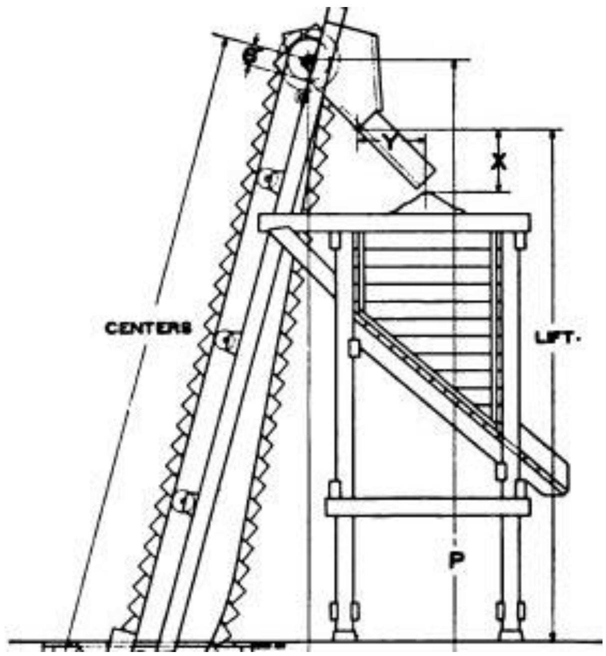


Figure 32. Illustration of an inclined bucket elevator design (Jeffery Manufacturing Co. 1922)

SECTION FIVE
Analysis of Converted Self-Unloaders

All three of the wrecks contained in this analysis reside beneath the Wisconsin waters of Lake Michigan. The wrecks were chosen for analysis because they exemplify a varied range of converted self-unloading characteristics, and represent some of the earliest and most notable wooden self-unloader conversions. Additionally, these vessels have extensive representation in the historical and archaeological record. With no examples of early converted self-unloaders still afloat, the archaeological record is one of the only tools available with which to understand these vessels. The following analysis is based on data gathered from a compilation of field notes, National Register of Historic Places documentation, archaeological field reports, data recovery reports, detailed site plans, research projects, and underwater photographs.

Early self-unloading designs were simple in construction and had many similar characteristics, although they were not uniform in design or construction; many early self-unloaders were not converted using drawn plans still available in the historic record. Each converted self-unloader had its own unique combination of modifications and self-unloading technology installed to alleviate transportation and labor costs. The original wooden hull construction of each converted vessel was also unique, representing a wide array of wooden vessel types, including both sail and steam powered vessels, and analyzing these differences can further add to the understanding of these early experimental vessels.

Historical analysis of enrollment records, shipping records, mining equipment catalogues, and photographs can reveal common general trends in shipbuilding techniques and design modifications, but a more in depth analysis of how these mechanisms worked in practice requires additional information. Archaeological analysis of known converted self-unloader wreck sites helps answer questions about the specifics of self-unloading features and how they differed from vessel to vessel across the Great Lakes region. This section analyzes multiple archaeological sites individually, highlighting their distinct original construction, and their self-unloading equipment design and features.

Adriatic

For just over ninety years, the converted self-unloading schooner-barge *Adriatic* lay in 2 to 15 feet of water 150 ft. south of Berth 1 of Bay Shipbuilding Company in Sturgeon Bay, Wisconsin. Originally laying on a heading of 153-degrees, the vessel remained embedded in the bottom of the bay, and its interior filled with 4 to 8 feet of silt. In 1934, years after the vessel had been abandoned at the old coal dock at the Leathem D. Smith Shipbuilding Company, the vessel burned to the waterline, leaving only the bottom 8 to 10 feet of hull and a few components of the self-unloading mechanism within the hull. An original Phase II archaeological survey was conducted on the site in 2013, documenting the upper portions of the hull and artifacts that could be seen above the thick layer of silt. In 2016 and 2018, due to adverse construction effects nearby, a mitigation project prompted a full Phase III archaeological excavation of the site and the vessel was removed. The information in this section comes from both the Phase II and Phase III surveys of the site (Zant and Thomson 2013:1).

Prior to removal, remaining the hull retained remarkable structural integrity, demonstrating the strength of wooden shipbuilding in the nineteenth century, and the longitudinal strength of schooner-barge construction. Characteristics of *Adriatic*'s Davidson hull construction could be seen throughout the site. The vessel's iron hogging arches and strapping, iron lined keelson, and floor keelsons were all identified during excavation. Additionally, the vessel's incredibly sharp turn of the bilge and flat bottom were documented in detail (Zant and Thomson 2013:2; James, Lafferty, et all 2019:134-142, 149-150).

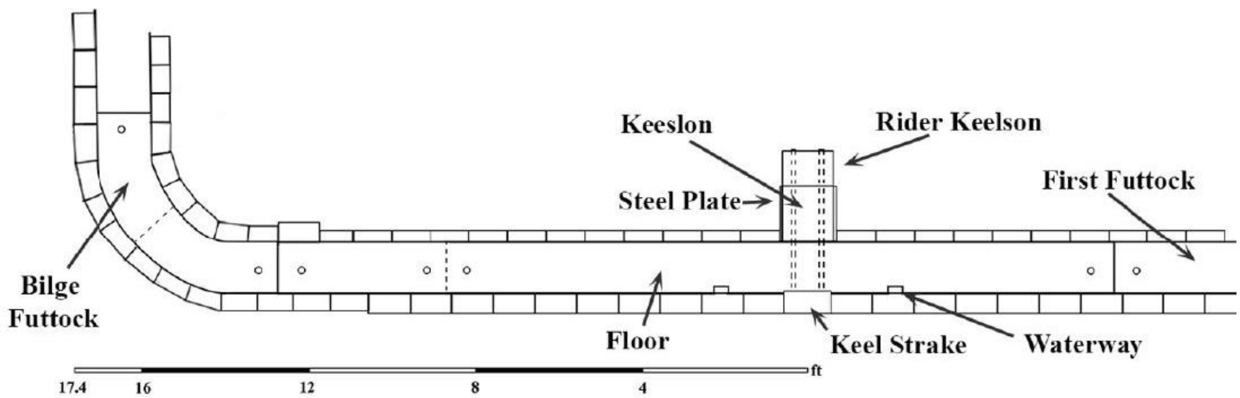


Figure 33. Schematic of *Adriatic*'s turn of the bilge and keelson structure (James, Lafferty, et all 2019)

Figure 34. Iron strapping inside *Adriatic*'s hull (left) and the thick iron plating along the keelson (right) (PanAmerican Consultants, Inc.)

Although the vessel was abandoned, partially salvaged, and later burned, most components of *Adriatic*'s self-unloading machinery remained inside the hull, protected by a thick layer of silt. At the time of the 2013 survey, two sections of the vessel's pan conveyor were visible above the silt near the vessel's bow. Additionally two large gears and one large fly wheel were located off the starboard side of the ship, along with a long, hollow metal tube. Near the stern of the ship, along the starboard side, two parallel wooden timbers associated with the hoppers and belt conveyor system were identified, running 25 feet in length before disappearing beneath the silt (Zant and Thomsen 2013:3-5).

The 2016 and 2018 excavations uncovered additional components of the self-unloading machinery, identifying the belt conveyor system and rollers, pan conveyor buckets, hopper doors, gears and wheels. *Adriatic* was equipped with a standard belt conveyor with a rubberized belt that sat atop two rollers situated at 45-degree angles on the belt conveyor base. The rollers remained remarkably intact with grease still located inside the grease-fittings for each roller. Evidence of *Adriatic*'s belt rollers was also located. Three rollers of varying sizes were identified, still attached to a tensioner (Stephens-Adamson Manufacturing Company 1916:91; James, Lafferty, et. all 2019:164-165).

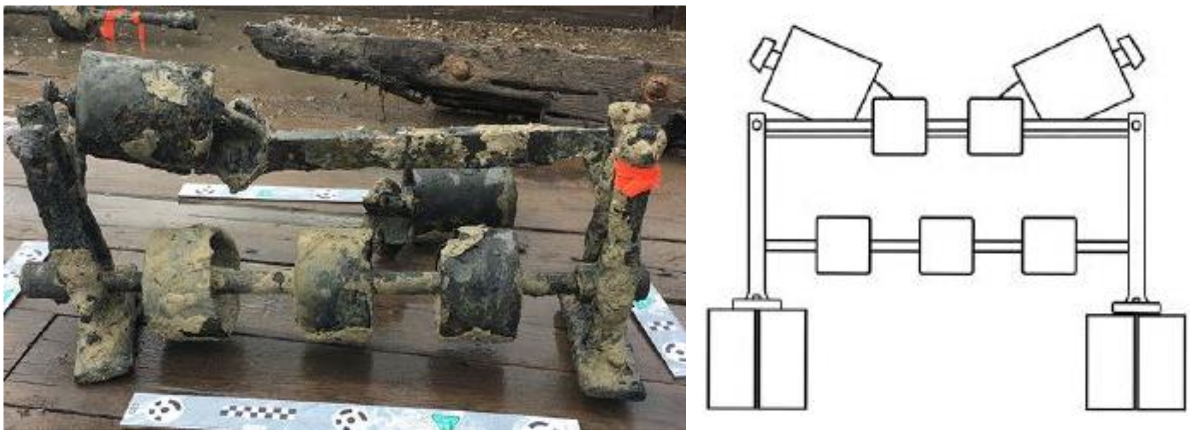


Figure 35. Belt conveyor base and rollers recovered from *Adriatic* (left) and a reconstruction schematic of the same belt conveyor base and rollers (right) (PanAmerican Consultants)

Figure 36. Two large belt conveyor rollers and tensioner recovered from the *Adriatic* shipwreck (PanAmerican Consultants)

Adriatic's hopper doors sat along a wooden support structure that ran the length of the ship. The hopper doors had attached metal chutes that opened and closed manually with ratchet bars and chains. A specialized crank handle that fit securely on one end of each ratchet bar, was used to turn the bar, engaging and disengaging the ratchets. A crewmember manually turned the crank handle, releasing the crushed stone through the hopper chute doors. The ends of the chutes were attached to the ratchet bars with thin metal chains, and would wrap around the bars to close the hopper chute doors. The top of this wooden structure was identified in the 2013 survey. No evidence of the hoppers was located during either survey. Since the hopers were likely comprised of large vertical wooden timbers, they were likely destroyed during the 1934 fire (Zant and Thomson 2013:6; James, Lafferty, et all 2019:152).

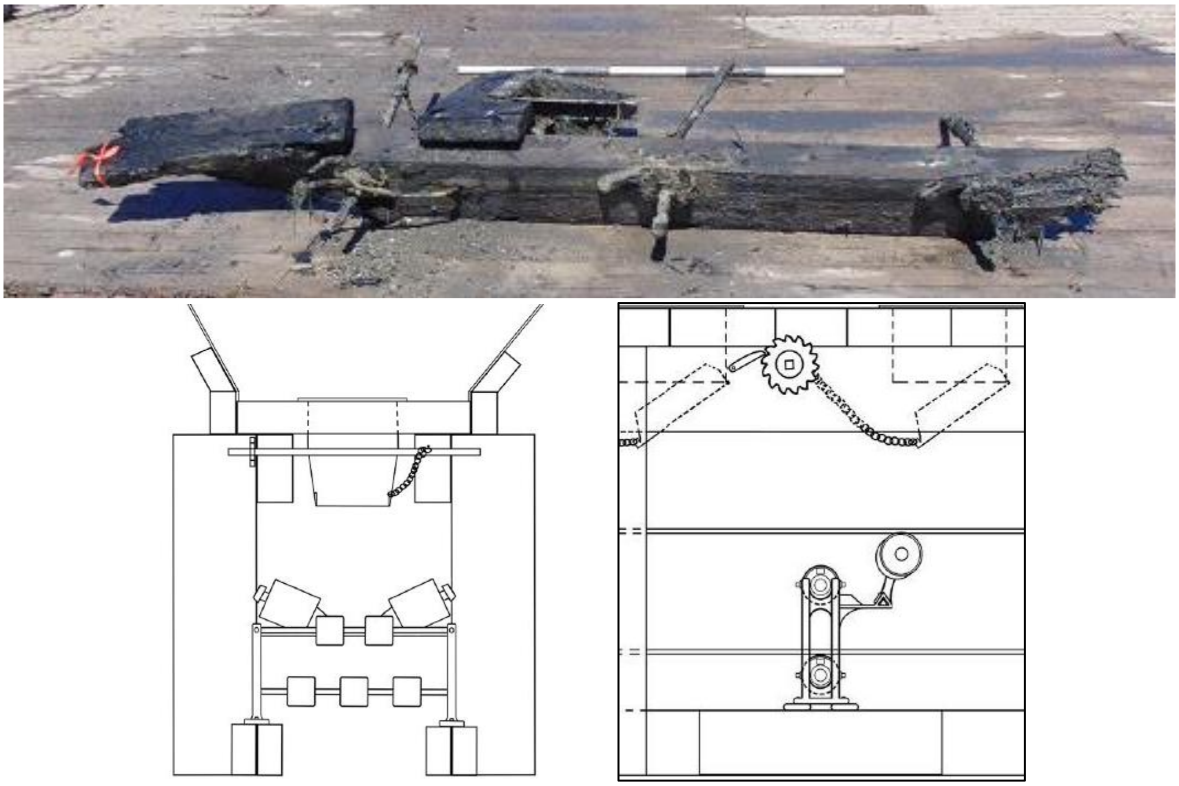


Figure 37. *Adriatic*'s recovered wooden support with hopper chute doors (top) and schematics of the hopper chute doors and belt rollers (bottom) (PanAmerican Consultants)

Figure 38. A hopper chute door recovered from *Adriatic* (PanAmerican Consultants)

Adriatic's bucket elevator was an inclined pan conveyor system designed by the Stephens-Adamson Manufacturing Co. and consisted of a series of flat bottomed buckets, connected by a series of rollers and links/bars. During the initial 2013 survey, only two small sections of the pan conveyor buckets were visible above the silt. At the time of the 2016 excavation, 18 buckets were identified, still connected to the lower sprocket wheel (Zant and Thomsen 2013:4-6).

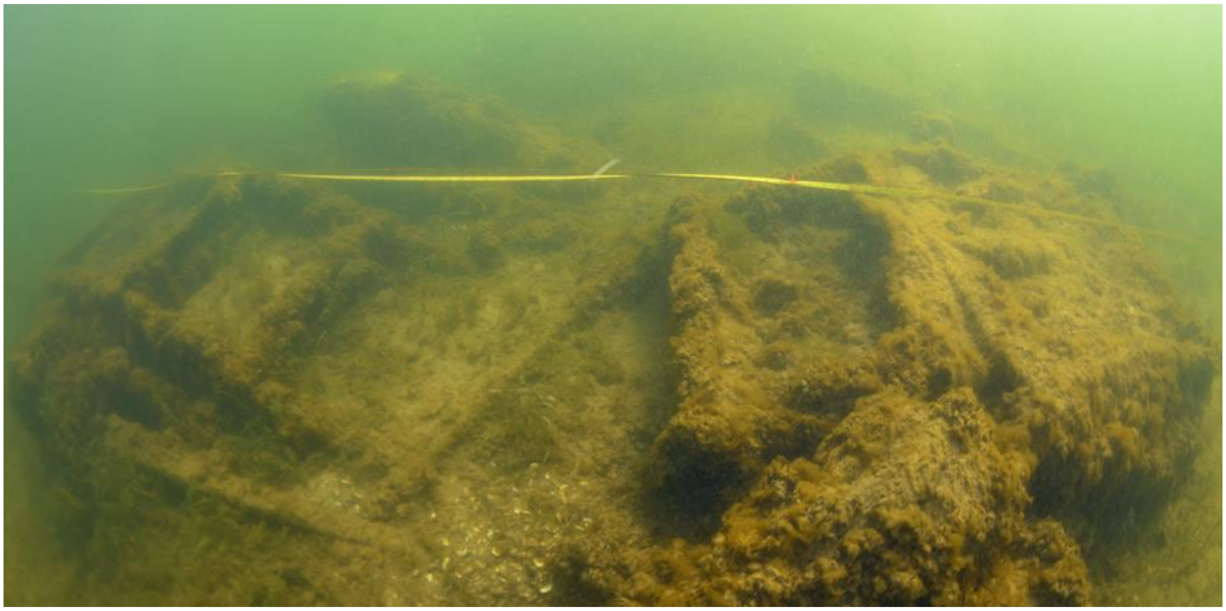


Figure 39. Pan conveyor sections visible above the silt in 2013 (Wisconsin Historical Society)

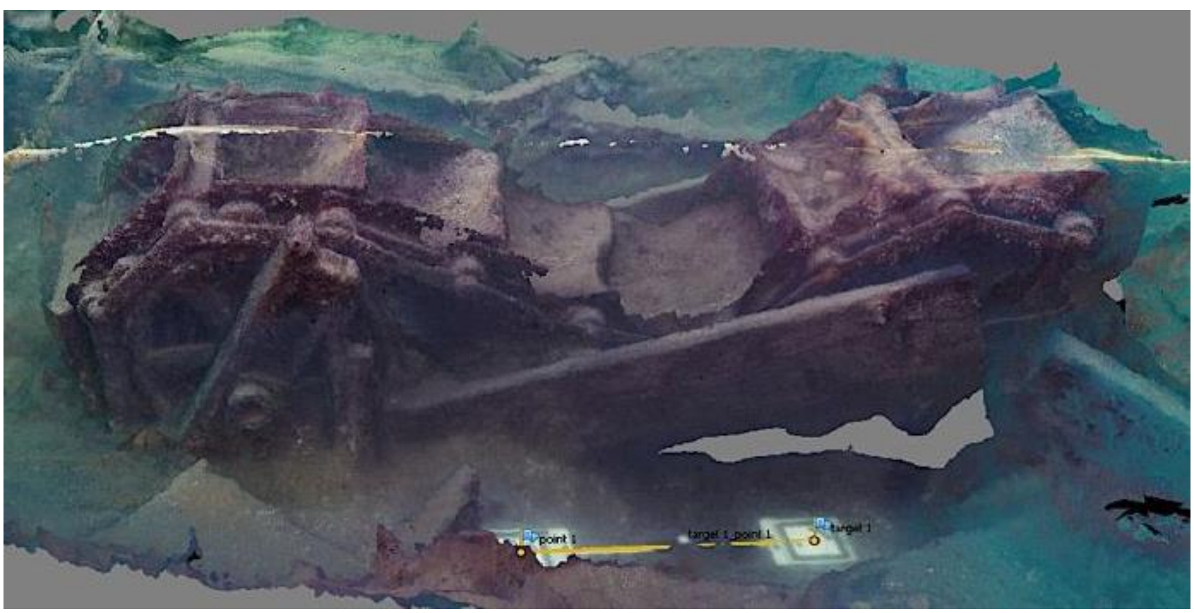


Figure 40. Photogrammetry of the 18 extant pan conveyor buckets after excavation (PanAmerican Consultants)

This sprocket wheel and remnants of the pan conveyor were located about 20-feet aft of *Adriatic*'s bow. Unlike the three other vessels discussed in this report, *Adriatic*'s self-unloading tower and elevator were located at the vessel's bow as opposed to the stern. An additional sprocket wheel was also recovered from the area, but it was no longer attached to any of the buckets. Evidence of salvage of a portion of the pan conveyer is evident at the ends of the articulated buckets. It is likely that these were salvaged from the vessel following the 1934 fire. The pan conveyor buckets were an almost identical match to the size and shape of the bucket system highlighted in a 1913 manufacturing catalogue from the Stephens-Adamson Manufacturing Co. (Zant and Thomsen 2013:4-6; James, Lafferty, et al 2019: 79-86).

Figure 41. The 18 pan conveyor buckets after recovery. Note the evidence of dismantling and salvage (PanAmerican Consultants)

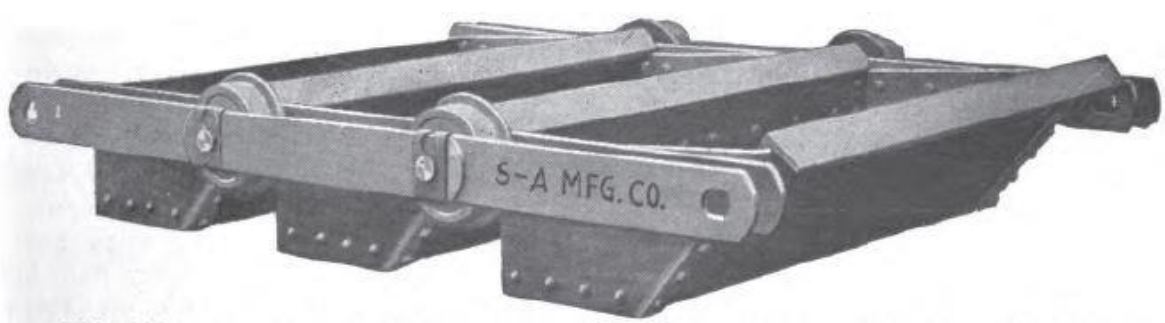


Figure 42. Illustration of the S-A Manufacturing Co.'s pan-conveyor (Stephens-Adamson Manufacturing Company 1913)

Although difficult to identify in the archaeological record, it was noted in historic documents and photographs that *Adriatic*'s pan conveyor was installed at an incline of 45-degrees. The upper implements of the pan conveyor were not identified *in situ*, likely due to the damage caused by the fire and subsequent salvage, however, two gears, a single fly wheel, and a long, hollow metal tube were located near the vessel's bow, just off the starboard side hull. Although these were disarticulated, they have been identified as components of the upper section of the pan conveyor that were deposited over the side of the wreck following the fire (*Door County Advocate* 1934; Zant and Thomsen 2013:4-6; James, Lafferty, et al 2019:116-120).

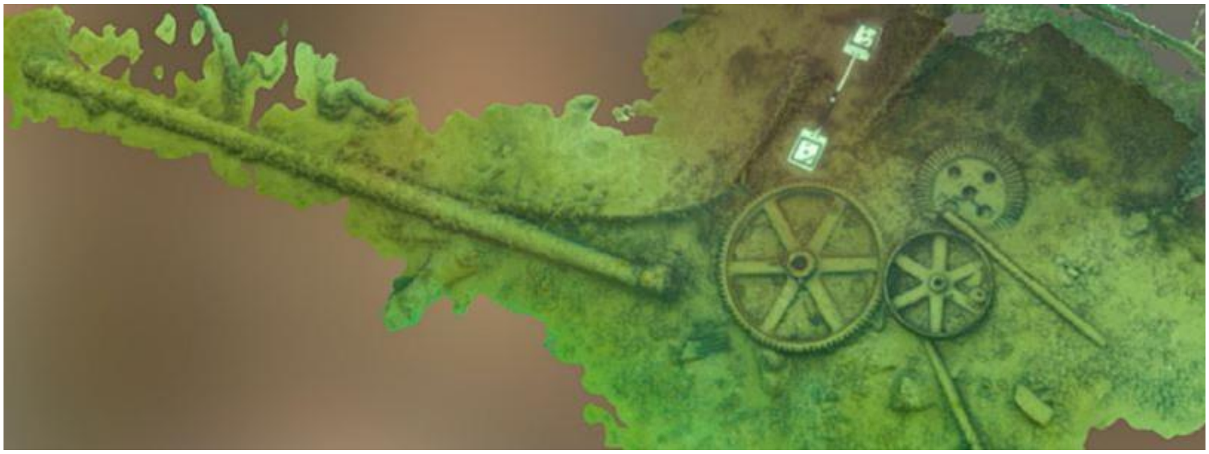


Figure 43. Three gears laying of *Adriatic*'s starboard side (PanAmerican Consultants)

No evidence of the vessel's athwartship conveyor or elevator boot was identified during either investigation of the site, and the vessel's self-unloading boom was also not extant. Historic images of *Adriatic* following its abandonment but before the 1934 fire show that the self-unloading boom had been removed at the time of abandonment while the self-unloading tower and elevator remained intact (*Door County Advocate* 1934; Zant and Thomsen 2013:5).

Transfer

The remains of the self-unloading schooner-barge *Transfer* lie broken on an even keel in 120 feet of water, 6.0 miles southeast of the main Milwaukee harbor entrance in the waters of Lake Michigan on a heading of 85-degrees. Despite the vessel's broken condition, all of its hull construction elements and much of its self-unloading machinery remain on the wreck site. A Phase II archaeological survey of *Transfer* was conducted in 2019 identifying many of the key identifying self-unloading schooner-barge components (Kiefer, Zant, et al 2020:1).

Figure 44. *Transfer*'s stern, looking forward (Wisconsin Historical Society)

The wreckage measures 200.6 feet in overall length, and the wooden hull of the ship has broken at the turn of the bilge. This is very common when vessel's with an extremely sharp turn of the bilge hit the lake bottom after sinking. *Transfer*'s starboard side hull has fallen outward while the vessel's port side hull has fallen inward, masking many of the port side self-unloading mechanisms beneath. Additionally, the vessel's wooden hogging arch can be seen near the bow along the starboard side hull. Since *Transfer* was not a Davidson-built schooner-barge, the vessel's keelson, rider keelson, and sister keelsons are readily apparent running along the ship's centerline. Despite this, the vessel's overall breadth left plenty of room in the hold for the installation of self-unloading machinery (Kiefer, Zant, et al 2020:1-3).

From historic documentation, it is known that *Transfer*'s self-unloading tower and bucket elevator were removed prior to the vessel's abandonment and scuttling in Lake Michigan. An account of the scuttling indicates that all of the cabin windows were smashed in, and the vessel was rammed three times by a tug near the bow in order to ensure the sinking. It is likely that this ramming is what caused the vessel's broken nature on the lake bottom (Kiefer, Zant, et al 2020:23).

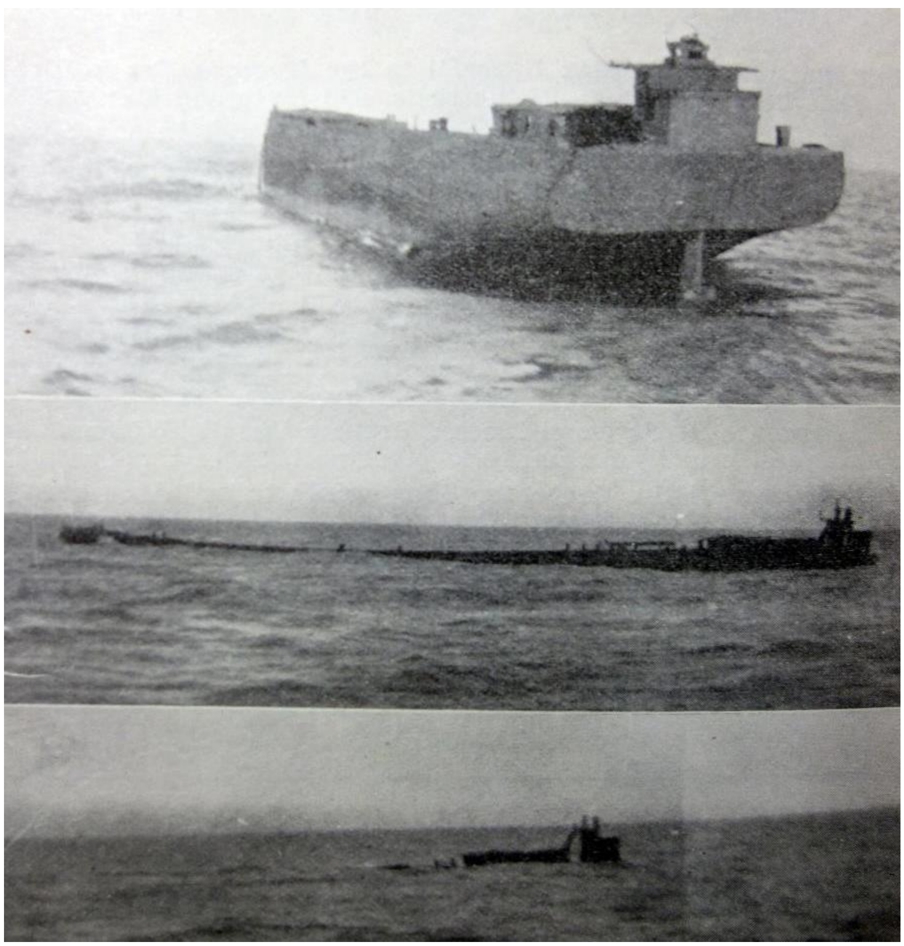


Figure 45. The abandonment of *Transfer* (Milwaukee Electric Railway and Light Co. 1923)

Although the bucket elevator was removed, some evidence of it remains on site. The elevator and elevator boot were located along the centerline of the ship near the stern. The elevator boot still remains mostly intact. It has upright sides and a curved middle section that would have followed the curve of the bucket elevator. This curved section of the elevator bucket is broken, revealing the interior. An assortment of chain, sprockets, and other metal components of the self-unloading equipment remain inside. It is probable that these were tossed in during the dismantling of the bucket elevator and left when the ship was abandoned. A single, V-shaped bucket remains on the site near the vessel's portside bow. It is not known if this was originally part of the bucket elevator, or used for something else, however, its design and shape match many elevator bucket designs from the time period (Kiefer, Zant, et al 2020:7).

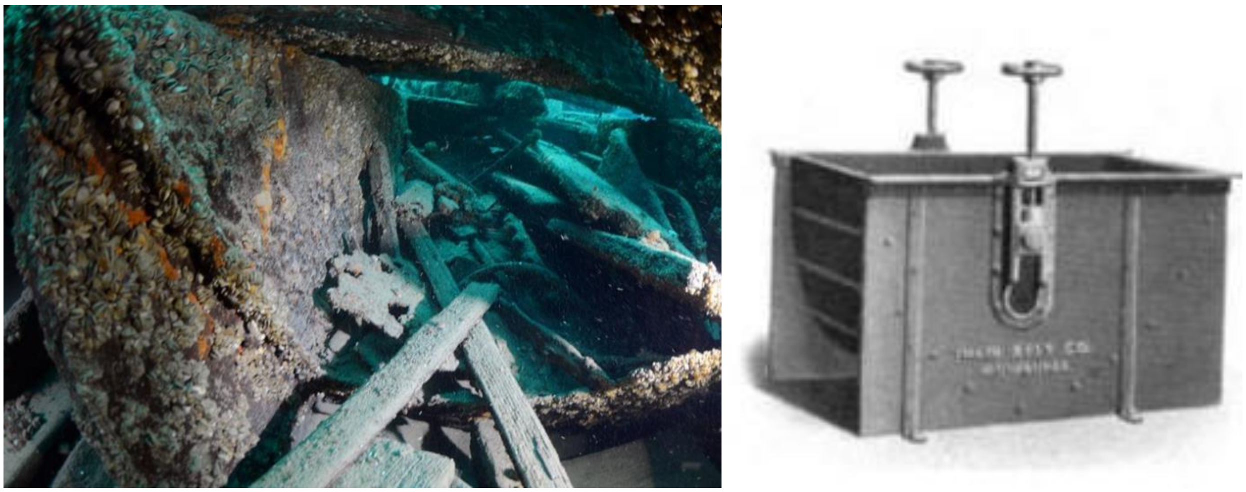


Figure 46. *Transfer*'s elevator boot and artifacts (left) and illustration of a Chain Belt Co. elevator boot (right) (Wisconsin Historical Society; Chain Belt Co. 1923)

Figure 47. A single V-shaped bucket located in *Transfer*'s bow (Wisconsin Historical Society)

Transfer was equipped with a cable conveyor system to move coal from the hoppers to the bucket elevator. Cable conveyor systems were easy to maintain and could handle a lot of cargo without breaking. Although the port side conveyor lies beneath the fallen port side hull, portions of the vessel's starboard side cable conveyor can be seen amongst the wreckage. *Transfer's* specific cable conveyor system was outfit with 6-inch diameter disks attached to a 2-inch diameter steel cable at equal intervals. The cable passed through a "U" shaped steel trough to bring the coal aft and deposit it at the athwartship conveyor (Kiefer, Zant, et al 2020:5-6).

Figure 48. *Transfer*'s cable conveyor (left) and the Jeffery Manufacturing Co. Cable Conveyor (right) (Wisconsin Historical Society; Jeffery Manufacturing Co. 1922)

This cable conveyor system sat beneath parallel wooden hoppers lined with thin sacrificial wooden planking. Small doors or slots would have opened in the bottom of the hoppers for the coal to funnel into the cable conveyor. The hoppers themselves were largely damaged during the sinking; however, small sections of thick timbers lined with thinner wooden sheeting can be seen running along the vessel's keelson (Kiefer, Zant, et al 2020:5-6).

At turning point for the cable conveyor, near the vessel's bow, a single, broken gapped sheave wheel. This wheel had gaps cut out for the circular disks to align in order to turn the cable conveyor and keep the conveyor rotating. A second gapped sheave wheel would have been located near the vessel's stern, but it was not located at the time of the survey. Two large beveled gears were located at the vessel's stern, on either side of the elevator boot. These were used to operate the rotation of the cable conveyors and keep them moving when in operation. Although it was not possible to determine which company designed the conveyors found on *Transfer* specifically, many of the components look similar to the Jeffery Manufacturing Co. Steel Cable Conveyor system (Kiefer, Zant, et al 2020:6).

Figure 49. A gapped sheave wheel designs (left) and *Transfer*'s broken gapped sheave wheel (right) (Jeffery Manufacturing Co. 1922; Wisconsin Historical Society)

One of the vessel's athwartship conveyors remains relatively intact on the port side of the ship. The conveyor appears to be a metal flight/scraper conveyor, which is made up of small, metal dividers that progress along a wooden support structure, advanced by roller chains (similar to a large modern bicycle chain), that was advanced by sprocket gears, located near the vessel's hull walls. Roller chain remains loosely draped across the entire stern section of the vessel. No evidence of the vessel's starboard side athwartship conveyor was located during the 2019 survey (Kiefer, Zant, et al 2020:6).

Figure 50. *Transfer*'s bevel gears and athwartship conveyor, with sprocket gear and roller chain (Wisconsin Historical Society)

During its conversion to a self-unloader, most of *Transfer*'s deck planking was removed to allow coal to be piled high above the vessel's bulwarks. Unlike *Adriatic*, the ship never traversed the open lake after its conversion, so heavy waves were not a concern, and the deck planking was not needed to keep the vessel's interior dry. The ship's deck beams, deck shelf, and knees, however, were left in place and are now scattered throughout the wreck site. The vessel was equipped with numerous metal tie rods that extended across its width. These were likely added to *Transfer* during its conversion into a self-unloader for additional hull support following the removal of the deck planking to allow it to carry more coal cargo reducing stress on the vessel's hull (Kiefer, Zant, et al 2020:4).

Figure 51. *Transfer*'s tie rods extending through the port side hull (Wisconsin Historical Society)

EMBA

Located 5 miles east of Milwaukee's North Point, the self-unloading schooner-barge *EMBA* lies in 170 feet of water in Lake Michigan. The vessel remains upright and almost completely intact, including its self-unloading tower and bucket elevator. All of its hull construction elements and its self-unloading machinery remain on the wreck site. A Phase II archaeological survey of *EMBA* was conducted in 2012, identifying many of the identifying self-unloading schooner-barge components (Thomsen and Meverden 2012:1).

Figure 52. Photomosaic of *EMBA* (Wisconsin Historical Society)

Despite the vessel's sharp turn of the bilge, *EMBA*'s hull remains completely intact, except for the bow, where the vessel collided with the lake bottom upon its sinking. Large rocks were added to *EMBA*'s hoppers during its abandonment and scuttling to ensure its sinking. This is likely why the vessel's bow hit the lake bottom with a force strong enough for it to break. Because of its intact nature, with the self-unloading tower and bucket elevator remaining upright and in place, *EMBA* offers the most complete look at a self-unloading schooner-barge's machinery *in situ* as it operated prior to its abandonment and sinking (Thomsen and Meverden 2012:2).

EMBA's unloading tower protrudes from the weather deck and rises 20 feet vertically above the deck. The tower is supported by four legs and four guy wires. The guy wires connect the top of the tower with the vessel's rail on either side. The four support legs are tied to one another via an A-shaped base. This base is constructed of I-beams and connects the unloading tower with the weather deck and provides a wide footprint for resistance to leveraging the deck. A wooden platform atop the tower holds a winch that raised and lowered the unloading boom. The winch is driven by a drive chain and drive gear located on the port side of the tower's conveyor system (Thomsen and Meverden 2012:5).

Figure 53. *EMBA*'s bucket elevator and self-unloading tower (Wisconsin Historical Society)

The bucket elevator (pan-conveyor) itself consists of 36 buckets connected to one another with a chain on either end and driven by the upper drum with a drive gear, located on the starboard side of the unloading tower. As the buckets came over the top of the conveyor, they dumped cargo into a large metal hopper before cycling down below decks to be filled from the athwartship conveyor located below decks, just beneath the unloading tower. The hopper funneled the cargo onto the unloading boom. The unloading boom was fastened to the deck beams forward of the unloading tower. Although the boom was removed prior to the vessel's scuttling, its pivoting mount remains on the deck. This mount allowed the boom to swing over either side of the vessel to unload cargo. The mount is attached to four longitudinal timbers fastened to the deck beams. The pivoting base consists of two iron plates with bearings between them that allowed the boom to swing (Thomsen and Meverden 2012:5).

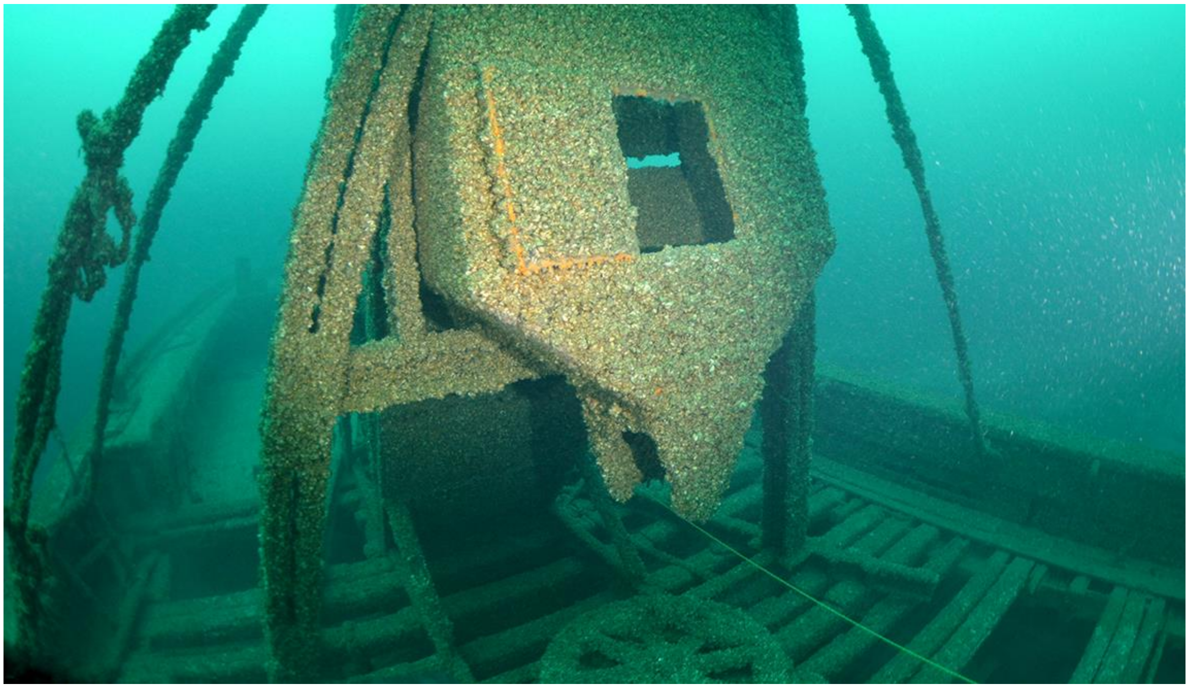


Figure 54. *EMBA*'s self-unloading boom hopper and pivoting mount (Wisconsin Historical Society)

EMBA is also the only self-unloading schooner-barge archaeological site in which the hoppers remain intact on site, and offer some insights into their construction. The hoppers are constructed out of thick wooden timbers, arranged vertically. The hopper walls were covered by a layer of thin wooden sacrificial planking, which are also fastened vertically. The top the hopper wall planks are fastened to a longitudinal timber that is fastened to the deck stanchions above. An identical timber, fastened to the ceiling planking of the outer hull, supports the top of the opposite hopper walls. At the bottom of the hopper, a similar longitudinal timber supports the bottom of the wall, and is held in position by strongbacks that are fastened to the bottom of the deck stanchion at angle of 50-degrees (Thomsen and Meverden 2012:4).

The hoppers were emptied through iron doors located on bottom of the hopper's inner wall, which would slide upward in a steel track that is fastened to the hopper wall on either side of the door. Crew members would have walked along either side of the vessel's keelson to operate the hopper doors manually. The hopper doors emptied directly onto two parallel belt conveyors located beneath, similar to the orientation of *Adriatic*'s belt conveyors. The belt conveyor moved the cargo aft where it emptied onto a lower, athwartship belt conveyor that moved the cargo to the vessel's elevator boot located below, just beneath the self-unloading tower.

The belt conveyor itself was removed before the vessel was abandoned and scuttled, leaving only the wooden framing and supports. The athwartship conveyor framing also remains in place; however, it is uncertain if the conveyor belts themselves are extant, due to the deep silt that has accumulated inside the hull. The vessel's elevator boot is also largely obscured by silt (Thomsen and Meverden 2012:4).

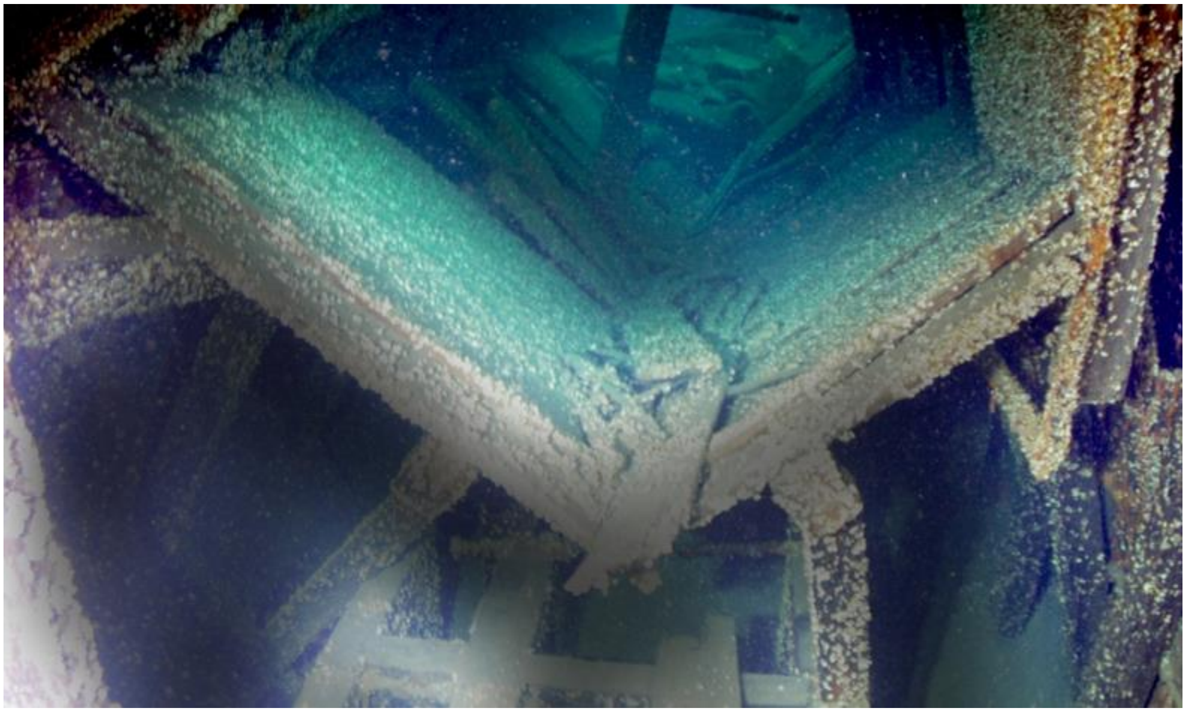


Figure 55. The upper portion of *EMBA*'s hoppers showing tie rods extending across the hold, and the removed deck planking (Wisconsin Historical Society)

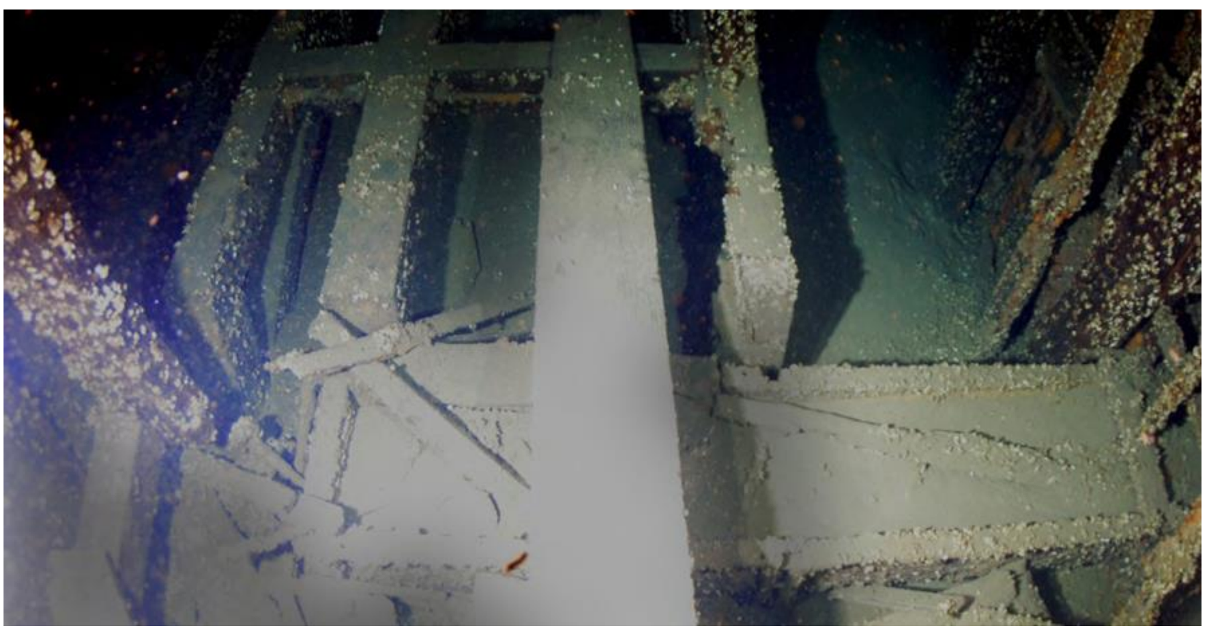


Figure 56. The aft end of the longitudinal belt conveyor supports and the athwartship belt conveyor (Wisconsin Historical Society)

Similarly to the conversion of *Transfer*, *EMBA*’s deck planking and a few deck beams were removed during its conversion to a self-unloader to allow coal to be piled high above the vessel’s bulwarks. Since the ship never traversed the open lake after its conversion, heavy waves were not a concern. Most of the ship’s deck beams, deck shelf, and knees, however, were left in place, along with a narrow section of deck planking running along the vessel’s bulwarks. This walkway was left in place to allow crew members to move along the vessel’s deck during operation. The vessel was also equipped with numerous metal tie rods that extended across its width. As with *Transfer*, these were likely added during its conversion for additional hull support following the removal of the deck planking (Thomsen and Meverden 2012:4-5).

Figure 57. The upper portion of *EMBA*’s hoppers showing tie rods extending across the hold, and the removed deck planking (Wisconsin Historical Society)

SECTION SIX
Discussion

Analyzing known early converted self-unloader wreck sites individually allows the small nuances and idiosyncrasies of each shipbuilder and equipment manufacturer to be identified and studied, formulating an in depth typology of early self-unloader design. It is the broader exploration of bulk cargo industries (primarily stone, sand, and coal), however, which offers an understanding of the larger economic trends and evolving maritime industrial growth in the Great Lakes region. By examining the role early converted self-unloaders played in the development and evolution of maritime industrial commerce on a regional level, a broader understanding of maritime innovation can be achieved (Raistrick 1972; Palmer and Neaverson 1998; Palmer et al. 2012).

Formulating an understanding of the early technological and economic components of self-unloading machinery in the Great Lakes allows for a comprehensive understanding of the industrial and economic landscapes of a region. The development of technologies reveals a cycle of innovation. As industrial markets continue to grow, adaptations to transportation systems are required to meet a growing demand for products and raw materials; the ability to handle higher volumes of cargo at a cheaper rate becomes the highest priority (Palmer et al. 2012:233-234). As industry changes, technological innovations change to reflect these improvements. It is these patterns of development that reflect the larger patterns of economic growth and development in a region, and these patterns of economic development, in turn, spur new industrial changes.

By analyzing the components of early self-unloading machinery as effective mechanisms of maritime industrial ingenuity and development, it is possible to see a pattern of the changing economic landscapes and transportation needs of the Great Lakes at the start of the 20th century. The development and use of this labor-saving technology reflects adaptations in maritime commerce to adjust to changing commercial demands for bulk materials. The abandonment of many of these early self-unloaders, in the 1920s and 1930s in lieu of more modernized self-unloading technology, further demonstrates this pattern of economic change. Even after railroads began to dominate the Midwestern landscape, and stretch ever further westward, the fastest and most inexpensive mode of transportation for bulk cargo remained waterborne.

By the turn of the 20th century, the U.S. economy had fully recovered from the Panic of 1893, which had had an adverse effect on many industries in the Great Lakes region. With capitol once again flowing into the region and the U.S. growing rapidly, demand for raw materials for industry was on the rise (Timberlake 1997:516-518). After the turn of the 20th century, Great Lakes trade was largely focused on bulk commodities. This was especially true of the stone industry. Hinterland communities were growing rapidly, and demanded increasing amounts of raw materials to support their development. This demand for more materials meant larger cargos of materials needed to be transported at a faster rate. Unfortunately, unloading times for traditional schooners and schooner-barges remained painfully slow (Lafferty 1998:155-156).

To meet these growing demands, companies developed new technologies in manufacturing and production. To establish broader markets, the relationship between cost of transport and total product production cost is vital. This means that the lower the cost of transportation, the more profitable an industry will be. If the costs of transportation outweigh the costs saved by increased production rates, the product has little value to the producer. The resolution of this issue lay in the ability to ship higher volumes of stone in a more cost effective and rapid manner (Palmer et al. 2012:233).

This necessity is the impetus for the evolution of nearly all transportation systems. With reduced costs of manufacture and increased production, the speed of movement and the ability to handle larger tonnages became progressively more important in the shipping industry (Lafferty 1998:157, 161; Palmer et al. 2012:234). As innovations in mechanized production developed and more products were produced at a higher rate and lower cost, the demand for additional product also increased exponentially. This required the need for faster, more economical ways to transport materials in order to maintain profitability. While many big companies, with larger vessels, were able to maintain this profitability with older means of transportation, smaller competitors in the hinterlands of the Great Lakes, such as the Leathem and Smith Stone Company, and required innovative methods of maintaining a stake in commerce. This fundamental problem was addressed by the development of self-unloading technology and the conversion of old wooden vessels.

Though speed of transport was greatly assisted by the development of dockside steam powered machinery for unloading cargo, these large apparatuses were often complicated and cumbersome, and still required 48 hours, or more, to unload a vessel of over 2,000 tons. Although faster than manual unloading techniques, this time in port cost companies a considerable amount of money for labor and idle time. More time spent in port, meant less time traversing the Lakes, leading to fewer trips during any one season and fewer profits (Cross 1938:229; Lafferty 1998:156). The Leathem and Smith Company felt this drain directly, as vessels were continually held up for lengthy unloading processes before arriving at their quarry to load a cargo of stone. This is exemplified by a newspaper report detailing the prolonged unloading of the schooner-barge Paisley which was delivering coal to Sturgeon Bay in 1913.

After eleven days, with a large crew of men using a combination of manual labor and steam powered buckets to unload its cargo, the vessel was finally emptied and made ready to take on a cargo of stone (*Sturgeon Bay Advocate* 1913a, 1913b). This was not a unique case. Without the capability to unload multiple vessels at once, smaller companies such as this were unable to maintain the transportation speeds necessary to keep costs low and turn large profits. To maintain a competitive edge, these smaller companies needed a method for getting vessels in and out of port faster. This need lead to the development, and continued improvement of self-unloading technology as a cost-effective solution.

Over time, as industrial markets continue to grow, adaptations to transportation systems are required to meet a growing demand for products and raw materials; the ability to handle higher volumes of cargo at a cheaper rate becomes the highest priority (Palmer et al. 2012). As industry changes, technological innovations also change to reflect these improvements. It is these patterns of development that reflect larger patterns of economic growth and development in a region, which in turn, spur new industrial changes. By analyzing converted self-unloaders as specialized industrial tools, crafted specifically as a mechanism of economic development, it is possible to understand the evolving nature of Great Lakes regional trade and industrial expansion at the end of the nineteenth century. Thus, allowing the design and construction of sailing canallers to be placed within a larger historical and regional context. Vessel size, shape, design, and construction, were all influenced by the necessity to transport more cargo at a faster rate to increase profit.

This development of self-unloading machinery reflects the larger patterns of economic growth and expansion in the Great Lakes. Self-unloading technology met the growing need for faster transportation throughout the region. In turn, many industries throughout the Great Lakes region became more profitable due to the more cost efficient methods of transportation. With an increase in profitability, and lower transportation rates, consumers could purchase higher tonnages of cargo, increasing demand. Following this pattern, many industries in the Great Lakes experienced booms in the years after the introduction of self-unloading technology. In other words, self-unloading technology answered a need for increased speeds in transportation, and in turn, led to economic growth throughout the Great Lakes region.

Following the introduction of self-unloading technology, rates of production increased and costs of transportation decreased significantly for companies employing self-unloaders. On average, self-unloading vessels could unload up to 25 times faster than traditional methods using shovelers and clam-shell bucket systems. *Adriatic* had an unloading rate of 250 to 375 tons per hour, taking only four to six hours to completely unload. This unloading rate was over 22 times faster than the rate of unloading *Paisley*, a vessel that had a carrying capacity of only 500 tons more than *Adriatic* (*Sturgeon Bay Advocate* 1913a, 1913b; Lafferty 1998:157).

Self-unloaders not only allowed companies to increase the number of trips made throughout the shipping season, but profitability for many companies was also increased by a decrease in shipping costs themselves. Although the installation of self-unloading technology took up considerable amounts of cargo space within vessel's hulls, these vessels were able to return higher profits for their owners than other vessels with larger carrying capacities. In part, this was due to the faster unloading times discussed previously. By the 1910s, many ports had developed into bustling centers of trade and were equipped with improved dock facilities, and steam powered unloading machinery, making the unloading process easier and less labor intensive than it had been mid-century. While many smaller ports were equipped with some steam powered machinery for unloading they lacked funding for expensive but efficient unloading equipment such as Hewlets or Brown Hoists, so the process remained more arduous and labor intensive. This kept freight costs to and from these small ports high. In addition, to cover overhead costs an additional unloading charge per ton was added once a ship reached these smaller, unimproved ports (*Sturgeon Bay Advocate* 1913a; Lafferty 1998:157- 158).

Because they did not require large unloading crews or the operation of large pieces of dockside machinery, cargo transported by self-unloaders did not require this overhead cost, and therefore, were cheaper to operate at any port. Self-unloaders were also able to enter unimproved ports and unload without the need for large crews and expensive dockside equipment. Because of this, companies and vessel owners did not have to charge as much per ton for cargo to turn a profit on materials. By increasing the ability to ship higher volumes, transportation costs were lower, which in turn, led to the capacity to establish broader markets for these raw materials (Raistrick 1972:127; Palmer et al. 2012:124, 233). In many instances, this led to a boom in industries using self-unloaders for transportation of bulk cargos.

Although early self-unloaders were effective mechanisms in the development of the maritime industrial and economic landscapes of the Great Lakes, the pattern of economic and technological development continued to evolve as the twentieth century wore on. As markets continued to grow, so too did the need for reduced costs of transport and the ability to ship higher volumes of cargo. Faster self-unloading technology and larger cargo capacities were needed to maintain this growth, and the shipping industry was once again faced with a need to adapt to meet those needs. As new adaptations to self-unloading technology develop, older technology became outdated, reflecting yet additional changes in maritime industrial landscapes.

The very patterns of economic development reflected in the evolution of labor-saving technologies and self-unloading machinery in turn spur new industrial changes, leading to an ever changing and evolving maritime industrial landscape. While this is not unique to the Great Lakes, this evolution can clearly be seen through the rapid development of new machinery to cope with the growing demand for stone and other bulk cargos in the region. Although early converted self-unloaders were instrumental in ushering in this era of modern maritime industrial transportation, their older designs could not maintain profitability as increasing volumes of cargo and speeds of transportation were demanded. This evolution, from early converted self-unloaders, to larger, purpose-built self-unloading bulk carriers, allowed the maritime industrial and economic landscape of the Great Lakes region to enter the modern era.

Technology constantly evolves because the economic need for new technology is ever changing. This constant process reflects the shifting nature of maritime industrial landscapes. Once the effectiveness of technology is felt, the profitability of the technology increases and the demand for transportation of materials is not only met, but demand for more materials grows. Over time the effectiveness of early technology begins to dwindle because profitability and performance needs to be increased, thus leading to the development of new, more cost effective technology (Palmer and Neaverson 1998:145- 146; Palmer et al. 2012:234). Early self-unloaders, specifically self-unloading schooner-barges, were a cog in this wheel of maritime technological advancement; they were not the ultimate solution, but an essential missing link. Without their original effectiveness though, maritime commerce on the Great Lakes, and throughout the world, would not have advanced as it has today. The design features of modern self-unloading bulk carriers closely resemble the configurations of these century old first self-unloaders.

Each modification to self-unloading technology is aimed at increasing carrying capacity and speed. As early as 1924, articles detailing the impracticability of converting standard bulk carriers into self-unloaders were published in marine engineering journals. The main reason for this lay in the loss of cargo space, increased draft, and altered center of gravity in vessels following the installation of heavy self-unloading machinery (Penton and Sadler 1924:57- 58). At this point, companies began to brainstorm new and innovative ways of increasing the effectiveness and profitability of self-unloading technology.

In 1923, Leathem D. Smith of the Leathem D. Smith Shipbuilding Company developed the tunnel scraper system. This system was not only cheaper to install than a traditional belt conveyor system, but it also allowed for vessels to maintain a lower center of gravity, making them more stable when loaded. The tunnel-scraper system made use of two longitudinal tunnels, located beneath the vessel's hoppers, equipped with a scraper. The scraper would pull the cargo toward another hopper, which would deposit cargo into a pan-conveyor to be raised onto the self-unloading boom (Smith 1929:83; Lafferty 1998:166).

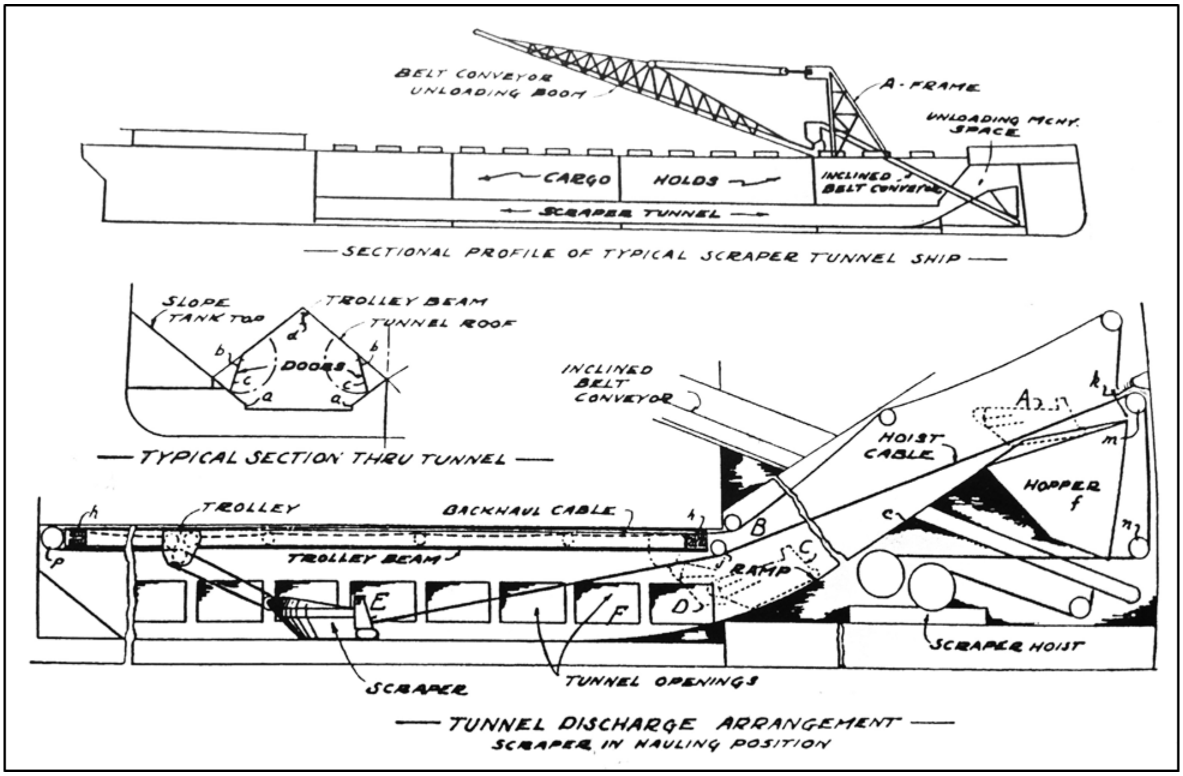


Figure 58. Drawing of Leathem D. Smith's tunnel-scraper system (Lafferty 1998)

Although Smith's patented tunnel-scraper system was a viable answer to the issues of carrying capacity and instability in converted wooden self-unloaders, other shipping companies began to develop their own versions of converted steel self-unloaders in order to meet the growing needs of bulk cargo transportation. Between 1932 and 1936, the Bradley Transportation Company had six steel vessels converted to self-unloaders by the American Ship Building Company as a solution for independent ship owners to compete with larger companies and major fleets. The demand for the transportation of limestone and other stone products remained high, as did the necessity for a vessel that could unload without the use of an "unloading rig."

An article published in a journal of marine engineering and naval architecture in 1938 still expressed the need to develop a self-unloading design that would "make it possible to unload such materials as limestone and coal rapidly, but also cheaply" (Cross 1938:229). The article goes on to express the necessity of maintaining high cargo capacities, and highlights the continued development of the self-unloader as a "child of the Depression." Although self-unloading machinery obviously developed prior to the Great Depression, the author describes the increased demand for technology designs to maintain efficiency but were inexpensive to install (Cross 1938:230).

Following the boom in shipping during the 1920s, the Great Depression hit the Great Lakes region harshly. Though the demand for limestone remained throughout the 1930s, the demand for other bulk cargos fell off sharply. It was out of this decline that innovations in steel-hulled self-unloaders developed. Although there was not enough capital to construct purpose-built self-unloaders, new developments in the conversion of old steamers allowed shipping to maintain its profitability and keep many companies in the region in business through the Depression (Cross 1938:230- 231).

Using vessels that were over 500 ft. in length and nearly 25 years old, the Bradley Transportation Company was able to develop vessels that could unload cargos rapidly while maintaining high volumes of cargo. During conversion, the vessel's tank tops and side tanks were removed, and the hold stringers were cut back almost in half. By removing these components of the vessels, the side slopes of the hoppers could be set lower in the hull, thus allowing for higher carrying capacities while keeping low centers of gravity. Unlike Smith's tunnel-scraper system, the conversion of the Bradley vessels made use of the belt and pan-conveyor system of unloading.

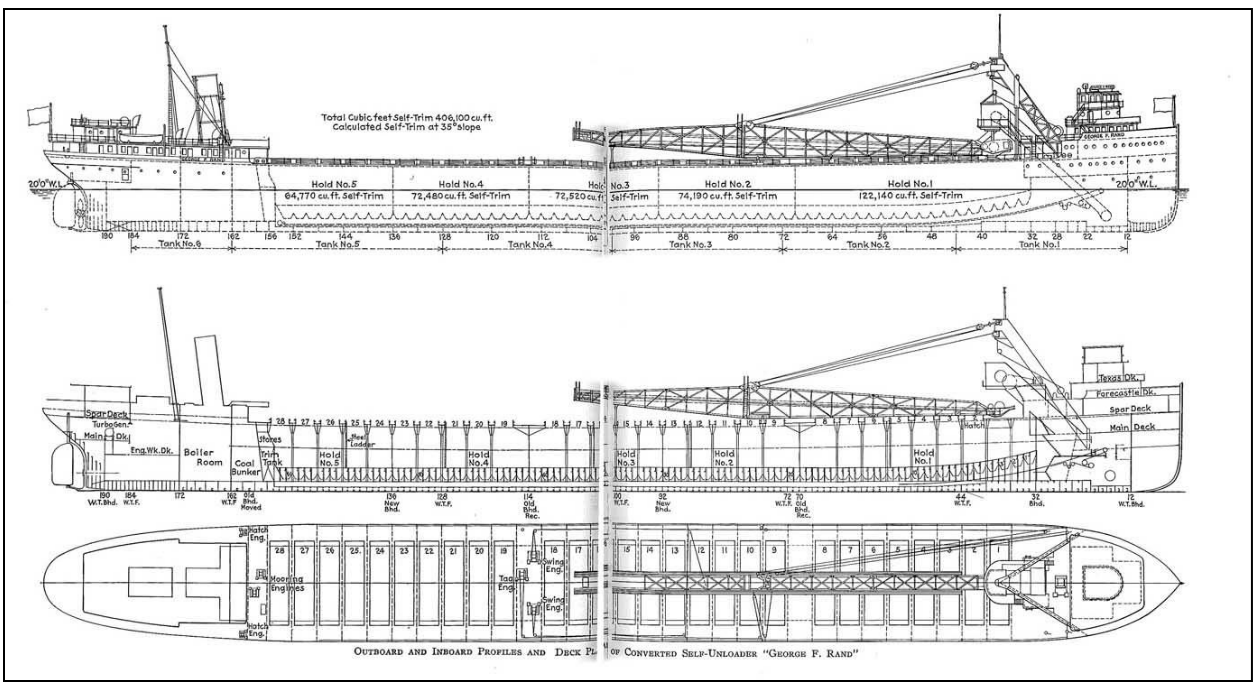


Figure 59. Schematics of the Bradley Transportation Company's converted self-unloader, *George F. Rand* (Cross 1938)

To further increase unloading speeds, the hopper gates were spaced closer together, allowing more cargo to be loaded onto the belts at a higher rate. The belts themselves operated at a speed of 356 ft. per minute. This spacing also allowed for additional hold capacity. Post World War II welded construction insured that much of this self-unloading machinery could be prefabricated, which saved costs and installation time. Additionally, these self-unloaders were equipped with booms nearly 200 ft. long. This allowed vessels to have deeper drafts, higher cargo capacities, and to remain in deeper water and still unload cargo in shallow ports (Cross 1938:231- 232).

While not the only developments in self-unloading technology, the conversion of the Bradley Transportation Company's self-unloading fleet represents an example of the type of advancements that were being made in self-unloading technology throughout the 1930s. These vessel conversions also demonstrate the effects of economic trends on the development of shipboard unloading technology. The success of these vessels spoke to the well-crafted design of self-unloading machinery to maximize transportation speeds and carrying capacities, and to the improvements and adaptations that were developed as industries in the Great Lakes continued to evolve (Cross 1938:240).

As designs for self-unloaders evolved throughout the 1920s and 1930s, wooden vessels were quickly discarded as viable candidates for vessel conversion. As prices of steel construction became more affordable, converted wooden self-unloaders and the technology they were outfit with, became outdated, and many of these vessels were unceremoniously abandoned. While abandonment was a common practice in the Great Lakes, the abandonment of early self-unloaders was unlike the abandonments of other old wooden vessels which were usually repurposed into wharves, dry docks, or salvaged for parts. The methods of abandonment for vessels such as *Adriatic*, *Transfer*, and *EMBA*, can give additional insight into the changing economic and industrial maritime landscapes of the western Great Lakes during the 1920s and 1930s.

Aside from the effects innovations in self-unloading technology had on economics and the advancement of trade, abandonments reveal the depreciating value placed on antiquated technology. Although many new developments in self-unloading technology closely resembled their older counterparts, little to no value seemed to be placed on the machinery once it was no longer in use. Archaeological investigations reveal that only the self-unloading tower and boom were removed from *Transfer* prior to its scuttling, but evidence of the vessel's pan-conveyor, belt conveyors, and gear systems remain on the site. *EMBA* remains with its entire self-unloading outfit intact save for its self-unloading boom, and all components of *Adriatic*'s self-unloading machinery, including gears associated with the vessel's self-unloading tower, remain on site. Only the unloading boom, and structural supports for the self-unloading tower no longer remain on the *Adriatic* site; components which were likely destroyed by the fire which burned the vessel to the waterline, nearly five years after its abandonment at an unused coal dock (*Door County Advocate* 1934:4; Meverden and Thomsen 2012:17; Zant and Thomsen 2013:10).

Most of the machinery on board these vessels was not salvaged, nor was it removed and repurposed in newer self-unloading vessels. While a deviation from common practices in the region, these abandonments demonstrate the changing economic atmosphere in the Great Lakes during the 1920s and 1930s. Self-unloading machinery was now cheap enough that extraordinary measures were no longer necessary to salvage old machinery. *Transfer*'s scuttling in 1923 acquired some fanfare when the Milwaukee Electric Railway and Light Company reported the event in its annual internal publication, "Rail and Wire." Care was taken to open all of *Transfer*'s portholes and drill holes in the vessel's hull to ensure its proper scuttling. The barge was then rammed three times by another vessel, and photographs were taken as it slipped beneath the surface of Lake Michigan (Milwaukee Electric Railway and Light Company 1924:25).

This same fanfare was not expressed when *Adriatic* and *EMBA* ignominiously came to the ends of their careers. By the late 1920s, the country was slipping into the Depression, and companies had turned their attention to developing new technologies to maintain profitability in shipping despite the failing economic atmosphere. It was simpler, and more cost effective, to scuttle old vessels than try to salvage small components of its machinery. Sometime after 1927, *Adriatic* was simply tied up to an old coal dock at the Leathem and Smith Shipbuilding Company yard in shallow water. The vessel remained untouched by the company, used only as a popular fishing spot until it burned to the waterline in 1934 (*Door County Advocate* 1933:1; *Door County Advocate* 1934:4). Due to the depressed economic atmosphere in 1932, a Roen Transport Company's proposal to raise *Adriatic* for use at their stone quarry never materialized (*Door County Advocate* 1932:4). By 1932, the Depression was in full force and *EMBA* was simply towed out into Lake Michigan and scuttled unceremoniously (Meverden and Thomsen 2012:18).

Analyzing the artifacts and components of machinery remaining on abandoned converted wooden self-unloaders demonstrates shift into a modern, economic-centric era of shipping where more focus was placed on new developments in technology rather than developing modifications and adaptations for older vessels. Likewise, the 20th century marked the end of the age of wooden vessel construction, and converting old wooden hulls became less economical. This shift from modification and adaptation to the building and creation of purpose-built, cost-effective vessels possibly marks the progression of the Great Lakes shipping industry into the modern era.

SECTION SEVEN
Conclusions and Recommendations

The development of self-unloaders reflects a unique era in the evolution of maritime industry, and represents an important innovation in the transportation of bulk materials. Without these important technological advancements in the Great Lakes region, modern shipping technology would likely not have developed in the way that it did over the course of the last hundred years. Self-unloaders were a unique solution to technological and economic issues facing maritime industry and transportation in the first decades of the 20th century. As a relatively simple and inexpensive solution to the needs of bulk cargo transportation, self-unloaders were an important link between modern mechanized shipping and traditional methods of waterborne transport, helping propel maritime industry into the modern era.

The use of converted wooden vessels, such as *Adriatic*, *Transfer*, and *EMBA*, was an economical way to adapt these labor-saving technologies throughout the Great Lakes region. The continued use of wooden vessels was a common occurrence in the Great Lakes due to easy access to large tracts of forest. This tradition was continued in the western Great Lakes longer than in other regions because the construction and maintenance of wooden vessels remained cheaper than building out of iron or steel until the vast timber resources of the Great Lakes region were exhausted around the turn of the 20th century.

The particular use of schooner-barges in conversions to self-unloaders was due to their particular construction, making them the best suited vessels to handle the installation of self-unloading machinery while maintaining the highest cargo capacities. A sharp turn of the bilge, and relatively flat hull bottom made these vessels early models of today's bulk carriers. Without the need for propulsion machinery within the hull, schooner-barges had the largest holds of all wooden contemporaries for the addition of hoppers and conveyor systems.

The relatively small size of schooner-barges, in comparison to larger steel hulled vessels, made the ships ideal for entering the small, unimproved ports which dotted the Lake Michigan shoreline. Being able to enter ports and unload cargo quickly and effectively, allowed self-unloading schooner-barges to maintain cost effectiveness for their owners: a savings that could then be used to reduce prices for customers. Despite their lack of propulsion, the cost effectiveness of increased cargo capacity and unloading speeds made schooner-barges ideal vessels for conversion. Likewise, as shown with the differences in conversions between multiple early converted self-unloaders, self-unloading equipment could be adapted for various trades, industries, and environments to maintain the utmost effectiveness.

Despite this effectiveness, as with all new technology, continued advancements in shipbuilding and self-unloading machinery eventually rendered these vessels outdated and ineffective. As the needs for faster and more economical transportation of goods increased, and steel vessel construction became more affordable, smaller wooden vessels with slower unloading times were no longer needed. Unlike their predecessors, many these wooden self-unloaders were not repurposed, and were unceremoniously abandoned. The reason for this change is largely an issue of cost benefit analysis, and reflects the economic changes of the 1920s and 1930s, particularly with the onset of the Great Depression in 1929. As the United States continued to spiral into an economic depression, the cost of repurposing these old self-unloaders was not cost effective when money could be spent on building new vessels which could garner larger overall returns.

Maritime economies throughout the Great Lakes region were continually changing throughout the late 19th and early 20th centuries, and access to the rapid transportation of materials was a key component of maintaining profitability. This was evident prior to the turn of the 20th century, but the introduction of shipboard self-unloading technology became a turning point in Great Lakes maritime industry. Advancements in industrial production pushed the need for maritime industrial development to all new heights. The key was speed and cost effectiveness and convenience. With railroads not reaching many smaller Great Lakes ports until well into the twentieth century, waterborne trade remained the fastest and most effective means of transportation. It was out of this need that self-unloading technology developed. The use of schooner-barges for early conversions reflects Great Lakes maritime economies. Without economical means of producing larger steel vessels, many companies made use of the resources available to them, which is reflected in the use of old wooden vessels. Schooner-barges, equipped with self-unloading machinery, met the growing needs of maritime industrial transportation without the added cost of constructing a new vessel.

Adaptations to self-unloading technology demonstrate that the evolution of this technology was not a blanket development. The technology and mechanics of self-unloading equipment remained similar, but could be adapted for different industries in different areas and environments. When possible, self-unloaders were modified to carry even more cargo, maintaining a delicate balance between seaworthiness and maximizing cargo space.

Although only a contributing factor to the larger trends of industrial and economic development in the Great Lakes, the importance of early converted self-unloaders and the modifications developed onboard cannot be overlooked. The designs and implementation of this hull type paved the way for the effective bulk cargo transportation, and served as a prototype for the construction of later converted and purpose built self-unloading bulk freighters. By formulating an understanding of the catalysts of maritime innovation and design, a more comprehensive understanding of the nuances of maritime industrial heritage and culture in the late nineteenth century can begin to develop, revealing the broader regional context of self-unloading schooner-barges.

While an in depth historical analysis of self-unloading schooner-barges and other early self-unloading vessels has allowed for a greater understanding of the vessel type and an understanding of the economic and industrial contexts into which early self-unloaders fit, there is still much more to be learned from these wreck sites and their histories. This study has relied heavily upon documents, data, and research from wrecks in the Wisconsin waters of Lake Michigan. While additional research and photographic data has been used to expand the analysis, further research into other known early converted self-unloaders lost in the Great Lakes can significantly add to the breadth of this study.

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