INDIANA: **THE HISTORY AND ARCHAEOLOGY OF**

AN EARLY GREAT LAKES PROPELLER

A Thesis

by

DAVID STEWART ROBINSON

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

May 1999

Major Subject: Anthropology

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Approved as to style and content by:

Kevin J. Crisman
(Chair of Committee)

Charles E. Brooks
(Member)

Frederick M. Hocker
(Member)

Vaughn M. Bryant, Jr.
(Head of Department)

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ABSTRACT

Indiana: The History and Archaeology of an Early Great Lakes Propeller. (May 1999)

David Stewart Robinson, B.A., University of Rhode Island

Chair of Advisory Committee: Dr. Kevin J. Crisman

The early Great Lakes propeller *Indiana* was built as a combination passenger- and freight-carrying steam vessel in 1848 at Vermilion, Ohio by itinerant Lake Erie shipbuilder Joseph M. Keating. Over the span of its ten-year career, the vessel served the interests of its owners and several different shipping and railroad lines transporting passengers and a wide variety of cargoes before sinking on the evening of 6 June 1858 with a load of iron-ore "down-bound" for Cleveland.

Indiana holds an important place in the history of steamboat technology as the best-preserved extant example of an early propeller-driven Great Lakes vessel. Built seven years after the first propeller-schooners appeared on the lakes, at a time when scientific principals were being applied for the first time in ship design and screw propulsion was proving itself to be an efficient, reliable, and economical mode of transporting freight, *Indiana* represents a "second generation" of early Great Lakes propellers that were larger, faster, and better equipped than their predecessors to serve the burgeoning Great Lakes freight and passenger trades of the late 1840s and the 1850s. Although virtually undocumented elsewhere, the transition between the transient propeller-schooner of the early 1840s and the standardized propeller liner of the middle 1850s is clearly evident in *Indiana*'s archaeological remains.

This thesis presents the results of a multi-year archival and archaeological study of *Indiana*'s operational history and wreck site. Narrative descriptions of Vermilion, *Indiana*'s builder and owners, its ports of call, routes travelled, sinking, and salvage are provided in the introductory chapters (Chapters I and II). Chapter III presents an account of the archival and archaeological research that was conducted in the preparation of this thesis and includes a description of *Indiana*'s wreck site. The main body of this thesis (Chapter IV) contains a detailed description of *Indiana*'s hull construction, propulsion machinery, and deck equipment. Chapter V provides the supplementary evidence necessary for reconstructing *Indiana*'s hull form and construction. Conclusions are presented in Chapter VI. Appendices include materials analyses reports and an extensive list and tabulation of *Indiana*'s cargoes.

For my beloved

Hayley, Michael, Noah, and Joshua

ACKNOWLEDGMENTS

This study of the early Great Lakes propeller *Indiana* was completed with the generous support and cooperation of many different individuals, institutions, and organizations. It is my pleasure at this time to acknowledge their contributions. Dr. Kevin Crisman, chairman of my thesis committee, has my undying gratitude for selflessly sharing with me his vast knowledge of nautical archaeology and the history of American shipbuilding and seafaring. I am also greatly indebted to him for his expert assistance in the field, and for his continuous encouragement and enthusiastic support throughout my career and during all phases of the research and writing of this thesis. Committee members Dr. Frederick M. Hocker and Dr. Charles E. Brooks also deserve special recognition for their generous contributions of time and talent to this study and for their helpful editorial comments and suggestions. Drs. Crisman, Hocker, and Brooks have been a great inspiration to me. A special note of thanks is also due to Dr. Paul F. Johnston of the Smithsonian Institution, for his support and assistance throughout the project.

Financial support for archaeological fieldwork was provided by the National Trust For Historic Preservation, the Smithsonian Institution's Research Opportunities Fund, and the National Museum of American History's Ship Plans Fund. Additional funding was obtained through an INA Competitive Academic Scholarship, a Texas A&M University Academic Excellence Award, and, occasionally, from my parents-in-law, Carroll and Molly Harrington, whose frequent "loans" helped me make ends meet while I was conducting post-fieldwork archival research for this thesis.

Completing the reconstruction of *Indiana* would not have been possible without the hundreds of detailed measured drawings, photographs, and hours of video footage obtained by a dedicated group of professional and volunteer divers, archaeologists, and architects who composed the field crews each season during the three, two-week-long expeditions that were made to the site between 1991-1993. The individuals whose hard work made each campaign a success are:

1991 field season: Robert M. Adams, William H. Cohrs, Joseph R. Cozzi, Kimbra Cutlip, Peter Hentschel, Paul F. Johnston, Michael A. Lang, Raymond H. Siegfried III, John R. Steele, and John N. Stine;

1992 field season: Thomas K. Alburn, Richard K. Anderson, Jr., William H. Cohrs, Joseph R. Cozzi, Kevin J. Crisman, Robert Falvey, Alan T. Flanigan, Peter Hentschel, Paul F. Johnston, Hera Konstantinou, Michael A. Lang, John R. Steele, John N. Stine, and George

West; and

1993 field season: William H. Cohrs, Joseph R. Cozzi, Alan T. Flanigan, Peter Hentschel, Paul F. Johnston; John R. Steele, and John N. Stine.

I am especially indebted to Messrs. Steele and Cohrs, without whom *Indiana*'s existence may have remained unknown forever. The contributions these gentlemen made to the project are difficult to overstate. Both were vitally important members of the archeological team, and acted as our underwater guides, photographers, and documentation specialists. Mr. Steele also provided the project research vessel, *Lake Diver,* which he captained throughout the field investigations.

Two unofficial, but important, members of the project team were Richard and Cathy Robinson, owners of the Rainbow Lodge, in Luce County, Michigan. The Robinsons provided our archaeological teams with comfortable accommodations during each of the three expeditions, and made us feel right at home in the wilds of Michigan's Upper Peninsula.

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VanDereedt and John VanDereedt of the National Archives, Martin Toohey of the Great Lakes Branch of the National Archives, Richard Smith of the National Archives Cartographic Reference Branch, and Connie Carter and Virginia Wood at the Library of Congress.

Extensive documentation of *Indiana*'s machinery and commercial activities was painstakingly compiled by Richard Anderson, Jr., John Stine, C. Patrick Labadie, the late Dr. Richard Wright, and his research associate Gerald Metzler. Specifically, Mr. Anderson's notes and drawings provided the basis for the discussion of *Indiana*'s power plant and Dr. Wright and Messrs. Metzler, Stine, and Labadie's historical research provided the raw data necessary for analyzing and reconstructing *Indiana*'s operational history.

Donna Christianson and Harry Alden of the Center for Wood Anatomy Research, Madison,Wisconsin, graciously donated their valuable time to analyze and identify wood samples collected during the 1991 and 1992 field seasons. Additional wood, paint and caulking samples collected during the 1993 fieldwork were analyzed and identified by Melvin J. Wachowiak, Jr. and Camie S. Campbell of the Smithsonian's Conservation Analytical Laboratory.

All of the videographic images that appear in this thesis, including the videomosaic of the wreck, were created with the assistance of Douglas Gann who generously donated many hours of his time to capture and arrange the frames from the video tape to create the mosaic and other images appearing throughout this thesis. Many thanks to Doug for his great work and efforts.

A heartfelt thanks is extended to my wonderful family and friends: Robert and Linda Rivers, Melissa Rivers, Carroll and Molly Harrington, Alex and Bill Pepin, Stewart and Becky Robinson, Marcus and Diane Williamson, John and Linda Timpson, J. Cozzi and Hera Konstantinou, Adam Kane, John Bratten, Gregory Cook, Sheila Clifford, Elizabeth Baldwin, Edward Rogers, Roxani Margariti, J. B. Pelletier, Richard Swete, and Anne Lessmann for their steadfast moral support, comic relief, friendly advice, and editorial comments. I'd particularly like to thank Ms. Lessmann for all of her helpful comments, observations, and suggestions while editing the text of this thesis. A special debt of gratitude is also due to Messrs. Adam Loven and Gordon Cawood of the Lake Champlain Maritime Museum for their assistance in preparing several of the graphics appearing in this work.

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CHAPTER I

INTRODUCTION

The Sinking of *Indiana*

Early Sunday morning, June 6, 1858, shortly after the first rays of sunlight pierced the cold morning air and brightened the eastern sky above the harbor at Marquette, Michigan, the 349-ton Great Lakes propeller *Indiana* pulled away from the Cleveland Iron Mining Company's pier, heavily laden with 280 tons of iron ore, and headed out towards the open waters of Lake Superior, "downbound" for the company's docks in Cleveland, Ohio. In addition to the iron ore cargo, *Indiana* carried 21 persons on board, consisting of 17 officers and crew, including Captain William McNally and First Engineer John Perew, and four passengers: *Indiana*'s owner and John Perew's younger brother, Francis Perew of Cleveland; Samuel Burt of Marquette; S. Gales of Silver Lake, Ohio; and L. C. Tibbets of Cleveland.[1] Although the purpose of Francis Perew's trip to Marquette is unknown, it is likely that the industrious 33-year-old ship owner, who had retired from his position as *Indiana*'s master in 1855 to devote himself fully to the management of his growing fleet of Great Lakes freighters, had gone to Marquette intent on capitalizing on the region's rapidly developing iron mining industry by establishing new business opportunities there for his shipping interests.[2] Perew may also have wanted to see for himself the great engineering achievement of the recently completed canal at Sault Sainte Marie, Michigan, and to visit the newly opened Lake Superior frontier, whose "bracing climate" was said to be "...exceedingly salubrious and restorative."[3]

As *Indiana*'s single, large iron screw slowly churned Lake Superior's frigid, cobalt-blue waters, McNally guided the propeller past Ripley's Rock out of Marquette harbor and onto the lake, then set a course for Whitefish Point, 110 miles (177 km) to the E-NE, maintaining a minimum distance of two to three miles (3.2 to 4.8 km) offshore.[4] For the remainder of the day, *Indiana* reportedly pushed ahead at a "moderate rate," buffeted by "an aft wind and some sea, but not enough to render her condition at all precarious."[5]

Indiana's transit along Lake Superior's dangerous southeastern shore progressed smoothly and without incident until around eight p.m. Approximately 40 miles (64.37 km) west of Whitefish Point

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The style and format of this thesis follow those of *American Neptune*.

and about 10 miles (16.09 km) offshore, the "stuffing box," the water-tight through-hull bearing surrounding the propeller shaft, broke suddenly without warning.[6] Immediately, *Indiana*'s engine reportedly "began to work badly, and an attempt was made to improve her action by raising her stern further out of the water...in a short time her stern post split."[7] Water flooded into *Indiana*'s heavily laden hull faster than could be handled by the pumps, and "she began to fill very fast."[8]

The rapidly rising waters inside *Indiana*'s fireroom quickly extinguished the freshly stoked fires in the boiler's firebox, and within 15 minutes the vessel settled to the guards.[9] In the encroaching darkness, the water-filled *Indiana* wallowed helplessly, adrift on the open waters of the windswept lake, while all hands prepared to abandon ship. Hastening to lower *Indiana*'s two yawl lifeboats into the lake's pitching seas, one of the boats was "swung around violently against the propeller, knocking a hole in her bottom, rendering her nearly useless."[10] Despite this last-minute setback, both boats were deployed successfully, and everyone managed to escape safely from the rapidly sinking *Indiana.* Before abandoning *Indiana* altogether, however, the crew made a final attempt to save the stricken propeller by trying to tow it into shallower water.[11] Not surprisingly, this effort proved futile; the lines were cut, and *Indiana* was released to meet its destiny. Between 8:30 and 9:00 p.m., approximately 30 minutes after the reported failure of the stuffing box, *Indiana* plunged 118 feet (35.97 m) to the bottom of the lake, leaving large portions of its more lightly constructed and relatively buoyant upper works (i.e., the spar deck and spar deck cabin) essentially intact and afloat at the surface.[12] Lights in *Indiana*'s detached upper deck cabin continued to flicker brightly against the velvety black void of the nighttime sky above Lake Superior, and were clearly visible to the crew as they pulled their way slowly towards the dubious safety of the lake's dark, desolate, uninhabited shoreline.[13]

Indiana's Discovery

For 114 years, *Indiana*'s submerged hulk remained the silent, undisturbed scene of a long-forgotten event, until diver John R. Steele of Waukeegan, Illinois, and his long-time diving associate, William B. Cohrs of Indianapolis, Indiana, unexpectedly discovered a large acoustic target rising up from the bottom of the lake while using remote sensing equipment to search for the remains of the wrecks *John B. Cowle* (1902) and *John Mitchell* (1907) in June of 1972 (Fig. 1-1).[14] Excited by the potential of finding a previously undocumented shipwreck, Steele, Cohrs, and several of their associates immediately dived on the target to identify it.

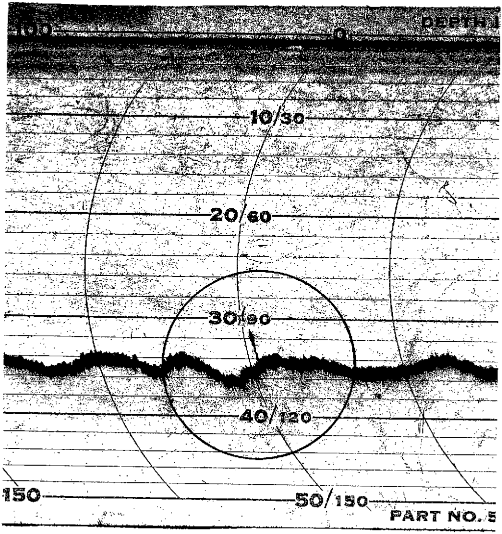


Figure 1-1. Bathymetric record of *Indiana*'s wreck site. Wreck appears as an anomalous positive elevation point extending approximately 15 feet (4 m) above the lakebed. (Courtesy of John Steele).

Unlike some wreck diving enthusiasts, whose passion for searching and exploring shipwrecks stems from a myopic desire to strip them of portable historic "relics," for personal collections, Steele was exceptional for making documentary films of the wrecks that he discovered.[15] During his first dive on *Indiana*, Steele filmed the entire wreck site and became intrigued by the propeller's primitive engine, whose wooden frame was unlike any of the more modern, iron-framed engines he had seen before on other wrecks.[16] From his initial observations, Steele concluded correctly that *Indiana* was indeed a very old steamboat by Great Lakes standards, far older than either the *Cowle* or *Mitchell*. A hand truck with the words "PROP INDIANA" stamped into one of its wooden handles, removed from the wreck by one of Steele's diving associates, provided the conclusive evidence Steele needed to identify the hulk as the 1848 propeller *Indiana*.[17]

Several years after *Indiana*'s discovery, Steele shared his knowledge of the wreck with the late Dr. Richard J. Wright, a prominent Great Lakes maritime historian and director of Bowling Green State College's Center for Archival Collections, and C. Patrick Labadie, curator of the Canal Park Marine Museum at Duluth, Minnesota.[18] Wright and Labadie viewed Steele's underwater movie footage and were impressed immediately by the "intact, exposed, upright, and undamaged" condition of *Indiana*'s primitive propulsion machinery.[19] After repeated viewings of Steele's film, Labadie prepared a series of rough pencil sketches of *Indiana*'s machinery and hull, as well as a conjectural drawing of *Indiana* as the propeller may have appeared while in service (Fig. 1-2).[20]

Recognizing the significance of Steele's discovery and *Indiana*'s unique research potential, Wright and Labadie discussed the possibility of mounting an expedition to recover selected elements of *Indiana*'s propulsion machinery for further study. In October 1978, the two prepared a National Register of Historic Places Inventory Nomination Form for the wreck site.[21] Upon review of the National Register Nomination Form several months later, the Michigan State Historic Preservation Officer (SHPO) certified *Indiana* as an historic property of "National" significance within the categories of invention, engineering, transportation, and commerce, eligible for nomination to the National Register.[22]

The Historic Significance of *Indiana*

As the Michigan SHPO recognized, *Indiana*'s historic significance transcends several different categories. First, *Indiana* is significant because its archaeological remains provide researchers with the first, best, and only opportunity, thus far, to study the actual design and construction of a well-preserved,

FEATURING SHIPS THAT NEVER DIE #214

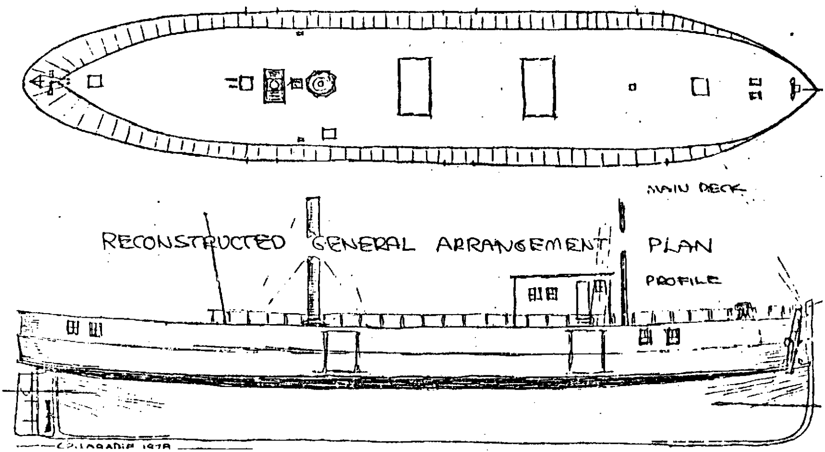


Figure 1-2. Preliminary reconstruction drawings of *Indiana*. Drawings prepared by C. Patrick Labadie from underwater films of the wreck made by John Steele. (After Wright, "The *Indiana* Salvage: Part I," 1).

early Great Lakes screw-propelled steamboat, and to document these features to a level of accuracy and detail that would be impossible to obtain from even the most exhaustive examination of the archival record. Despite the popular, although inaccurate, assumption among some archaeologists that much of the material culture of the nineteenth century already is well documented and therefore not worthy of archaeological investigation, very little written or graphic documentation (and virtually no photographs) is available for American merchant vessels, especially those that were built on the Great Lakes prior to the 1860s. In the case of *Indiana*, no detailed record, graphic or otherwise, describing its construction or appearance is known to exist, except for the most basic dimensional information that is recorded in its enrollment papers. This absence of important documentary information is in no way the fault of today's historians or archivists, but instead is a result of traditional shipbuilding practices and poor record keeping by Great Lakes District Custom House Collectors of the middle nineteenth century. Traditionally, the methods for designing and constructing ships are based on the experience of craftsmen who have experimented in practice. This experience is passed on through ships, tools, and other aids, and by manual and oral traditions. As a consequence, descriptions of actual shipbuilding techniques are only found occasionally in historic written records and literature.[23] This is not to say, however, that nothing was being written on the subject of naval architecture at the time of *Indiana*. In fact, quite the contrary is true. Publications devoted to the theoretical problems of naval architecture, measurement and calculation of displacement, stability, strength, water resistance, rigging, draft, etc., and analytical studies of concepts and definitions based on mathematical calculations, scientific investigations, and ship drawings, as they pertained to ship design and construction techniques, were being produced.[24] However, the abstract, theoretical nature of these writings, inspired by concepts and methods from the natural sciences, made them incomprehensible to practicing shipwrights of the time. Simply stated, shipwrights and shipbuilding theorists functioned in separate universes.

The former even appears to have harbored a certain degree of contempt towards the latter. This tendency is evident in the opening paragraph of an 1858 booklet, *The Shipwright's Handbook and Draughtsman's Guide*, written by Leonard H. Boole, a "marine and naval architect" from Milwaukee, Wisconsin. As a young man, Boole served a seven-year apprenticeship (from 1837 to 1844) with William H. Webb, one of America's greatest shipbuilders. In the introduction to his manual, Boole pointed out the necessity for a primer on naval architecture, despite what he described as a general distaste for such guides on the part of shipwrights. Boole also explained that he had first been inspired to write the book twenty years earlier, when after searching through "every book store in New York City," he was able to find only one treatise on shipbuilding, priced prohibitively high ($45) for the young apprentice.[25] Generally speaking, a majority of American shipwrights working during the first half of the nineteenth century ignored most theoretical problems and stuck instead to practical experience and half-models, skill, and measurements by eye. Even steamboats and steam machinery, which then represented the pinnacle of human technological achievement, were nonetheless the products of practical boatbuilders and mechanics who worked by rule-of-thumb. Advances were made by a fumbling process of trial and error without the benefits of technical literature, scientific knowledge, or trained engineering skill as they are conceived of today.[26]

A contemporary description of middle nineteenth century shipbuilding methodology survives from the 1853 journal of the Swedish naval lieutenant, O. E. Toll. After visiting England, France, and America to study shipbuilding practices, Toll recorded a tendency, which explains, in part, why so few plans of merchant vessels from the first half of the nineteenth century are in existence today:

> At private shipyards in America, and occasionally in England as well, ships are not built from plans, but from models, to which every shipwright in collaboration with experienced seamen makes the alterations and additions he considers advantageous to the construction in hand. It is therefore not without difficulty that drawings can be obtained, as these, as mentioned above, have to be made from measurements of the models; and the difficulties are increased by the desire to keep all such matters a closely guarded secret.[27]

While these traditional shipbuilding practices explain the absence of lines and construction plans for pre-1860 American merchant vessels, they do not account for the small number of block models, which have survived to the present, relative to the thousands of models that must have been produced in America alone up to that period. Unfortunately, block models are difficult to locate today, because they represented jealously guarded trade secrets of master shipwrights, and they were often destroyed to prevent them from falling into the hands of rivals.[28]

Photographs are another important form of graphic documentation that is largely unavailable to researchers studying American merchant craft pre-dating the 1860s, such as *Indiana*. Landscape photography was still in its infancy during the 1840s and 1850s, few photographs of Great Lakes ports and vessels were ever made, and even fewer have survived until today. The handful of photographs of circa 1840s Great Lakes propellers that do exist were all made late in the careers of these vessels, long after modifications and rebuilds had altered their original form and appearance. Alternatively, lithographic images of Great Lakes propellers dating from the 1840s do exist, but unlike photographs they are subjective depictions. Their accuracy is dependent on the artist's skills, knowledge, and attention to detail.

Custom House records for American merchant vessels that date prior to the 1860s (i.e., enrollment papers, builder's certificates, and inspection documents) are more numerous, but they are incomplete and generally less informative than models or plans would be if they were available. Large gaps exist in Great Lakes vessels' enrollment records preserved at the National Archives, particularly for those earlier than the 1860s. The incompleteness of the archival record appears to be rooted in the past: arcane laws of the time and insufficient documentation standards, staff, and facilities at many of the District Custom Houses on the Great Lakes were most likely to blame.

Surprisingly, the shortcomings of the Great Lakes District Custom House's record-keeping practices were recognized even in the middle nineteenth century. In 1855, John J. Henderson published an article in *The Monthly Nautical Magazine* entitled, "Shipbuilding on the Lakes," the focus of which was early shipbuilding at Buffalo, New York. After spending several days examining the Buffalo District Custom House records, Henderson concluded that the Custom House archival records were "not only...very incomplete, but several sets of books from the earliest period of those kept in the Custom House have been lost and were non-retrievable." Registers containing "Builder's Certificates" for the years 1822 to 1845 also were missing.[29] Henderson openly criticized the Custom House's record keepers in the article and remarked, "Little care seems to have been exercised by those in charge of the early official records of the District, to preserve them in a manner that they might be used by future historians." He also took issue with the manner in which the Great Lakes' 17 Custom House Districts were distributed around the Lakes, saying that their locations appeared to have been established to "suit the convenience of the Custom House, rather than being based on geographical position or the territorial limits of the states."[30] Although Henderson did not question the accuracy of the information contained within the vessel enrollments and builder's certificates, the poor maintenance of these documents does bring into question the veracity of the information they contain. Finally, Henderson noted that researching shipbuilding activity in the Buffalo District was complicated by the inadequacy of laws pertaining to vessel documentation in existence at that time, which in some instances did not require that Custom House Collectors keep records of all the vessels built in their respective Districts. Instead, as Henderson explained, the laws only required that the District Custom House Collectors maintain enrollment papers for those vessels that were enrolled in that particular District. If a vessel was built in a District and remained there after its launching (i.e., the managing owner of the vessel was a resident thereof), then a record of the vessel would be kept in that District's Custom House. Conversely, if the vessel's managing owner lived and planned to enroll the vessel in a different District than the one where it was built, then a "Ship Builder's Certificate" and a "Temporary Enrollment" form were issued to the vessel and carried with it to the new District where it would be enrolled. Thus, no official records were kept for vessels built within a particular District if they did not remain there after their construction was completed.[31]

Another mid-nineteenth century researcher who encountered problems similar to those described by Henderson was Israel D. Andrews, Consul of the United States for Canada and New Brunswick, who in 1853 prepared the first comprehensive Congressional report describing the trade of the Great Lakes. In the report, Andrews complained of difficulties that he had experienced in locating complete data during his study. According to Andrews, the difficulties stemmed from the region's

> ...great increase of business, and its diversified character in nearly all the Districts, and the limited clerical force allowed in some of them..., and the...many...incorrect and incomplete...returns from...the Great Lakes Custom Houses..., as well as ...the absence of proper legal requirements and authoritative departmental instructions in that respect, and the want of means (except at the private expense of officers and others) of furnishing such statistical data.[32]

Andrews also made the point that "the present arrangement of returns of the internal and coasting trade is mostly governed by the law of 1799, when trade was in its infancy, and commerce received rather than created law."[33] Additionally, he noted that "the reports on commerce and navigation now give the total tonnage of the United States, but do not state the character or class of vessels composing the mercantile marine of a country scarcely second to any in the world."[34]

Yet another individual, James L. Barton, made similar observations about the quality of Custom House records in 1846 in a brief letter report to Congressman Robert B. McClelland describing the "Value and Importance of the Commerce of the Great Western Lakes." At that time McClelland was the Chairman of the Committee on Commerce in the U.S. House of Representatives, and he requested the report because of the "utter want of concentrated information" available then, "concerning the trade and commerce of our great inland seas." Barton based his report on commerce statistics compiled from the Buffalo Custom House's books, which he specifically notes in his report, "contained only a representative sampling of the trade activity and types of goods being shipped in and out of Buffalo."[35]

Clearly, the lack of detailed archival documentation for *Indiana* is an unfortunate characteristic of contemporary shipbuilding practices, the primitive state of photography, and the incomplete archival records that exist for Great Lakes vessels dating from before circa 1860. However, the incompleteness of the historic record highlights the comparative wealth of information that is available only through the archaeological study of *Indiana*'s remains. It is the unique research potential of *Indiana*'s wreck site that makes its discovery so significant.

In addition to *Indiana*'s research potential, the vessel is significant from a technological perspective. At the time *Indiana* was built, screw-propulsion technology was still in its earliest stages of development. The period from 1849 to 1865 is characterized as one of great discussion and experimentation directed at making improvements in propeller design. This fact is evident from the dramatic increase in the number of propeller-related patents after 1849 (Fig. 1-3), and the numerous journal articles that begin appearing during this period. The words of one anonymous contemporary commentator, writing under the appropriate pseudonym "Helix," provide an interesting viewpoint on the status of screw propulsion development in 1849:

> We have yet to learn from that expensive teacher, Experience, the best form to be given to the propeller, a point which has never been so decided as to leave room for discussion. We have to learn the best shape for the vessel, for why, if side wheel steamers require a different form from sailing vessels, should it be unreasonable to suppose that the two kinds of steamers require different proportions? And more than all, we must trust less to guess-work and use more calculation, both in proportioning the engines and propellers to each other, and to the work they have to do, and in disposing the machinery in the hull with a view to the speed and sea qualities of the steamer. This is, we are aware, a simple thing, and one easily arrived at, yet three-fourths of the failures which have disgraced the cause of propellers have been due, in great part, to an utter want of the necessary calculations.[36]

According to contemporary naval architect John W. Griffiths, this situation had changed somewhat by 1856: There has been a general diffusion of knowledge on the importance of making some calculations before embarking in navigation by steam, whether inland, coastwise, or oceanward.[37]

Up until 1865, the development of the screw propeller had been completely, "empirical, intuitive, and in some cases fortuitous."[38] In fact, it was not until 1945, nearly 100 years after *Indiana* was built, that the theoretical aspects of a propeller's action through the water were understood well enough to allow for screw propellers to be designed mathematically from scratch with predictable results.[39] However, the mathematic design process was so involved that it was impractical for design purposes until the advent of digital computers.[40]

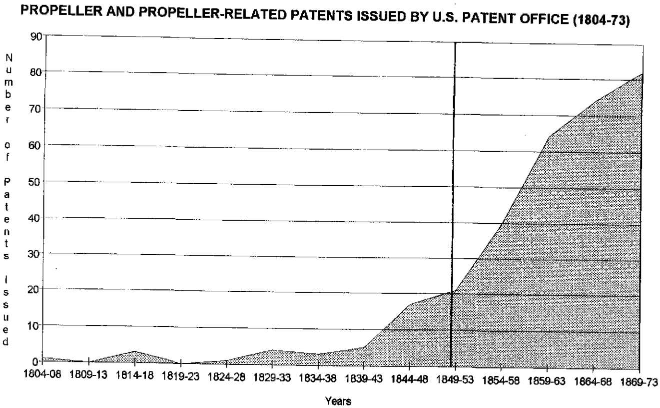


Figure 1-3. Propeller and propeller-related patents issued by the U.S. Patent Office (1804-1873). Graph depicts number of propeller and propeller-related patents issued annually before and after *Indiana*'s construction in 1848 (indicated by the vertical line). The graphed data suggests that *Indiana* was built during a brief period of gradual improvement in screw-propulsion technology between its introduction and widespread use and acceptance. (Graph by David S. Robinson).

Screw-propelled steamboats were introduced commercially in North America in 1839, when the iron-hulled propeller-ship *New Jersey* (formerly *Robert F. Stockton*, designed by John Ericsson and built in England in 1838), was put into service as a tow-boat on the Delaware and Schuylkill Rivers and the Delaware and Raritan Canal, outside of Philadelphia, Pennsylvania (Fig. 1-4).[41] During the 1840s, screw propulsion was introduced with varying degrees of acceptance throughout the United States and around the world. Nowhere was its diffusion more rapid and its acceptance more complete than on the Great Lakes, where the first propeller-driven steamboats appeared in 1841, just seven years before *Indiana* was built.[42] Between 1845 and 1849, the number of propellers on the Great Lakes swelled from eight to 45, representing an astounding increase of 462.5 percent. By comparison, the number of paddlewheel steamers grew from 52 to 93, an increase of only 78.84 percent.[43] During the twenty year period from 1840 to 1860, the tonnage of propeller-driven vesssels grew faster than did the tonnage of all other Great Lakes ships combined.[44]

The first "generation" of Great Lakes propellers, built between 1841 and 1845, were fitted primarily with the machinery of Ericsson's design which included twin, counter-rotating screws attached to a shaft within a shaft and positioned aft of the rudder. These first propellers fell into three different sub-categories: 1) propeller-barges; 2) propeller-schooners; and 3) propeller-towboats. Out of these three types, only the first two are described, because of the absence of any detailed information on propeller-towboats.

Propeller-barges were designed and built specifically for service in the expanding freight trade between Montreal and the Lake Ontario port of Kingston, via the Saint Lawrence River and the Rideau waterway systems.[45] The propeller-barges, which were driven by steam power alone, lacked masts, rigging, bowsprits, or figureheads, and were designed primarily for use on the protected waters of rivers and canals.[46] The dimensions of the Canadian-built propeller-barge *Ericsson* (87 feet [26.52 m] long, 16 feet, 6 inches [5.0 m] wide, 5 feet, 6 inches [1.7 m] deep, and 61.4 tons) were typical of the propeller-barges of the early 1840s.[47]

Propeller-schooners were introduced to the Great Lakes at approximately the same time as propeller-barges, but they were of a very different design. Unlike propeller-barges, propeller-schooners were designed and purpose-built for operation on the open waters of the Great Lakes. As their name implies, propeller-schooners were essentially sailing vessels constructed on the same plan as a Welland Canal schooner, with a bluff bow, full lines, a transom stern, and a schooner rig. Their compact

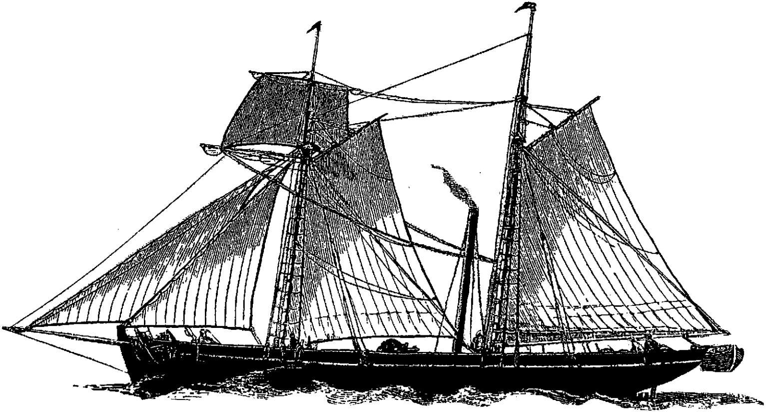


Figure 1-4. Ericsson's early propeller-driven vessel *Robert F. Stockton* (1838). (After Church, *The Life of John Ericsson*, 102).

propeller machinery was installed far aft to maximize cargo space. The addition of the propeller to an essentially unmodified schooner hull allowed the owners of propeller-schooners to offer a higher quality of freighting service, in terms of speed and reliability, than could be provided by schooners without propellers.

The impetus for introducing the propeller-schooner on the Great Lakes was generated by competition between merchants on Lake Ontario at Oswego, New York, and merchants on Lake Erie at Buffalo, New York, for the burgeoning upper lakes' freight and passenger trades. Although the Erie Canal terminated at both Oswego and Buffalo, less commerce was being funnelled through Oswego because the small size of the Welland Canal, which bypassed Niagara Falls and connected Lake Ontario with Lake Erie, presented on obstacle to all but the smallest of steamboats. The propeller-schooner provided a solution to Oswego's accessibility problem: unlike their sidewheel counterparts, they were not restricted by shoal waters or narrow locks and canals.[48] The first of the Great Lakes propeller-schooners, *Vandalia*, measured 91 feet (27.7 m) long, 20 feet, 2 inches (6.1 m) wide, 8 feet, 3 inches (2.5 m) deep, and 138 tons (Fig. 1-5). *Vandalia* had a capacity of 140 tons, and drew 2 feet, 6 inches (76.2 cm) of water light and 6 feet (1.8 m) loaded.[49]

Examination of the available information on the Great Lakes propellers built between 1841 and 1844 indicates that these vessels were substantially different from propellers built between 1845 and 1855.[50] The same also may be said for the propellers constructed after 1855.[51] These differences may be attributed to increases in the volume of passenger and freight traffic on the lakes, navigation improvements (i.e., the enlargement of interlake canals, the dredging of the Saint Clair flats, harbor channel maintenance, etc.), changes in the lake trade following the ascendancy of the railroad and the commencement of the Lake Superior iron-ore trade, improvements in screw-propulsion technology, and advancements in ship design theory. The propeller-schooners of the introductory period (1841 to 1844) were all essentially small sailing vessels fitted with auxiliary engines and propellers. These propeller-driven steamboats, which employed machinery of Ericsson's design, proved commercially successful, but they were slow and their small engines relatively weak. From what little is known about the design and construction of the first generation of Great Lakes propellers, there does not appear to have been any prior consideration given to the effect of screw propulsion on vessel performance (i.e., speed, stability, maneuverability, etc.). This conclusion is based on the types of hulls used for these vessels, which as a rule were full and blunt-ended. Analyses of propeller action published in 1849 revealed that the hull

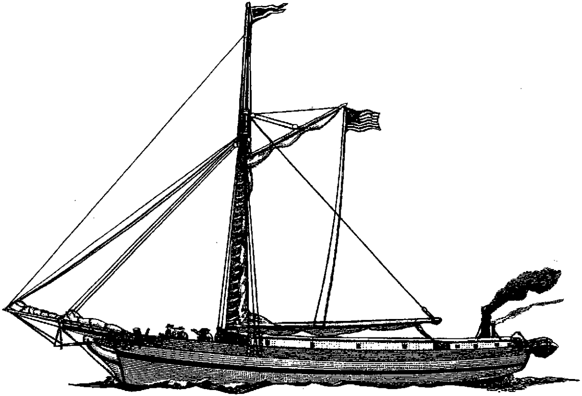


Figure 1-5. *Vandalia* (1841): the first propeller-schooner on the Great Lakes. Note location of smoke pipe far aft. (After Church, *The Life of John Ericsson*, 111).

shape of these early propeller ships was highly inefficient.[52]

In contrast, propellers built between 1845 and 1855 were much larger than those of earlier years.[53] They also exhibited greater variation in design and function, and had improved propulsion machinery (a screw designed by Richard F. Loper replaced the Ericsson screw as the most commonly employed propeller on the Great Lakes).[54] Significantly, the fineness of *Indiana*'s run (documented archaeologically during this study) also suggests that the hulls of these propellers were being designed specifically for screw propulsion. Also, the second generation of propellers bore a greater resemblance to contemporary sidewheel steamboats than sailing vessels. Some were even fitted with luxurious passenger accommodations, rivalling those of their sidewheel-propelled counterparts (Fig. 1-6).[55] Not until circa 1855 did the propellers of the Great Lakes become relatively standardized in their size and appearance (Fig. 1-7).[56] Although not the first, largest, or most elegant of the early Great Lakes propellers, *Indiana* is a product of the most dynamic period of improvement and experimentation in the developmental history of screw propulsion (1845-1855). Consequently, *Indiana*'s hull and machinery exhibit a unique combination of design and construction features that are a mixture of both old and new designs, all of which contribute to its technological significance.

In addition to *Indiana*'s importance from a technological perspective, *Indiana* is also notable for the role that it and other propellers played in the socio-economic development of the Great Lakes region. Steamboats freed humans for the first time of most of the natural limitations associated with water transport, and opened the North American interior, between the Appalachian and Rocky Mountains, to settlement. The importance of the steamboat in the western expansion of the United States is alluded to in the words of James L. Barton, who in 1846 wrote:

> The West! a name given only a few years since to a remote, boundless and unsettled wilderness, inhabited only by roving bands of Wild Indians and savage animals - visited only by the Indian trader, or some romantic spirit pleased with the novelty of an adventure into unknown regions, - a country which it appeared centuries must pass away before settlement and civilization would occupy it - has suddenly, as if by magic, with the powerful aid of steam, and the indomitable enterprise, industry, and perseverance of a free people, with the blessings of free institutions, securing to all the fruits of their own labor, been reclaimed from the wilderness...[57]

Movement into this region during the middle nineteenth century, characterized as one of the "great migrations" in the annals of world history, would not have been feasible without steamboats, which served as one of the all-important links between producers and consumers living in widely separated regions across North America. The growth of the west created a financial impetus that allowed the

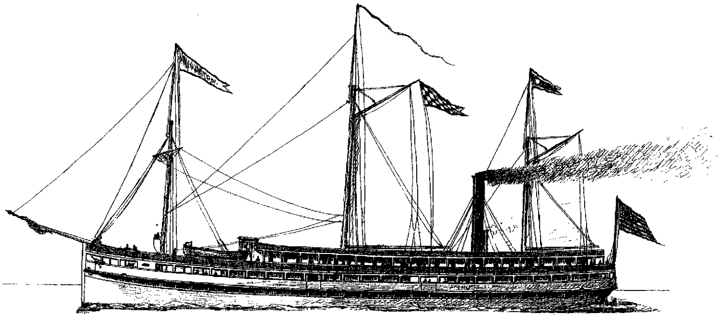


Figure 1-6. Early Great Lakes passenger-propeller *Princeton* (1845). Note the upper works (i.e., steering pole, open bow, location of pilot house, guard, location of smoke pipe, fantail stern). (After Anderson, *Great Lakes Steam Vessels*, 12).

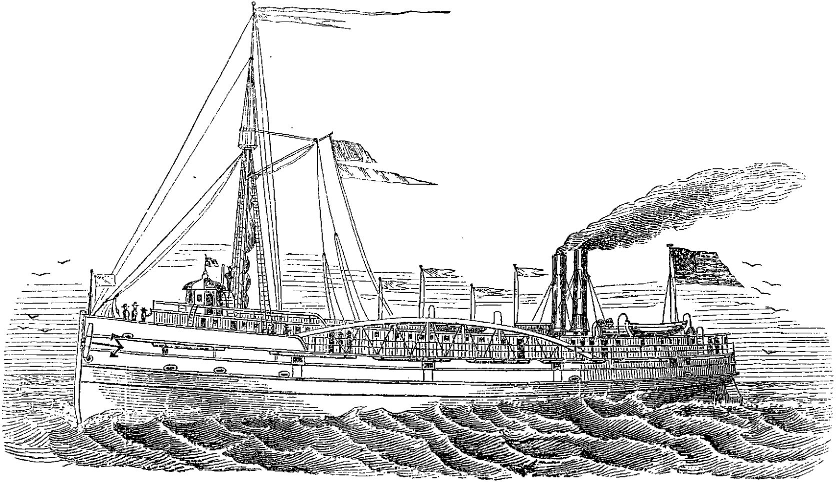


Figure 1-7. Typical Great Lakes propeller of the 1850s and 1860s. (From NARG-41, Washington, DC, courtesy Joseph Cozzi).

lakes steamers to become economically feasible.

The unprecedented influx of millions of immigrants into the United States during the middle nineteenth century and their westward migration by water via the canals and the lakes resulted in correspondingly large production of agricultural produce for market and a steady increase in inter-regional trade between North America's interior and eastern seaboard.[58] Trans-Appalachian trade of the 1840s and 1850s principally comprised the shipment of passengers and manufactured goods to the west and bulky agricultural produce to the east.[59] Enormous increases in the shipment of bulk agricultural commodities that began during the late 1830s and intensified during the early 1840s produced an ever increasing need for a vessel type that could provide relatively inexpensive and reliable transportation for the increasing volume of passenger and bulk freight traffic.[60] Propellers were ideally suited to these trades.

Propeller-driven steamboats, such as *Indiana*, filled a select niche in the rapidly growing Great Lakes transportation system by providing an economical, reliable, and versatile alternative to shipping freight and passengers by way of sailing vessel or sidewheel steamboat. They were superior to sailing vessels as freighters because, unlike sailing ships, the steam-powered propellers were not dependant upon the vagaries of the wind, which enabled them to provide comparatively more regular service. Propellers also possessed several important advantages over sidewheel steamboats: they were cheaper to build and operate; they could fit the narrow confines of the interlake canals; they could be operated more economically as multipurpose vessels (i.e., freighter, passenger steamer, tug boat); and in proportion to their size, they were able to carry far more freight than sidewheel steamers of similar dimensions.[61]

Finally, *Indiana* is also significant because of its associations, throughout its career, with individuals and organizations that were prominent in the nineteenth century Great Lakes commerce. Several of *Indiana*'s former owner and masters amassed large fortunes in the shipping business and built some of the Great Lakes largest merchant fleets. Others who owned *Indiana* were prosperous manufacturers, merchants, and original incorporators of Buffalo's first Board of Trade. The designer of the propeller employed on *Indiana*, Richard F. Loper, of Philadelphia, Pennsylvania, was a leader in American screw propulsion design technology. Loper's patented 1844 propeller design began replacing John Ericsson's screw on the Great Lakes by the middle 1840s and also was used widely elsewhere because of its superior performance.[62] The Pittsburgh-based firm that fabricated *Indiana*'s propeller, Spang & Company, was one of the earliest and largest manufacturers of iron products in the United States.[63] The New York & Erie Railroad Company and the People's Line were among the first organizations to provide combination rail and water service in the Great Lakes region. Nearly all of the individuals involved with *Indiana* contributed to the early development of trade on the Great Lakes.

The rapid evolution in the design of Great Lakes screw propellers between 1840 and 1860, and the equally rapid pace of screw-propulsion's acceptance on the Great Lakes correlate directly with the explosive growth and periodic shifts in the commerce of the lakes. This correlation provides a textbook example of economic historian Nathan Rosenburg's assertion that "events in the capital goods sector" determine the "pace of technical advance in the user industry."[64] *Indiana* was not constructed in a vacuum; it represented a purely capitalistic venture that was built to make its owners money by operating efficiently and profitably by taking advantage of the greater economy offered by screw-propulsion technology.[65] *Indiana*'s cargoes, the ports it visited as well as the frequency of these visits, its service to the region's railroads, and its association with a number of important people throughout its career together reflect *Indiana*'s important role in the development of Great Lakes commerce.

Notes: Chapter I

1. In keeping with the contemporary vernacular terminology, throughout this thesis the term "propeller" will be used to differentiate screw-propelled steamboats from their sidewheel-propelled counterparts, or "steamers," as they were then known. H. A. Musham, "Early Great Lakes Steamboats: The First Propellers, 1841-1845," *American Neptune*, vol. 17 (April 1957), 103-104; "Total Loss of the Propeller *Indiana* on Lake Superior," *Detroit Daily Free Press*, 12 June 1858; "Probable Wreck of Propeller," *Lake Superior Miner*, 12 June 1858; John B. Mansfield, *History of the Great Lakes*, vol. 2 (Cleveland, OH, 1972, [1899]), 501; Louis B. Lane, *Memorial and Family History of Erie County, New York*, vol. 2 (Buffalo, NY, 1906-1908), 399-401; Willis F. Dunbar, *Michigan: A History of the Wolverine State and its People, its Mining, Lumber, and Agricultural Industries*, vol. 1 (Grand Rapids, MI, 1965), 365; Alvah L. Sawyer, *A History of the Northern Peninsula of Michigan*, vol. 1 (Chicago, IL, 1911), 410-411; James M. Swank, *History of the Manufacture of Iron in All Ages* (New York, NY, 1965), 321. Mansfield notes that John Perew was born in France, which, according to Lane, is also Francis Perew's parents' country of origin. Since Francis was born in Clayton, New York, John Perew may be Francis's older brother. According to Mansfield, the elder Perew served as an engineer on the lakes for about eighteen years. Francis Perew's fellow passenger, Samuel Burt of Marquette, was probably a relative of the famous government surveyor, William A. Burt, who was credited with the first confirmed discovery of iron ore deposits on Lake Superior in 1844 near the present city of Negaunee, Michigan, and John Burt, the "visionary" President of Marquette's Iron Mountain Railroad which was the first iron way (circa 1857) on Michigan's Upper Peninsula.

2. According to one local source (*Lake Superior Miner*) Perew's involvement in Lake Superior trade gave him, "...a good chance...for an investment of a most profitable nature." *Through the Lakes of North America* (New York, NY, 1857), 7. The demand for iron ore came from processing and manufacturing centers on the lower lakes and in the east for which water shipment provided the least expensive means of transport. Mansfield, *ibid.*, 584, and Daniel J. Lenihan, ed., *Submerged Cultural Resources Study: Isle Royale National Park* (Santa Fe, NM, 1987), 32. The Cleveland Iron Mining Company was organized in 1849 by proprietors M. L. Hewitt, of Marquette, and John Outhwaite and Samuel L. Mather, of Cleveland. The Cleveland, Jackson, and Lake Superior companies were in operation (e.g., mining and shipping iron ore) several years before any other firms and were often referred to as the "three old companies" of the Marquette Range. Sawyer, *ibid.*, 411. The first cargo of iron ore shipped for the Cleveland Iron Mining Company left the wharf at Marquette on board the two-masted brigantine *Columbia* on 14 August 1855. Harlan Hatcher, *The Great Lakes* (New York, NY, 1944), 305-306. Shipment of iron ore from Michigan's Upper Peninsula increased dramatically from 1,449 tons in 1855 to 114,401 tons in 1860. Dunbar, *ibid.*, 369. By 1899, iron ore comprised one third of all trade on the Great Lakes. Lenihan, *ibid.*, 32; Sawyer, *ibid.*, vol. 1; and John A. Burke, "Barrels to Barrows, Buckets to Belts: 120 Years of Iron Ore Handling on the Great Lakes," *Inland Seas*, vol. 31, no. 4 (1975), 266-277. The Cleveland Iron Mining Company was eventually consolidated with the Jackson Iron Company (1848), the Pioneer Iron Company (1857), and the Iron Cliffs Company (1864) to form the lakes' largest iron mining organization: the Cleveland-Cliffs Iron Mining Company. Sawyer, *ibid.*, 432.

3. William Pettit, "Remarks respecting the Copper District of Lake Superior, made at the Monthly Meeting of the Franklin Institute, March 18th, 1847," *The Journal of the Franklin Institute*, ser. 3, vol. 13 (1847), 339. During the summer following the opening of the Sault Sainte Marie Canal, tourists began booking passage on excursion steamers to, "view the wonders of the canal and of Lake Superior." See Hatcher, *ibid.*, 305-306. The price of tickets for a round-trip excursion to Lake Superior from Cleveland was $40 in 1857. See Disturnell, *ibid.*, 93.

4. *The Coast Pilot for the Lakes* (Chicago, IL, 1863), 52.

5. "Probable Wreck of a Propeller," *Lake Superior Miner*, 12 June 1858.

6. The 110 miles (177 km) of shoreline between Marquette and Whitefish Point is the graveyard of approximately 135 ships, including *Indiana.* See David D. Swayze, *Shipwreck! A Comprehensive Directory of Over 3,700 Shipwrecks on the Great Lakes* (Boyne City, MI, 1992), 38. "Total Loss of Propeller *Indiana* on Lake Superior," *Detroit Daily Free Press*, 12 June 1858.

7. "Loss of the Propeller *Indiana*," *Painesville Telegraph*, 17 June 1858.

8. "Total Loss of Propeller *Indiana* on Lake Superior," *Detroit Daily Free Press*, 12 June 1858.

9. *Ibid.*

10. *Ibid.*

11. *Ibid.*

12. "Probable Wreck of a Propeller," *Lake Superior Miner*, 12 June 1858; "Total Loss of Propeller *Indiana* on Lake Superior," *Detroit Daily Free Press*, 12 June 1858.

13. "Total Loss of Propeller *Indiana* on Lake Superior," *Detroit Daily Free Press*, 12 June 1858.

14. John Steele, Personal Communication.

15. Richard J. Wright, "The *Indiana* Salvage (Part I)," *The Detroit Marine Historian*, vol. 33, no. 4 (December, 1979), 2.

16. John Steele, Personal Communication.

17. *Ibid.*

18. Wright, *ibid.*, 2, 3.

19. *Ibid.*, 2.

20. Richard J. Wright, *National Register of Historic Places Inventory Nomination Form for Propeller Vessel* Indiana (Lansing, MI, on file with the Michigan Department of State, Bureau of Michigan History, State Historic Preservation Office, prepared 20 December 1978 and accepted by the Michigan State Historic Preservation Officer 22 May 1979).

21. *Ibid.*

22. *Ibid.*

23. Olaff Hasslöff, Henning Henningsen, and Arne Christensen, Jr., *Ships and Shipyards, Sailors and Fishermen* (Rosenkilde and Bagger, Denmark, 1972), 62-70.

24. Louis B. Hunter, *Steamboats on the Western Rivers: An Economic and Technological History* (New York, NY, 1993 [1949]), 88.

25. Leonard H. Boole, *The Shipwright's Handbook and Guide* (Milwaukee, WI, 1858), 7.

26. Hunter, *ibid.*, 64, 176.

27. Hasslöff, Henningsen, and Christensen, Jr., *ibid.*, 69.

28. *Ibid.*, 64.

29. John J. Henderson, "Ship-Building On the Lakes," *The Monthly Nautical Magazine*, vol. 1, no. 4 (1855), 294.

30. *Ibid.*, 290.

31. *Ibid.*, 289, 290.

32. Israel D. Andrews, *Report on the Trade and Commerce of British North American Colonies, and Upon the Trade of the Great Lakes and Rivers.* U. S. House of Representatives, Executive Document No. 136, 32d Congress, 2d Session (Washington, DC, 1853), 2, 45.

33. *Ibid.*, 3.

34. *Ibid.*, 2.

35. James L. Barton, *Lake Commerce. Letter to the Hon. Robert McClelland Chairman of the Committee on Commerce, in the U.S. House of Representatives in Relation to the Value and Importance of the Commerce of the Great Western Lakes* (Buffalo, NY, 1846), 18.

36. "Helix" (pseudonym), "The Screw Propeller," *Journal of the Franklin Institute*, ser. 3, vol. 18 (1848), 330.

37. John W. Griffiths, *The Shipbuilder's Manual and Nautical Referee* (New York, NY, 1856), 100.

38. Corlett, E. C. B., "The Screw Propeller and Merchant Shipping," in *The Advent of Steam, The Merchant Steamship before 1900*, Robert Gardiner, and Basil Greenhill, eds. (Annapolis, MD, 1993), 102.

39. *Ibid.*, 103.

40. *Ibid.*

41. George H. Preble, *A Chronological History of the Origin and Development of Steam Navigation, 1543-1882* (Philadelphia, PA, 1883), 143.

42. Donald R. Dohrmann, *Screw Propulsion in American Lake and Coastal Steam Navigation 1840-1860, a Case Study in the Diffusion of Technological Innovation* (New Haven, CT, Yale University, unpublished dissertation, 1976), 14.

43. "Tonnage of the Lakes," *The Democracy*, 28 February 1855.

44. Dohrmann, *ibid.*, 16.

45. Rick Neilson, "The First Propellers at Kingston," *Fresh Water*, vol. 2, no. 2 (Autumn 1987).

46. *Ibid.*, 5.

47. *Ibid.*

48. William N. Still, Gordon P. Watts, and Bradley Rogers, "Steam Navigation and the United States," in *The Advent of Steam, The Merchant Steamship before 1900*, Robert Gardiner, ed. (Annapolis, MD,

1993), 71.

49. Richard F. Palmer, and Anthony Slosek, "The *Vandalia:* First Screw Propeller on the Lakes," *Inland Seas*, vol. 44, no. 4 (1988), 236-252.

50. Musham, *ibid.*, 103.

51. *Ibid.*

52. W. H. King, *Lessons and Practical Notes on Steam, the Steam Engine, Propellers, etc., etc., for Young Engineers, Students, and Others* (New York, NY, 1849), 131.

53. C. Patrick Labadie, *Submerged Cultural Resources Study Pictured Rocks National Lakeshore* (Santa Fe, NM, 1989), 23-25; Dohrmann, *ibid.*, 72-74.

54. Dohrmann, *ibid.*, 75-77.

55. Although Great Lakes propellers have been recognized primarily for their utility as freighters, many of them built between the mid-1840s and mid-1860s were also designed to carry large numbers of passengers, at first independently and then, later, as part of competing railroad lines. Examples of such combination passenger and freight propellers include: *Princeton* of 1845 which was described as having an "enormous" capacity "for the carrying of passengers as well as freight...," and cabins as, "...well furnished as any parlor, being supplied with capacious and well lighted state rooms, the latter extending nearly the whole area of the upper deck. Her steerage cabin is also well adapted to the accomodation of that class of passengers, being airy and very commodious, and affording every convenience that the emigrant can wish." *Daily National Pilot*, 27 August 1845. The 1852 propeller *Nile*, which was Francis Perew's command immediately before *Indiana*, had an upper cabin "finished in the modern style," and was predicted to "compare favorably with our [Great Lakes] first class [sidewheel] steamers," by the *Buffalo Morning Express* for 26 October 1852, and; the 1866 Northern Transportation Company propeller *Brooklyn*, whose workmanship was described as "being all that could be desired in a first-class passenger boat," with "...appointments...to conduce to the convenience and comfort of the travelling public...and cabins...larger than those of any other [sidewheel] steamer...", and staterooms that were "...large, well ventilated, handsomely furnished, and provided with all the little indispensibles to a *voyageur*," *Toledo Blade*, 26 April 1866. See also Labadie, *ibid.*, 25 and Musham, *ibid.*, 100, 101, 103.

56. C. Patrick Labadie, personal communication.

57. Barton, *ibid.*, 6-7.

58. Hunter, *ibid.*, 29-32; Andrews, *ibid.*, 45-279; James Cooke Mills, *Our Inland Seas, Their Commerce and Shipping for Three Centuries* (Cleveland, OH, 1976 [1910]), 114-125; George Brown Tindall, *America: A Narrative History* (New York, NY, 1984), 426-464; Marvin A. Rapp, *The Port of Buffalo: 1825-1880* (Durham, NC, Duke University, unpublished dissertation, 1947), 23-44; Lenihan, *ibid.*, 19-42; William Cronon, *Nature's Metropolis: Chicago and the Great West* (New York, NY, 1991), 55-93.

59. Dohrmann, *ibid.*, 60, 61.

60. *Ibid.*, 135, 136.

61. *Ibid.*, 80-82, 135, 136.

62. Donald Canney, *The Old Steam Navy: Frigates, Sloops, and Gunboats, 1815-1885*, vol. 1

(Annapolis, MD, 1990), 27; Dohrmann, *ibid.*, 75-78.

63. *The National Cyclopædia of American Biography*, vol. 22 (New York, NY, 1932), 446, 447 (entries for John Weakley Chalfant and Henry Chalfant); Swank, *ibid.*, 229.

64. Nathan Rosenburg, "Factors Affecting the Diffusion of Technology," *Explorations in Economic History*, vol. 10, no. 1 (1972), 20.

65. J. Richard Steffy, *Wooden Ship Building and the Interpretation of Shipwrecks* (College Station, TX, 1994), 23.

CHAPTER II

THE HISTORY OF *INDIANA*

Growth of the Lake Erie Port of Vermilion, Ohio

Indiana was built in 1848 in the small Lake Erie port town of Vermilion, Ohio.[1] Settled in 1808, Vermilion is located on the southwestern shore of Lake Erie at the mouth of the Vermilion River, in a part of northern Ohio referred to as the "Firelands" (Fig. 2-1).[2] The Firelands, or "Fire Sufferers' Lands," as they also were known, comprised a 500,000-acre (202,429.15-hc) parcel of property in present-day Erie and Huron Counties, both of which once formed part of Connecticut's "Western Reserve," a 120-mile (193.11 km) stretch of land encompassing the southern shore of Lake Erie. These "reserved" lands were retained initially by Connecticut when the state ceded the remainder of its western land claims of 1662 to the newly formed United States Federal government in 1786, then were transferred to the Federal government in 1800.[3] The Firelands portion of the Western Reserve was subdivided into lots that were granted to 1,870 Connecticut citizens by the state's General Assembly in 1792, as a form of relief to individuals whose homes and businesses were burned by British and Hessian troops occupying towns in coastal Connecticut during the American Revolutionary War.[4]

In 1794, "Mad" Anthony Wayne's victory at the Battle of Fallen Timbers on the Maumee River near Toledo, Ohio ended the threat of hostile native American populations in the region.[5] Shortly thereafter, a steady stream of settlers began to flow into the Firelands region via the Ohio River. Some of Connecticut's western pioneers were lured to Vermilion because of its fertile lands, rich natural resources, and convenient access to Lake Erie by way of the Vermilion River, which provided one of the lake's few natural harbors as well as a local source of water power for milling equipment.[6] Abundant timber and mineral resources in the region offered additional inducement for settling at Vermilion. Despite these attractions, a portion of the original grantees chose to remain in Connecticut and profited by selling their claims to European emigrants, who at the time were flooding into the United States in ever-increasing numbers.[7] As lands were cleared and homes were built, Vermilion began to take on the appearance of a small Connecticut seaport, a characteristic which it has retained up to the present.[8]

Like many of Lake Erie's ports, Vermilion's growth was tied directly to the development of lake trade, which had progressed slowly until the 1830s, when the completion of the Erie (1825),

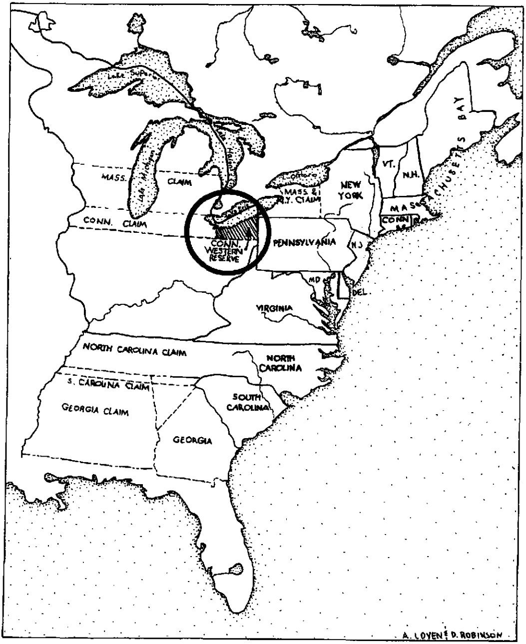


Figure 2-1. Connecticut's Western Reserve in northern Ohio. (Drawing by Adam Loven and David S. Robinson).

Welland (1829-33), Miami and Erie (1832), and Ohio and Erie (1832) Canals opened the Great Lakes Basin to interregional trade and swelled Lake Erie's traffic.[9] Export of lumber and iron ore emerged as the town's two most important early industries. The dense forests surrounding Vermilion, which then were rich with tall stands of "old growth" white oak, a timber very much in demand for shipbuilding because of its strength and resilience, provided a seemingly inexhaustible supply of lumber for export. Rough-cut logs brought to the town's saw mills on the river were hewn to produce ships' timbers, masts, cordwood, staves, and shingles, all of which were among Vermilion's earliest exported commodities.[10] Large deposits of bog iron in the Vermilion area also were utilized. The Huron Iron Company, which was founded in the 1820s as the Geauga Iron Company, flourished during the 1830s and 1840s by smelting Vermilion's bog iron in its blast furnace to create pig iron for export, and by manufacturing numerous cast iron items for local shipbuilders and farmers.[11] Increased local demand for such items led eventually to the relocation of the foundry to the Vermilion waterfront, where it could better serve the town's growing shipbuilding industry, which it supplied with nails, mast rings, and other iron necessities.

By the 1840s, the decade in which *Indiana* was built, Vermilion had established itself as a small yet thriving commercial center and shipbuilding port. The Vermilion River channel (seven feet [2.13 m] deep) easily accommodated most ships of the day, and the 15 to 20 foot (4.57 to 6.10 m) rise of the river's west bank provided an ideal site for building and launching boats.[12]

Shipbuilding had played an integral role in the development of the town's economy since Vermilion's earliest days. Between 1809 and 1841, nine vessels were constructed and launched from the river's west bank. Despite this relatively low number, the reportedly high quality of design and craftsmanship exhibited by the Vermilion-built vessels distinguished the port locally as a shipbuilding center of note and earned the town's shipbuilders a favorable reputation.[13] Vermilion's pioneer shipwright, Captain William Austin, was among the first builders on the Great Lakes. A Connecticut Yankee who had moved to Vermilion from New London, Connecticut, in 1809, Austin built Vermilion's first sailing vessel, the 30-ton schooner *Friendship*, in 1812.[14] Other Vermilion shipwrights, such as Augustus Jones, Fairbanks Church, Burton S. Goodsell, and Burton Parsons, also were famous in their day.[15] Jones and Church, in particular, were reported to have built some of the fastest, sleekest ships on the lakes, and were credited with marked improvements in the models and general construction of Great Lakes sailing craft, including a method for increasing hull capacity with only a minimal increase in draft.[16] An example of their craftsmanship was Jones's 58-ton schooner *Eclipse*, completed at Vermilion in 1823 and regarded by some at the time as, "one of the finest specimens of naval architecture on the lakes."[17] Vermilion's reputation as a shipbuilding center was enhanced further when the prominent nineteenth century Great Lakes shipwright, Fairbanks Church, left nearby Huron, Ohio, for Vermilion in 1826 to construct the 87-ton schooner *Lady of the Lakes.* Another renowned shipwright, Burton S. Goodsell, located his Vermilion shipyard in a prime location at the mouth of the river in 1834 and immediately embarked upon several ambitious projects, including the construction of Vermilion's first two steamboats, *Vermillion* (1838) and *Missouri* (1840).[18]

The Partnership of Alva Bradley and Ahira Cobb

The period between 1842 and 1860 was one of unparalleled prosperity and dynamic commercial and industrial growth in Vermilion, an era that local historians refer to as the town's "Golden Age."[19] Significantly, it was during this period that Vermilion's shipbuilding industry, led by captain Alva Bradley and merchant Ahira Cobb, two of *Indiana*'s original owners, replaced the lumber trade as the community's most important industry.

Exemplars of the mid-nineteenth century's business elite, Bradley and Cobb consciously and purposefully pursued material wealth from their modest beginnings and achieved financial success at very young ages (Fig. 2-2). Born 27 November 1814 in Ellington, Connecticut, Alva Bradley moved with his parents to a farm in Brownhelm, Ohio, near Vermilion, at the age of nine.[20] At nineteen, Bradley left home and headed to Vermilion to begin a 15-year-long career as a lake sailor, serving first on board the 50-ton schooner *Liberty*.[21] During the next eight years of his career, he also served on the lake vessels *Young Leopard, Edward Bancroft, Express*, and *Commodore Lawrence.* By the age of 27, he had advanced to the rank of captain and had established a close friendship with wealthy local merchant Ahira Cobb.

Like Bradley, Cobb achieved success early in life. Born 12 October 1814, in Tolland, Connecticut, Cobb moved with his family to Berlin, Ohio, in 1819. Shortly after arriving there, hardship befell the Cobb family when Ahira's father died unexpectedly from a sudden illness at the age of 36. Unable to adequately support themselves, the Cobbs returned to Connecticut in 1828. Back in Tolland, young Ahira worked as a tailor's apprentice, but he reportedly soon tired of the business. Exhibiting an "unmistakable...Yankee symptom," described as "a frequently expressed desire to go

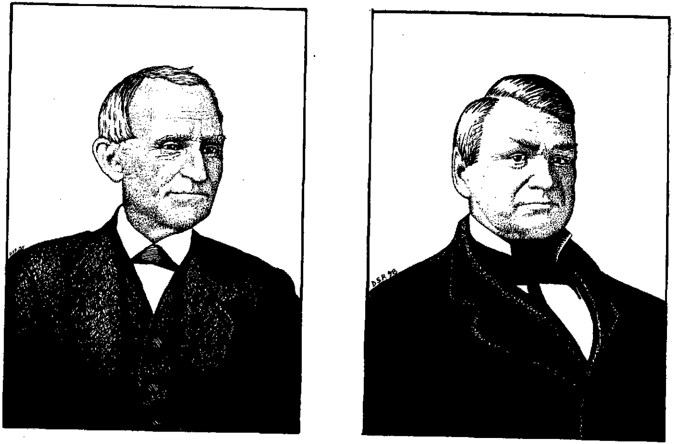


Figure 2-2. Alva Bradley and Ahira Cobb. (After Avery, *A History of Cleveland and Its Environs. The Heart of New Connecticut*, 426, 428). (Drawings by David S. Robinson).

west...as soon as parental authority was disposed of...to compete for the fickle smile of fortune," Cobb returned to Ohio the following year and found employment in Norwalk as a clerk for merchant and postmaster John Buckingham.[22] Demonstrating a keen business sense, Cobb formed a partnership several years later with Buckingham and B. L. Hill under the firm name of Cobb, Hill & Company, opening a store at in Erie County at Birmingham, Ohio, in 1836. Birmingham had been incorporated by a company from New York, which had erected there a $25,000 flouring mill, a $5,000 hotel, a sawmill, a forge, and numerous private dwellings.[23] When the company failed in 1837, Cobb successfully bid on these properties, and by the age of 30 he owned nearly an entire town.[24]

In 1841, Cobb and Bradley established what eventually became an extraordinarily successful business partnership. They and another local investor, Rodney Andrews of Brownhelm, Ohio, commissioned shipwright Burton Parsons to construct the 104-ton schooner *South America* (Fig. 2-3).[25] Significantly, *South America*'s construction coincided with the start of a 26-ship building boom in Vermilion that also sparked the start of the town's Golden Age. Between 1841 and 1867, Bradley, a master carpenter in his own right, and Cobb formed additional partnerships and contracted the construction of a total of 16 vessels with Vermilion shipwrights Burton Goodsell, Burton Parsons, Joseph M. Keating, John F. Squires, Isaac W. Nicholas, and Philip Minch for their budding freighting business.[26] By 1859, the peak of Vermilion's shipbuilding era, Bradley and Cobb had amassed a fleet of twelve vessels sailing on the Great Lakes.[27]

The degree of influence that Bradley and Cobb's shipping enterprises had on Vermilion's economy and shipbuilding industry was substantial. This influence is clearly evident from the economic decline Vermilion suffered following their 1859 removal to Cleveland, where Bradley and Cobb engaged more heavily in the iron ore trade and expanded their fleet of vessels. Their departure left a vacuum in Vermilion's economy from which the town never fully recovered, and precipitated the end of Vermilion's Golden Age. As Great Lakes historian Thomas A. Smith has noted, "When they left, most of the town's available capital went with them."[28]

Although Bradley and Cobb's departure from Vermilion certainly dealt a severe economic blow to the town, it alone was not responsible for Vermilion's economic downfall; their departure simply made Vermilion's economic and physical limitations more apparent. For many years, Vermilion (like most ports on the lakes) had struggled unsuccessfully to secure Federal funding for improving its harbor, and, consequently, the quality of Vermilion's harbor suffered. Adding to the town's financial woes was

Article of Association made and entered into by and between Ahira Cobb of Birmingham, Erie Co, Ohio, Rodney Andrews of Brownhelm, Lorain Co, Ohio, and Alva Bradley of Brownhelm, Lorain Co, Ohio for the purpose of Building a Schooner at the mouth of the Vermilion River, Ohio.

Article 1 The Capital Stock is to be fixed at Three Thousand two Hundred Dollars and all the said Vessel may cost over that amount to be held as debt against said Vessel to be paid out of her first earnings.

Article 2 The Stock to be held as follows viz Two Thousand Dollars to be held and paid in by Ahira Cobb, Five Hundred Dollars to be held and paid in by Rodney Andrews, Seven Hundred Dollars to be held and paid in by Alva Bradley, payments on all the above to be made by said parties according to the contract with O. A. Leonard and J. W. Pain that is the duebill from Huron Iron Co. for Iron Spikes to be furnished by said Bradley and Two hundred Dollars to be paid to said Leonard & Pain by said Bradley.

Article 3 In case of either party failing to pay in Stock according to contract with Leonard & Pain to be liable to pay all damage that the other party may sustain in consequence of said failure.

Article 4 It is hereby agreed that Alva Bradley is to be Master of said Vessel so long as he may own Stock in said Vessel. He being paid for his services out of the earning of said Vessel at such prices as is usual for Masters to have in this class of Vessels. But it is further agreed that at any time when the majority of Interest shall wish to change the Command of said Vessel, they may do so by paying said Bradley the amount of Stock in proportion to its real worth and giving him reasonable notice of the same.

Article 5 All meetings of Stockholders to be held at the Vermilion Harbour on the first day of January in each year and as much oftener as the Stock Holders may see proper.

Article 6 Any Stockholder may call a meeting by giving Thirty days notice in some newspaper published in Erie Co., Ohio.

Article 7 In all meetings of said Stockholders, Two Thirds of Interest being present shall constitute a quorum.

Article 8 In all cases of loss or profits in said Vessel shall be shared among the Stockholders according to the interest each may own.

Signed this 26th day A. D. 1841

Ahira Cobb
Alva Bradley
Rodney Andrews

Figure 2-3. Contract for the first vessel built for the partnership of Cobb and Bradley. (Transcribed from Bradley, *Ancestors and Descendants of Morris A. Bradley*, 37).

the exhaustion of local timber and bog iron supplies, as well as the rising prominence of rival lake towns Cleveland, Huron, Sandusky, and Black River, which relegated Vermilion to secondary status as a lake port.[29] Bradley and Cobb maintained business ties with Vermilion and continued to build ships there for nearly ten years after leaving, but the town's economy and stature nonetheless decayed quickly after their departure. In direct contrast, Bradley and Cobb's fortunes increased dramatically after arriving in Cleveland, where they developed one of the largest fleets of carriers on the lakes and became two very powerful figures of their day.[30] At the time of Bradley's death on 28 November 1885, he had commissioned the construction of a total of 23 ships and was the largest individual vessel owner in the entire Great Lakes System (Table 2-1).[31]

Operational History of the Propeller *Indiana*

In 1847, Bradley and Cobb entered into a partnership with fellow entrepreneurs David Squire and Theodore O. Chapman, both from Erie County, Ohio, and Buffalo grain merchant Merwin Spencer Hawley (b. 1807-d. 1887). Together these five men commissioned the construction of their first steamboat, the propeller *Indiana*.[32] Like Bradley and Cobb, Hawley also enjoyed an enormously successful career and served as both a founding member of Buffalo's Board of Trade and the President of Buffalo's International Bank before his retirement from business in 1863.[33] Although it is impossible to state with absolute certainty, it is likely that *Indiana* was constructed at Burton Goodsell's shipyard on the west bank of the Vermilion River, adjacent to the Huron Iron Company's furnace and a sail lofting area (Figs. 2-4 and 2-5).[34] Bradley and Cobb purchased the yard from Goodsell in the late 1840s, but whether their acquisition occurred before *Indiana*'s construction is unclear.[35] While the exact location within Vermilion where *Indiana* was built is not known, master carpenter Joseph M. Keating was unquestionably the builder, as his name appears on all the vessel's registration papers.[36]

Examination of U.S. Census records, city directories, historic maps, local histories, and genealogical repositories at the U.S. Library of Congress and several different historical societies around the Great Lakes produced no biographical information on Keating.[37] Perhaps it is fitting then that the sole testament to a master craftsman's existence are the ships that he produced and the archival documentation that these vessels generated. Examination of vessel enrollments suggests that Keating spent a significant portion of his shipbuilding career living and working along Lake Erie's southwestern shore, where he built eight ships at three different sites (one steamer and one schooner [possibly two] at

TABLE 2-1

VESSELS CONSTRUCTED FOR ALVA BRADLEY: 1841-1882

Date of Construction	Vessel Name	Registered Tonnage
1841	*South America*	104
1844	*Bingham*	135
1848*	*Ellington***	185
1848	*Indiana***	350
1849	*Oregon*	190
1852	*Challenge*	238
1854	*Bay City*	190
1855	*C. C. Griswold*	359
1856	*Queen City*	368
1856	*Wellington*	300
1858	*Exchange*	390
1861	*S. H. Kimball*	418
1863	*D. Wagstaff*	412
1864	*J. F. Card*	370
1865	*Escanaba*	568
1867	*Negaunee*	850
1870	*Alva Bradley*	934
1871	*J. S. Fay*	1,220
1871	*D. P. Rhodes*	937
1872	*T. P. Quayle*	893
1873	*John Martin*	937
1873	*Superior*	964
1882	*City of Cleveland*	1,610

*According to C. Patrick Labadie, the schooner *Ellington* was built in 1847.
**Built by Joseph M. Keating.

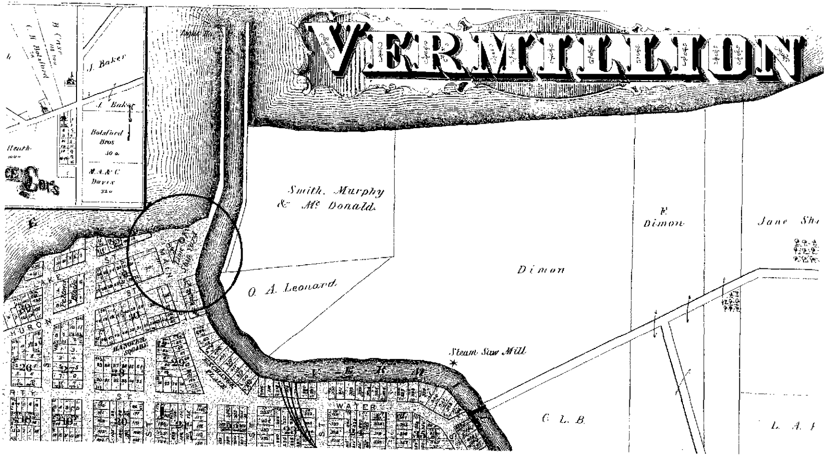


Figure 2-4. Vermilion waterfront circa 1870. Note "Ship Yard" on west bank of the river. (After Stewart & Page, *Combination Atlas Map of Vermillion & Vermillion Township, Ohio* [1977 reprint], 3, 4).

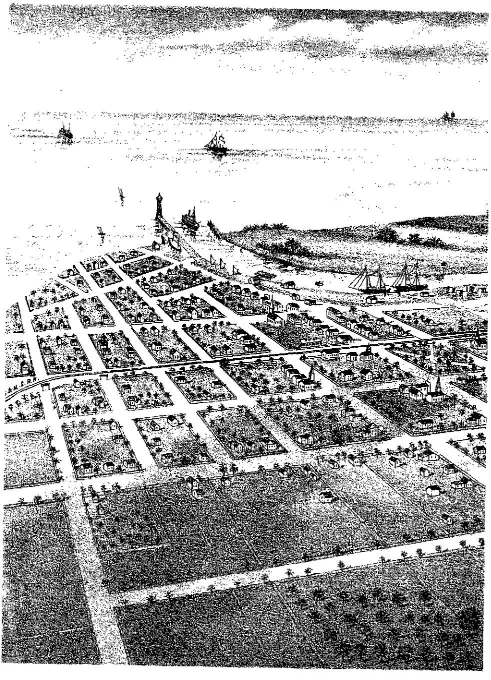


Figure 2-5. "Bird's-eye" view of Vermilion waterfront. Note sail loft, shipyard, and propeller at the river's mouth. (After Stewart & Page, *Combination Atlas Map of Vermillion & Vermillion Township, Ohio* [1977 reprint], 2).

Truago, Michigan [today's Trenton]; one schooner at Huron, Ohio; and three schooners and one propeller at Vermilion) [Table 2-2]) between 1846 and 1855.[38] Given the conspicuous absence of biographical information available on Keating and his movements between ports, he appears to have been an itinerant shipbuilder who worked in the yards of more established firms. While Keating's background and training remain a complete mystery, three of his ships (*Alvin Clark*, *Vermont*, and now *Indiana*) have been studied and documented. *Alvin Clark*, which may have been Keating's first vessel on the lakes, was built in 1846 and raised virtually intact from the bottom of Lake Michigan's Green Bay by private individuals in 1969. However, it never received the necessary conservation treatment required to preserve the hull. Consequently, the vessel fell into disrepair and was dismantled and destroyed in 1994. Fortunately, *Alvin Clark* was recorded during the early 1980s by C. T. McCutcheon, Jr., a noted expert on early Great Lakes shipbuilding, who published lines and construction plans of the vessel in 1983 (Fig. 2-6).[39] Documentation for the 1853 Keating-built schooner *Vermont* consists of a half-hull builder's model, presumably made by Keating himself, and a lines drawing derived from the model by workers employed by Works Progress Administration in 1936-1937 (Fig. 2-7). A plan of *Vermont*'s lines is now available from the collection of plans, models, photos, and drawings comprising the Historic American Merchant Marine Survey (HAMMS), housed at the Smithsonian Institution.[40]

Intentionally built as a "package" freighter designed for carrying both passengers and packaged freight (i.e., items packed in bags, boxes, barrels, etc.), *Indiana*'s dimensions were typical of most Great Lakes propellers built during the late 1840s: 349-34/95 registered tonnage, a measured length on deck of 146 feet, 6 inches (44.7 m), a beam of 23 feet (7.01 m), and a depth of hold of 10 feet, 10 inches (3.3 m).[41] According to the enrollment papers, *Indiana* was constructed with two decks, a round stern, no galleries, and a plain stem without a figurehead.[42] At the time of the launching, *Indiana* carried a single mast, probably with a gaff rig, for auxiliary sailing power.[43]

Indiana was the fifteenth vessel, the third steamboat, and the only large propeller built at Vermilion. It remains unclear whether or not the propulsion machinery was installed at Vermilion or at some another port nearby, such as Cleveland, where its unique "Bee-hive" boiler was designed and built by Luman Parmalee.[44] An entry in Ahira Cobb's personal ledger from 18 July 1849 shows that Cobb paid $500 to another Cleveland firm, McClelland and Baker, for a "propeller engine."[45] This entry provides a compelling clue regarding the source, if not also the builder, of *Indiana*'s engine. A nearly illegible, embossed maker's mark on *Indiana*'s capstan that appears to read "_ _CLE_LA_ _ & C°." (Fig.

TABLE 2-2

PARTIAL LIST OF GREAT LAKES VESSELS

CONSTRUCTED BY JOSEPH M. KEATING: 1846-1855

Vessel Type	Name of Vessel	Date	Place Built
Schooner	*Alvin Clark*	1846	Truago, Michigan
Steamer	*A. D. Patchin*	1847	Truago, Michigan
Schooner	*Ellington*	1847	not available
Propeller	*Indiana*	1848	Vermilion, Ohio
Schooner	*Challenge*	1853	Vermilion, Ohio
Schooner	*Vermont*	1853	Huron, Ohio
Schooner	*Bay City*	1854	Vermilion, Ohio
Schooner	*Africa*	1855	Vermilion, Ohio

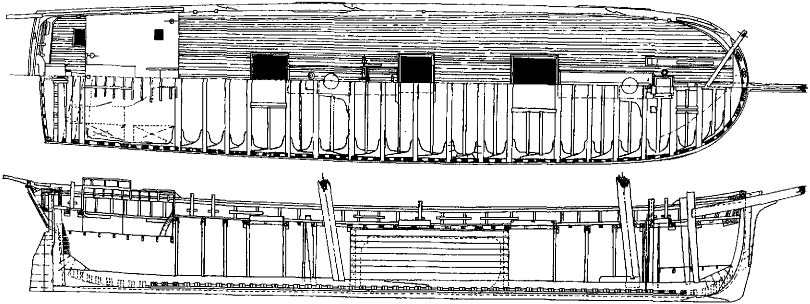


Figure 2-6. The Keating-built Great Lakes schooner *Alvin Clark* (1846). (After McCutcheon, "*Alvin Clark*: An Unfinished Voyage," 58).

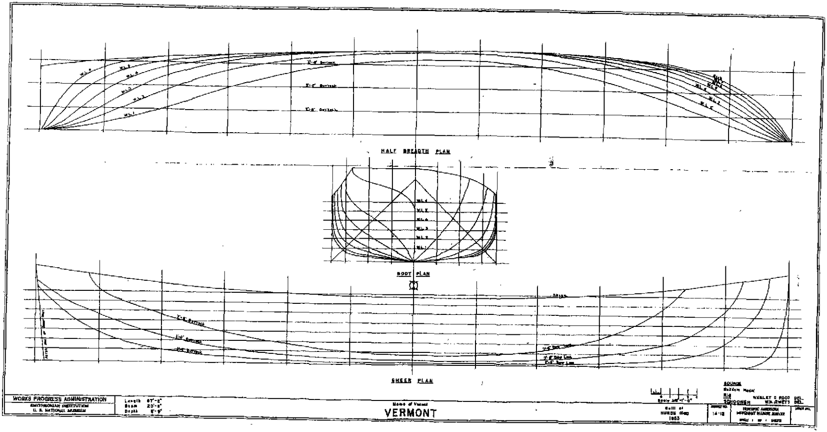


Figure 2-7. Hull lines derived from a half-hull builder's model of the Keating-built Great Lakes schooner *Vermont* (1853). (Plan courtesy of the Smithsonian Institution, NMAH).

2-8) suggests that McClelland and Baker may have supplied other items of *Indiana*'s equipment. An exception is *Indiana*'s four-bladed propeller, the only major component of the propulsion machinery exhibiting a legible maker's mark, which reads: "SPANG & CO." (Fig. 2-9). The Pittsburgh-based firm of Spang & Company was one of the United States' earliest and largest wrought iron manufacturers.[46] *Indiana*'s propeller may be the sole surviving example of what lakemen called a "Philadelphia wheel," which was named after the city of residence of its designer and patentee, Richard F. Loper (Fig. 2-10).[47] During the middle 1840s, Loper licensed rights to his invention to the large Philadelphia-based marine engine-building company of Reaney, Neafie and Company, who in turn made arrangements with a number of Great Lakes firms for their use of the propeller.[48]

The Loper propeller represented a significant improvement over the first commercially viable propeller, patented by John Ericsson in 1836, and it is considered to have been more influential on later screw development than was Ericsson's.[49] The four-bladed Loper screw, which consisted of sheet metal blades riveted onto a cylindrical hub, was a simpler and more practical design than the Ericsson model, with its cast inner section, strengthening ring, and numerous sheet metal outer blades (Fig. 2-11). Although the Loper propeller was remarkably successful, its thin blades could not withstand great forces. Consequently, by 1852, Loper had introduced an improved design made from cast iron, which turned out to be a stronger and more efficient model.[50]

Despite the fact that *Indiana* was the first and apparently the only screw-propelled steamboat built at Vermilion, its appearance on the lakes drew no attention from any of the local newspapers when it was launched during the spring of 1848.[51] One possible reason why *Indiana*'s launching garnered no press was the fact that propellers had become commonplace on the lakes by 1848, especially along the southern shore of Lake Erie, where most were being built after 1845.[52]

Following its launching, *Indiana* was registered at the nearby port of Sandusky, Ohio, on 13 May 1848.[53] Although Sandusky boasted what was arguably Lake Erie's best natural harbor and had developed into one of the largest grain markets in the United States by the middle of the nineteenth century, *Indiana* apparently spent very little time in its home port between 1848 and 1851. Historical evidence suggests *Indiana*'s avoidance of Sandusky may have been more than coincidental. In 1849, a cholera epidemic swept through the region, and Sandusky was hit particularly hard. During the height of the epidemic the town's businesses were brought to a standstill, and half of the city's population left. Most never returned, and Sandusky was referred to morbidly as the "city of the dead."[54] Ironically,

Figure 2-8. Graphite rubbing of embossed maker's mark on *Indiana*'s capstan. (Drawing by David S. Robinson).

Figure 2-9. Maker's mark (SPANG & C°) stamped into *Indiana*'s propeller blade. (Photo courtesy of the Smithsonian Institution, NMAH).

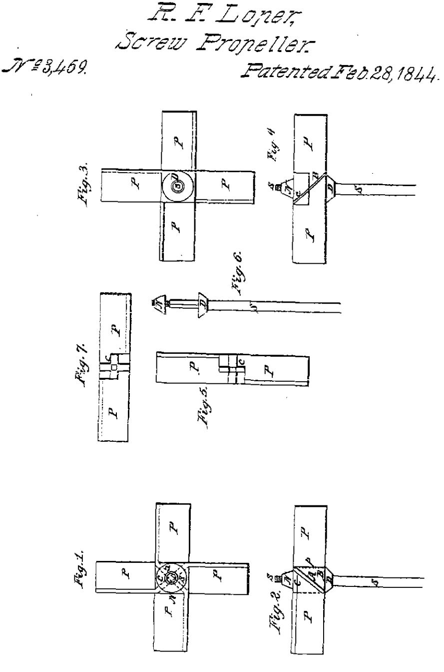


Figure 2-10. Patent drawings of Richard F. Loper's four-bladed propeller (1844). (Courtesy of the Smithsonian Institution, NMAH).

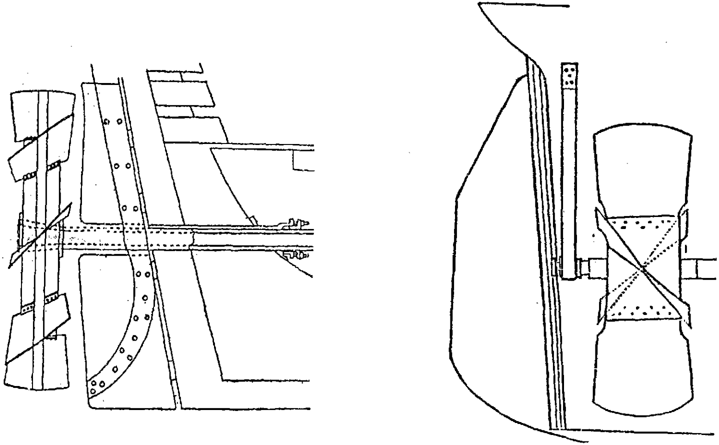


Figure 2-11. Propellers by Ericsson and Loper. (After Neilson, "The First Propellers at Kingston," 4; and MacFarlane, *History of Propellers and Steam Navigation*, 116, 119).

steamboats like *Indiana* helped spread the disease to cities across the lakes by transporting massive numbers of emigrants, many infected with the illness, who were flooding into the region.

Indiana's managing owner, Alva Bradley, also served as its first master between 1848 and 1850, before passing on command of the propeller to Captains Conkey and Kline.[55] The first four years of *Indiana*'s operational career passed essentially without event, except for a minor collision with the schooner *Cambria* on 21 April 1851, which resulted in a combined casualty loss of $200 for both vessels.[56] During these early years, Bradley and his associates employed *Indiana* from March to December in the general cargo trade as a combination passenger vessel and package freighter. *Indiana* was also operated as a "regular trader" between Buffalo and Detroit, although it did make occasional trips to Chicago, Milwaukee, Racine (Wisconsin), and Little Fort (St. Joseph, Michigan).[57] *Indiana* also visited frequently at Tonawanda (New York), Cleveland, and Monroe (Michigan) (Table 2-3).[58]

In 1850, *Indiana* became one of five north shore line propellers plying the busy route between Buffalo and Detroit, two of the most important transshipment points on the lakes at that time.[59] During its engagements in the commerce between Buffalo and Chicago, *Indiana* was joined by 19 other propellers, all in excess of 300 registered tons; 16 large, first-class steamers; and a multitude of sailing schooners and brigs that also made the transit.[60] As was commonly the case, merchandise and emigrants flooding into the Great Lakes region from the east comprised the majority of *Indiana*'s western or "upbound" shipments, while freights of grain and other raw products were usually carried on return or "downbound" voyages to Buffalo.[61] Reportedly, upbound propellers and steamers were frequently packed so tightly with passengers and cargo that the vessels' crews barely had enough room to move about their ships in order to navigate them.[62]

In the spring of 1852, Bradley and his partners, perhaps recognizing that marine steam technology was advancing daily and that screw-propelled vessels of *Indiana*'s size and age were quickly becoming obsolete, sold the four year-old *Indiana* to two of Buffalo's most prominent merchants: Lucius H. Pratt, a founding member of Buffalo's first Board of Trade, created in 1845; and Hiram Niles, a principal in the Buffalo-based firm of Niles & Wheeler, who later became one of the original incorporators of the Buffalo Board of Trade when it was officially chartered by the State of New York on 3 March 1857.[63] Pratt, who owned a two-third interest in *Indiana* and was its managing owner, was also listed as *Indiana*'s master on the 1852 enrollment but never actually served in this capacity; *Indiana* was instead commanded during the 1852 navigation season by Captains Spencer and Keith.[64] In

TABLE 2-3

SUMMARY OF *INDIANA*'S ANNUAL ACTIVITY

BASED ON A PARTIAL RECORD OF PORT ARRIVALS AND DEPARTURES

YEAR/ PORT	1848	1849	1850	1851	1852	1853	1854	1855	1856	1857	1858
Buffalo, NY	19	11	2	24	45	58	4	38	91	-	4
Chicago, IL	7	4	-	2	-	-	-	4	-	-	-
Cleveland, OH	-	-	2	8	1	2	21	3	90	52	-
Detroit, MI	8	4	-	19	7	-	-	-	-	-	4
Dunkirk, NY	-	-	-	-	-	-	-	-	-	50	-
Marquette, MI	-	-	-	-	-	-	-	-	-	-	1
Milwaukee, WI	2	1	-	1	-	-	-	-	-	-	1
Monroe, MI	-	-	-	1	-	14	-	-	-	-	-
Racine, WI	-	-	-	1	-	-	-	-	-	-	-
Sandusky, OH	1	-	-	-	5	2	-	3	-	2	-
Sault Ste. Marie, MI	-	-	-	-	-	-	16	-	-	-	-
St. Joseph, MI	1	-	-	-	-	-	-	-	-	-	-
Toldeo, OH	-	1	-	2	32	56	-	29	-	-	-
Tonawanda, NY	-	-	-	14	-	-	-	-	-	-	-
Vermilion, OH	3	-	-	-	-	-	-	-	-	-	-

addition to the ownership change, *Indiana*'s port of enrollment was transferred from Sandusky to Buffalo.[65]

At the start of the 1853 season, Pratt purchased Niles's one-third interest in *Indiana* and became its first sole owner on 1 April.[66] At the same time, Franklin Cameron was hired as *Indiana*'s master.[67] Near the end of the 1853 navigation season, Lucius Pratt sold his share in *Indiana* to another member of Buffalo's commercial elite, the long-time Buffalo resident, prominent manufacturer, merchant, and a fellow founder of the Buffalo Board of Trade, Samuel F. Pratt.[68] Samuel Pratt was a principal in the Pratt and Letchworth Company, a large iron and hardware company formed in 1850 that took over Buffalo's first rolling mill, the Buffalo Iron and Nail Works, and later pioneered the open-hearth steel casting process.[69]

During the 1852 and 1853 navigation seasons, *Indiana* operated as a "liner" under charter to the Union Steamboat Company, a subsidiary of the New York & Erie Railroad Company.[70] Liner service in the combined passenger and freighting business of the lakes emerged in 1845 with the introduction of propellers, but remained uncommon until the early 1850s, when the railroads from the east first reached the Great Lakes. Initially, the railroads utilized propellers as an economical means of providing connecting service between their western and eastern lines. Since competition for the carrying business was very sharp between rival railroads, the integration and control of steamboats on the lakes was considered indispensable to the successful competition for the trade.[71] In 1852, the New York & Erie Railroad reached the shores of Lake Erie with its track and organized a line of propellers to run from its railhead at Dunkirk to ports on Lake Erie, principally Detroit.[72] Since most propellers were primarily freighters rather than passenger vessels, they enjoyed less competition from the railroads than did their sidewheel steamboat counterparts. This combination of railroads and screw propellers hastened the decline of sidewheel steamers on the lakes while it contributed to the increased use of propellers.[73] Between 1854 and 1860, a significant number of the more than 50 large (e.g., 300 tons or more) propellers that were built in Buffalo and Chicago during that period were owned or chartered by railroads. Once continuous rail service reached Chicago and points further west, however, the railroads relegated screw-propelled steamboats to exclusive use as freighters.[74]

Between 1852 and 1853, *Indiana* travelled exclusively of Lake Erie, with Buffalo and Toledo as its most frequent destinations. Occasional stops were also made at Cleveland, Detroit, Monroe, and Sandusky. Analyses of the "Marine Intelligence" reports that appeared in local newspapers indicate that barrels of flour, animal hides, packaged merchandise, bushels of oats, and bushels of wheat were the most commonly carried commodities transported by *Indiana* during the 1852 and 1853 navigation seasons. On one voyage in 1852, *Indiana* carried a cargo of 2,240 railroad chairs, which were probably destined for use by the railroad company employing it at the time (see Appendix A).[75]

On 12 April 1854, *Indiana*'s ownership changed again, and the propeller was re-enrolled at Buffalo.[76] Watson A. Fox, another prominent Buffalo businessman and a founding member of the Buffalo Board of Trade, purchased a one-quarter share of *Indiana* and acted as the managing owner while employing *Indiana* as part of his short-lived, 13-ship "Clipper Line" (Fig. 2-12).[77] The Clipper Line was Fox's Buffalo-based organization, which was advertised as a group of Great Lakes ship owners and forwarding and commission merchants with offices in Boston, Buffalo, Chicago, Cleveland, Detroit, Milwaukee, New York City, and Toledo.[78] William A. Shepard, who acted as the New York City agent for the Clipper Line, also owned a one-quarter share of *Indiana*. Captain Francis Perew of Buffalo served as *Indiana*'s master and was its principal owner, with a 50 percent share in the propeller.[79]

Interestingly, *Indiana*'s 1854 enrollment papers indicate that substantial changes were made to its hull structure and rig between the 1853 and 1854 navigation seasons, although these changes are contradicted by newspaper accounts of *Indiana*'s sinking that describe its upper works and are not reflected in the archaeological record. The number of *Indiana*'s masts was apparently increased from one to two, and the number of decks was supposedly reduced from two to one with no change in *Indiana*'s registered tonnage.[80] Upon initial consideration, it seemed curious that the addition or subtraction of a deck would not have resulted in corresponding changes in *Indiana*'s tonnage. However, a review of the formula used for calculating a vessel's registered tonnage at that time indicated that *Indiana*'s tonnage would have remained the same even if the number of decks changed. The method for calculating a vessel's registered tonnage entailed deducting three-fifths of the ship's registered beam from its registered length, multiplying that difference by the beam, and multiplying that product by the registered depth of hold, and then dividing the final product by 95.[81] Neither decks nor masts are included in this equation; therefore, any alterations to these structures would not affect a vessel's registered tonnage.

One suggested explanation for the supposed structural changes that occurred between the 1853 and 1854 enrollments is that different inspection standards were applied at different ports.[82] However, this argument is invalidated by the simple fact that *Indiana*'s port of enrollment remained the same

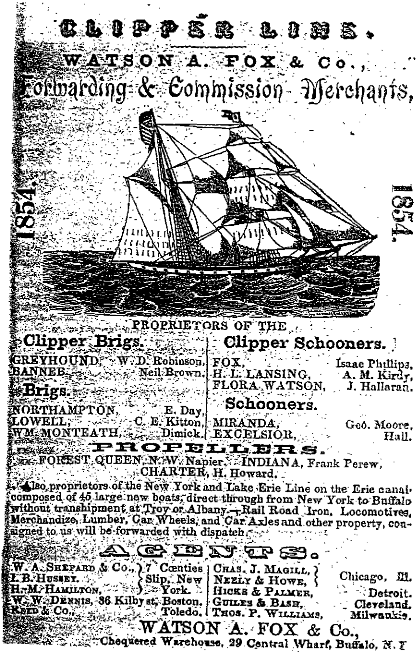


Figure 2-12. Advertisement for Watson A. Fox & Co.'s Clipper Line. In addition to owning shares in *Indiana*, Fox was the sole owner of the Clipper Line propeller *Forest Queen* (From Lotridge & Co., *Buffalo Business Directory*, 1854-1855, 13).

between 1853 and 1855, the years when the changes allegedly occurred.[83] Moreover, careful examination of the documents from this period reveals that the enrollment papers from both 1853 and 1854 were completed by the same registrar. In light of these facts, a more plausible explanation for the inconsistency may be that they are simply transcription errors that were carried over from one form to another. Despite the apparent changes and alterations in the number of decks and rig that are suggested by the enrollment papers, other historical documentation and *Indiana*'s remains provide no supporting evidence that *Indiana* was ever fitted with less than two decks or more than one mast during the course of its career.

Indiana's employment with the Clipper Line proved short-lived. On 27 April 1854, approximately two weeks after *Indiana* was put into service with two other propellers in the line, it struck the west pier (a large stone breakwater) at the entrance to Cleveland Harbor, "doing considerable damage" to itself.[84] The extent of the damages that were incurred by *Indiana* during the collision are hardly surprising, given that many Great Lakes mariners were of the opinion that entering the lakes' shallow harbors was among the most dangerous aspects of lake navigation, and that the "making" of those shallow harbors, "pounding over the bar," with a heavy sea running between two breakwaters or piers such as those at the entrance to the Cleveland harbor, was like "entering, often literally, the jaws of destruction."[85] These observations appear to be well founded. In December of the same year (1854), the schooner *Omar* struck one of the Cleveland piers; four persons were killed and the vessel was a total loss.[86] The piers at the entrances of Buffalo and Chicago's harbors claimed several victims in 1854 as well. Seven vessels were driven against the breakwater at Chicago in the month of April alone, amounting to $23,500 worth of cumulative property damage.[87] Just two years after *Indiana*'s collision with the west pier at Cleveland, the propeller *Manhattan* struck the same pier and sank for the third time, but was later refloated.[88]

Following *Indiana*'s collision, the *Cleveland Morning Leader* for 29 April 1854 reported, "The propeller INDIANA has gone into dry dock for repairs," because "She leaked considerably." *Indiana*'s repairs must have been extensive, because it appears to have been out of service for most of that season and was not mentioned in the newspapers' "Marine Intelligence" reports again until the beginning of August 1854.[89] Although the cost of the repairs was moderate, amounting to a total of $1,500, the loss of potential profits suffered by *Indiana*'s owners during the three months it was out of operation must have been substantial.[90]

After returning to service in August 1854, *Indiana* transported some of the earliest commercial bulk shipments of copper and iron ore to leave Lake Superior's Keewanaw and Ontonagon mines.[91] However, examination of business records from the Chippewa Portage Company, held at the Bayliss Public Library in Sault Sainte Marie, Michigan, revealed that *Indiana* was never portaged onto Lake Superior.[92] In fact, the archival record indicates that *Indiana* travelled only as far north as Sault Sainte Marie, where it was loaded with copper and iron ore from the Minesota, Forest City, Flint Steel, and Ridge mines, packed in barrels for ease of handling over the portage.[93] Of these mines, the Minesota, which opened in 1847 in the Ontonagon area of Michigan's Upper Peninsula, was among the most active copper mines in the region and enjoyed some brief acclaim for being the source of the largest single mass of native copper ever discovered.[94]

During one of *Indiana*'s voyages to the upper lakes late in the month of August, 1854, *Indiana* and its crew came to the aid of the steamer *Baltic*, which had grounded in shoal waters of Lake Huron.[95] Captain Perew was recognized later for his chivalry during the incident by Captain Averill of the *Baltic*, who published a note of thanks to him in the 16 September issue of the *Lake Superior Journal*, extending his gratitude to the crews of the vessels that had provided:

> ...prompt and preserving assistance with their respective craft in relieving said BALTIC from her dangerous situation on Middle Island Reef, Lake Huron...particularly to Captain Perew for remaining and assisting until BALTIC was again afloat on August 22.

Averill also noted that he hoped nobody would ever need "his services on a similar occasion, but in that of any other event their kindness will be gratefully remembered."[96]

Ironically, a little more than a month later, on 28 October, *Indiana* itself was in distress, hard on the rocks of the Saint Mary's River below Sault Sainte Marie, although it sustained only minor damages amounting to just $500.[97] By comparison, the propeller *Manhattan* was much less fortunate when it went hard aground in the Saint Mary's River in 1857, and sustained losses amounting to $17,300.[98] The river's strong currents, submerged rocks, and rock bars were well-documented hazards, and special pilots were recommended for vessels with crews that were unfamiliar with the river.[99]

Perhaps induced by the successive string of accidents and financial losses that *Indiana* had suffered over the course of the 1854 navigation season, Fox and Shepard sold their collective half-share of *Indiana* to Perew, who promptly re-enrolled the propeller at Buffalo on 5 May 1855.[100] *Indiana* appears to have been the first vessel Perew owned outright, and during the 1855 navigation season he served double-duty as both its managing owner and master, just as Bradley had before him (Fig. 2-13). Perew also shared another similarity with Bradley. Both had come from modest beginnings, but eventually rose to prominence in the history of Great Lakes marine affairs. Born 24 October 1825 at Clayton, New York, to parents of French origin, Perew had been orphaned as a young boy. His career on the lakes began in 1843, when he was 17 years of age.[101] After only a single season, he earned a permanent position in 1844 as a crewman on board the lake schooner *John Porter*, and the following year was appointed first mate on a different schooner hailing from Cleveland.[102]

In 1847 Perew built and was part owner of the schooner *Kosciuska*, a large vessel that he served on until 1850, when he left to become the master of the Great Lakes steamer *Belle*.[103] *Belle* was a small boat, built at Buffalo, that ran with the schooner *Fashion* and the steamer *Diamond* as part of a shipping line between Buffalo and Cleveland, making stops at all the major ports along Lake Erie's southern shore.[104] Perew served on *Belle* until it wrecked in Georgian Bay while under his command in 1852.[105] Undaunted by this experience, Perew soon afterwards joined a small group of investors who built the 800-ton propeller *Nile* in 1852, on which Perew served until he became the principal shareholder and master of *Indiana* in 1854.[106]

During the 1855 navigation season, *Indiana* spent the majority of its time travelling regularly between Buffalo and Toledo, carrying cargoes such as barrels of beer, bulk coal, kegs of butter, barrels of flour, live hogs, packaged merchandise, bushels of oats, barrels of pork, bags of potatoes, bags and bushels of wheat, and barrels of whiskey.[107] *Indiana* also made several trips to Lake Michigan, stopping at Cleveland and Sandusky while en route to Chicago and Milwaukee. On one such voyage, *Indiana* returned to Lake Erie with a squealing cargo of 700 live hogs.[108]

Middle Nineteenth Century Great Lakes Navigation and *Indiana*'s Routes

Information contained in contemporaneous charts, travelogues, and pilot books for the Great Lakes allows us to reconstruct the routes *Indiana* and other vessels followed while navigating between lower lake ports, such as Buffalo and Detroit on Lake Erie, and upper lake ports, such as Chicago, during the middle nineteenth century.[109] Lacking today's highly accurate, satellite-guided global positioning equipment, accurate and detailed charts, aids to navigation, and long range weather forecasts, safely navigating the lakes 140 years ago must have been uniquely challenging (Figs. 2-14 and 2-15). In addition to the usual natural and man-made navigational hazards faced by all mariners, the lakes'

Figure 2-13. Francis Perew. (After Lane, *Memorial and Family History of Erie County, New York*, 399). (Drawing by David S. Robinson).

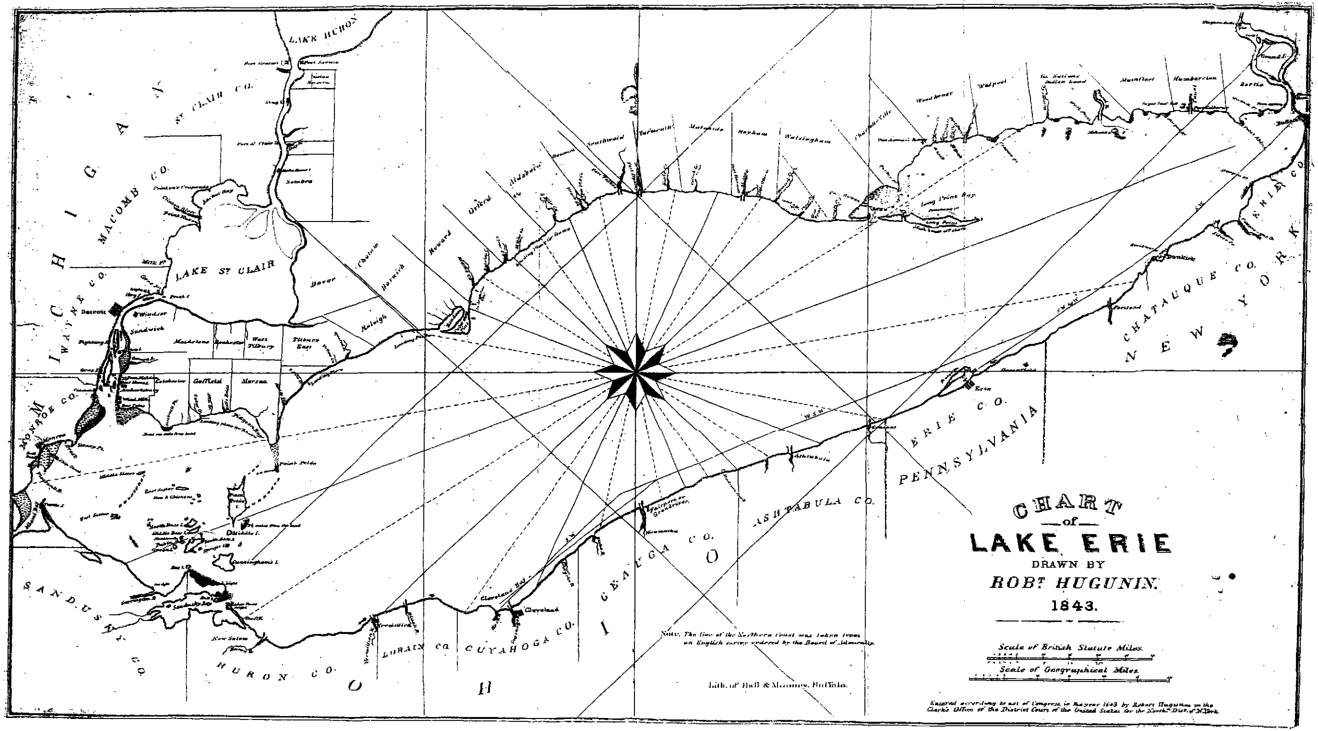


Figure 2-14. Chart of Lake Erie (1843). (Courtesy of the National Archives' Cartographic and Architectural Division, College Park, Maryland).

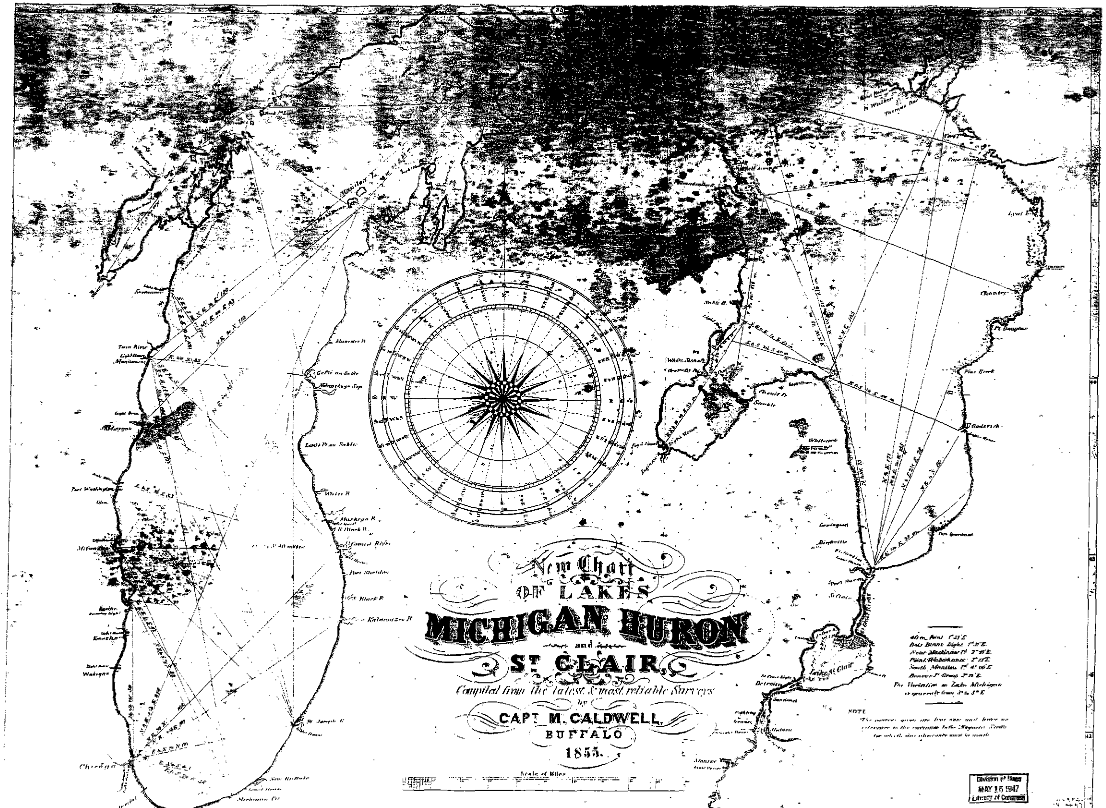


Figure 2-15. Chart of Lakes Michigan, Huron, and Saint Clair (1855). (Courtesy of the National Archives' Cartographic and Architectural Division, College Park, Maryland).

geographical location made them particularly prone to sudden weather changes, which were often accompanied by violent storms described as being every bit as "severe as any experienced on the Atlantic [and] responsible for the destruction of life and property."[110] Storms accompanied by high winds and large seas were particularly common on the lakes during the busy fall and early spring shipping seasons. Storms were especially dangerous to Great Lakes shipping because of the absence of protected inlets and harbors of refuge along some shorelines. Consequently, vessels frequently had to "ride out" the lake's most violent weather unprotected. Compounding this problem was the fact that, unlike the world's vast oceans, where mariners could endure storms usually without fear of running aground, the sea room of the lakes was limited. As a result, vessel collisions and groundings were commonplace. Another less well known navigational hazard of the lakes was the peculiar variation observed in compasses, not just on different parts of the lakes, but on different types of lake vessels as well. Such variations are described by Captain Thompson in the 1863 edition of *The Coast Pilot for the Lakes*:

> I find great difference in compasses on these Lakes; hardly two will agree. In going from a (sailing) vessel into a propeller or steamboat, the difference is seen immediately; and I fear that many accidents to boats and vessels have happened from this cause - not knowing how your compasses will lead you. There is no remedy for this difference, except by constant running on a route, when you will find out how your compasses will lead you; and by strict observation, the use of the LEAD [emphasis original], and a good look-out, you may run with safety in all pilotable waters.[111]

For trips from Buffalo to Detroit, *Indiana* would have been steered W-SW upon leaving Buffalo harbor on a heading towards Long Point, Ontario, on a true compass bearing of 250°. While making the nearly 50-mile (80.46-km) transit from Buffalo to Long Point at night or in the fog, the vessel's crew and master had to maintain a vigilant watch for the

> ...fleet of vessels wending their way towards Buffalo or the mouth of the Welland Canal, through which channel annually passes a great number of steam propellers and sail vessels on their way to Lake Ontario and the St. Lawrence River.[112]

When the lighthouse at the eastern end of Long Point finally came into view, the crew used the well-known reference point to verify their location. After passing the Long Point light, the captain maintained his W-SW course for approximately 110 additional miles (177.02 km), proceeding for most of this distance in British-Canadian waters. Towards the end of this second transit leg, the crew scanned the horizon ahead of them for yet another light to steer towards, the one located at the northernmost tip of Point Pelee Island. Once the Point Pelee Island light was in view, *Indiana*'s captain adjusted his course to a W-NW heading of 290-300°. On approaching the northern point of Point Pelee Island, the captain had to be particularly careful not to head too far northward, or he would risk running aground on the dangerous shoal extending south of Point Pelee. This course, the third leg of the journey to Detroit, was maintained for approximately 30 miles (48.28 km), until passing Pigeon Bay and coming up on Bar Point, located at the mouth of the Detroit River. For the final leg of the journey, ending at Detroit, most steam vessels ran up into the Detroit River through the eastern or "British" channel, then crossed over to the western side of the river, passing between Fighting and Grosse Islands, and followed the center of the river up to Detroit.[113]

Departing from Detroit for points north and west, *Indiana* would continue up the remainder of the Detroit River, passing to the east of Hog Island (present-day Belle Island) before crossing over to the west bank, between Hog Island's northern tip and the southern tip of Peach Island (present day Peche Island). Travelling past Grosse Point, *Indiana* emerge out onto shallow Lake Saint Clair, where water depths ranged from eight to 24 feet (2.44 to 7.32 m).

Upon reaching Lake Saint Clair, a heading of E-NE was maintained for two to three miles (3.2 to 4.8 km) out onto the lake, before turning N-NE towards the Point Huron stake 18 miles (28.97 km) away. Once at the stake, the course was changed yet again to N by E and maintained for a distance of five miles (8.5 km) up to the infamous Saint Clair "flats." These shoals or flats represented an "almost impassible...ruinous and destructive" obstacle to commerce between the lower and upper lakes, and they limited the maximum draft of vessels engaged in business above Detroit to about seven feet, six inches (2.3 m) (Fig. 2-16).[114] Since most vessels on the lakes drew more than that when fully loaded, it was impossible for them to pass over the flats without lightering.[115] Ironically, as one observer noted in 1846, the lakes' lowest water levels corresponded with the two periods of their greatest commercial activity: spring and fall. The same person also identified the flats as a particularly hazardous feature of the Great Lakes and described the severity of the problem they posed to shipping:

> ...steamboats and vessels are daily compelled, in all weather, to lie fast aground and shift their cargoes, passengers, and luggage into lighters, exposing life, health, and property to great hazard, and then by extraordinary heaving and hauling are enabled to get over [the flats]...[116]

Desperate to alleviate the bottleneck caused by the flats, a consortium of Great Lakes commercial men, including both steam and sail vessel owners, raised $30,000 worth of bond money and

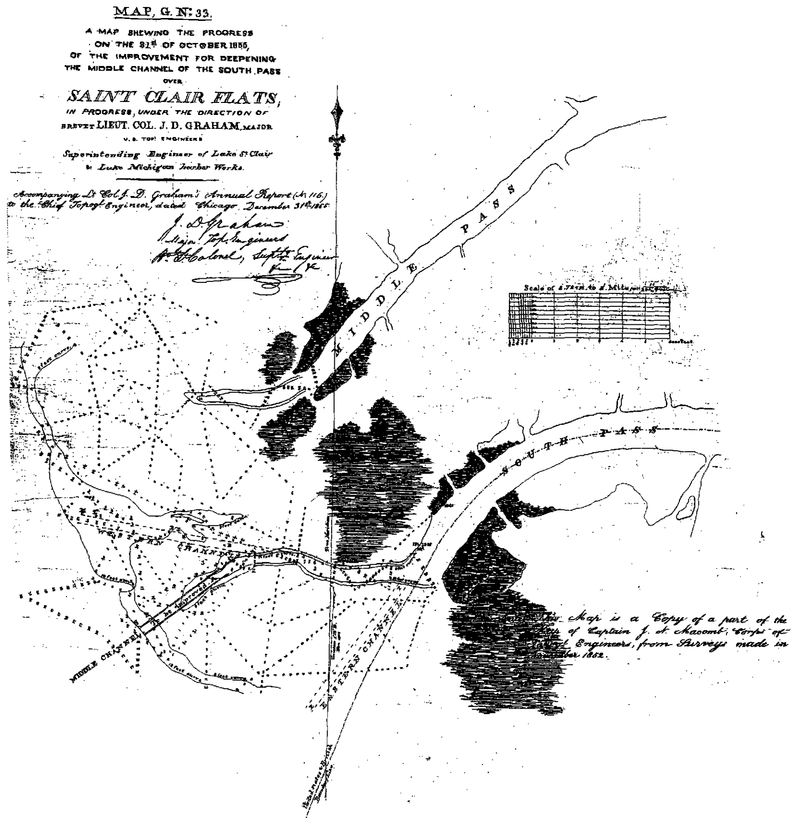


Figure 2-16. Bathymetric chart of the Saint Clair Flats depicting water depths over the Flats prior to completion of the 1855 channel dredging operations. (Courtesy of the National Archives' Cartographic and Architectural Records Division, College Park, Maryland).

obtained a steam dredge and an indeterminate number of mud scows from the Federal government to dredge and deepen the channel through the Saint Clair flats during the summer of 1846. The dredge (similar to the one in Fig. 2-17) and a scow were towed from Erie, Pennsylvania to the flats by steamboat. Once on site, a superintendent and a crew of 41 men worked unsuccessfully for two months to clear a channel through the flats.[117] Not until 1855 was a channel dredged successfully over the flats to a depth of 11 feet (3.35 m) (Fig. 2-18).[118] Significantly, this work occurred just several months after the completion of the Saint Mary's Falls canal at Sault Sainte Marie, Michigan, which opened Lake Superior to vessel traffic from the lower lakes. Also, it coincided with a marked increase in the size and number of screw-propelled vessels being constructed on the lakes. The depth limitations imposed by the shallow waters of Lake Saint Clair and the sand bars at the entrances of most of the harbors on the lakes directly affected the shape, depth, and size of the watercraft designed to navigate them. Furthermore, the navigational difficulties presented by the Saint Clair flats probably influenced *Indiana*'s operational activities to some degree and may have been one reason why *Indiana* spent most of its operational career on Lake Erie.

Once *Indiana* cleared the Saint Clair flats, the captain would have guided it up the Saint Clair River, towards Lake Huron. Generally speaking, navigation of the river was relatively easy as long as vessels were kept to the center of the river, where water depths averaged 40 to 50 feet (12.19 to 15.24 m). Elk or Stag Island, immediately north of Fort Saint Clair, could be passed on either side. Rapids on the river's American side, however, made running that channel particularly challenging, especially above Port Huron, where such rapids were simply unavoidable from either side of the river. Wood for refueling was available at several wharves on the Canadian side of the river.[119]

After reaching Lake Huron, *Indiana*'s captain would have steered N-NE for two-and-one-half miles (4.0 km) out onto the open waters of the lake before turning to a heading of N by W. The course was maintained for 73 miles (117.48 km), up to Point aux Barques, while keeping a minimum distance of one to one-and-one-half miles (1.61 to 2.4 km) from shore. From Point aux Barques, the course was adjusted slightly to N-NW and maintained for another 73 miles (117.48 km), up to Thunder Bay. In case of heavy westerly winds when crossing Saginaw Bay, vessels were "hauled well up" under the

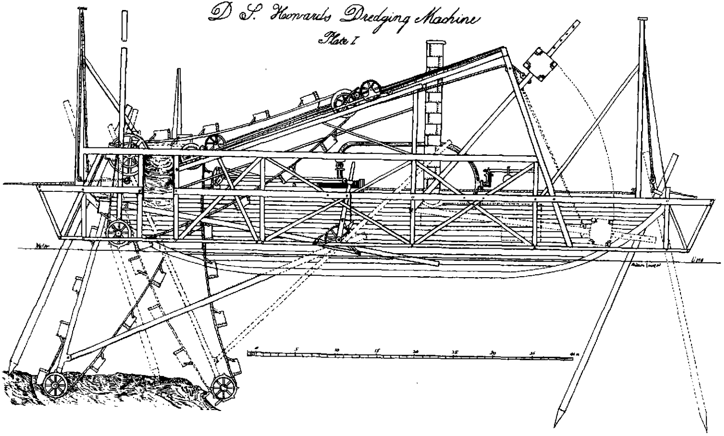


Figure 2-17. Contemporary depiction of the "dredging machine" used in 1855 at the Saint Clair Flats. (After Nystrom, "Description of a Dredging Machine Invented and Patented by D. S. Howard," Plate I).

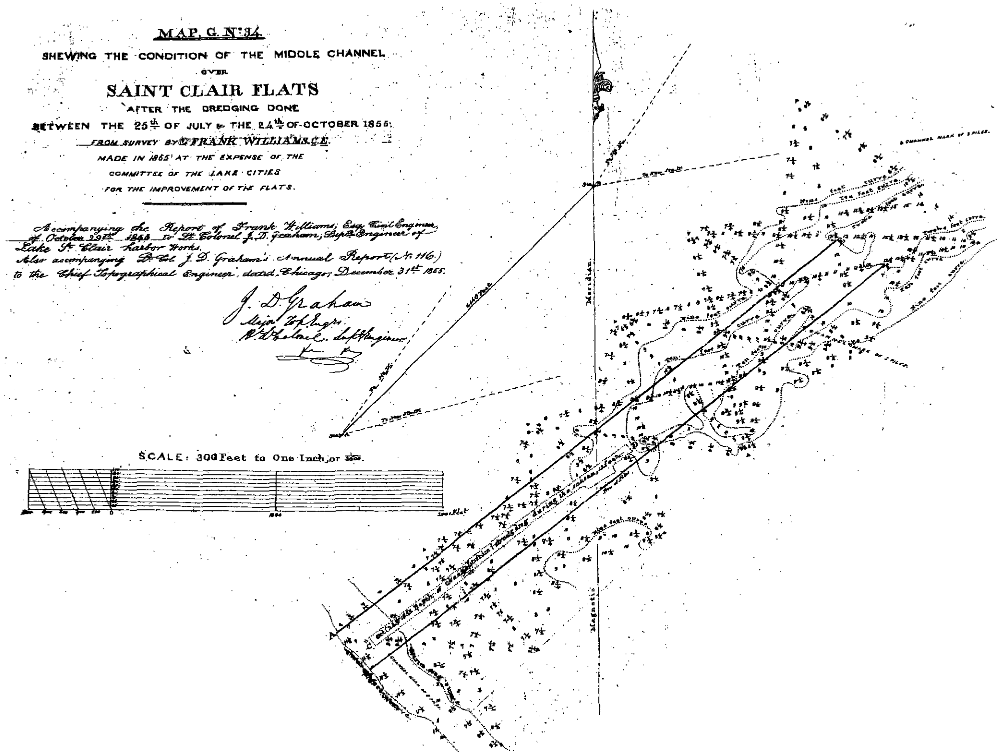


Figure 2-18. Bathymetric chart of the Saint Clair Flats following completion of the 1855 channel improvements. (Courtesy of the National Archives' Cartographic and Archictectural Division, College Park, Maryland).

highlands of Au Sauble, which could be approached to within two miles (3.22 km) of shore. From Thunder Bay, a course of NW by N was steered for approximately 30 miles (48.28 km) to Presque Isle. From Presque Isle, a course of NW by W 3/4 W was followed for 50 miles (80.46 km) to the entrance of the Straits of Michilimackinac (referred to today simply as the Straits of Mackinac). From the entrance of the Straits, *Indiana* was run on a westerly course until abreast of Cheboygan (Michigan), then NW by W 1/4 W for 16 miles (25.75 km) to old Fort Mackinac. From old Fort Mackinac, a course of W 1/4 S was followed for 18 miles (28.97 km) out onto Lake Michigan, to a point several miles N-NW of Waugoshance Point.

Once *Indiana* was out on Lake Michigan and had travelled several miles N-NW of Waugoshance Point, the helm was turned onto a SW 1/2 S course, which was held for 75 miles (120.7 km), until coming abreast of today's South Manitou Island and Sleeping Bear Point. From this point, a direct transit to Chicago could be made by following a S by W 3/4 W course for a distance of 218 miles (350.8 km). Return trips from Chicago to Detroit or Buffalo would simply follow in reverse order the routes described above.

The Final Years of *Indiana*'s Operational Career

At the conclusion of the 1855 season, Perew retired from his career on the lakes to devote himself completely to the management of his growing fleet of vessels. He appointed his former first mate, William McNally, as *Indiana*'s captain.[120] The 1856 season proved to be the most active of *Indiana*'s career, when the propeller travelled exclusively between Buffalo and Cleveland. In that year the vessel made approximately 45 round trips between the two ports, carrying such items as kegs of butter, barrels of eggs, barrels of flour, animal hides, live hogs, bundles of iron, barrels of lard, barrels of meal, merchandise, bushels of oats, barrels of pork, bags of rye, boxes of starch, barrels of whiskey, and bales of wool. On 22 of these trips, *Indiana* carried cargoes consigned to the Central Railroad.[121]

Indiana suffered only one minor misfortune during the 1856 season, when it ran aground off Point Abino, Ontario, on 27 September. The incident was reported in the *Buffalo Morning Express* for 29 September as follows:

> The propeller INDIANA bound from Cleveland for this port with a cargo of flour consigned to the Central Railroad, went ashore at about 6 o'clock Saturday morning at Point Abino, during a dense fog. A tug was dispatched during the morning to assist her off and after lightering her of some 360 bbls of flour, she was pulled off and came into port during the afternoon. She sustained no damage.

Once again, *Indiana* was fortunate to have run aground without incurring major damages. By contrast, when the barque *Jesse Hoyt* had run aground at Point Abino in December of 1854, it sustained extensive damages that amounted to $5,000.[122]

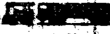
In 1857, *Indiana* was chartered again by the Buffalo, New York & Erie Railroad and spent the entire season transporting freight and, presumably, some passengers, between Cleveland and the railroad's northwest terminus at Dunkirk, New York.[123] Cargoes listed in the local newspapers' Marine Intelligence reports were extremely limited in their variety that year, and consisted of just one box of candles, 507 pounds of fish, and 602 tons of merchandise.[124] *Indiana* nearly completed the navigation season without mishap, until it struck Cleveland's west pier for the second time in its career on 21 October.[125] An account of the accident appeared in the *Detroit Daily Free Press* the next day:

> The propeller INDIANA, Capt. McNally, in coming into the harbor yesterday morning, got swung upon the west pier inside, and after remaining there till there was danger of being jammed to pieces, was towed in by the tug *Peter Smith*. The wind was in the North East, the vessel light, and she hugged the east pier too close. She is uninjured.

Although *Indiana* had reportedly escaped harm during the incident, Perew chose to put it in drydock at Cleveland for a general refitting.[126] Given that the average lifespan for a good steamboat on the Great Lakes was 10 to 12 years, it is not surprising that Perew wanted *Indiana*'s nine-year old hull refitted.[127] After the vessel underwent a nearly complete refitting during the winter of 1857-1858, Perew transferred its port of enrollment from Buffalo to Cleveland on 27 March 1858. His propeller, now valued "at about $13,000," was back in service.[128]

E. C. Bancroft, the Buffalo, New York & Erie Railroad Line's agent in Detroit, paid Perew $6,000 to charter *Indiana* for the 1858 season (Fig. 2-19).[129] In this capacity, *Indiana* ran briefly as a liner on a direct route between Buffalo and Detroit with the propeller *North America*, "receiving and delivering property to the Buffalo, New York & Erie Railroad at Buffalo, and to the Michigan Central and the Detroit & Milwaukee Railroads at Detroit, free of cartage charges."[130] Due to the sluggish post-depression economy following the infamous Panic of 1857, freighting business soon fell off, and Bancroft was forced to transfer *Indiana* to the People's Line, which he also represented.[131] The People's

BUFFALO, NEW YORK

 **1858.** 

And Erie Railroad Line.

THIS LINE HAVING PERFECTED ARRANGEMENTS for the safe, speedy and cheap transportation of property to and from

N. York, Boston & Philadelphia

is prepared to contract on as favorable terms as any other route, and would most respectfully solicit the patronage of Merchants, Millers, Shippers and the public generally, assuring them that all business entrusted to this Line shall be done to their satisfaction in every respect.

THE PROPELLERS

INDIANA & NORTH AMERICA

Will run regularly between

DETROIT AND BUFFALO DIRECT,

During the season, receiving and delivering property to the

BUFFALO, N. YORK & ERIE RAILROAD,

AT BUFFALO, AND

MICHIGAN CENTRAL RAILROAD,

AND

DETROIT & MILWAUKEE RAILROAD,

AT DETROIT, FREE OF CARTAGE CHARGES.

Arrangements for the transportation and accommodation

OF LIVE STOCK

Have also been made as favorable and expeditious as by any other route.

Also, with TWO (responsible and reliable) CANAL LINES for the transport of property on the Erie Canal to Albany, New York, and by the

WESTERN RAILROAD TO BOSTON.

Also, Boston freight, via NEW YORK CENTRAL RAILROAD, (if consigned.)

The undersigned, in resuming the Forwarding and Transportation business, in which he has been for the last ten years engaged, respectfully solicits the patronage of his old friends and patrons, assuring them he shall endeavor to merit and receive their patronage. Apply to

GEORGE DAVIS, General Agent.

Office No. 1, Courtlandt street, cor. Broadway, N. Y.

J. S. SHEAFE,

Buffalo, New York & Erie Railroad Office, Buffalo.

FOOTE, LITTLE & CO.,

Lloyd street, Buffalo.

PALMER & BECKWITH,

Merchants' Transportation Line, Buffalo.

HENRY M. BANCROFT,

General Agent, Buffalo.

☞ Be particular and mark Railroad goods "via Buffalo, care of J. S. Sheafe," and ship from pier New York and Erie Railroad, foot of Duane street, New York.

E. C. BANCROFT, Agent, Detroit,

Warehouse foot of Second St.

apr8 d&m

Figure 2-19. *Freighting agent E. C. Bancroft's 1858 newspaper advertisement for the propellers Indiana and North America providing direct service between Buffalo and Detroit for the Buffalo, New York & Erie railroad, the Michigan Central railroad, and the Detroit & Milwaukee railroad. (From the Detroit Free Press, 9 April 1858).*

Line thus employed a fleet of six propellers (*Indiana, Acme, Racine, Pittsburgh, Adriatic,* and *Globe*), all of which were utilized principally as freighters between Buffalo and ports on Lake Michigan.[132] Prior to commencing service with the People's Line, temporary arrangements were made with the Cleveland Iron Mining Company to charter *Indiana* for "a week or two" in early June to travel to Marquette, Michigan, to pick up a single load of iron ore.[133] On the upbound trip to Marquette, as *Indiana* was docking at Detroit on Saturday, 29 May, one of the deck hands, who was preparing to heave a line to shore, was "seized with a fit, fell overboard, and before he could be rescued, was beyond resuscitation."[134] Although tragic, the accident had little effect on the propeller's schedule, and *Indiana* departed from Detroit and continued the upbound voyage for Marquette several days thereafter.

On the way up, *Indiana* met the downbound steamer *Illinois* on Lake Huron, near Au Sauble, and later was observed towing the schooner *M. L. Sargent* through the canal at Sault Sainte Marie.[135] Captain John Spaulding, of the propeller *Northern Light,* noted that *Indiana* arrived at Marquette late Wednesday night, on June 2, just as he was leaving there.[136]

The development of the Lake Superior iron ore industry marks an important era in the history of the American iron trade, and until about 1877, the mining of iron ore in the Lake Superior region was confined to the territory in the immediate vicinity of Marquette.[137] In 1850, the first shipment of Lake Superior iron ore, which consisted of about five tons packed in barrels, was sent to Pennsylvania via the lakes.[138] In 1858, a total of 15,876 gross tons of iron ore had been shipped; five years later, the total had grown to 203,555 gross tons. By 1873, the amount had reached 491,449 tons.[139] Iron was being consumed faster than it could be mined for the construction of railroads and their cars and locomotives, iron ships and their boilers and steam engines, and iron bridges. Clearly, Marquette represented the epicenter of an industry that was rapidly becoming the world's largest of that era. The town played a vitally important role in the development of American civilization and the advancement of the United States as a nation of greatness and power.[140]

When *Indiana* arrived at Marquette in June 1858, both the town and its iron industry were still in their developmental infancy. In fact, the lakeside mining village that greeted *Indiana*'s crew and passengers on the night of 2 June consisted of just two churches, a large hotel, several taverns and stores, several iron mines and about 1,000 citizens (Fig. 2-20).[141] At the time, Marquette's iron mines, including one of its first and largest, the Cleveland Iron Mining Company mine, were yielding approximately 80 percent pure iron, which was being exported in increasingly large quantities to Detroit,

Figure 2-20. Rare circa 1858 photograph of the Marquette waterfront taken from Ripley's Rock (visible in foreground). Pier on the left side of the photograph is that of the Cleveland Iron Mining Company and was *Indiana*'s point of departure on its final voyage. (Photo courtesy of the Marquette County Historical Society).

Cleveland, and Pittsburgh.[142] Because of its proximity to Lake Superior's ore fields via the lakes and to Ohio's own coal fields, Cleveland was a common destination for iron ore shipments from Marquette, and it eventually became one of the country's most prominent iron and steel production centers. A strap railroad for trains of four-ton capacity flatcars connected the mines, which were located four to twelve miles (6.44 to 19.31 km) from downtown, with a small pier at Marquette's harbor (Fig. 2-21).

During the three days *Indiana* spent at Marquette, a portion of the propeller's crew would have been paid approximately 25 cents per hour, in addition to their ordinary wages, to load iron ore onto *Indiana* from the small rail cars on the dock, using wheelbarrows (Fig. 2-22).[143] Because of the extreme weight and inherent difficulty involved in removing the ore from the hold, a large quantity of it was loaded onto *Indiana*'s deck, a work-saving method that was employed for many types of cargo and was common during the period.[144] Although this loading method saved time and effort, deck loading often proved to be a dangerous practice, particularly with iron ore, because it made vessels excessively top-heavy and could not be jettisoned quickly. As shipments of iron ore increased and bulk-freight carrying vessels began being designed and built specifically for the ore trade, the practice of loading iron ore on deck was abolished. Instead, it was stored properly below-decks, in the hold.[145] Despite the hazards of deck-loading iron ore, which are recognized today, this practice had little to do with *Indiana*'s loss on the evening of 6 June 1858 while down-bound from Marquette to Cleveland.

Within one week of *Indiana*'s sinking, published reports began appearing in local newspapers such as the *Cleveland Morning Leader*, the *Detroit Daily Free Press*, and Ontonagon's *Lake Superior Miner*. Although no one particular source was credited with the published accounts of the sinking, portions of these reports had apparently been obtained directly from *Indiana*'s crew and passengers upon their arrival at Detroit on Friday afternoon, 11 June, on the propeller *Iron City*. The *Detroit Daily Free Press* for 12 June 1858, gave the following account of *Indiana*'s loss:

TOTAL LOSS OF THE PROPELLER *INDIANA* ON LAKE SUPERIOR

> The propeller *Iron City* came in yesterday afternoon, bringing the intelligence of the sinking of the propeller *Indiana* on Lake Superior last Sunday evening, and fetching down the crew. The *Indiana* had been employed in the People's line during the spring, but as freights were dull, she was chartered about a week since to go to Marquette for a load of iron. She left that place early Sunday morning with a cargo of 280 tons of iron for the Cleveland Iron Mining Co. About 8 o'clock the same evening, when about 40 miles above Whitefish Point, and 10 miles from shore, she broke the stuffing box of her shaft, and this occasioned the splitting of her sternpost, when she began to fill very fast. In about 15 minutes the fires had become extinguished, and

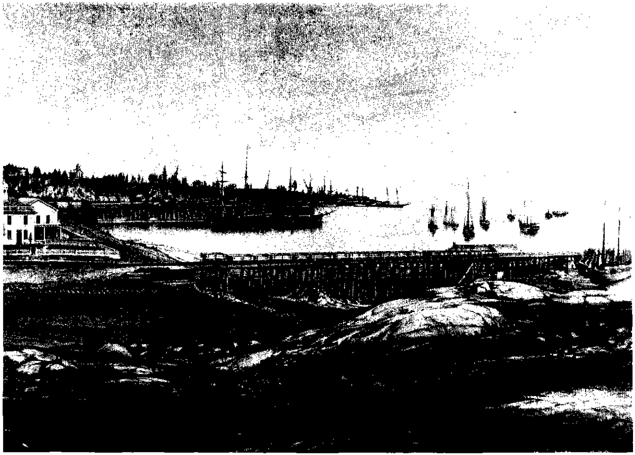


Figure 2-21. Cleveland Iron Mining Company's pier at Marquette, Michigan, circa 1858. Note the rail cars on the pier in which iron ore from the company's mines was transported to the waterfront for shipment. (Courtesy of the Marquette County Historical Society).

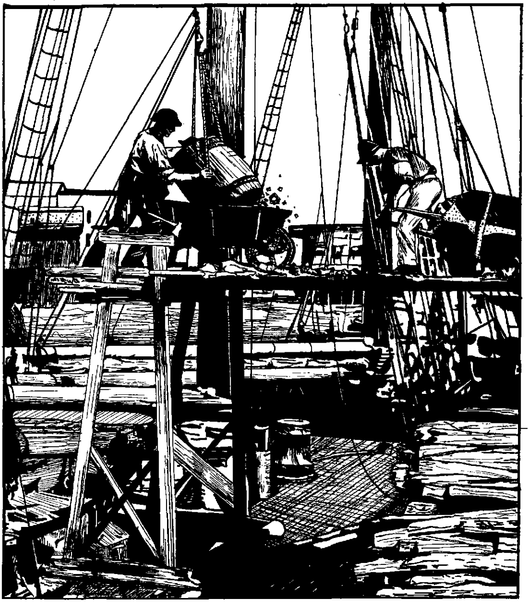


Figure 2-22. Using wheelbarrows to unload bulk cargo. (Drawing by Adam Loven).

> she had settled to her guards. The crew consisted of 17 men all told, and there were 4 passengers including, Mr. Frank Perew, of Cleveland, the owner of the boat, thus making 21 persons on board. They lowered the two boats, but one of them swung around violently against the propeller, knocking a hole in her bottom, rendering her nearly useless. The whole number, however, were accommodated in the two boats, and after they had embarked in them, a line was attached to the propeller and they started to tow her ashore. After working for some time, it was found to be useless and they cut loose and rowed away, leaving her to her fate. The lights were seen for a long time after they left the vicinity, but it is probable that the upper deck was detached from the hull. At the rate at which she was filling she must have sunk in a very short time. The propeller *Mineral Rock* and the schooner *St. Paul*, which passed the place within the next day or two, reported having seen large portions of the wreck, and this fact goes to confirm the opinion that the upper works must have floated off. The water in the vicinity was 60 fathoms deep.
>
> The crew reached the shore in the course of a couple of hours, and camped out for the night. Monday morning they fixed up a sail with a table cloth and some other pieces of cloth, and bore away for Whitefish Point. In the course of the afternoon, the lake became so rough that they were obliged to land and remain until the next morning. Tuesday night they reached the Point, and Wednesday morning the schooner *St. Paul*, on her way down, took them off and brought them to the Sault. Thursday the *Iron City* took them on and brought them down to this city.
>
> The *Mineral Rock*, on her way up on Monday, discovered many fragments of the wreck, and not having met the *Indiana* as expected, suspicions of the truth were excited. She met the *Iron City* at Marquette, and the latter on the voyage down turned aside from her course, and coasted along in the expectation of finding the crew on shore. They, however, had already been taken on board of the *St. Paul*, as already stated.
>
> The *Indiana* was extensively refitted and repaired last winter, and was valued at about $12,000. She was owned by Frank Perew, of Cleveland, but had been chartered for the season by E. C. Bancroft, of this city, for $6,000. She was insured for $9,000, of which $2,300 was in the Northwestern, and the remainder divided between the Mercantile of N.Y., and the Toledo Mutual.

Additional details of *Indiana*'s sinking arrived at Ontonagon, Michigan, with the upbound vessels *Mineral Rock* and *North Star*, whose crews appear to have been the first to see *Indiana*'s floating wreckage. Their accounts were published in Ontonagon's *Lake Superior Miner* on 12 June 1858, which read, in part, as follows:

> PROBABLE WRECK OF PROPELLER
>
> The propeller *Mineral Rock*, Redman Ryder Master, which arrived at this port on Thursday Morning, reports having passed portions of what seemed to be the wreck of a propeller, off Whitefish Point, on her passage up on Tuesday last. The main part of the wreck had the appearance of some 50 feet of the upper deck, with two of the fenders thrown across it in such a manner as to induce Capt. Ryder to believe that she had blown up. Should these painful surmises be correct they doubtless tell the sad fate of the propeller *Indiana*, as she was the only boat on that part of the lake at the time...having left Marquette at 7 o'clock Sunday morning.
>
> The *Indiana* was commanded by Captain McNally, of Cleveland, and her first engineer was also a Clevelander, a Mr. Perew; Francis Perew one of the proprietors of

> the boat, and L. C. Tibbets, both from Cleveland; S. Gales, of Silver Creek; and Samuel Burt, of Marquette, constituted as far as we could learn, her list of passengers...The *Indiana* having towed the *Sargent* through the canal on her way up...Officers of the *Mineral Rock* kept a sharp lookout with the glass and ran around the main portion of the floating wreck and noticed a winch different from those now in common use on such boats, and the precise kind as *Indiana* had.
>
> Since the above was in type, the arrival of the *North Star* furnishes the following additional particulars concerning the wreck: the propeller *Indiana* was moving at a moderate rate, with the wind aft and some sea, but not enough to render her condition at all precarious. When a few miles off White Fish Point, on Sunday evening, she sprung a leak of so great dimensions that within a half an hour she was entirely submerged in 40 fathoms of water, the passengers and crew having barely time to save themselves and a few necessaries from the wreck. They took to the small boats and were all saved. They hailed a schooner which left Marquette on the same morning, and went with her to the Soo [Sault Sainte Marie], where officers of the *Star* saw and conversed with them. It is reported that the *Indiana* was insured, but this is only a rumor, and may or may not be reliable.

The sinking of *Indiana* reportedly marked the first loss on the lakes of a cargo of Lake Superior iron ore.[146] Newspaper accounts of the sinking reported that the propeller had gone down in 40 to 60 fathoms (73 to 110 m) of water.[147] It was perhaps because of these reports, as well as *Indiana*'s advanced age, the relatively low value of its bulk cargo, and the remoteness of its wreck site, that no reported attempts were made to salvage any portion of *Indiana*'s machinery, hull, or cargo. On October 16, 1858, four months after the sinking, *Indiana*'s final enrollment papers were surrendered at Cleveland, and the story of its loss began fading from the public's collective memory.[148]

Recent Investigations of *Indiana*

Since *Indiana*'s discovery in 1972, the wreck site has been a focus of research for numerous individuals, agencies, and institutions. *Indiana*'s wreck site has also been a popular destination for sport divers, who, unfortunately, have removed virtually all of the portable artifacts from the site over the twenty-six years since the discovery of the wreck. Research undertaken by Wright and Labadie during the mid-1970s (described earlier in Chapter 1) ultimately led to the active involvement of the Smithsonian Institution in the salvage and subsequent study of *Indiana*'s propulsion machinery between 1979 and 1990. Smithsonian staff first learned of *Indiana* in 1978, when Wright and Labadie consulted with the museum while preparing the National Register Nomination Form for the vessel. Shortly thereafter, the Smithsonian embarked on a campaign to recover *Indiana*'s unique power plant for study and exhibition in the Smithsonian's National Maritime Museum's Hall of Maritime Enterprise.

Plans for salvaging *Indiana*'s propulsion machinery were formulated late in 1978 and early 1979 in consultation with the State of Michigan, the National Trust for Historic Preservation, and the National Council on Historic Preservation.[149] Salvage operations were conducted over a ten-day period in late July and early August of 1979 by a project team composed of personnel from the Smithsonian Institution, Bowling Green State University, the Michigan Division of History, the U.S. Army Corps of Engineers, and the U.S. Navy.[150] *Indiana*'s discoverer, John Steele, and several of his associates also joined the team and provided supplemental logistical support during the project. The Smithsonian's project staff was led by Museum Specialist John L. Stine, who also served as the overall director of the salvage operation. Underwater work was performed by U.S. Navy divers deployed from Harbor Clearance Unit Two, Little Creek, Virginia, and a team of diving reservists from Chicago. The U.S. Army Corps of Engineers provided topside support and the project's work platforms, which consisted of the derrick barge *Coleman*, the tug *Lake Superior*, and the tender *Bayfield* (Fig. 2-23).[151] By the end of the project, the crew had successfully recovered *Indiana*'s engine, boiler, propeller, rudder and steering quadrant, and a number of other hull components, all of which were immediately transported to the Smithsonian Institution for conservation, study, and display (Fig. 2-24).

Additional work on *Indiana* was sponsored by the Smithsonian between 1980 and 1984. Over five summers, a small team of divers working under Stine's direction revisited the wreck site to recover several machinery components left behind during the previous year's salvage project. During this time, Steele and his associates also retrieved a safe that contained a coin, a small clasp, and a medicine bottle, as well as an assortment of miscellaneous parts and tools associated with *Indiana*'s propulsion system (Fig. 2-25). At the direction of the State of Michigan, the team also began measuring and photodocumenting various aspects of the hull.[152]

Documentation of *Indiana*'s engine and boiler was undertaken on a part-time basis by Stine and historic resources documentation specialist Richard K. Anderson, Jr. between 1981 and 1991. This ten-year long documentation effort resulted in a series of exquisitely detailed scale and perspective drawings, accompanied by a 31-page report describing the propulsion plant (Figs. 2-26, 2-27, and 2-28).[153]

Additional artifacts, such as *Indiana*'s capstan, bower anchor, and steam whistle, which were recovered by sport divers years before the Smithsonian's involvement with *Indiana*, were transferred to the museum for permanent curation and display during the early 1980s. In 1984, the capstan, anchor, steam whistle, propeller, and two feed water pumps were conserved and put on public display in a

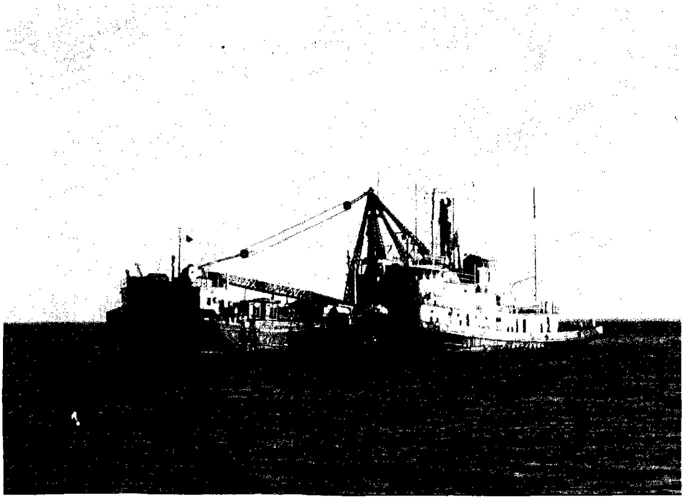


Figure 2-23. Salvage vessels anchored over *Indiana*'s wreck site during the 1979 project. (Photo courtesy of the Smithsonian Institution, NMAH).

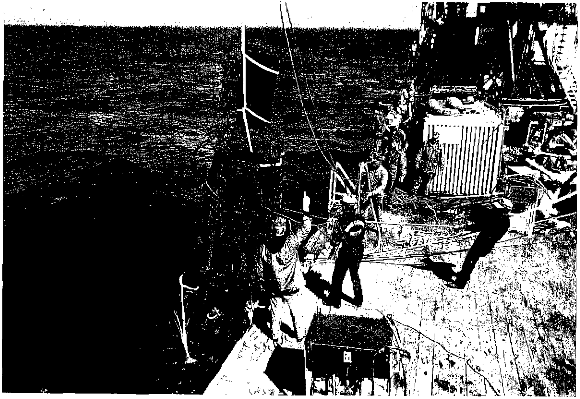


Figure 2-24. Recovery of *Indiana*'s engine. (Photo courtesy of the Smithsonian Institution, NMAH).

Figure 2-25. William Cohrs and John Steele with salvaged *Indiana* materials. (Photo courtesy of the Smithsonian Institution, NMAH).

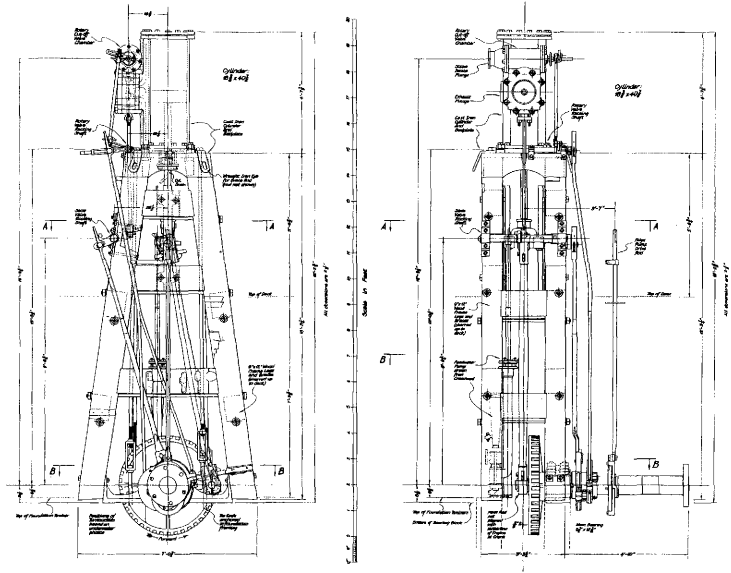


Figure 2-26. Elevation plan of *Indiana*'s engine. (Drawing by Richard K. Anderson, Jr., courtesy of the Smithsonian Institution, NMAH).

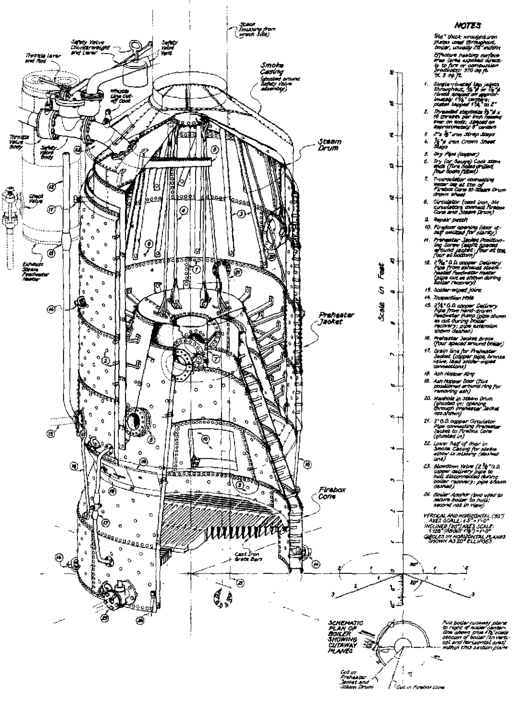


Figure 2-27. Isometric plan of *Indiana*'s boiler. (Drawing by Richard K. Anderson, Jr., courtesy of the Smithsonian Institution, NMAH).

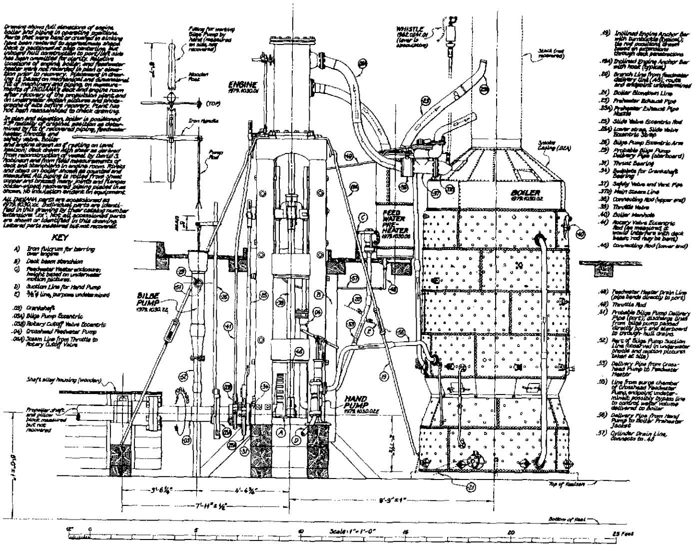


Figure 2-28. Elevation plan of *Indiana*'s power plant. (Drawing by Richard K. Anderson, Jr., courtesy of the Smithsonian Institution, NMAH).

permanent exhibit established in the Smithsonian's National Museum of American History's Hall of American Maritime Enterprise (Fig. 2-29).

Also in 1984, Frederick M. Hocker, now a professor in the Nautical Archaeology Program at Texas A&M University, was working as a summer intern at the Smithsonian and conducted archival research to identify the manufacturer of *Indiana*'s machinery. Although the specific source for *Indiana*'s machinery proved elusive, Hocker's report, outlining the results of his research, did provide an inventory of steam engine manufacturers in the Great Lakes region and several helpful suggestions for future research on the subject.[154]

Between 1985 and 1988, documentation of *Indiana*'s propulsion plant continued, but little else was undertaken on the project. Efforts to conserve and exhibit *Indiana*'s power plant had stalled because of funding constraints and unanticipated space limitations at the museum. Stine retired from his position with the Smithsonian and professor Wright passed away unexpectedly, leaving the *Indiana* Project without leadership, funding, or direction.

The *Indiana* Project was "reborn" in May 1989, when Stine, who had continued working at the museum part-time as a volunteer, introduced the then newly-hired Director of the Smithsonian's Hall of Maritime Enterprise, Dr. Paul F. Johnston, to the project. An archaeologist by training and an outspoken advocate for the preservation of submerged cultural resources, Johnston was intrigued by *Indiana*'s research potential. That summer, he made several reconnaissance dives on the wreck with John Steele to determine whether additional documentation was necessary for producing a final report on the project. Johnston concluded from these reconnaissance investigations that the wreck was in excellent condition and that additional recording of the hull and site was indeed necessary.

In the fall of 1990, Johnston contacted Dr. Kevin J. Crisman, professor of Nautical Archaeology at Texas A&M University, for his advice and assistance in undertaking an archaeological study of *Indiana*. This conversation led to an introduction to the author, whom Johnston subsequently invited to use *Indiana*'s archaeological reconstruction as a Master's thesis topic.

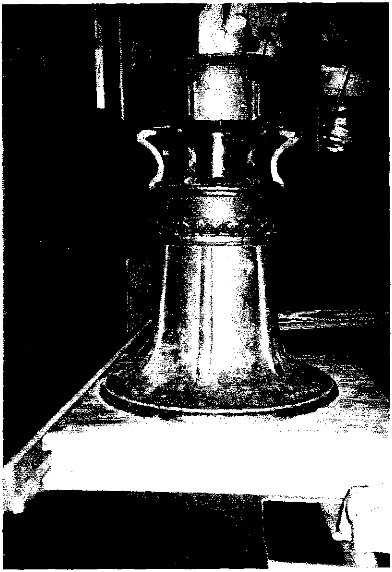


Figure 2-29. *Indiana's* capstan on exhibit in the Hall of American Maritime Enterprise at the Smithsonian Institution's National Museum of American History. (Photo by David S. Robinson).

Notes: Chapter II

1. Although *Indiana* was enrolled first at Sandusky, Ohio, the port of Vermilion, Ohio is listed as the location where the vessel was constructed. National Archives and Records Services, Washington, DC, Civil Reference Branch, Record Group 41, Records of the Bureau of Marine Inspection and Navigation: Abstracts of Enrollment and Certificates of Enrollment (hereafter NARG-41) for the port of Sandusky, Ohio (1847-1856), Microfilm of Great Lakes Records,15E-3, Row 11/33, Drawer 2, Roll 1.

2. Harlan Hatcher, *The Great Lakes* (New York, NY, 1944), 176.

3. Hatcher, *ibid.*; George Brown Tindall, *America: A Narrative History* (New York, NY, 1984), 251.

4. Hatcher, *ibid.*; Thomas A. Smith, "The Firelands and the Settlement of Vermillion," *Western Reserve Magazine* (April/May 1980), 37.; Thomas A. Smith, Oulanie Thepy*: The Golden Age of Harbour Town, Vermillion, 1837 to 1879* (Perrysburgh, OH, 1973), 47.

5. Hatcher, *ibid.*

6. Hatcher, *ibid.*; Smith, *ibid.* (1980), 38, 39.

7. Smith, *ibid.*; William Cronon, *Nature's Metropolis: Chicago and the Great West* (New York, NY, 1991), 29, 110; Tindall, *ibid.*, 452, 453; Douglass C. North, *The Economic Growth of the United States, 1790-1860* (Englewood Cliffs, NJ, 1961), 245; Marvin A. Rapp, *The Port of Buffalo, 1825-1880* (Durham, NC, Duke University, unpublished dissertation, 1947), 25.

8. Hatcher, *ibid.* The author also noted Vermilion's similarity to the small towns of coastal Connecticut when he visited there in January 1993.

9. Hatcher, *ibid.*, 177.

10. Smith, *ibid.* (1980), 39.

11. *Ibid.*, 42.

12. *Ibid.*

13. *Ibid.*; Smith, *ibid.* (1973), 10.

14. Smith, *ibid.* (1973).

15. Smith, *ibid.* (1980), 43.

16. Smith, *ibid.* (1973), 10, 11.

17. Smith, *ibid.*, 11.

18. Smith, *ibid.*; Betty Trinter, *The Way It Was: Vermilion, 1807-1984* (New Washington, OH, 1984), 43.

19. Diane Chesnut, Personal Communication; Smith, *ibid.* (1973).

20. Crisfield Johnson, compiler, *History of Cuyahoga County, Ohio* (Cleveland, OH, 1879), 333.

21. *Ibid.*

22. *Marine History: The Lake Ports* (Detroit, MI, 1877), 120; *Cleveland* (Chicago, IL, 1918), 277.

23. Johnson, *ibid.*, 339.

24. *Ibid.*

25. Alva Bradley, *Ancestors and Descendants of Morris A. Bradley* (Cleveland, OH, 1948), 37-39.

26. *Ibid.*

27. *Cleveland, ibid.*

28. Smith (1973), *ibid.*, 34.

29. *Ibid.*, 24.

30. *Ibid.*, 18.

31. Bradley, *ibid.*

32. Richard J. Wright, *Indiana* history notecards with attached comments page (Xeroxed) (Washington, DC, Smithsonian Institution, National Museum of American History, Division of Transportation, *Indiana* files. n.d.), n.p.

33. Mark Goldman, *High Hopes: The Rise and Decline of Buffalo, New York* (Albany, NY, 1983), 105-106; Rapp, *ibid.*, 169.

34. Bradley and Cobb's Vermilion-built vessels were constructed on the west bank of the Vermilion River where the river enters into Lake Erie. Bradley, *ibid.*

35. Smith, *ibid.* (1973), 20.

36. NARG-41 for the ports of: Sandusky, OH (1847-1856), Microfilm of Great Lakes Records,15E-3, Row 15/5, Drawer 2, Roll 1, no. 9; Buffalo, NY (1850-1855), Microfilm of Great Lakes Records,15E-3, Row 11/33, Drawer 1, Roll 3, nos. 30, 32, 133, and 62; Buffalo, NY (1855-1859), Microfilm of Great Lakes Records,15E-3, Row 11/33, Drawer 1, Roll 4, no 43; and Cleveland, OH (1855-1860), Microfilm of Great Lakes Records,15E-3, Row 11/33, Drawer 1, Roll 3, no. 6. No Master Carpenter's Certificates exist in the National Archives for Sandusky, OH prior to 1862. Angie Spicer-VanDereedt, Personal Communication.

37. C. Patrick Labadie, Personal Communication; C. T. McCutcheon, Jr., Personal Communication.

38. C. Patrick Labadie, Personal Communication.

39. C. T. McCutcheon, Jr., "*Alvin Clark*: An Unfinished Voyage," *Wooden Boat Magazine*, vol. 52, no. 3 (1983), 52-58. See also: Sam Manning, "The *Alvin Clark* Revisited," *Wooden Boat Magazine*, vol.

52, no. 3 (1983), 66-68; and Peter H. Spectre, The *Alvin Clark*: The Challenge of the Challenge," *Wooden Boat Magazine*, vol. 52, no. 3 (1983), 59-65.

40. "Hull Lines of the 1853 Great Lakes Schooner *Vermont*," Historic American Merchant Marine

Survey (HAMMS), Survey No. 14-12 (Washington, DC, Smithsonian Institution, National Museum of American History, Division of Transportation, n.d.).

41. Julius F. Wolff, Jr., *Lake Superior Shipwrecks* (Duluth, MN, 1990), 265; NARG-41 for the port of Sandusky, OH (1847-1856), Microfilm of Great Lakes Records,15E-3, Row 11/33, Drawer 2, Roll 1, no. 9.

42. *Ibid.*

43. *Ibid.*

44. Thomas Drew Stetson, "The Bee-Hive Boiler of Lake Erie," *Journal of the Franklin Institute*, ser. 3, vol. 27 (1854), 356-358.

45. Ahira Cobb's great-grandson, Carl B. Cobb, owns Ahira Cobb's personal ledger and supplied the Smithsonian with Xeroxed copies of the portion of the ledger containing references to *Indiana*. (Washington, DC, Smithsonian Institution, National Museum of American History, Division of Transportation, *Indiana* files).

46. Editors, *The National Cyclopædia of American Biography*, vol. 22 (New York, NY, 1932), 446, 447 (entries for John Weakley Chalfant and Henry Chalfant); James M. Swank, *A History of the Manufacture of Iron in All Ages* (New York, NY, 1965), 229.

47. Donald R. Dohrmann, *Screw Propulsion in American Lake and Coastal Steam Navigation 1840-1860, a Case Study in the Diffusion of Technological Innovation* (New Haven, CT, Yale University, unpublished dissertation, 1976), 75, 76. See also Edwin T. Freedley, *Philadelphia and Its Manufacturers* (Philadelphia, PA, 1859), 318, and David B. Tyler, *The American Clyde* (Newark, DE, 1958), 7.

48. *Ibid.*, 76.

49. Donald Canney, *The Old Steam Navy: Frigates, Sloops, and Gunboats, 1815-1885*, vol. 1 (Annapolis, MD, 1990), 27; Cedric Ridgely-Nevitt, *American Steamships on the Atlantic* (Newark, DE, 1981), 202. The *Buffalo Commercial Advertiser* for 16 January 1845 reported, "the machinery now adopted by Loper seems to be most approved."

50. Ridgely-Nevitt, *ibid.*, 189, chapter endnotes.

51. Vermilion had no newspaper until 1876, when the weekly *Vermilion Bugle* began publication. Trinter, *ibid.*, 32.

52. Although the first Great Lakes propellers were built on and around Lake Ontario, after 1845, most propellers were being constructed at ports on and around Lake Erie, principally in northern Ohio (i.e., Black River [OH], Buffalo [NY], Cleveland [OH], Detroit [MI], Fairport [OH], Huron [OH], Maumee [OH], Milan [OH], Perrysburgh [OH], Port Huron [MI], and Vermilion [OH]). C. Patrick Labadie and David S. Robinson, compilers, *Great Lakes Screw-Propellers:1841-1851* (unpublished manuscript, 1993). Two-thirds of the propellers built on the lakes prior to 1860 were constructed at Buffalo and Cleveland, which ranked first and second in the total tonnage of propellers being built in the United States. Dohrmann, *ibid.*, 15.

53. NARG-41 for the port of Sandusky, OH (1847-1856), Microfilm of Great Lakes Records,15E-3, Row 11/33, Drawer 2, Roll 1, no. 9.

54. In addition to the obvious health implications, *Indiana*'s avoidance of cholera-stricken Sandusky was

also a wise choice from an economic standpoint. During cholera epidemics on the lakes, vessels entering the port of Buffalo had to stop at the harbor's entrance, and the passengers and crew had to pass a medical inspection before the vessel was allowed into the harbor by the Harbor Master. Vessels ignoring this protocol, or those that were determined by the Buffalo Common Council (overseer of the city's Committee on Wharves and Piers which had jurisdiction over the harbor) to be carriers of "pestilential or infectious disease" were fined $50 and invoiced for any additional costs. Rapp, *ibid.*, 253, 266, 267. *The Ohio Guide, American Guide Series Illustrated* (New York, NY, 1943 [1940]), 310. At the height of the cholera epidemic, between July and September 1849, 400 Sandusky residents succumbed to the disease. Trinter, *ibid.*, 50.

55. Alva Bradley served as *Indiana*'s master for the 1848-1850 navigation seasons before he stepped down from the position and was replaced by A. B. Conkey. Conkey commanded *Indiana* from April to July of 1851 and was then replaced by Captain Kline, who served as *Indiana*'s master for the second half of the 1851 navigation season (July-November). Gerald C. Metzler, compiler, *Partial List of* Indiana*'s Voyages and Cargoes, Based on Newspaper Marine Intelligence Reports* (Washington, DC, Smithsonian Institution, National Museum of American History, Division of Transportation, *Indiana* files, unpublished manuscript, n.d.).

56. *Buffalo Morning Express*, 28 April 1851.

57. According to Albion, in respect to their functions, merchant vessels might be divided into three general categories: transient ship, regular trader, and liner or packet. Transient or "tramp" vessels picked up cargoes wherever they might be found, carried them wherever business directed them at that moment, and traveled between different ports for a year or more without visiting the same one twice. Regular traders, in contrast, were generally limited to trade between two or more particular ports, and, unlike liners, were operated as individual units that did not usually conform to fixed schedules. Such vessels were usually owned by general commercial firms, to whom shipping was a side line. Regular traders carried the firm's own goods and, when possible, filled the remainder of the hold with the goods of others. Usually two or more partners owned such a ship jointly and occasionally two firms would join in ownership, although no one firm usually owned more than three such vessels. Despite their name, the schedules of the regular traders were characteristically irregular. Liners, on the other hand, traveled on fixed schedules and on standard routes between two or more points. Robert Greenhalgh Albion, *Square Riggers on Schedule: The New York Sailing Packets to England, France, and the Cotton Ports* (Princeton, NJ, 1938), 15-18.

58. Metzler, *ibid.*

59. *Ibid.*; James C. Mills, *Our Inland Seas: Their Shipping and Commerce for Three Centuries* (Cleveland, OH, 1976 [1910]), 145.

60. Mills, *ibid.*

61. Metzler, *ibid.*; David S. Robinson and Hayley C. Robinson, "Preliminary Analyses of the Early Great Lakes Propeller *Indiana*'s Cargoes and Commercial Activity, 1848-1858" (unpublished manuscript, 1991), n.p.

62. Mills, *ibid.*

63. Hunter notes that the average lifespan of western steamboats (i.e., river boats and those of the Great Lakes) in 1860 was very brief (only 5 years) as compared to 8.66 years for eastern steamers and 20 to 30 years for sailing vessels. He also provides a particularly illuminating passage, quoting Joel R. Poinsett's response to a query by Alexis de Toquecville, regarding the short lives of American vessels. The contents of this passage may explain, in part, Bradley and his associates' decision to sell *Indiana*

only four years after they had commissioned its construction. The quote, which refers to eastern steamboats and is, according to Hunter, equally applicable to western steamers, reads as follows: "What makes our ships last such a short time is the fact that our merchants often have little disposable capital at the beginning. It's a calculation on their part. Provided the vessel lasts long enough to bring them in a certain sum, a surplus over the cost, the end is obtained. Besides there is a general feeling among us that prevents our aiming at the durable in anything: there reigns in America a popular and universal faith in the progress of the human mind. They are always expecting that improvements will be discovered in everything, and in fact they are often right. For instance, a few years ago I asked the builders of steamboats for the North River why they made their vessels so fragile. They answered that, as it was, the boats would probably last too long because the art of steam navigation was making daily progress. As a matter of fact, the vessels which steamed at 8 or 9 miles an hour, could no longer a short time afterwards sustain a competition with others whose construction allowed them to make 12 to 15." Hunter, *ibid.*, 100, 101, 103; Rapp, *ibid.*, 169, 178, 179.

64. NARG-41 for the ports of Sandusky, OH (1847-1856), Microfilm of Great Lakes Records,15E-3, Row 11/33, Drawer 2, Roll 1, no. 9, and Buffalo, NY (1850-1855), Microfilm of Great Lakes Records,15E-3, Row 11/33, Drawer 1, Roll 3, no. 30. Although Pratt was listed as *Indiana*'s master on the 1852 enrollment document, Captain Spencer served as its master for all of the 1852 navigation season, except for the last recorded trip of the year on 29 November when F. Keith served as *Indiana*'s master. Metzler, *ibid.*

65. NARG-41: Buffalo, NY (1850-1855), Microfilm of Great Lakes Records,15E-3, Row 11/33, Drawer 1, Roll 3, no. 30.

66. *Ibid.*, no. 32.

67. *Ibid.*

68. *Ibid.*, no. 133.

69. Goldman, *ibid.*, 22, 64, 65; Robert Holder, *The Beginnings of Buffalo Industry* (Buffalo, NY, 1960), 14.

70. Metzler, *ibid.*; Albion, *ibid.*; The Union Steamboat Company was incorporated in Buffalo on 15 April 1854 by Albert L. Willis and Benjamin W. Blanchard of New York City, Henry Harley of Pittsburgh, and Elisha A. Buck and Stephen D. Caldwell of Buffalo with its principal office in Clarkstown, NY. The Company was formed with one-million dollars of capital stock (10,000 shares at $100 per share) for the purpose of, " building for its own use, equipping, furnishing, fitting, purchasing, chartering, towing, and owning steam, sail, and other boats, ships, and vessels, and property to be used by the said company in lawful business, commerce, trade, and navigation upon the Lakes Michigan, Superior, Huron, St. Clair, Erie, and Ontario, or any of the same, and rivers connecting said lakes..." *Certificate of Incorporation and By-Laws of the Union Steamboat Company, together with the Act of Incorporation and the Acts Amendatory Thereof and Parts of the Revised Statutes Referred to Therein, etc.* (Buffalo, NY, 1873), 35, 36. Labadie notes that passenger- and package freight-carrying propellers were most successful when coupled with railroad systems extending from the lakes to the eastern seaboard. C. Patrick Labadie, *Submerged Cultural Resources Study: Pictured Rocks National Lakeshore* (Santa Fe, NM, 1989), 29. The first line of propellers serving railroad interests on the lakes was organized in 1851 by Crawford and Company for the Northern Railroad (later the Ogdensburgh and Vermont Central railroads) to Boston. Completed in 1850, the Northern Railroad was the first of the northeastern railroads to reach the Great Lakes. The propeller line provided service between Cleveland, on Lake Erie, and the road's railhead at Ogdensburgh on Lake Ontario. This line of propellers was later reorganized to form the Northern Transportation Company which eventually extended its service to Chicago. Thomas D. Odle, *The American Grain Trade of the Great Lakes, 1825-1873* (Ann Arbor, MI,

University of Michigan, unpublished dissertation, 1951), 84-89; Dohrmann, *ibid.*, 59.

71. Dohrmann, *ibid.*, 56-58.

72. Odle, *ibid.*; Dohrmann, *ibid.*

73. Dohrmann, *ibid.*

74. Dohrmann, *ibid.*, 60.

75. Metzler, *ibid.*; Robinson and Robinson, *ibid.*

76. NARG-41 for the port of Buffalo, NY (1850-1855), Microfilm of Great Lakes Records,15E-3, Row 11/33, Drawer 1, Roll 3, no. 62.

77. *Ibid.*; Metzler, *ibid.*; Rapp, *ibid.*, 169.

78. S. C. A. Lottridge & Co., *Buffalo Business Directory, 1854-5* (Buffalo, NY, 1854), 13.

79. NARG-41 for the port of Buffalo, NY (1850-1855), Microfilm of Great Lakes Records,15E-3, Row 11/33, Drawer 1, Roll 3, no. 62.

80. *Ibid.*

81. Board of Lake Underwriters,"Rules, etc. Relative to the Construction of Sail Vessels and Propellers to Class A1," *Proceedings of the Board of Marine Inspectors of the Association of Lake Underwriters, Held at Buffalo, August 1856* (Buffalo, NY, 1856), 12.

82. Paul F. Johnston, Personal Communication.

83. NARG-41 for the port of Buffalo, NY (1850-1855), Microfilm of Great Lakes Records,15E-3, Row 11/33, Drawer 1, Roll 3, nos. 44, 62, and 133.

84. Richard J. Wright, National Register of Historic Places Inventory Nomination Form (20 December 1978); *Cleveland Morning Leader*, 28-29 April 1854.

85. "Inland Navigation: Modeling Sail Vessels for the Lakes," *The Monthly Nautical Magazine*, vol. 1, no. 1 (1854), 12.

86. *Democracy*, EXTRA: Casualty List, 28 February 1855.

87. *Ibid.*

88. Labadie, *ibid.*, 156.

89. Metzler, *ibid.*

90. *Democracy*, *ibid.*

91. *Lake Superior Journal*, 19 August, 26 August, 9 September, 30 September, and 14 October 1854; Willis Frederick Dunbar, *Michigan: A History of the Wolverine State* (Grand Rapids, MI, 1965), 361-365.

92. Janus Storey, Personal Communication. The peculiar spelling of Minesota Mine reportedly originated from a clerical error in the mine's original Charter application. Dunbar, *ibid.*, 363.

93. *Lake Superior Journal, ibid.*

94. Dunbar, *ibid.*, 363.

95. *Lake Superior Journal*, 16 September 1854.

96. *Ibid.*

97. *Democracy*, 6 November 1854 and EXTRA: Casualty List, 28 February 1855.

98. Labadie, *ibid.*, 156.

99. *The Coast Pilot for the Lakes* (Chicago, IL, 1863), 49.

100. NARG-41 for the port of Buffalo, NY (1855-1859), Microfilm of Great Lakes Records,15E-3, Row 11/33, Drawer 1, Roll 4, no. 44.

101. Louis B. Lane, *Memorial and Family History of Erie County, New York*, vol. 2 (Buffalo, NY, 1906-1908), 399-401.

102. *Ibid.*

103. *Ibid.*

104. *Marine History* (Detroit, MI, 1877), 69.

105. *Ibid.*

106. Lane, *ibid.*

107. Metzler, *ibid.*; Robinson and Robinson, *ibid.*

108. Metzler, *ibid.*

109. *The Coast Pilot for the Lakes on both Shores* (Chicago, IL, 1863); *Ensign, Bridgman & Fanning's Lake and River Guide* (New York, NY, 1856); *Through the Lakes of North America* (New York, NY, 1857); *New Chart of Lakes Michigan, Huron, and St. Clair, Compiled from the latest and most reliable Surveys* (Buffalo, NY, 1855); Robert Hugunin, *Chart of Lake Erie* (Buffalo, NY, 1843); "Map, G. No. 33: A Map Shewing [sic] the Progress on the 31st of October 1855, of the Improvement for Deepening the Middle Channel of the South Pass Over the Saint Clair Flats," in J. D. Graham, *Annual Report (No. 116) to the Chief Topographical Engineer* (Chicago, IL, 1855); "Map G. No. 34. Shewing [sic] the Condition of the Middle Channel Over Saint Clair Flats after the Dredging Done between the 25th of July & the 24th of October 1855," in J. D. Graham, *Annual Report (No. 116) to the Chief Topographical Engineer* (Chicago, IL, 1855).

110. *Ensign, Bridgman & Fanning's Lake and River Guide, ibid.*, 107.

111. "Remarks on the Mariner's Compass by Capt. Thompson," *The Coast Pilot for the Lakes, ibid.*, iv.

112. Disturnell, *ibid.*, 145.

113. *Ibid.*; *The Coast Pilot for the Lakes*, *ibid.*, 69-71.

114. James L. Barton, *Lake Commerce. Letter to the Hon. Robert McClelland Chairman of the Committee on Commerce, in the U.S. House of Representatives in Relation to the Value and Importance of Commerce of the Great Western Lakes* (Buffalo, NY, 1846), 27; Odle, *ibid.*, 103-105; Graham, *ibid.* ("Map, G. No. 33.").

115. Barton, *ibid.*

116. *Ibid.*

117. *Ibid.*, 28; James L. Barton, *Commerce of the Lakes. A Brief Sketch of the Commerce of the Great Northern and Western Lakes for a Series of Years; To Which is Added, An Account of the Business Done Through Buffalo on the Erie Canal, For the Years 1845 and 1846. Also, Remarks as to the True Canal Policy of the State of New York* (Buffalo, NY, 1847), 53, 54. Odle describes in detail the hazards of the Saint Clair flats and the efforts to improve their navigability. He also provides a concise overview of the general conditions of the lakes during the mid-nineteenth century, the pressing need for navigation improvements throughout the entire Great Lakes system, and the politics that were involved with obtaining Federal funds for such improvements. Odle, *ibid.*, 98-134.

118. Barton, *ibid.*; Graham, *ibid.* ("Map, G. No. 34."); Odle, *ibid.*

119. Disturnell, *ibid.*, 124; Editors, *The Coast Pilot for the Lakes* (Chicago, IL, 1863), 63.

120. Metzler, *ibid.*

121. *Ibid.*; Robinson and Robinson, *ibid.*

122. *Democracy*, 28 February 1855.

123. *Detroit Daily Free Press*, 4 April 1857.

124. Metzler, *ibid.*; Robinson and Robinson, *ibid.*

125. *Detroit Daily Free Press*, 22 October 1857.

126. *Cleveland Plain Dealer*, 14 June 1858; *Detroit Daily Free Press*, 27 April, 11 May 1858

127. Hunter, *ibid.*, 101.

128. *Detroit Daily Free Press*, 12 June 1858.

129. *Buffalo Morning Express*, 17 April 1858; *Cleveland Plain Dealer*, 14 June 1858.

130. Metzler, ibid.; *Detroit Free Press*, 9 April 1858.

131. *Detroit Free Press*, 10 June 1858.

132. *Ibid.*

133. *Ibid.*

134. *Cleveland Morning Leader*, 7 June 1858.

135. *Detroit Daily Free Press*, 9 June 1858; *Lake Superior Miner*, 12 June 1858.

136. *Cleveland Morning Leader*, 7 June 1858.

137. Swank, *ibid.*, 320, 326.

138. *Ibid.*, 324.

139. *Ibid.*, 327.

140. Swank, *ibid.*, 525. Between 1849 and 1955 the Marquette Range alone produced 283,000,000 tons of iron ore. Dunbar. *ibid.*, 503.

141. Disturnell, *ibid.*, 66.

142. John A. Burke, "Barrels to Barrows, Buckets to Belts: 120 Years of Iron Ore Handling on the Great Lakes," *Inland Seas*, vol. 31, no. 4 (1975), 267; Dunbar, *ibid.*, 504.

143. Burke, *ibid.*, 268, 269.

144. *Ibid.*, 269.

145. *Ibid.*

146. *Painesville Telegraph*, 17 June 1858.

147. *Ibid.*; *Cleveland Morning Leader*, 14 June 1858; *Detroit Daily Free Press*, 12 June 1858; *Lake Superior Miner*, 12 June 1858.

148. NARG-41 for the port of Cleveland, OH (1855-1860), Microfilm of Great Lakes Records,15E-3, Row 11/33, Drawer 1, Roll 3, no. 6.

149. Julius F. Wolff, Jr., "Salvaging the Engine of the *Indiana*," *Inland Seas*, vol. 35 (1979), 293, 294; Richard J. Wright, "The *Indiana* Salvage: Part I," *Detroit Marine Historian*, vol. 33, no. 4 (1979), 1-4; Richard J. Wright, "The *Indiana* Salvage: Part II," *Detroit Marine Historian*, vol. 34, no. 5 (1980), 2-4.
150. *Ibid.*

151. *Ibid.*

152. John R. Halsey, "Michigan's Underwater Archaeology Program," in Johnston, Paul F., ed., *Proceedings of the Sixteenth Conference on Underwater Archaeology*, Special Publication Series, no. 4 (1985), 144.

153. Richard K. Anderson, Jr., "The Propulsion Plant of the Propeller Ship *Indiana*: Notes on its Construction and Operation Based on Field Measurements and Examinations" (unpublished manuscript on file at the National Museum of American History, Division of Transportation, Smithsonian Institution, Washington, DC, 1991); Richard K. Anderson, Jr., "Addendum to 1991 Report" (unpublished manuscript on file at the National Museum of American History, Division of Transportation, Smithsonian Institution, Washington, DC, 1992).

154. Frederick Hocker, "*Indiana's* Engine Builder" (unpublished manuscript on file at the National

Museum of American History, Division of Transportation, Smithsonian Institution, Washington, DC, 1984).

CHAPTER III

THE *INDIANA* ARCHAEOLOGICAL PROJECT: 1991-1993

Preparation for the 1991 Field Season

Archaeological investigation of *Indiana*'s wreck site was conducted in three, two week-long field campaigns over a three year period between 1991 and 1993. Logistical planning and preliminary research for the first of the three field campaigns began in January of 1991, when the author and Dr. Kevin Crisman travelled to Washington, D.C. to meet with Dr. Paul Johnston, review the Smithsonian's *Indiana* Project files, and conduct preliminary archival research at the National Archives. The meeting established the roles and responsibilities of the project's key personnel, outlined the 1991 project goals, and scheduled the fieldwork for August 3 to 17. This two-week window was selected to take advantage of the warm and stable weather and calm lake conditions that typically prevail on Lake Superior late in the summer.

The goals of the 1991 field season were to document *Indiana* sufficiently to produce plans of *Indiana*'s hull lines and a deck or site plan of the wreck. A secondary objective of the project, requested by the State of Michigan, was to remove from the wreck all line and any other potentially hazardous debris that had been left behind by previous Smithsonian expeditions. Dr. Johnston would serve as Principal Investigator for the project and be responsible for obtaining project funding and supervising all aspects of the field research. The author would act as Project Manager and Principal Ship Reconstructor. Responsibilities in this role included directing the collection of archaeological data in the field and preparing the lines drawing and deck or site plans of *Indiana* for inclusion in the museum's Ships Plans Collection and a monograph that the museum planned to publish on the wreck. These drawings would also be included in this thesis and any future articles or reports on the wreck. Dr. Crisman would act as a project advisor and chair of the author's thesis committee. Dr. Johnston expected that twelve divers diving twice daily for ten days would be required to derive the data necessary to fully document the wreck.

Funding for the fieldwork was provided by generous contributions from the National Trust for Historic Preservation, the Smithsonian Institution Research Opportunities Fund, and the Smithsonian Institution's National Museum of American History's Division of Transportation's Ship Plans Fund. Logistical support was provided by the Institute of Nautical Archaeology at Texas A&M University, Arthur B. Cohn, Richard K. Anderson, Jr., C. Patrick Labadie, Thomas L. Farnquist, and Terrance K. Conable.

Preliminary 1991 Research

After meeting with Dr. Johnston, the Smithsonian's *Indiana* files were examined to establish the extent of the museum's previously recorded historical and archaeological data. This examination of the museum's files identified specific areas in the existing research where additional information would be required to complete *Indiana*'s reconstruction. Underwater photographs and field notes from earlier expeditions were also reviewed for information that would be useful for planning a documentation strategy for *Indiana*. Examination of the file revealed that a single two-week long field season would probably be inadequate to achieve all of the museum's objectives for the project. Furthermore, it was also apparent that significant additional historic research would be necessary to obtain enough comparative data to prepare an accurate reconstruction of *Indiana*'s lines and construction.

Preliminary archival research was initiated by the author and Dr. Crisman in Record Group 41 of the Civil Reference Branch at the National Archives in Washington, D.C. This research produced a complete set of *Indiana*'s enrollment papers which contained the basic dimensional data and ownership information that would form the foundation for reconstructing *Indiana*'s hull and operational history. No additional documentation for *Indiana* was located during this preliminary research effort or during any of the author's subsequent research trips to the National Archives.

Preparations for Diving on *Indiana*

Archaeological investigations were conducted on *Indiana* between 1991 and 1993. These annual expeditions consisted of three two-week archaeological field surveys. The first two field campaigns were both undertaken during the first two weeks of August, during a brief window of moderate wind and weather conditions on the lake. The 1993 campaign was conducted in June because of scheduling constraints.

Undertaking any type of underwater archaeological work requires a great deal of advance logistical planning, a fact that was especially true for the *Indiana* Project because of the site's remote location, the large size and complexity of the wreck, and the site's extreme depth and cold water temperature. The requisite permits for the project were obtained from the Michigan State Historic

Preservation Office and the Michigan Department of Natural Resources prior to the start of each field campaign. Because of *Indiana*'s close proximity to the charted path of upbound commercial vessels travelling between Marquette and Whitefish Bay, a route travelled by enormous 1,000-foot (304.8-m) freighters (Figs. 3-1 and 3-2), the author contacted the U.S. Coast Guard-Group Sault Sainte Marie to alert them to the project, to discuss planned diving operations, to confirm the protocol for the project's emergency contingency plan, and to request them to issue a "Notice to Mariners," diverting commercial vessel traffic from the project area during the two-week field season. This last step was particularly important because it minimized the possibility of the project's small dive vessel being run down while anchored on site. It proved especially important when heavy fog became a problem briefly during the 1992 field season.

The project's dive boat, the 26-foot (7.92-m) *Lake Diver* (Fig. 3-3) was provided by John Steele, who, along with William Cohrs, also graciously donated their time, expertise, and assistance to the project. Equipment, personnel, and logistical support related to diving safety were provided by the Smithsonian Institution's Diving Safety Officer, Michael A. Lang, and his assistant, Kimbra Cutlip, both of whom also acted as Divemasters during the project. The project's team of divers was assembled from students and staff of Texas A&M University's graduate program in Nautical Archeology, members of the Smithsonian's staff, and volunteers from the sport diving community.

The strictly enforced safety policies of the Smithsonian Institution's scientific diving program required that a Project Diving Safety Plan be completed for the project and also mandated that all project divers undergo a comprehensive diving medical exam, provide the Smithsonian's Diving Safety Officer proof of adequate diving experience, and successfully complete an open water check-out dive on the wreck with the Smithsonian's Diving Safety Officer. In addition to the diving-related paperwork, a list of recording tasks to be accomplished in the field was created, and the requisite recording equipment (i.e., rules, tape measures, underwater cameras, submersible clipboards and pencils, drafting film, etc.) were purchased and assembled.

Securing a reliable source of pure, high-pressure air for filling the project divers' scuba air cylinders in the remote woodlands of Michigan's Upper Peninsula proved to be something of a logistical challenge. For the 1991 field campaign, airfills were obtained from a local vendor; however, during the 1992 and 1993 field campaigns, the Smithsonian's Museum of Natural History loaned a high-pressure air compressor to the project.

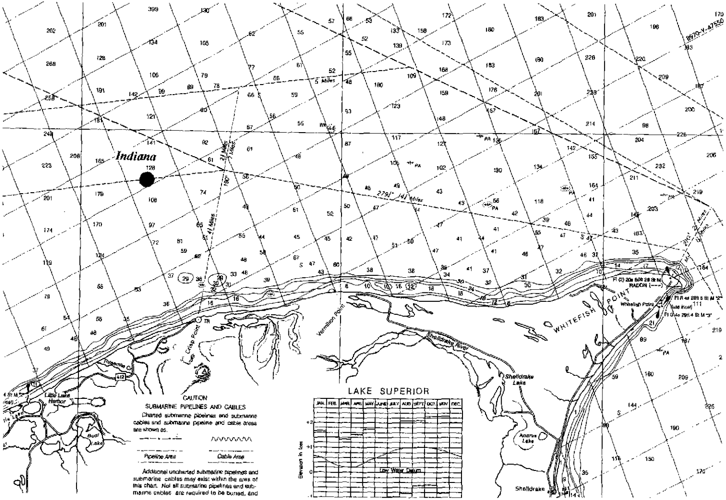


Figure 3-1. Excerpt of NOAA navigational chart showing location of *Indiana*'s wreck site relative to the charted shipping lanes (represented by dashed lines). (From NOAA Chart No. 14962 - "St. Marys River to Au Sable Point").

Figure 3-2. Close encounters with enormous bulk freighters were a common occurance during field investigations at *Indiana*'s wreck site. (Photo by Alan Flanigan).

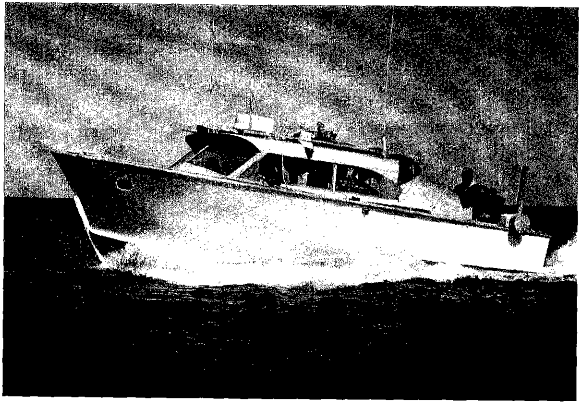


Figure 3-3. *Indiana* Project survey vessel *Lake Diver*. (Photo by David S. Robinson).

The great depth and frigid temperature of the water at *Indiana*'s wreck site also required special logistical consideration and planning. In addition to being potentially dangerous, the site's environment and the project's time and resource limitations placed real constraints on the quantity and quality of archaeological work that could be performed underwater. Generally speaking, dives below 60 feet (18.29 m) are considered deep dives, and the recommended maximum depth limit of recreational diving is 130 feet (39.62 m). Because all but one of the project divers held only recreational diving certifications and were not commercial divers trained in deep diving, *Indiana*'s 120-foot (36.58-m) depth was the limit of most dive team member's training and experience. Also, the cold temperature and great depth of the water at the site made project divers particularly susceptible to hypothermia, decompression sickness, hypercapnia, and nitrogen narcosis.

Decompression sickness, commonly known as "the bends," is caused by an overabundance of absorbed nitrogen in the blood and tissues of a diver's body as a result of breathing air underwater beyond a specified period or depth known to be safe. Statistically, occurrences of decompression sickness are much higher after dives conducted at or below 100 feet (30.48 m) when the no decompression time limits are approached and/or exceeded. Extremely cold water temperatures on *Indiana*'s wreck site, which hovered around 39° F (3.89° C), added to the risk of decompression sickness by impeding blood circulation and increasing fatigue in the project divers, both of which are contributing factors in decompression-related illnesses. Because of the cold water temperatures at the site, dive profiles and decompression schedules for the project were calculated using the next greatest depth (130 feet [39.62 m]) and next greatest time, to provide a margin of safety. For dives to 130 feet (39.62 m), the U.S. Navy's dive tables recommend a 10-minute "no decompression limit," or 10 minutes of bottom time. Since an average of five to seven minutes of bottom time was lost during each dive while descending to the wreck, moving around the site, setting up, unpacking, and then repacking recording equipment, the recommended 10-minute limit would allow only three to five minutes of actual working time on the wreck, which clearly was insufficient to complete the required recording tasks. Therefore, all dives on *Indiana* were planned as decompression dives, with 25 minutes of bottom time and two decompression stops during ascent at 20 and 10 feet (6.10 and 3.05 m), amounting to a total dive time of approximately 50 minutes. As a means of reducing the risk of decompression sickness, divers breathed pure oxygen for 10 minutes after surfacing to increase the rate at which potentially harmful nitrogen was "off-gassed" by the body (Fig. 3-4). Although Dr. Johnston originally anticipated making

Figure 3-4. Project divers breathed pure oxygen for 15 minutes after surfacing from dives as a prophylaxis against decompression illness. (Photo by David S. Robinson).

two dives a day, divers were limited to just one dive per day to allow adequate time for residual nitrogen to be metabolized and removed naturally from their bodies. Despite these precautionary measures, concerns over the risks inherent to decompression diving were omnipresent in the subconscious of every project diver.

With a maximum bottom time of just 25 minutes, and only 18 to 20 minutes of working time available on each dive, tasks had to be planned carefully in advance and performed expeditiously underwater to achieve the missions of the project. As a result, divers tended to feel rushed, which increased anxiety levels and underwater breathing rates. Breathing rates were also faster than normal because of the increased density of air at depth and the cold water temperatures. On several occasions, two of the project's most experienced divers reported feelings of suffocation, faintness, and tingling, symptoms commonly associated with hypercapnia or an overaccumulation of carbon dioxide in the blood. Fortunately, the divers recognized these symptoms and corrected the problem by consciously controlling their breathing rates. Uncontrolled, severe hypercapnia can lead to dizziness, followed by sudden loss of consciousness, and death.

Project divers were also affected to varying degrees by nitrogen narcosis. Nitrogen narcosis is a state of stupor or unconsciousness caused by breathing compressed air at depths exceeding 100 feet (30.48 m). Nitrogen narcosis inhibits a diver's ability to concentrate and makes performing even simple tasks difficult. Although no one on the project team complained of feeling the effects of narcosis, ample evidence in the field notes collected during dives indicated virtually all of the divers were affected. Particularly frustrating in light of the project's extreme time constraints was the fact that narcosis slowed the documentation process.

Extremely cold water temperatures at the site necessitated that all of the project divers wear dry suits to maintain normal body temperatures. Despite the additional thermal protection offered by dry suits, overexposure to the cold was a constant concern. Discomfort resulting from immersion in the near freezing water made it difficult to concentrate on and perform underwater tasks. More importantly, however, the cold water had a profoundly adverse effect on several different scuba regulators employed by project divers. On three separate occasions, ice formed inside the regulators' second stages and caused them to "free flow" uncontrollably, rapidly depleting the diver's air source and forcing premature termination of the dive. To prepare for such emergencies, divers were equipped with two air cylinders, both of which were fitted with separate regulators to create a pair of completely independent air supply systems. To ensure that neither supply was exhausted during the course of a dive, divers breathed down each air supply in increments of 500 psi (pounds per square inch), switching between cylinders. Using this system and technique prevented divers from completely emptying either cylinder, which would have negated the benefits of the redundant system. Typically, divers returned to the surface with 1,500-1,700 psi of air remaining in each cylinder.

Location and Description of *Indiana*'s Wreck Site

Indiana's wreck site is located in 120 feet (36.58 m) of water in the southeastern corner of Lake Superior, 3.6 statute miles (5.8 km) offshore, near the present commercial shipping lane designated for upbound traffic. The approximate center point of the wreck lies on a magnetic compass bearing of 343° from Crisp Point, in Luce County, Michigan, 15 miles (24.14 km) west of Whitefish Point, at 46° 48' 60" N and 85° 17' 12" W (Fig. 3-5).

The sparsely settled land adjacent to *Indiana*'s wreck site is as scenic as it is desolate. The rugged shoreline, which is exposed to the full fury of Lake Superior's high seas and winds, consists of a narrow, unbroken stretch of steeply sloping white sand and pebble beach, backed by 40- to 60-foot (12.19- to 18.29-m) sand bluffs capped with coniferous trees (Fig. 3-6). The only navigable break in the shoreline within a 10- mile (16.09-km) radius of the site is the maintained entrance into Little Lake Harbor of Refuge. Two other breaks in the beach are formed by the nearby outlets of the Two-Hearted and Little Two-Hearted Rivers. The closest population centers to *Indiana*'s wreck site are the small communities of Newberry and Paradise. Sault Sainte Marie, Michigan, the largest city in the region, is 50 miles (80.46 km) away.

Coincidentally, *Indiana*'s wreck site also lies in close proximity to several sites bearing names that have figured prominently in *Indiana*'s past. Ironically, *Indiana*'s final resting place lies only 5.5 miles (8.9 km) northwest of Vermilion, Michigan, a locale sharing the same name as the Ohio town of *Indiana*'s origin. Ten miles (16.09 km) north of *Indiana* is located the wreck of the 174-foot (53.04-m), 525-ton schooner *Frank Perew*, the namesake of *Indiana*'s last owner, which foundered during a gale in 1891 and was a total loss.[1] Just outside of Marquette, the point from which *Indiana* departed on its final voyage, the 190-foot (57.91-m), 649-ton schooner *Alva Bradley* ran aground and was heavily damaged during an October gale in 1887.[2] Approximately 14 miles (22.53 km) northeast of *Indiana* (reportedly the first loss of a Lake Superior iron ore cargo) is the most infamous of Great Lakes shipwrecks (and

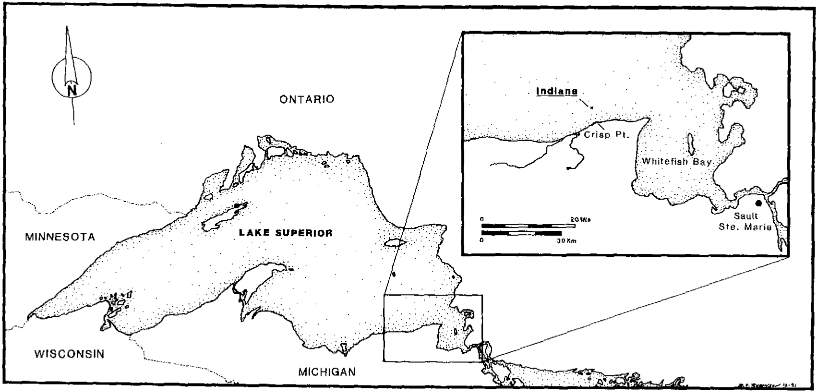


Figure 3-5. General location of *Indiana*'s wreck site. (Drawing by David S. Robinson).

Figure 3-6. Shoreline adjacent to the wreck site. (Photo by David S. Robinson).

the most recent loss of Lake Superior iron ore), *Edmund Fitzgerald,* lost just outside of Whitefish Bay in 1975, during a tempestuous November gale. Built in 1958, 110 years after *Indiana,* the massive *Fitzgerald* and the comparatively diminutive *Indiana* together represent opposite ends of the spectrum in the developmental history of screw-propelled Great Lakes iron ore carriers.

The destructive power of Lake Superior is clearly illustrated by the 135 reported vessel casualties between Marquette and Whitefish Point, particularly the loss of the 729-foot (222.20-m), steel-hulled *Edmund Fitzgerald.* Additional factors, such as the extreme depth and frigid water temperatures at *Indiana*'s wreck site and the proximity of the wreck to a busy shipping channel, also made *Indiana* a potentially dangerous dive location. Consequently, special precautionary measures were required to ensure the safety of the dive team members. Since weather, wind, and wave conditions tend to be the most favorable during the summer months, archaeological fieldwork was scheduled for the months of June and August. Weather and water conditions and forecasts were checked every morning and were monitored carefully throughout the day. At the site's unprotected location at the southeastern corner of the lake, the region's prevailing northwest winds have an uninterrupted fetch of approximately 280 miles (450.60 km). The lake's surface conditions can change within minutes, and dangerously large, steep seas could develop during the course of a dive. If poor weather threatened or seas were higher than three feet (91 cm), field work was suspended or postponed until conditions improved. On several days that were too windy to work safely at the site, the sound of the breaking surf pounding the shoreline was loud enough to be heard clearly through the woods, more than one mile (1.6 km) from the lake. Over the course of the three two-week field seasons, however, inclement weather resulted in just eight lost work days.

One particularly beneficial aspect of *Indiana*'s wreck site was its excellent underwater visibility, which ranged between 20 and 40 feet (6.10 and 12.19 m). Because of the water's clarity and the reflective quality of the white sand lake bed, ambient light on the site was abundant, and underwater flashlights were unnecessary, except when divers worked inside *Indiana* below the main deck. During the month of June, underwater visibility on the wreck was at its greatest (approximately 40 feet [12.19 m]). However, water clarity was found to be inversely proportional to water temperature, which in June measured a uniform 39° F (3.89° C) throughout the water column. By comparison, in August, when thermal stratification and periodic thermal inversions of the water column, known as "seiche," created episodic temperature differentials of more than 30° (39 to 72° F [3.89 to 22.22° C]) between the surface and the bottom, underwater visibility was reduced by half.

As expected, water currents at the site, although present, were minimal. The wreck is swept by a slight (less than two miles per hour [3.22 km per hour]), yet constant, west-to-east current, created by the flow of Lake Superior's waters into the lower lakes via the Saint Mary's River at Sault Sainte Marie. This current was less noticeable at depth than near the water's surface.

A review of hydrographic charts of the area surrounding *Indiana* revealed that the wreck lies on the southwestern corner of a submerged peninsular plateau of glacial till, surrounded by deep water in excess of 200 feet (60.96 m) to the north, west, and east (Fig. 3-7). Notably, these water depths correlate closely with those reported in the newspaper accounts of *Indiana*'s sinking, which stated that the propeller was lost in water approximately 200-360 feet (60.96-109.73 m) deep.[3]

Because of the site's extreme depth, cold water temperature, and the absence of wood-boring aquatic biota and corrosive chlorides in the lake's fresh water, the wreck has benefitted from nearly ideal preservation conditions. Lake Superior's frigid, fresh waters have limited destructive fungal growth in the wood and have slowed the corrosion processes that affect metal hull components. In fact, *Indiana*'s wooden hull components were so well preserved that divers experienced difficulty when attempting to remove samples for species identification. Unlike Great Lakes wrecks located in shallower water, *Indiana* has been neither torn apart by wave action nor crushed into the sand under the weight of the ice sheets, 20 to 30 feet (6.10 to 9.14 m) in thickness, that often form along the periphery of the lake during the winter months.

Occupying an area measuring approximately 6,500 square feet (1,981.22 sq m), *Indiana*'s 146 foot, 6 inch (44.7 m) hull is oriented on a bow-first compass bearing of 315° and lies upright on an essentially level lake bed, with a slight three degree list to starboard (Fig. 3-8). The after third of the hull is preserved intact to the level of the main deck and rises to a maximum height of approximately 14 feet (4.27 m) above the bottom at the stern. By contrast, the forward two-thirds of the hull are progressively more disarticulated and flattened ahead of the engine space, from which point both sides of the hull are splayed outward and the deck is collapsed down into the hold. A layer of iron ore cargo, approximately two to four feet (0.61 to 1.22 m) thick, obscures the deck, fore and aft of the engine space. Additional overburden, consisting of sand and wooden debris, covers most of the forward third of the wreck. At the bow, only the stem assembly, windlass, a small detached section of decking, riding bitts, and a portion of the forward starboard quarter are exposed above the lake bed.

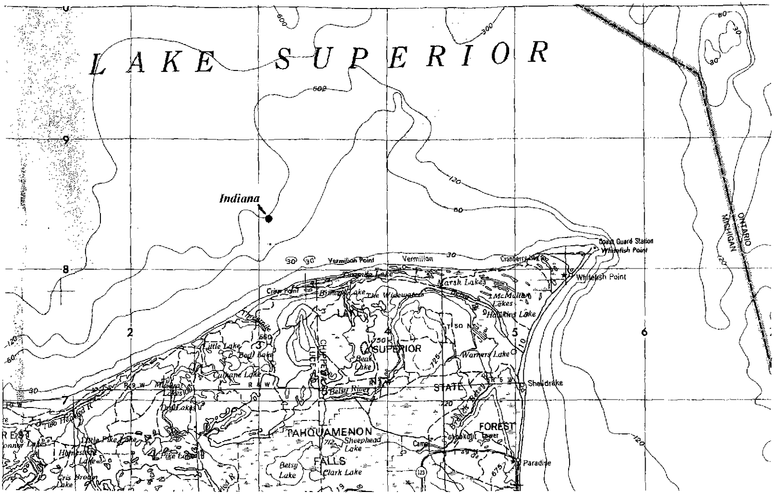


Figure 3-7. Excerpt of USGS quadrangle map depicting bathymetric contours in the vicinity of the wreck site. (From U.S. Geological Survey Quadrangle Map No. NL 16-6, "Sault Sainte Marie, Michigan").

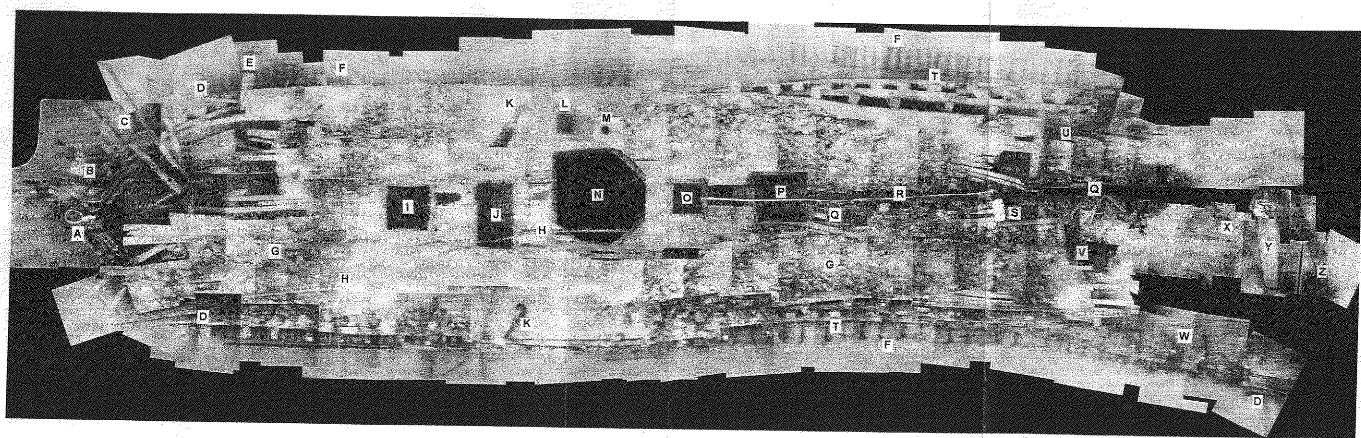


Figure 3-8. Computer-generated videomosaic site plan of *Indiana*. From left to right: A) sternpost; B) external hanging knee; C) radial deck beam; D) truss anchor; E) transverse deck beam; F) sponson-guard; G) iron ore cargo; H) truss rod; I) after hold hatchway; J) engine hatchway; K) queen post; L) fireroom companionway; M) opening for fireroom ventilator; N) boiler hatchway; O) fueling hatchway; P) forward hold hatchway no. 2; Q) cargo winches; R) possible steering chain hatchway; S) "monkey ladder" deck stanchion; T) frame head; U) ceiling; V) forward hold hatchway no. 1; W) dagger knee; X) riding bitts; Y) windlass bitt; Z) stem. (Mosaic image assembled by David S. Robinson and Douglas Gann using underwater video footage recorded by Thomas Alburn).

No portion of *Indiana*'s upper deck or superstructure was preserved in its original location, although long sections of both the port and starboard main deck bulwarks, several upper deck support stanchions, and a single starboard life boat davit were found partially buried under sand alongside the hull. From the condition of *Indiana*'s hull, it appears that the forward end of the vessel struck the lake bed first. Consequently, the heavy load of iron ore on deck caused *Indiana*'s main deck to collapse into the hold approximately 55 feet (16.76 m) forward of the sternpost.

East of the extant hull wreckage, approximately 100 to 325 feet (30.48 to 99.06 m) abaft the stern, are three smaller debris fields containing additional wreckage. The hull and these three areas of debris are all clearly visible in a side-scanning sonar image of the site, recorded by John Steele during the 1992 field season, and are labeled respectively as features A-D (Fig. 3-9). Only Features A (the hull) and B (a detached section of the aftermost portion of the main deck) have been examined. Features C and D remain unidentified at present.

Feature B (Fig. 3-10), located approximately 100 feet (30.48 m) abaft the hull, consists of a 13 by 15 foot (3.96 by 4.57 m) section of *Indiana*'s elliptical fantail decking. Attached to this section of decking are the remains of several of the stern's external hanging knees, a heavy, central counter timber, deck beams, decking, a massive towing cleat, planked bulwarks, and vertical deck and rail stanchions that supported a lighter upper deck.

Much of *Indiana*'s current condition is attributable to the damages incurred during the original wrecking event, and to a lesser extent, the cumulative processes of degradation that took place in the following 140 years. Since one of the principal objectives of this study was to reconstruct graphically *Indiana*'s original appearance, it is essential that the environmental and human events or "site formation processes" that have altered its form are interpreted and described. The importance of such analysis is echoed in the words of the late maritime archaeologist Keith Muckelroy, one of the first to note the significance of shipwreck site formation processes in the interpretation and analysis of shipwrecks:

> Given that maritime archaeology is concerned with the study of ships and seafaring, and that its principal sources of data lie in the remains of such activities preserved on the seashore or sea-bed, it follows that the interpretation of such data is closely bound up with an understanding of what is involved in a shipwreck. The shipwreck is the event by which a highly organized and dynamic assemblage of artifacts are transformed into a static and disorganized state with long-term stability. While the archaeologist must observe this final situation, his interest... is centered on the former, whose various aspects are only indicated indirectly and partially by the surviving material. If the various processes which have intervened between the two states can be identified and described, the researcher can begin to disentangle the evidence he has

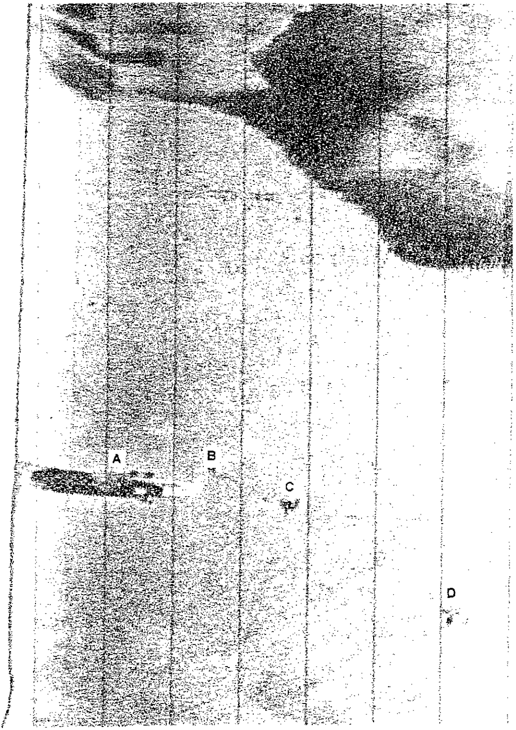


Figure 3-9. Acoustic image of the wreck site produced by side-scanning sonar. (Image courtesy of John Steele).

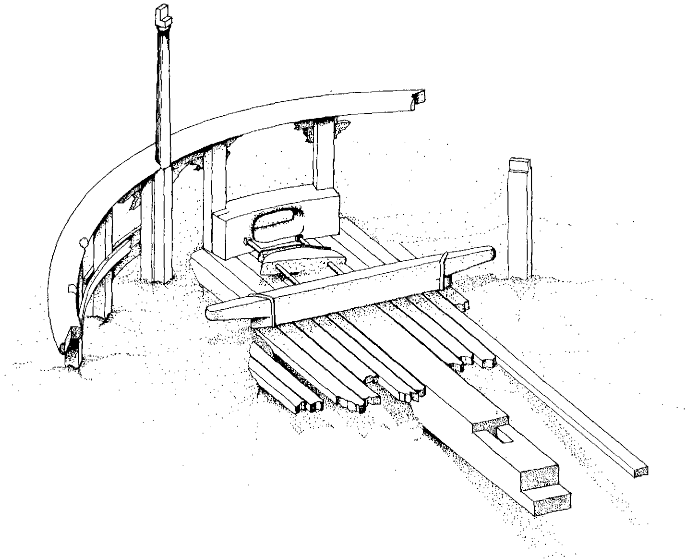


Figure 3-10. Perspective plan of Feature B (fantail wreckage). (Drawing by Peter Hentschel).

uncovered.[4]

As noted above, the collapsed and fragmentary condition of the forward two-thirds of *Indiana*'s hull, as well as the large volume of iron ore in that area, indicate that the vessel sank bow first. As is common among steamboat wrecks, when *Indiana*'s bow slid beneath the waves, the heavily laden lower hull separated from the comparatively buoyant upper works.[5] When iron ore on and below decks shifted forward, bulkheads and fasteners connecting the main and upper decks failed to hold. Consequently, neither the upper works, sailing rig, smoke pipe, nor furnishings are present at the wreck site. Eyewitness accounts from crew and passengers on board *Indiana* and from those on board other vessels nearby reported that *Indiana* was indeed fitted with an upper deck that tore away from the lower hull as it sank. These accounts conflict with the information contained in the propeller's final enrollment papers, in which *Indiana* is described as having only one deck:

> The propeller *Mineral Rock*, (Redman) Ryder Master, which arrived at this port on Thursday morning, reports having passed portions of what seemed to be the wreck of a propeller, off of Whitefish Point, on her passage up on Tuesday last. The main part of the wreck had the appearance of some 50 feet [15.24 m] of the upper deck, with two of the fenders thrown across it...[6]

> The lights were seen for a long time after they (crew and passengers) left the vicinity, but it was probable that the upper deck was detached from the hull. The *Mineral Rock* and the schooner *St. Paul*, which passed the place within the next day or two, reported having seen large portions of the wreck, and this fact goes to confirm the opinion that the upper works must have floated off.[7]

Indiana must have struck the bottom of Lake Superior with explosive force, judging from the deposition of the wreckage and the condition of the hull. It appears that the damages occurred in a single catastrophic moment, when the tremendous upward force of the hull's impact with hard sand lake bed acted with the downward force from the massive weight and inertia of the hull, machinery, and deck cargo to flatten *Indiana*'s forward half. Specifically, the concentrated weight of iron ore piled on deck caused the deck beams to break at their centers (Fig. 3-11). Without support from the beams, the deck collapsed and the iron ore cargo spilled into the hull. The downward pressure from the collapsed deck forced apart the sides of the hull, breaking the forward frames at the turn of the bilge. In the bow, the port side of the hull tore away cleanly from the stem assembly, while the starboard side remained attached. When the starboard side of the hull fell outward, the attached stem was pulled over with it, breaking from the keel at the gripe (Fig. 3-12). As *Indiana* sank, the buoyancy of the water wrenched the section of the overhanging elliptical stern, or "fantail" decking, away from the hull. This damage

Figure 3-11. Deck beams broken at their centers. View is from inside of the hull looking forward. (Digital image of underwater video footage recorded by Tom Alburn captured by Douglas Gann).

Figure 3-12. Break in the stem at the gripe (circled). (Photo by Kevin Crisman).

may also have occurred when the upper deck and cabin separated from the rest of the hull.

The 1991 Field Season

Fieldwork on the *Indiana* wreck site commenced on 3 August 1991. The 1991 field crew consisted of the author and fellow graduate student Joseph Cozzi of the Nautical Archaeology Program at Texas A&M University; Raymond Siegfried, III; Paul Johnston, John Stine, Michael Lang, and Kimbra Cutlip of the Smithsonian Institution; Robert Adams, a Texas A&M Nautical Archaeology Program alumnus; Peter Hentschel; and John Steel and his long-time diving associate William Cohrs of Indianapolis, Indiana. Steele's 26-foot (7.92-m) boat *Lake Diver* served as the project's research vessel, and a 16-foot (4.88-m) inflatable boat provided by the Institute of Nautical Archaeology was employed as a chase boat and tender when conditions allowed.

The first day of the project, part of the team prepared equipment and discussed the goals of the project, while Steele and Cohrs relocated the wreck and attached a mooring line and buoy to the hull at the sternpost. The following day, divers were briefed about the survey's overall objectives, divided into teams, and assigned specific recording tasks. The first "check-out" and reconnaissance dives on the wreck were made on 4 August. The check-out portion of the dive was conducted by Lang and Cutlip, who together evaluated the open water skills of each diver, as per the Smithsonian's diving program's standard policy. Once divers had "checked-out" successfully, they toured the wreck and familiarized themselves with its layout.

The primary objective of the 1991 field campaign was to record *Indiana*'s hull. The orientation of the hull was recorded using a hand-held submersible compass. To record the shape of the hull, a fiberglass measuring tape was laid down the longitudinal center line of the hull, and attached with the zero point at the after face of the sternpost. Then a series of offset stations, located at regular intervals along the length of the hull, was established 5, 10, 15, 20, 30, and 50 feet (1.52, 3.05, 4.57, 6.10, and 15.24 m) forward of the sternpost. Excessive distortion in the forward two-thirds of the hull prevented measurement of hull curvatures forward of the 50-foot (15.24-m) offset station.

The method employed to record *Indiana*'s hull curvature was an accurate, although cumbersome, variation of a technique used on a project conducted earlier by Dr. Crisman, at the wreck site of the nineteenth century Lake Champlain sailing canal boat *General Butler*. The technique employed on *Indiana* utilized a weighted plumb line, divided into one-foot (30.48-cm) increments, that was suspended from a nail tacked to the top of the sheer strake at each station, and a large, leveled measuring stick, fabricated from a 10-foot (3.05-m) section of steel conduit, with a measuring tape attached to its upper edge and three line levels secured to its lower edge. The zero-end of the stick was placed against the side of the hull and held level so that it was even to one of the foot marks on the plumb line. The distance where the measuring stick intersected the vertical weighted line was recorded at the one foot (30.48 cm) intervals marked on the line at each station. Using this method, a single diver could record offsets at two or three stations per dive. Recording all of the offset stations required two days to complete.

Once the curvature of the hull was recorded, athwartships measurements across the deck were taken at each of the offset stations. Locations and dimensions of important deck features that intersected the center line tape were then measured by divers, who recorded dimensional data and any additional observations underwater on clipboards fitted with sheets of mylar drafting film. Dimensions and locations of the hull's primary structural members (i.e., keel, posts, keelson, frames, deck beams, planking, decking, ceiling, and bulwarks) were recorded in detail and were sampled for wood species identification.

Immediately after dives, project team divers were interviewed by the author to record additional observations and impressions that were not recorded underwater. While the dive teams worked steadily on the documentation of the hull, Dr. Johnston spent each dive photographing the site from above with a 35-mm Nikonos underwater camera system, so that an interpretive, overall site plan of the wreck could be created from the series of overlapping photographs made of the deck at each offset station. Additionally, extensive videotape footage was recorded of the exterior and interior of the hull and the disarticulated fantail section. The stem, stern, and other important hull features were also photographed and videotaped extensively.

1991 Research

Recorded data from the 1991 field season were analyzed, and the preliminary results from this examination were published by the author in the *Institute of Nautical Archaeology Quarterly*. The 1991 field data were also used by the author in Dr. Frederick Hocker's Advanced Ship Reconstruction class in the spring of 1992 to prepare a preliminary set of hull lines and construction plans and to create a half-hull model of *Indiana*. This class project proved very useful for identifying important gaps in the 1991 data. After discussing the results of the 1991 field season with Drs. Crisman and Johnston, the author recommended that additional fieldwork be undertaken to augment the 1991 archaeological data.

After progressing as far as possible in the analysis of the archaeological data generated by the 1991 fieldwork, the author turned his attention to reconstructing *Indiana*'s operational history by analyzing contemporary "Marine News" newspaper accounts of documenting *Indiana*'s activity throughout most of her ten-year career. The accounts had been collected, transcribed, and organized chronologically by Labadie, Wright, and Wright's graduate student Gerald Metzler during the 1980s. After carefully examining all of the transcribed Marine News reports, the author, with generous assistance from his wife, Hayley C. Robinson, inventoried all of *Indiana*'s documented arrivals and departures to and from different Great Lakes ports and inventoried all of the documented varieties and quantities of cargoes that *Indiana* hauled during her ten years of service.[8] This information was then organized by year in a tabular format to enhance the presentation and interpretation of the data (see Appendices).

Analyses of this information was undertaken to determine the nature of the commerce in which *Indiana* was involved and to document *Indiana*'s annual activity so that her operational history could reconstructed. Additionally, these data were examined for any recognizable patterning in *Indiana*'s routes, ports, and cargoes that might reflect broader trends in the commerce of the lakes during the ten-year period (1848 to 1858) of *Indiana*'s service. Significantly, distinct patterns were recognizable. *Indiana*'s season followed the annual April to December cycle of the lakes without any significant deviation. Although it carried a wide variety of items, *Indiana*'s most common cargo was grain which was the principal staple of the Great Lakes trade before iron ore. The ports *Indiana* visited most frequently (i.e., Buffalo, Cleveland, Detroit, Toledo, Dunkirk) were also the busiest ports on the Great Lakes.

In addition to the analyses of *Indiana*'s construction and operational career, the author and Dr. Hocker travelled to the Smithsonian in December of 1991 to document the construction of *Indiana*'s rudder and propeller. The results of this documentation effort are presented in Chapter IV.

The 1992 Field Season

The second season of fieldwork was conducted between 31 July and 14 August 1992, and it had several specific recording goals. These primary tasks of the 1992 season included surveying the site with side-scanning sonar; recording construction details above and below decks; the complete documentation of the stem, sternpost, and remaining vestiges of the upper works; the recovery of additional wood samples; the full documentation of the interior and exterior of the vessel using an underwater video camera with the intent of eventually creating a digital video mosaic of the entire wreck site; and finally, the removal of all vestigial debris from the earlier Smithsonian expeditions.

Because of the long list of tasks to be completed, logistics for the 1992 field season were more structured than in the first year. The crew for the 1992 *Indiana* Project was larger than the 1991 team and included several highly experienced, talented archaeologists and documentation specialists. The 1992 field team consisted of the author; fellow Texas A&M University graduate students Joseph Cozzi and Alan Flanigan; Kevin Crisman; marine biologist Hera Konstantinou; Robert Falvey; underwater videographer Thomas Alburn; Paul Johnston, John Stine, Michael Lang, and Kimbra Cutlip, from the Smithsonian Institution; Peter Hentschel; historic resources documentation specialist Richard K. Anderson, Jr.; John Steele; William Cohrs; and George West.

The initial task of the 1992 project entailed surveying *Indiana*'s wreck site with a side-scanning sonar. For the side-scanning sonar survey, Steele used his own Klein Model-521 sonar system to produce high-quality acoustic images of the entire wreck site, including the debris designated as Features B, C, and D, described earlier.

The first underwater tasks of the 1992 field season were to locate and buoy the wreck and to conduct a check-out and orientation dive for new project divers. As in 1991, Lang and Cutlip conducted the check-out and orientation dive. During the orientation dive, Alburn videotaped most of the wreck site. This videotape footage proved very useful later in the project when it was used for pre-dive briefings and discussions about certain aspects of the site or construction features of the hull.

To accomplish the task of documenting the lower portions of the stem and the sternpost, deep sand overburden was removed by an airlift and hand digging. No artifacts were uncovered during the excavation, but the missing fourth blade from *Indiana*'s propeller was discovered at the close of the 1992 field season, wedged into the base of the sternpost. In addition to recording the dimensions of *Indiana*'s hull timbers, a total of 35 individual wood samples were removed from 30 different structural components for analysis and wood species identification throughout the project. Wood samples recovered in 1991 and 1992 were identified by researchers at the Center for Wood Anatomy Research, U.S. Forest Products Laboratory, Madison, Wisconsin. Samples of hull paint and what appeared to be caulking were also collected during the 1992 season and given to the Smithsonian's Conservation Analytical Laboratory for compositional analysis. Researchers at the laboratory conducted scanning electron microscopy/energy dispersive analysis, fournier transform infrared, x-ray diffraction, and gas chromatography analyses. Additional wood, paint, and caulking samples were recovered from the site in 1993 and were subjected to the same examinations.

Unfortunately, time ran out before all of the documentation tasks could be completed and debris from the earlier Smithsonian field work could be removed, so an abbreviated third season of fieldwork was scheduled for the summer of 1993.

Because of the project's time constraints, the author determined that a highly effective additional method of documenting *Indiana*'s wreck site would be to utilize the newly-devised technique of video-mosaic imaging. The process entails creating a composite digital image from individual frames captured from videotape footage recorded underwater. As with a traditional photomosaic, the video footage is recorded at a constant height above the wreck, using a reference when possible. Although use of a reference grid for positioning control would have been ideal, such a grid would have been prohibitively time consuming to establish for the *Indiana* Project and therefore was not employed. Furthermore, the inventors of the technique, Harley Seeley and Kenneth Vrana of Great Lakes Visual/Research, Inc., reported that to videodocument a 12-foot (3.66-m) by 33-foot (10.06-m) area (located in just 25 feet [7.62 m]) of water) using a rigid grid required 11 hours of underwater time.[6]

Based on these figures, 133 hours of underwater time would have been required to video-document *Indiana*'s approximately 30-foot (9.14-m) by 160-foot (48.77-m) wreck site. Over the course of a two-week field campaign, the most time any one diver spent on the wreck during any given year did not exceed a total of 4.2 hours. In fact, the combined bottom time from all three seasons of fieldwork amounted to only 104.75 hours, 28.25 hours less than would have been necessary just to shoot the videomosaic with a reference grid. Obviously, a less time-consuming technique of recording the video footage was required. The simplest solution was for Alburn to videotape the wreck from a fixed distance above it, while swimming a series of five parallel lines along the length of the hull. In addition to plan view footage, Alburn also videotaped port and starboard profiles of the wreck.

This video footage was eventually used to create the first and only extant composite images of *Indiana*'s wreck site, made by capturing individual videotape frames using *Video-Snappy* computer software. Effects of distortion from the wide angle camera lens were removed using another computer software program called *Kai's Power Goo.* Finally, individual images were imported into *Adobe Photoshop*, where they were pasted together digitally to create color and black-and-white videomosaic images of the site (see Fig 3-8).

1992 Research

During the interval between the 1992 and 1993 field seasons, the author made two research trips to Washington, D.C., presented a paper on *Indiana*'s design and construction at the Society for Historical Archaeology's Conference on Underwater Archaeology, and conducted archival research in Buffalo, Cleveland, and Vermilion. While in Washington, D.C., the author: 1) recorded *Indiana*'s propeller and rudder assembly with Dr. Fred Hocker's assistance; 2) conducted archival research at the Library of Congress and the National Archives; 3) documented additional items recovered from *Indiana*; and 4) assisted Smithsonian Behind the Scenes Volunteer David Shepard in lifting the lines from a half-hull model of the 1844 coastal screw-propelled steamboat *Decatur* (Figs. 3-13 and 3-14).

In Buffalo, the author conducted research at the Buffalo Public Library and the research library of the Buffalo & Erie County Historical Society. Research in these repositories produced several interesting documents, including biographical information and a photographic image of *Indiana*'s final owner Francis Perew, lithographic and photographic images (circa 1846 and 1847, respectively) of the propeller *Globe*, the 1856 Association of Lake Underwriters Board of Marine Inspectors' "Rules, &c. Relative to the Construction of Sail Vessels and Propellers to Class A1," and additional information concerning two of *Indiana*'s owners, Merwin S. Hawley and Samuel F. Pratt. Finally, the author travelled to Cleveland and Vermilion to conduct archival research at the Case Western Reserve Library and the Great Lakes Historical Society's research library.

In January of 1993, Dr. Johnston and the author presented professional papers at the annual meeting of the Society for Historical Archaeology's Conference on Underwater Archaeology that described the interim results of the most recent field research on *Indiana*. This information also appeared in the form of an interim report, co-written by the author and Dr. Johnston and published in the *International Journal of Nautical Archaeology*.[10]

Several days before the start of the 1993 field campaign, a day was spent conducting archival research in Marquette. This brief research effort proved very successful, and produced two previously unknown newspaper accounts of *Indiana*'s sinking which included the names of *Indiana*'s four

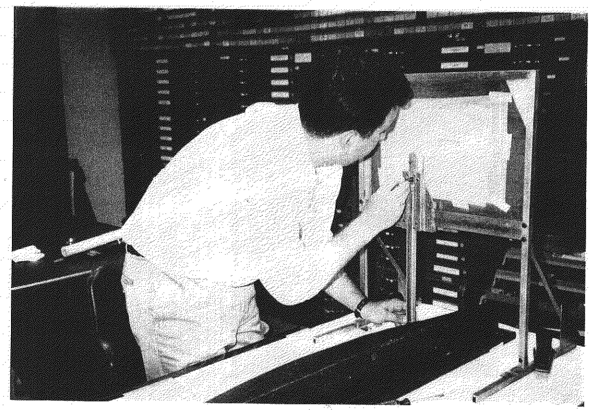


Figure 3-13. U.S. Coast Guard naval architect David Shepard lifting lines from the builder's half-hull model of the coastal propeller-packet *Decatur* (1844). (Photo by David S. Robinson).

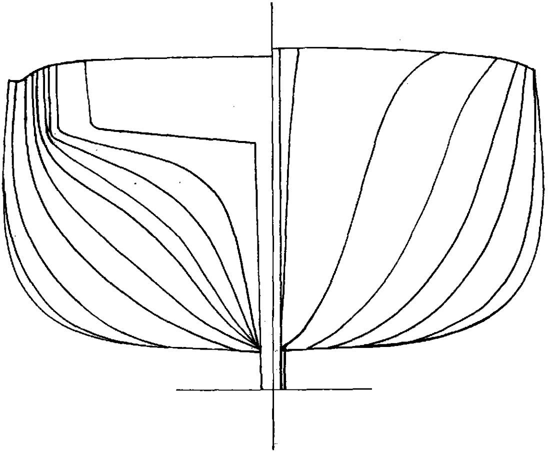


Figure 3-14. Body plan of coastal propeller-packet *Decatur* (1844). (Drawing by David Shepard).

passengers, information indicating *Indiana* had two decks when it sank, and detailed descriptions of events that had occurred immediately before and after the time of the sinking.

The 1993 Field Season

The third and final season of field work was scheduled for June of 1993, instead of August because of conflicting schedules among members of the project team. The 1993 project team consisted of the author, Joseph Cozzi, and Alan Flanigan of Texas A&M University; Paul Johnston, John Stine, and Michael Lang of the Smithsonian; Peter Hentschel; John Steele; and William Cohrs. The main goals of the 1993 field season were to remove debris from the earlier Smithsonian expeditions, to re-measure the hull's curvatures using a newly-invented submersible digital goniometer, to examine and document in greater detail the displaced sections of upper works, to document what effect the Smithsonian's salvage operations had on *Indiana*'s hull, to take measurements to correct or verify those recorded during the first two seasons, and finally, to carefully examine the damages to *Indiana*'s stern so that the sequence of events leading to her loss might be reconstructed.

The first underwater task of the 1993 field campaign involved recording *Indiana*'s cross-sectional hull curvatures using a submersible digital goniometer, an ingenious device devised by Cozzi that proved very fast and easy to use.[11] It consisted of an electronic carpenter's level contained in a modified waterproof 110-mm camera housing manufactured by Ikelite, Inc. The device was used to record the curvature of the hull, from the sheer to the keel, as a series of angles divided into one-foot (30.48 cm) increments. These data sets were recorded at each of the 1991 offset stations, then plotted on graph paper to recreate the cross-sectional shape of the hull.

Also completed during the 1993 field season was a preliminary assessment of the site's integrity, based on casual observations recorded during dives and thorough review of the video and photographic data. The most striking aspect of the wreck is the magnificent state of preservation of individual hull components after more than 135 years underwater. In most areas where the hull remains were intact, planking seams were secure and individual timbers comprising the hull were solid. In fact, the condition of the wood was so good that obtaining samples of it with a hammer and chisel was difficult. Remarkably, even paint residue was visible in many areas. Iron elements in the hull also appeared well preserved. Most of the iron hull components have retained most of their original mass and strength, although now they are covered by a moderately heavy layer of surface corrosion.

One disturbing aspect of the wreck site is the almost total absence of portable artifacts. Portable objects of perceived value have been removed by relic-seeking sport divers since the vessel's discovery. This loss of material data from the archeological record is unfortunate because it detracts from the interpretation of the wreck and hinders our understanding of the daily life of *Indiana*'s crew. Furthermore, it made it impossible to differentiate areas of specialized activity within the hull, such as the galley, ship's stores, or crew's quarters.

One additional aspect of the wreck to be considered was the effect that the removal of machinery has had on the integrity of *Indiana*. The hull appears to have sustained only minor physical damage as a consequence of earlier salvage operations. Damage that had occurred was isolated to the removal of several small sections of decking and coamings around the perimeter of the engine and boiler hatches. In several ways, the removal of these elements was actually beneficial to the study and interpretation of *Indiana*'s design and construction. Having the machinery available for study at the surface greatly facilitated their documentation and, consequently, increased the level of detail that could be obtained. Also, without the engine and boiler in the hold, more areas of the hull's interior were accessible for documentation. Regrettably, the precise original positions of these elements were not documented prior to their 1979 salvage. Film footage of the wreck shot by John Steele in 1972 represents the only permanent record of the machinery in its original context within *Indiana*'s hull.

Investigation into the Cause of *Indiana*'s Loss

The final objective of the field investigation was to locate physical evidence for the cause of *Indiana*'s loss. Historical accounts attributed her sinking to a massive leak caused by a burst stuffing box or "stern pipe" that had probably overheated and "caused the splitting of her sternpost," after which "she immediately commenced filling."[12] Examination of these members alone initially revealed less dramatic evidence of the catastrophic failure than had reportedly occurred. When the damage sustained by these members was compared with other damages that were visible in the inner sternpost, propeller, stern tube bearing, and rudder it became possible to reconstruct a hypothetical sequence of events that led to *Indiana*'s loss. Descriptions of these damages and a reconstruction of the events leading up to the failure of *Indiana*'s stuffing box are presented in the next chapter describing *Indiana*'s construction.

Notes: Chapter III

1. Julius F. Wolff, Jr., *Lake Superior Shipwrecks* (Duluth, MN, 1990), 64.

2. *Ibid.*, 51.

3. See: "Arrival of The *Iron City*," *Cleveland Morning Leader*, 14 June 1858; "Total Loss of Propeller *Indiana* on Lake Superior," *Detroit Daily Free Press*, 12 June 1858; "Probable Wreck of a Propeller," *Lake Superior Miner*, 12 June 1858; and "Loss of the Propeller *Indiana*," *Painesville Telegraph*, 17 June 1858.

4. Keith Muckelroy, *Maritime Archaeology* (Cambridge, England, 1978), 157.

5. According to Hunter, "Frequently when a steamboat sank in deep water the cabin broke loose from the hull and floated off..." Louis B. Hunter, *Steamboats on the Western Rivers, An Economic and Technological History* (New York, NY, 1993 [1949]), 437. Lenihan has observed that "Few elements of deck structures have been located from any of the [wrecks of] wooden vessels" he has investigated in the Great Lakes. He attributes this absence to the fact that deck structures were of comparatively lighter construction, were easily demolished, and usually separated from the hull during or soon after the wrecking event. Daniel J. Lenihan, ed., *Submerged Cultural Resources Study: Isle Royale National Park* (Santa Fe, NM, 1987), 229.

6. *Lake Superior Miner, ibid.*

7. *Detroit Daily Free Press, ibid.*

8. Gerald C. Metzler, compiler, *Partial List of* Indiana's *Voyages and Cargoes, Based on Newspaper Marine Intelligence Reports* (Smithsonian Institution, National Museum of American History, Division of Transportation, *Indiana* files, unpublished manuscript, n.d.).

9. Kurt Stepnitz, "Video-mosaic Imaging: Electronic Techniques Improve Results in Underwater Archaeological Documentation," *Photo* (April, 1992), 24-27.

10. Paul Forsythe Johston and David Stewart Robinson, "The wreck of the 1848 propeller *Indiana*: interim report," *The International Journal of Nautical Archaeology and Underwater Exploration*, vol. 22, no. 3 (1993), 219-235.

11. J. Cozzi, "The Goniometer: an improved device for recording submerged shipwreck timbers," *The International Journal of Nautical Archaeology and Underwater Exploration*, vol. 27, no. 1 (1998), 64-84.

12. *Cleveland Morning Leader, ibid.*

CHAPTER IV

THE CONSTRUCTION OF *INDIANA* BASED ON THE FIELD INVESTIGATIONS OF 1991-1993

Introduction

The principal purpose of this thesis was to record previously undocumented details of the design and construction of an early Great Lakes screw-propelled steamboat. In this chapter, the materials, dimensions, and assembly of *Indiana*'s extant hull elements, as they were recorded under water during the 1991 to 1993 archaeological field investigations, are presented. Also included in this chapter are descriptions of the principal components of *Indiana*'s propulsion system and some of the miscellaneous artifacts that were recovered by the Smithsonian Institution and others during the late 1970s and early 1980s. Descriptions of *Indiana*'s propulsion machinery are based primarily on Anderson's 1991 study, while the descriptions of *Indiana*'s miscellaneous artifacts derived from data collected during the several research and documentation trips to the Smithsonian that were made by the author between 1991 and 1993.

During the course of the underwater field research and the documentation work at the Smithsonian, thousands of measurements were recorded and dozens of drawings were created. Additionally, samples of wood and paint were collected, numerous photographs were taken, and hours of underwater video-footage were recorded. All of these data served as the basis for the numerous illustrations that are included in this chapter as well as the site plan and reconstructed lines and construction plans that appear in Figs. 3-8, 5-13, and 5-15.

Descriptions of individual hull components are presented in approximately the same sequence as they were assembled during *Indiana*'s original construction. Descriptions of *Indiana*'s propulsion system and miscellaneous artifacts are included at the end of the chapter. Although every effort has been made to the present this information to the reader in as clear and concise a manner as possible, because of the complexity of many of the structures and the technical nature of these descriptions, the reader is encouraged to refer frequently to the illustrations and plans that are included in this chapter and others throughout the text.

Species Analyses and Identification of Wood Specimens

Analyses of wood specimens recovered during field investigations revealed that *Indiana*'s hull was constructed entirely of white oak (*Quercus alba*), with the exception of the decking, bulwarks, and bulkheads, all of which were fashioned from white pine (*Pinus strobus*).[1] White oak was the premier wood selected by nineteenth- century American shipbuilders, principally because of its superior durability, strength, resistance to rot, and versatility. Because of its growth pattern, every structural member (i.e., keel, frames, beams, planking, knees, etc.) of a ship could be obtained from white oak. Perhaps even more importantly, its widespread availability throughout the northeastern United States and the Great Lakes region made it an economical choice for shipbuilders. White pine was also common in the northeastern United States and around the Great Lakes. For a time it was considered the most valuable timber tree in the Northeast because of its softness, straight and inconspicuous grain, good resistance to rot, and superior workability. Like white oak, white pine was frequently used in shipbuilding, and was preferred for decking, upper works, and masts for its light weight. Complete results from the analyses of the wood samples recovered from *Indiana* are included in Appendix B.

Compositional Analyses of Paint and "Caulking" Specimens

White paint samples recovered from the exterior of *Indiana*'s hull were identified as a combination of lead carbonate, barite, barium sulfate, and an unidentified drying oil. Green paint samples collected from *Indiana*'s trim were identified as a mixture of barite, quartz, lead carbonate, lead chromate mixed with Prussian blue (to give the mixture a chrome green color), arsenic (possibly as an emerald green coloring agent), copper oxalate, and an unidentifiable drying oil.[2] Samples of a white material recovered from the seams between the hull planking were thought to be caulking, but analysis revealed that this material contained the same constituents as the white paint samples and did not exhibit the systematic distribution of fibers in the matrix that would be expected of "oakum" caulking.[3] Oakum, consisting of teased-out hemp rope treated with pine tar and prepared in a thread form, most certainly would have been used to render planking seams throughout *Indiana*'s hull watertight; however, no evidence of any such caulking was obtained during this study. Complete results from the analyses of paint and caulking samples recovered from *Indiana* are also included in Appendix B.

Fasteners

Fastenings used to join *Indiana*'s hull timbers consisted of iron bolts, spikes, and nails. Dimensions of these different fasteners and their relationship to individual hull components were recorded when possible, but time and the logistical constraints of the project permitted only a cursory examination of *Indiana*'s fasteners. Fortunately, the type, number, and patterning of hull fasteners could be determined in most cases from photographs and videotape footage of the wreck.

One interesting aspect of *Indiana*'s fastening was the absence of treenails. Although treenails were commonly employed by North American shipbuilders at the time of *Indiana*'s construction, none were observed in its hull remains during the field investigations.[4] The apparent absence of treenails in *Indiana*'s hull may be attributed to the ready availability of iron fasteners from the Vermilion-based Huron Iron Company, located in close proximity to the shipyard where *Indiana* was constructed. *Indiana*'s builder also may have chosen iron fasteners over treenails because of the former's comparative quickness and ease of installation and superiority in resisting shearing forces.[5] Additional deterrents to the use of treenails include the weakening of frames resulting from the drilling of large holes required to receive them and the treenails' tendency to break and decay.[6] Furthermore, the non-saline properties of the Great Lakes' fresh water allow iron to corrode slowly and may have actually improved the gripping strength of iron fasteners in some cases. The limited corrosion that did occur should have slightly increased the holding power of the fasteners.[7]

While the exclusive use of iron fasteners throughout *Indiana*'s hull may have been economical, this system would have added to the overall weight of the hull. Controlling the overall weight of *Indiana*'s hull to reduce draft while maximizing cargo capacity would have been critical elements for *Indiana*'s builder to monitor during the construction process, particularly because of *Indiana*'s somewhat exaggerated length-to-breadth ratio (6.4:1) and the numerous shoal waters *Indiana* was required to navigate. It is interesting to note that for sailing ships built during the 1830s, New York shipbuilder Lauchlin McKay calculated that the average weight of the fasteners used in a ship's hull and rigging amounted to 68 pounds (30.84 kg) of iron per ton of measurement.[8] Applying McKay's calculations to *Indiana* and using its registered tonnage of 349 tons, *Indiana*'s hull and rig contained an estimated 23,732 pounds (10,764.76 kg) of iron fastenings.

The Keel, Stem, and Sternpost

The Keel

The backbone of *Indiana*'s hull comprised four structural elements: keel, stem, sternpost, and keelson. The keel, stem, and sternpost were the first hull components to be assembled on the stocks, and they defined *Indiana*'s overall length between perpendiculars. The dimensions and design of these members was determined by the construction requirements of the ship, the availability of materials, and the builder's knowledge.

Indiana's keel served as the hull's principal longitudinal timber and helped keep the boat on a straight course while underway. Extending below the bottom of the hull, the keel also protected *Indiana*'s hull from damage caused by accidental groundings. However, the hull's upright orientation on the lake bed, minimal deadrise, and intactness, as well as large amounts of immovable debris surrounding the hull, made the keel almost entirely inaccessible for documentation. During field investigations, both the extreme forward and after ends of the keel were located, indicating that the keel is preserved intact over its full length, estimated at approximately 143 feet (43.59 m). Unfortunately, the forwardmost end of the keel proved impossible to record accurately, because it was obscured by approximately two feet (61.0 cm) of loose sand overburden that could not be excavated quickly enough to expose the keel for more than a few seconds. In contrast, the after end of the keel was buried less deeply, and was therefore more accessible for documentation and sampling.

Measurements of the keel's after end were recorded at two separate locations: 3 to 5 inches (7.6 to 12.7 cm) forward of the sternpost rabbet, and approximately 5 feet (1.5 m) forward of the sternpost rabbet. Measurements taken at both of these locations indicated that the keel's molded dimension, measured from the rabbet to the bottom of the keel, was just 4 inches (10.16 cm). The keel's sided dimension measured 10 inches (25.4 cm). The recorded molded height of the keel below the rabbet may represent only a portion of the keel's original molded dimension (as measured from the rabbet), because of the probability that a skeg for the rudder may have been attached to the keel where the measurements were recorded. Presuming that the skeg was about 2 inches (5.08 cm) thick, the keel's molded dimension between the garboard rabbet and the heel may instead have actually been closer to 6 inches (15.24 cm), rather than the 4 inches (10.16 cm) that was recorded. A short section of the keel's aftermost end is missing from the area directly below the sternpost and may have broken off when the iron rudder skeg became detached from the hull. No evidence of a keel shoe was noted.

The Stem Assembly

The first structure to be erected onto *Indiana*'s keel was most likely the stem. The stem served as the termination point for all of the forward hull components adjoining it. Like the keel, the stem was a vitally important structural member that had to be built and fastened strongly. Despite the strength of the stem's construction, *Indiana*'s bow sustained massive damage when the bottom of the hull struck the lake bed. Upon impact, the deck forward of amidships collapsed under the weight of the iron ore cargo and forced apart both sides of the hull. While fastenings and wooden structural components connecting the stem to *Indiana*'s port side failed, those on the starboard side did not. Consequently, when *Indiana*'s starboard bow peeled away, the entire stem assembly was pulled over onto its starboard side along with it, breaking free from the keel at the gripe just above the scarf.

Indiana's stem assembly is a complex structure composed of several interrelated members that include the stem proper, the apron, a stem piece, two hawse pieces, two hooks, a section of the main deck, the clamps, and a single surviving deadwood timber (a windlass and its massive wooden bitt, located immediately abaft the stem assembly, will be described later in the chapter with *Indiana*'s other deck equipment). The stem and apron comprise the principal members of the stem assembly, and both were hewn from massive, single pieces of white oak that remain fastened together securely and are preserved over their entire measured length of 25 feet, 2 inches (7.67 m) (Fig. 4-1).

In profile (from head to foot), the leading edge of the stem proper flares, giving the stem and apron a combined molded dimension that ranges from a minimum of 1 foot, 5-3/4 inches (0.5 m) at the head to a maximum of 3 feet, 7-1/2 inches (1.1 m) at a point approximately 5 feet (1.52 m) above the foot of the stem assembly. From this point, the leading edge of the stem sweeps aft in an easy arc, forming an rounded forefoot that met the slightly rockered forward end of *Indiana*'s keel. The stem assembly was flat-scarfed to the keel, to which it was securely fastened with four large blind drift bolts measuring approximately 1 inch (2.54 cm) in diameter, visible at the forefoot where the keel has split in half, lengthwise (Fig. 4-2).

The breadth or sided dimension of the stem's leading edge tapers slightly from 4-3/4 inches (12.07 cm) at the head of the stem to 3-5/8 inches (9.19 cm) at the forefoot. In contrast, the sided dimension of the apron's after face flares somewhat towards the keel, from 1 foot-3/4 inches to 1 foot, 4-3/4 inches (32.39 to 42.55 cm). The stem rabbet is completely exposed on the port side because of the absence of hull planking. The rabbet extends from the level of the main deck, 10 feet, 2 inches

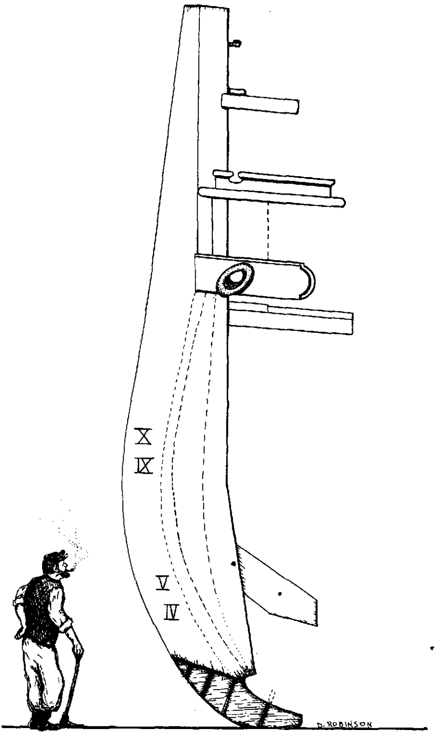


Figure 4-1. *Indiana's* stem assembly. (Drawing by David S. Robinson).

Figure 4-2. Forefoot of *Indiana*'s stem. (Photo by Kevin Crisman).

(3.10 m) below the head of the stem, to a measured distance of 23 feet, 2 inches (7.06 m) below the stem's head. The width of the rabbet (measured between the rabbet and bearding lines) flares from a minimum of 2-3/4 inches (6.99 cm) at its upper terminus to a maximum of 9-1/2 inches (24.1 cm), 22 feet (6.71 m) below the head of the stem. A second rabbet, cut into the sides of the apron for a single stem piece and the forwardmost of two hawse pieces that were faired into either side of the apron and deadwood, extends from the level of the main deck to a point approximately 20 feet (6.10 m) below the head of the stem. This second rabbet runs roughly parallel with the stem rabbet and varies in width from 6 to 12 inches (15.24 to 30.48 cm). The accessible starboard hawse piece measured 6 inches (15.24 cm) molded and 1 foot, 1/2 inch (30.61 cm) sided.

Four Roman numerals carved into the port side of *Indiana*'s stem at the 4, 5, 9, and 10 foot (1.22, 1.52, 2.74, and 3.05 m) waterlines indicate *Indiana*'s draft when both light and loaded. As in several other areas of the hull, white paint residue was visible within the recesses of the incised numerals (Fig. 4-3).

An iron eye bolt and thimble fastened to the after face of the apron, 1 foot, 4-1/2 inches (41.9 cm) below the head of the stem, provide the only archaeological evidence of *Indiana*'s sailing rig and represent one of the two pieces of hardware present on *Indiana*'s stem assembly. Examinations of photographs and illustrations of other mid-nineteenth century Great Lakes steamers and propellers suggest that this eyebolt on *Indiana*'s apron served as the anchor point for the forestays of the main mast. The inside and outside diameters of the eyebolt measured 2-1/2 inches (6.4 cm) and 4-1/2 inches (11.4 cm), respectively. The inner and outer diameters of the thimble measured 2 inches (5.08 cm) and 3-3/8 inches (8.573 cm), respectively.

The only other iron hardware attached to the stem was a partially preserved iron strap or "nosing" piece affixed to the stem's leading edge. The nosing measured 1 inch (2.54 cm) thick and 2-1/2 inches (6.4 cm) wide. Iron spikes spaced 1 foot, 4 inches (40.64 cm) apart held the nosing in place. The uppermost end of the nosing terminates in a break located 3 feet, 7 inches (1.09 m) below the head of the stem. The nosing appears to extend the full length of the stem, although the foot of the stem was buried too deeply beneath sand to determine the precise location of the nosing's lower limit.

Secondary elements comprising the stem assembly include two hooks (an upper deck hook and a breast hook), a triangular section of the main deck, the forward terminus of the clamps, and a single deadwood timber. Careful examination of these features provided substantial evidence for determining

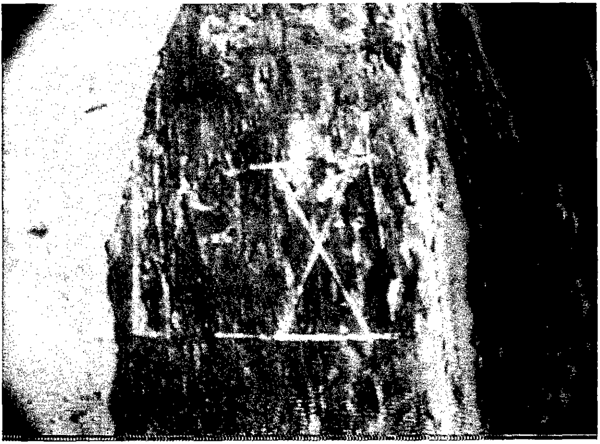


Figure 4-3. White paint residue visible in the nine-foot (2.74-m) draft mark incised on the port side of *Indiana*'s stem. (Digital image of underwater video footage recorded by Thomas Alburn captured by Douglas Gann).

the original shape and assembly of *Indiana*'s demolished bow.

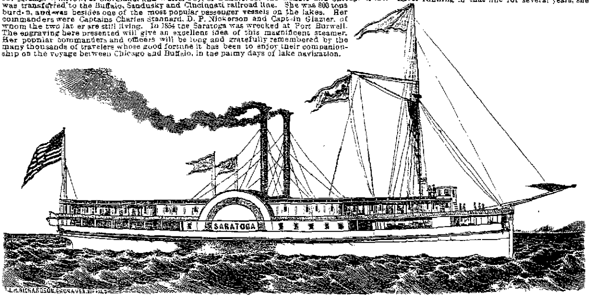
The two hooks are fastened to the after face of the apron. The smaller, partially intact, uppermost deck-hook is located 2 feet, 10-1/2 inches (87.6 cm) below the stem's head and corresponds with the forward terminus of a lightly constructed upper or "spar" deck. The forward edge of the deck-hook is cut to fit securely around the after face of the apron, and it is fastened in place with two iron bolts, spaced 6-1/2 inches (16.5 cm) apart. At the point where the deck-hook joins the stem, a small, crescent-shaped nailer piece, 19 inches (48.26 cm) long and 2-1/2 inches (6.4 cm) thick, is scabbed to the top of the hook. Two fastener holes, 1 inch (2.54 cm) in diameter and drilled into both sides of the apron 1 foot, 8 inches, and 2 feet, 8 inches (50.80 and 81.28 cm) above the hook, indicate the former location of a spar deck rail. The intact port arm of the hook measured 6 inches (15.24 cm) thick, 2 feet, 6-1/2 inches (72.4 cm) long, and ends in a vertical half-lap.

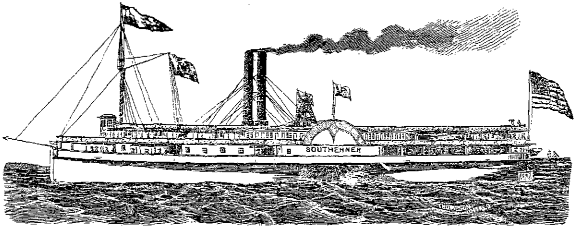
A second, larger, hook or breast-hook also is attached to the after face of the apron, 5 feet, 7 inches (1.70 m) below the head of the stem. As with the smaller, upper-deck hook, the forward edge of the breast-hook was also recessed (1 foot, 2 inches [35.56 cm]) to fit around the after face of the apron. The arms of the breast-hook measured 5 feet, 11 inches (1.8 m) long and 3-1/2 inches (8.89 cm) thick and taper in width from 2 feet, 2 inches (35.56 cm) at the throat to approximately 5 inches (12.70 cm) at their ends. A low, 6-3/4 inch (17.15 cm) rail is secured to the upper face of the breast-hook. This rail is topped with a 2-inch- (5.08-cm-) thick cap, which flares in width from 2 inches (5.08 cm) at the ends of the arms to 1 foot (30.48 cm) where it abuts the sides of the stem. Two (one on each side) 6-inch- (15.24-cm-) wide fairleads for mooring lines are carved into the port and starboard sides of the rail's upper face. Based on its location on the stem (relative to the triangular section of the main deck described below) and its construction, this breast-hook is believed to correspond with the inferred position of the main deck rail. Furthermore, construction details of this hook suggest that the sides of the hull were open at the bow, between the main deck rail and the spar deck, in a manner that was common for Great Lakes steamers built during the middle to late 1840s (Fig. 4-4).[9]

Beneath the breast-hook for the main deck's handrail, 10 feet, 2 inches (3.09 m) below the head of the stem, is located a triangular section of decking representing the forward terminus of the main deck. This decking section is part of an assemblage of several additional hull components, some of which are still are attached to the starboard side of the hull. These components include a crescent-shaped nailer piece, several strakes of decking, three heavy edge-joined deck reinforcement timbers, the

THE SARATOGA.

The steamer Saratoga, in her day one of the most elegant and popular craft on the great lakes, was built in 1846 by Moses & Sandford, at Cleveland, for Messrs. Winslow, of Cleveland, and Walter Joy, of Buffalo, for the Buffalo and Chicago trade. After running in that line for several years, she was transferred to the Buffalo, Sandusky and Cincinnati railroad line. She was 800 tons burden, and was besides one of the most popular passenger vessels on the lakes. Her commanders were Captains Charles Stannard, D. P. Nickerson and Captain Glazier, of whom the two latter are still living. In 1854 the Saratoga was wrecked at Port Burwell. The engraving here presented will give an excellent idea of this magnificent steamer. Her popular commanders and officers will be long and gratefully remembered by the many thousands of travelers whose good fortune it has been to enjoy their companionship on the voyage between Chicago and Buffalo, in the palmy days of lake navigation.





STEAMER SOUTHERNER, THE FIRST OF THE CLEVELAND AND DETROIT LINE.

The once famous steamer Southerner was built at Trenton, Mich., in 1847, for the Monroe and Buffalo line. She had a carrying capacity of over five hundred tons, and was considered in those days one of the finest vessels afloat. After running several years, she was transferred to the Cleveland and Detroit line, being with the Baltimore the pioneers of that line. She was commanded by Capt. L. A. Pierce, who has ever since been connected with this popular line, and is now general manager. Col. L. D. Rucker, now a well known railroad manager, was for a time clerk on the Southerner. In 1863 she was wrecked in Lake Erie. The accompanying cut gives a very good representation of this once popular steamer.

Figure 4-4. Contemporary lithographs of the Great Lakes steamers *Saratoga* (1846) and *Southerner* (1847). Note the construction of both vessels' upper works, particularly their open bows at the main deck level, a common feature of Great Lakes steamboats of the late 1840s. (Lithographs from *Marine History. The Lake Ports*, n.p.).

forward ends of the clamps, port and starboard trailboards, a stem piece, hawse timbers, and the windlass and windlass bitt.

The 3-inch-(7.62-cm-) thick crescent shaped nailer piece is scabbed onto the after face of the apron and to the upper face of a heavy athwartships timber, which hereafter will be designated as the forwardmost transverse deck reinforcement timber. The arms of the nailer piece measured 26 inches (66.04 cm) long and taper in width from 10 inches (25.40 cm) at the throat, to 5 inches (12.7 cm) at their ends.

Seven deck planks, each measuring 2 inches (5.08 cm) thick and 4-3/4 to 8 inches (12.07-20.32 cm) wide, are preserved in their original positions immediately abaft the apron. Together, the planks represent the surviving portion of the forward terminus of the main deck.

Beneath this decking are three massive athwartships timbers averaging 6-3/4 inches (17.15 cm) thick and approximately 1 foot, 4-1/2 inches (41.9 cm) wide. The leading edge of the forwardmost deck reinforcement timber measures 1 foot, 4 inches (40.64 cm) across, and it is fastened to the after face of the apron. The trailing edge of the aftermost reinforcement timber measured 8 feet, 3 inches (2.51 m) across its face and is located a distance of 4 feet, 2 inches (1.27 m) abaft the inboard face of the apron.

The outboard ends of each deck reinforcement timber rest on top of the converging forward ends of the port and starboard clamps, where they are secured in place with a single large iron spike. The flat-nibbed ends of the clamps are let into notches cut into the inboard faces of the forwardmost hawse pieces (Fig. 4-5). These athwartships deck reinforcement timbers performed an important function by providing necessary strength and rigidity to the bow, and, with the clamps, they served the same purpose as a deck hook.

The outboard edges of the forward main deck section that are attached to the stem assembly are defined by "cheek pieces" that are secured to the stem immediately above the level of the deck, and the clamps positioned immediately below the deck. These cheek pieces are a vestigial part of a commonly employed ornamental feature known as "trailboards," which decorated the bows of most wooden ships until the era of the clipper ship (circa 1845-1859), after which time their use declined.[10] In most instances, trailboards extended from the foot of the figurehead to a point slightly abaft the hawse holes. The after portions of the trailboards, perforated by the hawse holes, were referred to specifically as the cheek pieces.[11] Since *Indiana* lacked a bowsprit or a figure-head, the trailboard is significantly shortened and includes just the cheek piece portion, which begins at the stem rabbet, described above (Fig. 4-6).

Figure 4-5. The forward end of *Indiana*'s starboard clamp. (Digital image of underwater video footage recorded by Thomas Alburn captured by Douglas Gann).

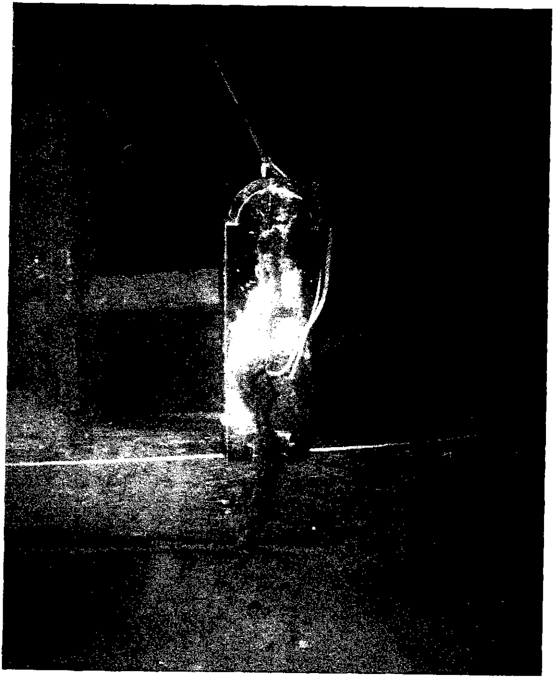


Figure 4-6. *Indiana*'s port cheek piece. (Photo by Kevin Crisman).

Indiana's port and starboard cheek pieces are each fitted with a single, iron hawse pipe 6 inches (15.24 cm) in internal diameter that passes through both a thick hawse timber and the cheek piece. More than simply a decorative flourish, the ornate check pieces actually served an important function by expanding the radius of the hawse hole's lower edge, which prevented the anchor chain cable from cramping and knocking as it passed through the hull, and reduced the amount of wear suffered by the hull, windlass, anchor chain, hawse pipes, and the ship's crew during anchoring operations.[12]

Because of the stem assembly's present orientation on its starboard side, only the port cheek piece was completely accessible for documentation. The cheek piece is of laminate construction and was fabricated from two timbers: an underlying piece approximately 7 inches (17.78 cm) thick and a tombstone-shaped decorative outer piece 2-1/2 inches (6.4 cm) thick with a molded edge. The cheek piece's overall dimensions measured 1 foot, 2-3/4 inches (37.47 centimeters) wide, and 4 feet, 1/2 inch (1.23 meters) long. The underlying piece is essentially the same size, but it is approximately three times thicker.

A single, diagonal deadwood timber is fastened to the after face of the stem, 18 feet, 5 inches (5.62 m) below its head (see Fig. 4-1). The timber measures 3 feet, 4-1/2 inches long (8.25 cm) and is sided 1 foot (30.48 cm) and molded 1 foot, 4 inches (40.64 cm). Laboratory analysis of a small sample taken from this white oak member indicated that it was fashioned from either the heartwood of a large branch or the trunk of a sapling.[13] The after or lower end of the deadwood timber is bevel-cut to form an 84° angle from vertical. Based on the arrangement of the bow timbers in *Alvin Clark*, it was supposed initially that the beveled end of *Indiana*'s deadwood fitted against the top of the keelson and the forward face of the windlass bitt.[14] However, when the author reconstructed this area of the bow on paper, the beveled end of the deadwood terminated above the keelson. This finding indicated that the deadwood must have butted against another deadwood timber that had been fastened to the top of the keelson's forward end but was torn away when the stem toppled onto its starboard side.

The Sternpost Assembly

Indiana's plumb sternpost assembly is preserved intact and in its original upright position. The sternpost assembly consists of inner and outer posts, both of which were fashioned from single pieces of white oak. Because of the intactness of *Indiana*'s stern and the large quantity of accumulated debris inside the hull, documentation of the sternpost assembly was limited to its exterior and an accessible portion of the inner post's upper extremity.

The head of the inner sternpost measured 11-1/2 inches (29.2 cm) molded (9-1/2 inches [24.1 cm] to the rabbet) and 1 foot (30.48 cm) sided. The overall length of the inner sternpost could not be measured because of debris in the interior of the hull. The after corners of the inner post were chamfered to create a rabbet for the ends of the hull planking.

The overall length of the outer sternpost was 13 feet, 4-1/2 inches (4.1 m). From head to foot, its sided dimension tapered from 11-1/2 to 9-1/2 inches (29.2 to 24.1 cm). In contrast, its molded dimension, which was measured from the after edge of the sternpost to the side of the hull, flares from 9-1/2 inches at its head to 1 foot, 1 inch (24.1 to 33 cm) at its foot.

The top of the sternpost assembly terminates 8 inches (20.32 cm) below the adjacent plank-sheer, thereby creating a notch for a heavy fore-and-aft cantilevered counter beam that originally extended 6 feet, 6 inches (2.0 m) aft of the sternpost and supported *Indiana*'s overhanging elliptical fantail deck (Fig. 4-7). This counter beam, which was displaced during the sinking, measured 1 foot (30.48 cm) square by 14 feet, 8 inches (4.47 m) long. The forward end of the counter timber was lap-joined to the underside of a heavy transverse deck beam, which for the purposes of this discussion has been designated, "Transverse Deck Beam 1" (TDB 1). TDB 1's dimensions measured 6 inches (15.24 cm) molded and 1 foot (30.48 cm) sided. TDB 1 is broken, with its starboard outboard end in its original position and its longer port side section collapsed into *Indiana*'s after hold. The counter beam described above is still attached to the underside of a detached section of *Indiana*'s elliptical fantail main deck wreckage, which is now located approximately 100 feet (30.48 m) abaft *Indiana*'s stern. *Indiana*'s counter timber is a relative of the "horn timbers" found in the hulls of later wooden vessels constructed with overhanging round or elliptical sterns.

Eight feet, 2 inches (2.49 m) below the sternpost assembly's head, *Indiana*'s single 8-inch-(20.32-cm) diameter propeller shaft passes through a hole passing through the stern deadwood and both the inner and outer sternposts. To accommodate the propeller shaft, the sided dimension of the sternpost assembly and the adjoining stern deadwood expand 1 foot (30.48 cm) above and below the shaft to a maximum breadth, or sided dimension, of 1 foot, 8 inches (50.8 centimeters). This bulge in the sternpost assembly is termed a "shaft boss" (Fig. 4-8).

The shaft boss is strengthened on both sides by a pair of iron straps spiked to the sides of the outer post, measuring 1 inch (2.54 cm) thick, 3-3/4 inches (9.53 cm) wide, and 3 feet, 9 inches (1.14 m)

Figure 4-7. The top of *Indiana*'s sternpost assembly was cut lower than the sheer to accomodate the heavy fore-and-aft cantilever counter beam that supported the overhanging fantail deck. (Photo courtesy of the Smithsonian Institution, NMAH).

Figure 4-8. *Indiana's* shaft boss. (Photo courtesy of the Smithsonian Institution, NMAH).

long (Fig. 4-9). A similarly-sized third strap abuts the lower end of the pair's forward strap and extends down to a point that is even with the bottom of the keel. Because excessive vibration was a real concern among the designers of early wooden screw-propelled vessels, the employment of such iron strapping to reinforce the shaft boss seems to be a commonly applied solution to the problem.[15] Descriptions of similar arrangements appear in both the archival and the archaeological record. In maritime historian Cedric Ridgely-Nevitt's treatise *American Steamships on the Atlantic*, the use of iron strapping in the construction of the 1851 Atlantic coastal propeller *S. S. Lewis* is described as follows:

> She is the only early screw steamer for which detailed scantlings are available, and these show her to have been strongly built and cleverly reinforced in critical areas. Heavy composition reinforcements were bolted on either side to tie the keel and the two vertical posts (sternpost and rudder post) together. Furthermore, iron and composition plates were added to reinforce the propeller post where it was bored out for the stern tube and shaft.[16]

Archaeological evidence of iron strapping propeller-boss reinforcement also was found on the wreck of a propeller believed to date from the 1850s, discovered on Bird Key Bank near Fort Jefferson in Florida's Dry Tortugas, during a National Park Service archaeological survey of the area. Archaeologist Dr. Richard Gould surveyed the site in 1990 and observed that:

> The propeller and shaft assembly can be viewed as overbuilt in relation to the rest of the structure...There is clear evidence for this in the deadwood assembly surrounding the propeller shaft in the form of heavy iron strapping wrapped around the outer composite covering of the deadwood...There were five straps on each side...[17]

Although Gould hypothesized that this heavy strapping around the stern deadwood of the Bird Key Bank wreck was a later addition to the hull, designed to minimize the adverse affects of propeller torque and vibration experienced during the vessel's sea-trials, the iron strapping on the sterns of both *Lewis* and *Indiana* appears to have been an integral part of these vessels' original construction.[18]

In addition to the iron reinforcement strapping around the propeller boss, the after face of *Indiana*'s outer sternpost is perforated by an iron or steel stern tube bearing (Fig. 4-10). This intact bearing, which could only be examined externally, consisted of a top flange and a bottom collar, bolted together around the propeller shaft with four 1-1/2-inch- (3.81-cm-) diameter bolts, that were secured to the after face of the outer sternpost with five bolts 1-1/2 inches (3.81 cm) in diameter. A 3/4-inch- (1.9-cm-) thick section of the 2-1/4 inches- (5.71 cm-) thick bottom collar's bearing surface was fabricated from different metal (possibly Babbit metal) than were the top flange and rest of the bottom collar. While the exact material composition and internal configuration of *Indiana*'s stuffing box are unknown,

Figure 4-9. Shaft boss reinforcement straps (outlined). (Photo courtesy of the Smithsonian Institution, NMAH).

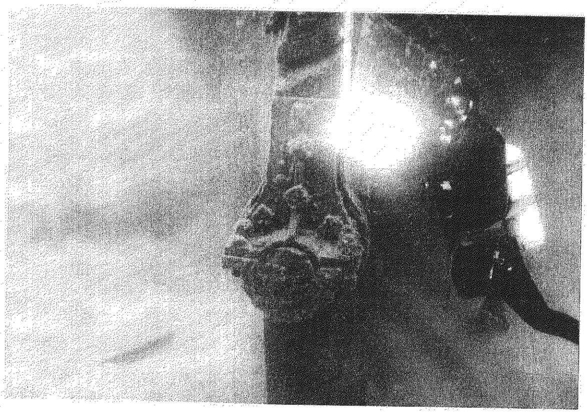


Figure 4-10. After surface of the stern tube bearing. (Photo courtesy of the Smithsonian Instituion, NMAH).

brass or Babbit metal and iron were commonly used materials in propeller bearings of the late 1840s and early 1850s.[19] One 1846 source noted, "that steel was the best material for the bearing of the toe or extreme end [of the propeller shaft] ...and....the best form was that of two hemispheres, working under a constant jet of cold water."[20]

To minimize wear in the stern tube bearing and carry most of the propeller's weight, the end of *Indiana*'s propeller shaft was supported by an iron "hanger bearing," a sling-like contrivance that was essentially an extremely long U-bolt with a bearing surface at the bottom of the "U" where it passed under the shaft. The top of the hanger bearing was secured around the heavy counter timber, described above, and was centered directly above the propeller shaft. Significantly, exactly such a hanger bearing was an integral part of Richard Loper's propeller design (Fig. 4-11). Loper is the designer to whom *Indiana*'s propeller design has been attributed. *Indiana*'s hanger bearing was recovered during the Smithsonian's salvage operations and is now in permanent storage at the Smithsonian's storage facility in Silver Hill, Maryland.

In April of 1994, the author examined, photographed, and measured *Indiana*'s hanger bearing (Fig. 4-12). The threaded tops of the hanger bearing's wrought iron arms passed through the fantail deck on either side of the heavy counter timber, and were secured with iron nuts (Fig. 4-13). The "sling" portion of the hanger bearing that wrapped around the underside of the propeller shaft was fabricated from wrought iron, with a brass or Babbit metal inner sleeve 3/4 inch (1.91 cm) thick secured to the inside of the bearing surface. This inner bearing surface displayed evidence of uneven wear. The arms of the hanger bearing were round in cross section and measured 1-5/8 inches (4.13 cm) in diameter. Both arms were broken a short distance from the bearing sleeve (4-5/8 to 6-13/16 inches [4.62 to 17.30 cm]).

An additional iron plate is fastened to the after face of the sternpost at its base. The dimensions of the plate measured 5 inches (12.70 cm) wide and 1 foot, 2-1/2 inches (36.8 cm) long. The plate is perforated by four fastener holes, three of which still contain fasteners; the lowermost fastener hole is empty. The plate is broken at its lower end, immediately above the joint between the keel and sternpost. The break line crosses the base of the plate diagonally and bisects the lowermost fastener hole. The plate appears to be the vertical attachment flange for the absent horizontal iron rudder skeg that would have extended several feet (1.5 to 2.25 m) aft of the sternpost and supported the rudder (Fig. 4-14).

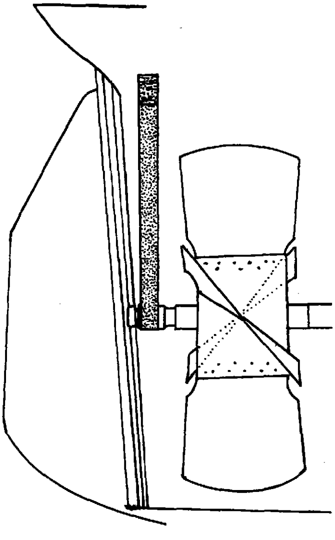


Figure 4-11. Contemporary illustration of Richard Loper's propeller. Note the hanger-bearing feature (shaded). (After MacFarlane, *History of Propellers and Steam Navigation*, 119).

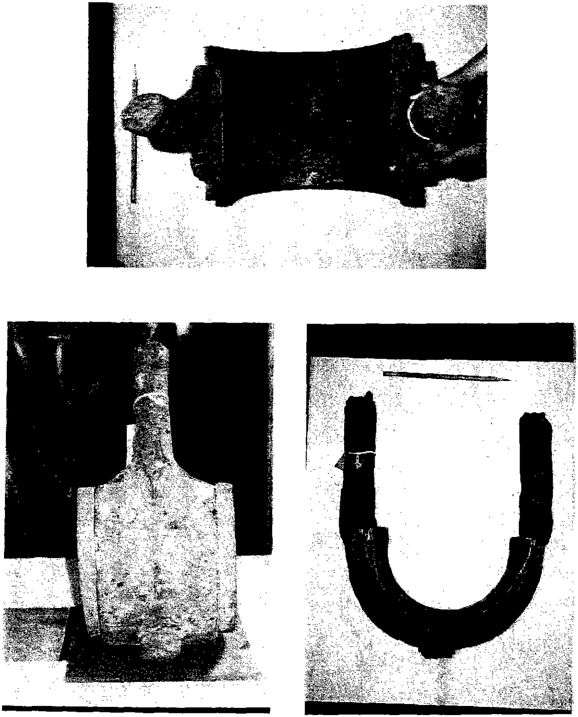


Figure 4-12. *Indiana*'s hanger bearing. (Photos by David S. Robinson).

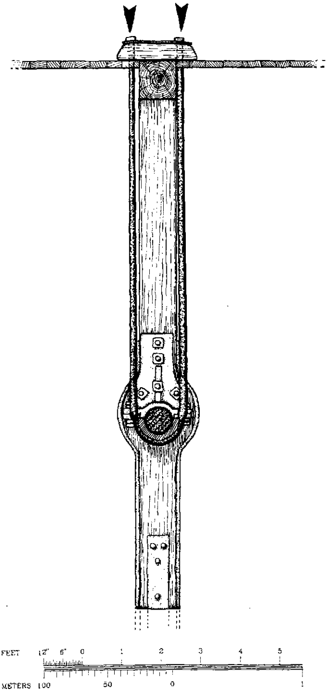


Figure 4-13. The tops of the hanger bearing's wrought iron arms passed through the main deck and were secured over the top of the large stern counter timber. (Drawing by David S. Robinson).

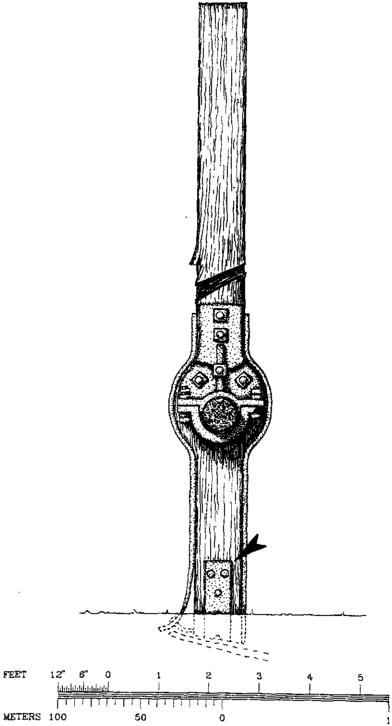


Figure 4-14. A vertical attachment flange for *Indiana*'s absent rudder skeg remains fastened to the after face of the sternpost at its heel. (Drawing by David S. Robinson and Peter Hentschel).

The Rudder Assembly

Along with the propeller and hanger bearing, *Indiana's* rudder assembly was recovered by the Smithsonian during the 1979 salvage expedition and brought to the museum's storage facility in Silver Hill, Maryland (Fig. 4-15). Unlike the propeller, the rudder was not conserved after its recovery, nor was it documented. In December 1991, the author and Dr. Frederick Hocker visited the Smithsonian's National Museum of American History's Hall of Maritime Enterprise and the museum's Silver Hill, Maryland storage facility to complete documentation of *Indiana's* propeller and record *Indiana's* rudder assembly. Documentation of the rudder was completed by the author in April 1993 during a return trip to Silver Hill. The descriptions of the rudder and steering quadrant that follow are based on these investigations.

Indiana's rudder assembly is constructed entirely of iron and consists of three principal components: the rudder post, the rudder blade, and the steering quadrant or steering yoke (Fig. 4-16). The rudder post measured 13 feet, 3-7/8 inches (4.04 m) in height, and is 3-1/2 inches (8.9 cm) square in cross section. The rudder post is capped by a flange 1 foot (30.48 cm) long and 6 inches (15.24 cm) wide. The flange is perforated by three fastener holes for securing the rudder post to the underside of *Indiana's* overhanging elliptical stern. Relative to the vertical rudder post, the flange forms a slightly acute angle of 85°. This angle corresponds with the rake of *Indiana's* counter. The rudder blade's overall dimensions measured 4 feet, 4-3/4 inches (1.30 m) wide and 8 feet, 5 inches (2.5 m) tall. The blade is fashioned from four rolled-iron plates, each 1/4-inch (0.64-cm) thick, which are riveted to the rudder stock, a bar 3 inches (7.62 cm) in diameter on each side of the blade. An additional piece, or "back piece," measuring 10 inches (25.40 cm) wide and 5 feet (1.52 m) high, is riveted onto the blade's trailing edge. This back piece was probably added to the rudder blade to increase the rudder's area and, thus, the helm's responsiveness.

The rudder stock extends to a height of 14 feet, 3 inches (4.34 m) above the bottom of the blade. The top of the stock forms a pintle that is square in section, on which was mounted a manually operated tiller. This iron tiller, observed on the deck of the detached fantail wreckage during the Smithsonian expeditions of the early 1980s, is now absent from the wreck. A diamond-shaped steering yoke connects the rudder stock to the top of the rudder's trailing edge or "rudder horn." On either side of the yoke's forward end, two iron rudder blocks provided attachment points for connecting the rudder to the steering chains.

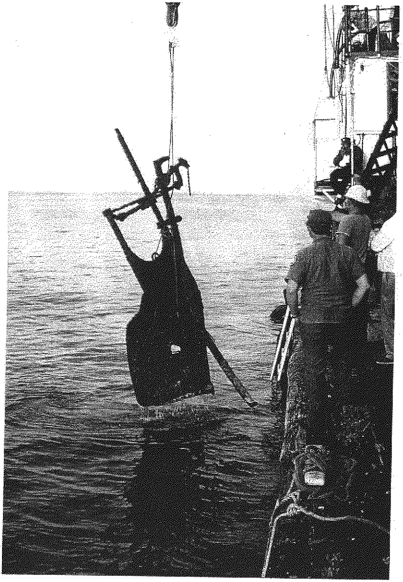


Figure 4-15. Recovery of *Indiana*'s rudder during the 1979 salvage campaign. (Photo courtesy of the Smithsonian Institution, NMAH).

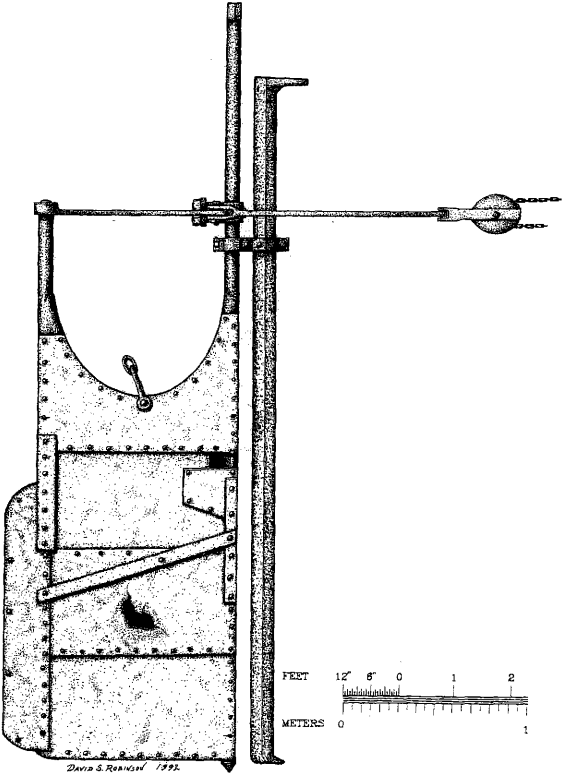


Figure 4-16. Starboard elevation of *Indiana*'s rudder. (Drawing by David S. Robinson).

Repairs and apparent modifications to the blade and steering quadrant indicate that this rudder is old and may therefore be *Indiana*'s original rudder. These repairs consisted of the addition of several small sheet iron reinforcement patches on either side of the blade in areas that were damaged. Two such patches were riveted onto the leading edge of the blade, where the rudder stock was cracked in two places. A second narrow, vertical reinforcement patch was riveted on both sides of the blade's trailing edge. Another long, narrow reinforcement strip was riveted diagonally across the face of the blade. The final repair, made to one of the steering quadrant's arms that had broken, consisted of two plates, 6 inches (15.24 cm) long and 1/4- inch (0.64-cm) thick, that were welded to either side of the arm over the break.

The Framing

Much of *Indiana*'s hull framing was obscured by its intact overhanging main deck, extensively preserved ceiling and hull planking, and a deep layer of overburden that filled the hull. Only several frames at the starboard bow, where there were "air strakes" in the ceiling, or where decking or hull planking was torn away, were exposed enough to be examined and measured (Figs. 4-17 and 4-18).

A total of approximately 80 frames are represented in *Indiana*'s hull. This quantity was determined by counting the visible frames, as well as those that were obscured under planking and overburden, but whose locations were easily discerned by the pattern of fasteners on the outside of the hull. Unfortunately, determining the types of the obscured frames (i.e., cant frames, half frames, or square frames) was impossible. Archaeological evidence suggests that *Indiana*'s hull contained a total of 70 to 75 square frames, six or seven half frames, three or four cant frames, two hawse pieces, and a stem piece. For recording purposes, each of the frames was numbered, beginning with F 1, the aftermost frame adjoining the inner sternpost, and ending with F 81, a stem piece that was attached to the apron in the bow. Except for the three forwardmost framing members (F 79 to F 81) and the aftermost frame (F 1), which are all single frames, *Indiana*'s frames were all "double-sawn." Interestingly, cant frames were used in the framing at the stern but not at *Indiana*'s bow, probably because the bow was too fine down low to need cant frames.

Double-sawn frame construction was common in nineteenth-century Great Lakes craft. As the name implies, frames of this type were built from two layers of butt-joined timbers, sawn to shape, and bolted together to form a double frame. The late Howard I. Chapelle noted that double-sawn frames

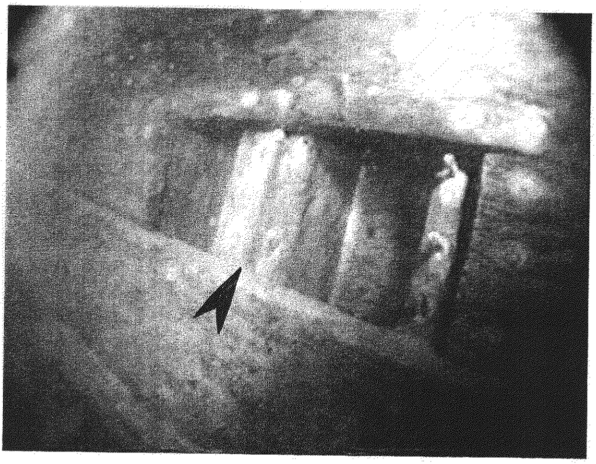


Figure 4-17. Framing visible in an "air strake" cut into the ceiling. (Photo courtesy of the Smithsonian Institution, NMAH).

Figure 4-18. The majority of framing visible and accessible for documentation was in *Indiana*'s heavily damaged bow. (Photo courtesy of the Smithsonian Institution, NMAH).

must all be laid down in the mold loft so that patterns can be made and bevels taken from the mold loft drawing.[21] This step enabled the builder to check his work against the lines to create a boat that bears a closer resemblance to its intended design.[22] Chapelle also noted that hard curves formed by an abrupt turn of the bilge, like those found in relatively flat-floored vessels such as *Indiana*, are relatively easy to fabricate with sawn frames.[23] A hypothetical reconstruction of a square frame found in *Indiana*'s hull is depicted in Fig. 4-19.

Indiana's double-sawn frames were, on average, evenly spaced apart 1 foot, 10 inches (55.88 cm) on center. The only significant deviation from this spacing occurred between midships frames F 47 and F 48, and F 48 and F 49, which were spaced 1 foot, 7 inches (48.26 cm) and 1 foot, 5 inches (43.18 cm) apart on center. On average, the frames' molded dimensions measured 11 inches (27.94 cm) over the keel, 9-1/2 inches (24.1 cm) at the bilges and 5-1/2 inches (14.0 cm) at the uppermost limit of the futtocks. In contrast with the frames' somewhat variable molded dimensions, the frames' sided dimensions remained relatively constant at 10 inches (25.4 cm) with individual timbers comprising the double frame measuring between 4-1/2 inches (11.4 cm) to 5-3/8 inches (13.65 cm). At the turn of the bilge, joints between the ends of the short floor timbers and the curved foot of the first futtock were fastened together with a single bolt 1 inch (2.54 cm) in diameter driven through the joint horizontally.

The individual timbers comprising the frames consisted of grown pieces (i.e., cut along the grain), which were butt-joined and iron-fastened. Butts between the adjacent floor timbers and futtocks within the double frames were staggered in a pattern referred to as the "long and short floor" system of framing. This system consisted of a frame composed of a floor timber and futtock. The adjacent space between the separate floor timbers was occupied by a "filling frame" which was made up of either long or short floor timbers below the futtocks. The long and short members alternated throughout the length of the vessel to strengthen the vessel's floor. This method of framing was recommended by the American Shipmasters' Association in their 1867 *Rules for the Construction of Wooden Vessels*, particularly for flat-bottomed vessels.[24]

Indiana's forwardmost preserved framing members (F 79 to F 81) consist of two hawse pieces and a badly damaged stem piece. Each of these forward framing members extends above the planksheer, from the underside of the breasthook for the main deck rail to a point approximately 22 feet (6.71 m) below the head of the stem. The stem pieces (F 81) filled the space on either side of the apron, which was rabbeted to allow the stem piece to be faired into it. The stem piece was secured to

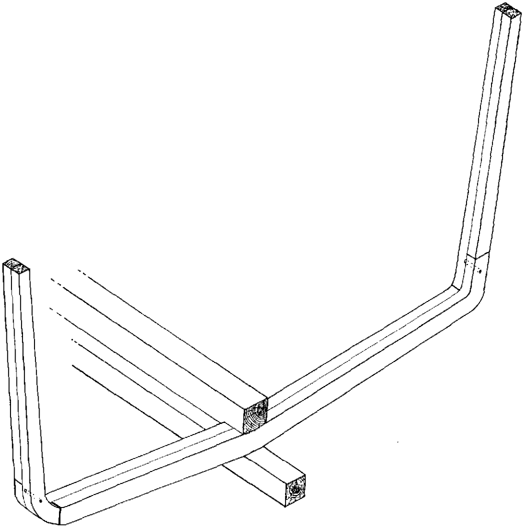


Figure 4-19. Hypothetical reconstruction of one of *Indiana's* frames. (Drawing by David S. Robinson).

the apron with drift bolts, which are staggered in pairs along its length.

Immediately abaft each stem piece (on either side of the hull) was a robust hawse piece (F 80), which measured 6 inches (15.24 cm) molded and 1 foot, 1/2 inch (31.8 cm) sided. Extending from the deadwood to above the main deck, F 80 served as one of the bow's principal strength members, and it is the timber through which the hawse pipe passed. F 80 also served as the anchor point for the forward ends of the clamps, which were let into and bolted in notches cut into F 80's inboard face. Like F 81, F 80 appears to have been secured to the sides of the apron and deadwood. One inch (2.54 cm) abaft F 80 is a second hawse piece (F 79), molded 6 inches (15.24 cm) and sided 5 inches (12.70 cm). Archaeological evidence indicates that the heels of F 79 port and starboard halves fit into notches 2-inches (5.08 cm)deep, which were cut into the sides of the keelson.

The Keelson

One well-documented characteristic of Great Lakes wooden ship construction was the extensive use of multiple internal longitudinal stiffening elements (i.e., keelsons, rider keelsons, sister keelsons, assistant keelsons, cousin keelsons, bilge strakes, and stringers). Although the existing body of information concerning these features derives primarily from vessels that both post-date and are much larger than *Indiana*, evidence hinting at the use of multiple keelsons in *Indiana* was discovered during the 1992 field work, shortly after the central keelson was located.

Hand excavation conducted in a small area immediately abaft the stem assembly uncovered a large fore-and-aft timber, positioned directly over the hull's longitudinal centerline, presumed to be the keelson. Identification of this timber as the keelson was confirmed by the presence of a similarly sized longitudinal member located near the stern, abaft the after engine bed timber. The keelson measured 9-1/2 inches (24.1 cm) molded and 11-1/2 inches (29.2 cm) sided. Notches 6-1/4 inch (15.88-cm) wide, and 2-inch (5.08-cm) deep were cut into both sides of the keelson, 6-3/4 inches (17.15 cm) from its square-cut forward terminus (Fig. 4-20). The notches appear to have been intended for the heels of the aftermost hawse pieces (F 79). Underlying the keelson, at its forward end, was a second unidentified longitudinal timber of undetermined size, believed to be deadwood.

After locating the forward end of the keelson, an effort was made to follow it as far aft as possible, hand fanning sand along the way, and examining its upper face for evidence of mortises and scarf joints. Approximately 10 feet (3.05 m) of the keelson was exposed before immovable wreckage

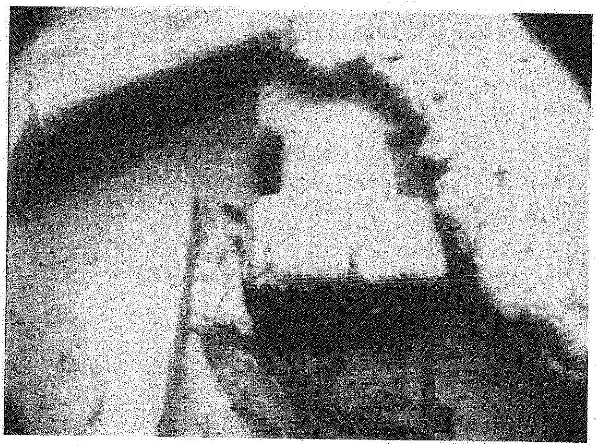


Figure 4-20. The notched forward end of the keelson. (Digital image of underwater video footage recorded by Thomas Alburn captured by Douglas Gann).

made further excavation impossible. Although no further details of construction were noted, three more longitudinal timbers, of apparently equal molded height but narrower sided dimensions, were uncovered alongside the central keelson (Fig. 4-21). The innermost of the three longitudinal members was oriented on a line parallel to the keelson. The other two longitudinal timbers were oriented at an angle relative to the line of the keelson and appeared to be converging towards the bow. Unfortunately, project time constraints prevented additional excavation and examination of these features. However, it is believed that these timbers may have been sister keelsons.

The Ceiling

The interior of *Indiana*'s hull is ceiled over its entire length, from the keelson to the level of the main deck (Fig. 4-22). Dimensions of individual ceiling strakes were recorded where they were the most accessible on the port side of the hull at F 27 and F 57 and on the starboard side at F 67. The dimensions of individual ceiling strakes at these frames are presented in Table 4-1. Iron ore cargo, wooden fuel, structural debris, and thick sediments prevented complete measurement of the ceiling below the turn of the bilge.

The uppermost limit of the ceiling is defined by two clamp strakes, whose purpose was to provide the hull with additional longitudinal stiffness and to help support the deck beams. The uppermost clamp measured 4-1/2 inches (11.4 cm) thick and 1 foot, 4 inches (40.64 cm) wide, and it appeared to be composed of three planks, joined together end-to-end with flat nibbed scarfs. Two feet, 2 inches (66.04 cm) from the clamp's forward end, its lower edge tapers upward to form a nib 5-1/2 inches (14.0 cm) wide. The nibbed forward ends of the clamps were let into blind notches cut into the inboard faces of the large hawse piece (F 80), where they were secured in place with spikes. In contrast, the after end of the clamp does not taper, but instead abuts the forward face of the inner sternpost, where it is square fastened to F 1 with two iron spikes. The top of the uppermost clamp is notched to fit the underside of *Indiana*'s transverse deck beams and the radial deck beams located at the stem. The variable spacing and sided dimensions of the 3-inch- (7.62-cm-) deep notches corresponds with the deck beams' slightly irregular spacing. Between each deck beam, the tops of the clamp and sheer strakes are each capped with a single filler piece, 4 inches (10.16 cm) thick, 1 foot (30.48 cm) wide, and of variable length. These filler pieces occupy the vertical gap between the top of the clamp, the planksheer, and the upper faces of the deck beams (Fig. 4-23).

Figure 4-21. Longitudinal timbers, possibly representing sister keelsons, partially exposed along the starboard side of the keelson. (Photo by David S. Robinson).

Figure 4-22. *Indiana*'s hold is ceiled completely over the entire length of the hull. (Photo courtesy of the Smithsonian Institution, NMAH).

TABLE 4-1

CEILING DIMENSIONS AT F 27, F 57, AND F 67
(widths and thicknesses presented in inches)

Location/ Strake No.	F 27	F 57	F 67
Upper Clamp	16-3/4 x *	20-1/2 x 4	20-1/2 x 3-1/2
Lower Clamp	14-3/8 x *	14-1/2 x 4	14-3/4 x 3
3	13 x *	12-3/4 x 3-1/2	15 (space) x *
4	13-3/8 x *	12-3/4 x 3-1/2	14-1/4 x 2-1/4
5	13-3/4 x *	13-3/4 x 2-1/2	12-3/4 x *
6	11-3/4 x *	12 x 2-1/2	12 x 4-1/2
7	12-3/8 x *	12-3/8 x 2	12-1/8 x 5
8	11 x *	11 x 2	11-3/4 x 5
9	12 x *	12 x 4	*
10	*	* x 4	*
11	*	* x 4	*
12	*	* x 5-3/4	*
13	*	* x 3	*
14	*	* x 2-1/2	*

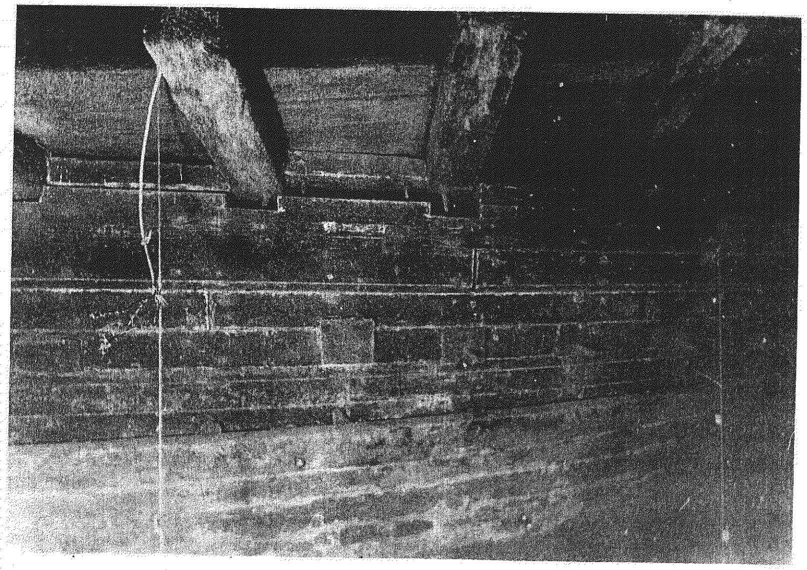


Figure 4-23. Fillets of wood were used by *Indiana*'s builder to occupy the gap between the top of the clamp, the planksheer, and the upper faces of the deck beams. (Photo courtesy of the Smithsonian Institution, NMAH).

A second clamp strake, located immediately below the upper clamp, measures 4 inches (10.16 cm) thick and 1 foot, 2-1/2 inches (36.80 cm) wide. It is substantially heavier then the series of three to six diminishing ceiling strakes below it. These diminishing ceiling strakes, located between the second clamp and the bilge ceiling, measured 2 to 3 inches (5.08 to 7.62 cm) thick and 11 inches to 1 foot, 2 inches (27.94 to 35.56 cm) wide. Planks within these lighter ceiling strakes are butt-joined and square-fastened to the frames with four spikes per frame and six spikes per joint (three spikes on either side of the joint). Ceiling at the turn of the bilge consisted of three strakes of heavy bilge ceiling, which measured between 4-3/4 inches (12.07 cm) to 5-3/4 inches (14.61 cm) thick, and 11-3/4 inches (29.85 cm) to 1 foot, 1/8 inch (30.79 cm) wide. Planks within the strakes are joined together with flat nibbed scarfs, measuring 2 feet, 7-1/2 inches (80.01 cm) long.

Although the interior of *Indiana*'s hull below the bilges was virtually inaccessible for detailed examination and documentation, probing and hand-fanning of sediments in the vicinity of the engine bed timbers revealed that the ceiling continues across the bottom of the hull to the keelson and diminishes in thickness below the turn of the bilge. The author noted the presence of ceiling directly adjacent to the keelson during an examination of the engine bed timbers in 1993. The thickness of the ceiling adjoining the keelson is calculated to be 3 to 4 inches (7.62 to 10.16 cm). This figure was determined by comparing the difference between the keelson's full molded dimension, measured at the bow, and the keelson's molded height above the ceiling, adjacent to the engine bed timbers. Evidence of the diminished thickness of the ceiling strakes between the keelson and the turn of the bilge was apparent from the thicknesses of the first two strakes below the heavy bilge ceiling, which measured 3 inches (7.62 cm) and 2-1/2 inches (6.4 cm), respectively.

Planking

Most of *Indiana*'s planking was preserved in place and accessible for measurement. Planking strake widths were recorded in six separate locations on the port side of the hull; at the sternpost rabbet; at the offset stations at 5, 10, 15, and 30 feet (1.52, 3.05, 4.57, and 9.14 m), and near amidships, at F 50. The remarkable soundness of the planks and their seams precluded measurement of thicknesses everywhere except at F 50, where the port side of the hull is broken and disarticulated. Dimensional data recorded at the offset stations and F 50 are presented in Table 4-2.

Individual planks within the strakes of *Indiana*'s hull planking are butt-joined and are fastened

TABLE 4-2

PLANKING DIMENSIONS AT OFFSET STATIONS AND F 50
(widths only; presented in inches; measured only where accessible)

Location/ Strake No.	Sternpost	5 ft Station	10 ft Station	15 ft Station	30 ft Station	F 50 (90 ft)
Sheer	7	8	7-3/4	7-1/4	4	15
2	6	7-1/4	7-1/4	6-3/4	12	6-3/8
3	1-1/2	1-3/4	1-1/4	1-1/4	5-7/8	5-7/8
4	5-5/8	6-1/4	6-3/4	*	1-5/8	6-5/8
5	5 -1/2	6	7-1/2	*	6-1/4	6-1/8
6	1-3/4	2-1/2	2	*	2	5
7	*	*	5-1/2	*	5	8
8	*	*	7	*	6-1/2	8-1/8
9	*	*	7-1/4	*	8-1/2	9-3/8
10	*	*	7	*	7-3/4	9-1/8
11	*	*	8-1/2	*	8	9
12	*	*	6-5/8	*	9	10-1/8
13	*	*	7-5/8	*	8	8-3/4
14	*	*	7-1/4	*	8-1/2	*
15	*	*	7-1/8	*	9	*
16	*	*	6-7/8	*	13	*
17	*	*	7-1/4	*	9	*
18	*	*	7-1/8	*	*	*
19	*	*	6-7/8	*	*	*
20	*	*	7-1/4	*	*	*
21	*	*	7-1/4	*	*	*
22	*	*	6-3/4	*	*	*
23	*	*	6-3/8	*	*	*
24	*	*	6-5/8	*	*	*
25	*	*	6-3/4	*	*	*

securely to the frames with two iron spikes per frame except where four spikes were used at the joints (see Fig. 4-23). The hull planks range in thickness from 1-3/4 to 3 inches (1.45 to 7.62 cm) and in width from 4-1/2 inches to 1 foot, 3 inches (11.4 to 38.10 cm).

Indiana's 3-inch- (7.62-cm-) thick sheer strake was formed in essentially the same manner as the upper clamp strake; its top is notched to fit the beams of *Indiana*'s overhanging deck, and the sheer strake is capped by the filler pieces used to occupy the spaces between the deck beams. Archaeological evidence suggests that the sheer strake, like the clamp, was also composed of three planks scarfed together. Extensive disarticulation of the forward third of the hull, combined with the intact starboard guard, made it difficult to determine the exact number and configuration of individual planks comprising the sheer strake. Only the after section of the port sheer strake was preserved over its full length and accessible for documentation. This preserved port sheer strake section measured 60 feet (18.29 m) long and was joined to the strake's middle section with a flat nibbed scarf 3 feet, 8 inches (1.12 m) in length. Between the sternpost rabbet and F 13, the port sheer strake's lower half was cut away to accommodate a stealer piece that measured 7-1/4 inches (17.78 cm) wide, and 19 feet, 5 inches (5.9 m) long.

One particularly interesting feature of *Indiana*'s hull planking is a subtle stylistic nuance that is visible in the sheer strake and in the two strakes below it (see Fig. 4-23). The lower edge of the sheer strake has a beaded edge. The two strakes immediately below the sheer strake are reduced in their thicknesses and are recessed 1-1/2 inches (3.81 cm) from the sheer and the rest of the hull strakes. The lowermost of the two strakes also has a beaded lower edge like the sheer strake. This minor stylistic flourish seems trivial, but it undoubtedly would have added to the cost of the planking. What makes it curious is the fact that it was covered almost entirely by the sponson guard. Why someone would spend the time and money to create and install hull planking in this way when they knew it was going to be essentially invisible is unclear. It may be that sheathing on the sponson guard was a later addition to the hull although there was no archaeological evidence to support this theory.

The Deck

Viewed from above, *Indiana*'s deck visually dominates the wreck site, with its many interesting features and clues hinting to the overall layout of the hull. Included among these features are: one after hold hatchway, an engine hatchway, a boiler hatchway, a fireroom companionway, an opening for a fireroom ventilator pipe, a fueling hatchway, two forward hold hatchways, and a small rectangular opening that may be for the passage of the helm's steering chains (see Figs. 3-8 and 5-15).

Deck Framing

Indiana's deck was supported by an underlying framework originally composed of 54 individual beams, including 34 full transverse beams, six pairs of half-transverse beams, three edge-joined transverse forward deck-support timbers (located at the bow), and 11 radial counter beams (located at the stern). In addition to these deck beams, the remains of 10 carlings, or longitudinal deck beams, are preserved around five of the hatchways.

During the documentation process, each of the transverse deck beams was numbered and counted, beginning with TDB 1 at the stern, and their sided and molded dimensions and interbeam spaces were measured. Of the 54 deck beams, only 14 of the 40 transverse beams and five of the radial beams are preserved in an undamaged condition. The other 35 deck beams are either missing, partially intact, or broken and buried beneath heavy overburden. In cases where beams were absent, their dimensions and spacing were ascertained from the notches cut for them in the clamp and the sheer strake. On the starboard side, the last preserved deck beam dado corresponds with TDB 34; on the port side, the last preserved evidence of a deck beam is at TDB 28.

Except for a relatively small, unknown number of deck beams at the bow, all of the deck beams fit into notches cut into the tops of the clamp and sheer strake and extend beyond the sides of the hull. Where deck beams intersect frames, the frame tops were cut to accommodate them, and a single iron drift bolt was driven through the beam and into the frame top to secure it in place. Deck beams that do not pass over the tops of frames are fastened less securely into the sheer strake's upper edge with a single drift bolt.

Perhaps because so many deck beams were secured to the hull in this manner, *Indiana*'s builder, Joseph Keating, chose to strengthen the connection between the deck and the hull by attaching diagonal hanging knees, or "dagger knees," to the underside of each transverse deck beam. Additional strength and support for the deck was obtained by securing the overhanging outboard ends of the transverse deck beams to the sides of the hull using concave-shaped diagonal braces and by affixing external hanging knees to the outside of the hull around the overhanging stern, beneath each radial counter deck beam.

Indiana's 40 transverse deck beams averaged 5-5/8 inches (14.28 cm) molded along their full lengths, with 3 inches (7.62 cm) of camber. Sided dimensions ranged from 7 inches to 1 foot (17.78 to 30.48 cm) but were typically 8-1/2 inches (21.59 cm). Deck beams around hatchways were significantly heavier than deck beams located elsewhere in hull and averaged 11 inches (27.94 cm) sided. The deck beams between TDB 4 and TDB 26, where six of *Indiana*'s seven known hatchways are located, are spaced more closely together than deck beams elsewhere in the hull, with an average spacing of 2 feet, 8-1/2 inches (82.60 cm), as compared to 3 feet, 1-1/4 inches (94.62 cm). Apparently, Keating wanted to reinforce the deck frame around the engine, boiler, and numerous hatchways located in this part of the hull.

Indiana's overhanging fantail stern was supported by 11 radial deck beams, extending outboard of the sides of the hull to give the fantail an elliptical shape when viewed from above (Fig. 4-24). The radial deck beams measure from 8 to 14 feet (2.44 to 4.27 m) long, are sided 6 inches (15.24 cm), and molded 4 to 5 inches (10.16 to 12.70 cm). The radial beams are secured to the top of the hull in a similar manner as the transverse deck beams, except that they are supported from below by a series of external hanging knees secured to the underside of each radial deck beam on the hull's exterior (rather than by dagger knees on the interior of the hull). The forward ends of the counter beams were spiked to the after face of the heavy TDB 1, which measured 6 inches (15.24 cm) molded and 1 foot (30.48 cm) sided.

The solution to the potential weakness caused by fastening the deck to the top of the sheer strake was the addition of diagonal dagger knees under the transverse deck beams on the interior of the hull, hanging knees under the radial deck beams also on the exterior of the hull, and diagonal deck braces under the transverse deck beams on the hull's exterior. *Indiana*'s dagger knees were fabricated from naturally curved timbers, and affixed with six iron fasteners per knee to the underside of each deck beam, the adjacent ceiling strakes, and underlying frames. The vertically-oriented bodies of the dagger knees all cant forward at an angle of about 65° from vertical (Fig. 4-25). Their sided dimensions (4-1/2 to 5 inches [11.40 to 12.70 cm]) are fairly uniform, while their molded dimensions range from 1 foot (30.48 cm) at the throat to 5 inches (12.70 cm) at the toes. The upper or horizontally-oriented arms measured 2 feet, 3 inches (68.58 cm) long, while the knee's bodies were substantially longer at 3 feet, 3 inches (99.06 cm).

Naturally curved hanging knees, spiked to the exterior of *Indiana*'s hull and to the undersides of 10 of the 11 radial deck beams that extend outboard of the hull at the stern, helped support *Indiana*'s

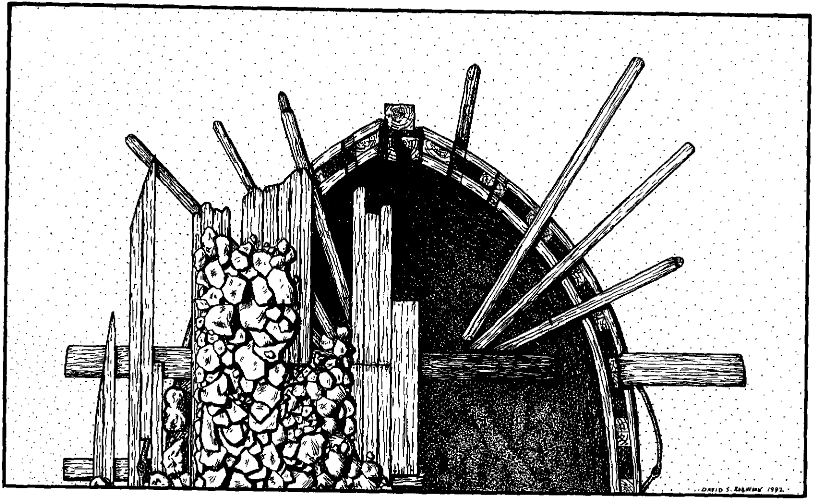


Figure 4-24. Radial deck beams in *Indiana*'s overhanging fantail stern. (Drawing by David S. Robinson).

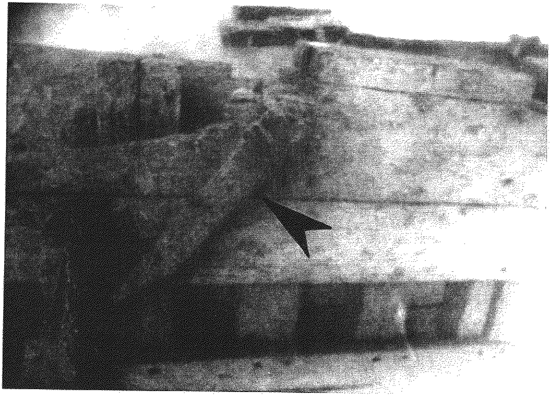


Figure 4-25. *Indiana*'s dagger knees are unique in that they all are canted forward over the full length of the hull. (Photo courtesy of the Smithsonian Institution, NMAH).

overhanging elliptical fantail (Fig. 4-26). The sided dimensions of these knees measured between 4 and 5 inches (10.16 and 12.70 cm). Their average molded dimensions ranged from 10 inches (25.40 cm) at the throat, to 3-3/4 inches (9.53 cm) at the toes. The average length of the horizontal arms was 2 feet, 9-1/2 inches (85.1 cm), and 2 feet, 7 inches (78.74 cm) for the vertical bodies. The knees were secured to the sides of the hull and the undersides of the radial deck beams with six to seven spikes per knee.

Sponson Guards

A unique element of *Indiana*'s deck construction are its sponson guards. "Guard" is a general term used to describe extensions of the main deck beyond the line of the hull at the sides. Generally speaking, guard is used interchangeably with other terms, such as "sponsons" (also "sponson guards" and "sponsings"), "outriggers" (also "outrakers"), "overhang," and "bustles," all of which have essentially the same meaning.[25] However, the term "sponson" is somewhat different than the others, because it describes not only a projecting deck structure laid on diagonal bracing timbers but is also a lightly constructed air-filled chamber that protrudes from the side of the hull to increase stability and buoyancy.[26]

Guards were adopted initially for use on sidewheel steamers to protect the projecting paddlewheels from injury and to provide bracing and support to the outer ends of the paddlewheels' shafts.[27] The width of the guards generally was determined by the width of the paddle wheels and their housings. Despite their almost universal use on the river steamboats of the west, guards were an eastern innovation. Their first recorded use was on Robert Fulton's *Steamboat* of 1807, the most famous of the Hudson River steamers (they were installed during an extensive rebuild in 1808).[28] Robert L. Stevens, son of American inventor Colonel John Stevens, who had conducted some of the most successful early experiments with screw propulsion, also adopted the "outboard" or "sponson guards."[29]

From the small body of comparative data available on other early Great Lakes propellers only the passenger propeller *Princeton* (1845) may have also had wide (extending more than 2 feet [60.96 cm] on each side) guards (see Fig. 1-6). The available literature indicates that most of the early, screw-propelled steamboats were built with flat sides in an attempt to make their hulls as narrow as possible to allow them to pass through the locks of the Welland Canal.[30]

As with all of the stern-wheeled steamboats of the United States' western rivers, which were built with guards even though they served no structural function, guards were included on *Indiana*

Figure 4-26. Hanging knees on the exterior of *Indiana*'s hull helped support the radial deck beams at the stern. (Photo courtesy of the Smithsonian Institution, NMAH).

probably for the sole purpose of increasing its available deck space.[31] By extending the deck beyond the sides of the hull, guards provided additional room for deck structures, freight and fuel, served as passageways between different parts of the boat, and supplied passengers with a pleasant promenade.[32] Guards possessed one defect in boats with a narrow beam: they increased the tendency to roll.[33]

Indiana's guards are notable because of the way they are constructed; the guards' braces are covered by up to eight strakes of planking measuring 7 to 8 inches (17.78 to 20.32 cm) wide and 2 inches (5.08 cm) thick (Fig. 4-27) to create an enclosed space, nearly airtight and waterproof, which would by technical definition be a sponson guard. Perhaps *Indiana*'s builder constructed the guards in this fashion to counteract any tendency to roll by providing *Indiana* with an additional measure of buoyancy and stability. Sheathing the guard braces would also have helped protect the braces and streamline the hull by reducing a potential source of drag.

Bracing for *Indiana*'s guards begins 11 feet, 6 inches (3.5 m) forward of the sternpost's after face (directly below TDB 2). This aftermost bracing piece consists of a triangular six-inch- (15.24-cm-) thick piece of wood, measuring 3 feet, 4 inches (1.01 m) by 2 feet, 9 inches (83 cm) by 5 feet, 1 inch (1.85 m) that was fastened to the outside of the hull with eight (5/8 inch [1.58 cm]) iron spikes (Fig. 4-28). The hypotenuse or the widest leg of the triangular piece was shaped to create a fair, shallow, concave curve or "fillet" that formed a smooth transition between the sides of the hull and the outboard ends of the transverse deck beams.

Forward of the guard's triangular aftermost bracing piece, the ends of the transverse deck beams are joined to the sides of the hull by a series of diagonal bracing timbers that were cut, rather than bent, to form the fillet between the side of the hull and the outboard edge of the main deck. These timbers typically measured 6 inches (15.24 cm) sided, 7 inches (17.78 cm) molded, and were approximately 4 feet (1.22 m) long. Spacing of these concave diagonal braces was somewhat variable, ranging from 1 foot (30.48) to 1 foot, 10-1/2 inches (57.20 cm), and seemed to correspond generally with the spacing of *Indiana*'s frames, instead of the spacing of the deck beams. The heels of the braces are stepped into a shallow groove in the upper edge of the seventh planking strake below the sheer, where they are fastened to the outer hull planking with two 5/8-inch (1.58-cm) iron spikes. The heads of the braces are fastened to the two waterway strakes and the laminate guard strake or wale which is composed of two 3-inch- (7.62-cm-) thick layers of timbers. The inner layer measured 7 inches (17.78 cm) wide, and the outer layer measured 9 inches (22.86 cm) wide. In instances where the braces and

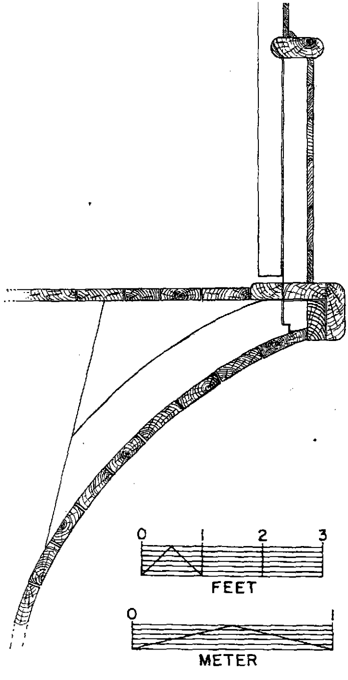


Figure 4-27. Cross-sectional view of one of *Indiana's* sponson-guards. (Drawing by David S. Robinson and Peter Hentschel).

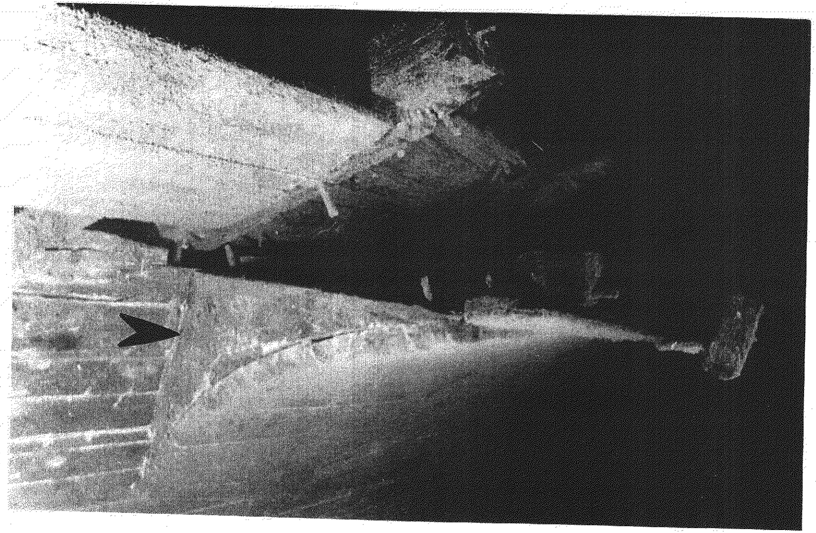


Figure 4-28. After end of the starboard sponson-guard. (Photo courtesy of the Smithsonian Institution, NMAH).

deck beams intersected or adjoined each other they were cut and fastened a necessary to fit securely together. The combination of the waterways and the guard strakes covered the top and outboard ends of the deck beams and the heads of the sponson guard braces, protecting the joints between them and creating a longitudinal strengthening member.

The port side sponson guard assembly has fallen off the side of the hull and now lies partially buried in the sand alongside the hull approximately 8 feet (2.44 m) from the wreck. The exposed portion of the port sponson guard extends a distance of 95 feet, 4 inches (29.05 m). Within this distance, a total of 52 sponson guard braces was documented.

The starboard sponson guard remains attached to the hull and is preserved intact over its full length of 119 feet, 7 inches (36.45 m). A full complement of 65 sponson guard braces, including the aftermost triangular end piece, are preserved. As on the port side, the size of these braces decreases toward the bow. The guard is faired into the sheer strake at F 73 between TDB 39 and TDB 40. Approximately amidships, two of the brace pieces on both sides of the hull are doubled for some unknown reason.

Hatchways

Indiana appears to have had at least eight hatchways or openings on the main deck: one leads down to the 33-foot- (10.06-m-) long after cargo hold, four lead to the 24-foot, 6 inches- (7.50-m-) long machinery space, one appears to have been a passageway for the helm's steering chains; and two provide access to a large forward cargo hold. The position of each of these hatchways was recorded relative to a central datum line established along the hull's longitudinal axis. Each hatchway is described below in the order they are encountered as one proceeds from the stern to the bow (see pages 107 and 273). The distances that are provided were measured from the after face of the sternpost to the inside edge of each hatchways' after headledge, or athwartships coaming.

After Hold Hatchway. A cargo hatchway for the after hold is located 29 feet, 11-1/2 inches (9.14 m) forward of the sternpost's after face. The opening of the hatchway measures 5 feet (1.52 m) square, and it is framed by TDB 8 and TDB 10, which are sided 8-1/2 inches (21.60 cm). The hatchway is framed athwartships by two carlings, or hatch partners, 7-1/2 inches (19.1 cm) sided and 5 feet, 2 inch (1.87 m) long. The ends of the carlings are fitted into mortises 1 inch (2.54 cm) deep, cut into the sides of TDB 8 and TDB 10. Between TDB 8 and TDB 10 is located TDB 9, which is referred to as a half-beam, or ledge, because it is composed of two timbers or halves that are mortised into the outboard faces of the two carlings forming the hatchway.

The hatchway's coaming extends 6-1/2 inches (16.50 cm) above the deck and tapers from a thickness of 5-1/4 inches (13.34 cm) at its base to 3-1/2 inches (8.90 cm) at its upper edge. It is constructed so that the ends of the headledges overlap the ends of the fore-and-aft coamings to form a square lap joint. Each of these joints is secured with a single iron fastener, driven down through the coaming's corners and into the underlying deck beams. Six notches, 1 inch (2.54 cm) deep and 2 inches (5.08 cm) wide, were cut into the inside edges of the fore-and-aft coaming's upper faces to fit the six athwartships hatchway grating pieces that originally traversed the hatchway's opening. Additional support for the grating pieces was provided by battens, 1-1/2 inches (3.8 cm) thick and 2 inches (5.08 cm) wide, which were fastened to the inner surface of the head ledges. Thin iron plates that were once affixed to the top of the coaming to protect it from damage have fallen off and now lie scattered on the deck.

Engine Hatchway. *Indiana*'s engine hatchway is cut through the deck between TDB 11 and TDB 13 and lies 39 feet, 6 inches (12.0 m) forward of the sternpost's after end. The opening measures 3 feet, 8 inches (1.11 m) fore-and-aft and 5 feet, 2 inches (1.87 m) athwartships. It is framed by TDB 11 and TDB 13, respectively, sided 1 foot (30.28 cm) and 10-1/2 inches (26.7 cm), and two carlings that are 5-3/4 inches (14.61 cm) sided and 4 feet (1.22 m) long. Half-beam TDB 12 is sided 7-1/2 inches (19.1 cm); the two halves rest in mortises 1 inch (2.54 cm) deep that are cut into the carlings' outboard faces. TDB 13 is supported additionally by a single deck stanchion, measuring 3-5/8 inches (9.19 cm) sided, 6-3/4 inches (17.15 cm) molded, and 8 feet (2.44 m) long. The stanchion is positioned under the center of TDB 13 and was cut to fit over the top of the forward engine bed timber. However, only 2-3/4 inches (6.99 cm) of the stanchion's 6-3/4 inches (17.15 cm) molded thickness is actually supported by the bed timber; the remaining 4 inches (10.16 cm) are left hanging, completely unsupported, 9 inches (22.86 cm) below the top of the bed timber.

The engine hatchway's coaming (2 inches [5.08 cm] wide) extends 4-3/4 inches (12.07 cm) above the deck and is set back 1-1/2 inches (3.8 cm) from the edges of the hatchway's opening. At the corners of the hatchway, the fore-and-aft coamings overlap the headledges and are secured in place with a single iron fastener. The starboard coaming and carling were both removed during the 1979 salvage of *Indiana*'s engine.

<u>Boiler Hatchway</u>. *Indiana's* largest hatchway consists of an octagonal opening in the deck 8 feet, 6-1/2 inches (2.60 m) wide that fit around the vertical boiler. The opening is located 4 feet. 5-1/2 inches (1.36 m) forward of the engine hatchway and 47 feet, 7-1/2 inches (14.52 m) forward of the sternpost. It is framed by TDB 14 and TDB 17, which are sided 11-1/2 and 10-1/2 inches (29.20 and 26.7 cm) (respectively), and two carlings that differ in both their size and arrangement. The port carling is 4-1/2 inches (11.4 cm) molded, 6-1/2 inches (16.5 cm) sided, and 11 feet, 2 inches (3.40 m) long. Unlike any of the other carlings, it was cut to fit under and extend beyond both TDB 14 and TDB 17. Its ends are supported by two stanchions, 5-3/4 inches (14.61 cm) square, which are located directly beneath TDB 14 and TDB 17. In contrast, the shorter and stouter starboard carling measures 9 inches (22.86 cm) molded, and 9 feet, 2 inches (2.79 m) long, and its ends fit into mortises 1 inch (2.54 cm) deep cut into the outboard sides of TDB 14 and TDB 17. It is supported from below by three, rather than two, 5-3/4 inches (14.61 cm) square stanchions. As with the other half beams, TDB 15, sided 8 inches (20.32 cm), and TBD 16, sided 7 inches (17.78 cm), are mortised into the carlings.

In order to create the boiler hatchway's octagonal opening and provide a surface to which decking could be nailed, four diagonal timbers, sided 6 inches (15.24 cm), were mortised into the inside corners of the square frame formed by the deck beams and carlings. The outside of this square frame is strongly reinforced at its four corners, where the carlings join the deck beams, with four lodging knees, each of which is fastened to both the carlings and the deck beams. These lodging knees were the only examples of their type found in *Indiana's* hull.

Only a small portion of the boiler hatchway's 3-inch- (7.62-cm-) high coaming was preserved along the opening's port side. In cross-section, the coaming tapers from 3-3/4 inches (9.53 cm) at the deck to 2-1/4 inches (5.72 cm) at its top. The upper, inside edge of the coaming is mortised, perhaps to fit the base of the vertical bulkhead planking around the boiler. The rest of the coaming, portions of the diagonal hatchway framing pieces, and decking along the boiler hatchway's after edge were all removed during the 1979 salvage expedition. Coincidentally, the forward edge of the boiler hatchway, located 55 feet, 11 inches (17.04 m) forward of the sternpost, coincides with the point where the deck begins to collapse into the hull.

<u>Fireroom Companionway</u>. Between TDB 14 and TDB 15, approximately 3 feet (0.91 m) outboard of the boiler hatchway's port side. a small companionway leads down into the fireroom portion of the machinery space. The machinery space is defined by the remains of two badly damaged

bulkheads. The fireroom's after bulkhead (separating the after hold and the fireroom) is located 35 feet (10.67 m) forward of the sternpost, directly beneath the forward edge of TDB 10. The forward fireroom bulkhead (separating the fireroom from the forward or main hold) lies beneath the forward edge of TDB 18, 59 feet, 6 inches (18.1 m) ahead of the sternpost. Both bulkheads are constructed from vertical tongue-and-groove planking 1-1/2 inches (3.80 cm) thick and 1 foot (30.48 cm) to 1 foot, 2 inches (35.56 cm) wide.

The opening of the fireroom companionway measures 1 foot, 11-1/4 inches (59.06 cm) fore-and-aft and 2 feet, 2 inches (66.04 cm) athwartships. The companionway's coaming extends 4-1/4 inches (10.80 cm) above the deck and tapers in width from 3-5/8 to 2-1/2 inches (9.20 to 6.4 cm). The ends of the coaming pieces overlap the ends of the headledges, and the joint is secured together with a single iron fastener at each corner.

Below the fireroom companionway's outboard coaming is a ladder leading down into the fireroom (Fig. 4-29). The ladder is fastened to the port side ceiling, measures 2 feet, 2 inches (66.04 cm) wide, and has an overall length of approximately 7 feet (2.13 m). It is constructed from two vertical wooden pieces, 4 inches (10.16 cm) square, which are connected horizontally by four round iron rungs, 1 inch (2.54 cm) in diameter, and a horizontal wooden crosspiece, 2 inches (5.08 cm) thick and 4 inches (10.16 cm) wide, at the ladder's base. Not coincidentally, the boiler's furnace door, located on the port side of the boiler, was directly adjacent to the companionway ladder. An iron fire poker, one of the few exposed artifacts left in the hull, rests against the ceiling and the ladder.

<u>Opening for Fireroom Ventilator</u>. Centered 2 feet (60.96 cm) from the port edge of the boiler hatchway and located a short distance forward of the fireroom companionway is a circular opening 10-1/8 inches (25.70 cm) in diameter for *Indiana*'s fireroom ventilator. The opening is surrounded by a wooden coaming that measured 3 inches (7.62 cm) tall and wide. Attached to this ventilator opening would have been a bell-mouthed or cowl ventilator. This ventilator would have extended above the roof of the spar deck cabin and the opening would probably have been facing forward to provide much needed fresh air to the fireroom.

<u>Fueling Hatchway</u>. A small fueling hatchway located 1 foot, 7-3/4 inches (50.17 cm) ahead of the forward edge of the boiler hatchway opening and 57 feet, 6-3/4 inches (17.54 m) forward of the sternpost provided access to the forward end of the fireroom and was presumably used for transferring fuel below deck. The hatchway's opening is framed by TDB 17 and TDB 18 and measures 2 feet, 7-1/4

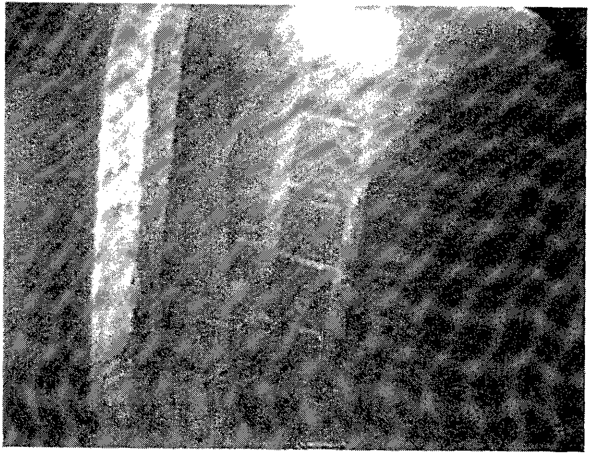


Figure 4-29. Ladder leading into the fireroom from the main deck. (Digital image of underwater video footage recorded by Thomas Alburn captured by Douglas Gann).

inches (79.38 cm) fore-and-aft and 2 feet, 11 inches (88.90 cm) athwartships. The coaming (6-7/8 inches [17.46 cm] high) is flat-tapered and measures 5 inches (12.70 cm) wide at the deck and 3 inches (7.62 cm) wide at its top. The headledges overlap the coaming pieces at their ends and are secured together with a single iron fastener. Not surprisingly, a large amount of firewood that lay on top of scattered chunks of coal was noted in the forward end of *Indiana*'s fireroom directly below this hatchway.

Forward Hold Hatchway No. 2. The aftermost of two large hatchways providing access to the forward cargo hold is located between TDB 19 and TDB 21, 64 feet, 9 inches (7.77 m) forward of the sternpost. At this point, the deck has collapsed almost completely into the hold, and the sides of the hull start to splay outward. Only the hatchway's after headledge and starboard coaming piece are extant, but they contained enough information to determine the dimensions and construction of the hatchway.

The hatchway's opening originally measured 6 feet (1.83 m) fore-and-aft and 5 feet, 8 inches (1.72 m) athwartships. TDB 19 and TDB 21 frame the hatchway's opening fore-and-aft, and both are sided 10-1/2 inches (26.7 cm). TDB 20, a half-beam located between the two beams, is sided 8 inches (20.32 cm). Intact decking and iron ore overburden made it impossible to determine the dimensions of the two carlings that framed the hatchway athwartships, but, based on the dimensions of the carlings around the after cargo hold's hatchway, they were probably sided about 8 inches (20.32 cm).

Additional support for TDB 19 is provided by a single uniquely shaped stanchion, positioned directly under the center of the deck beam. The stanchion measured 4 inches (10.16 cm) molded and 7 inches sided (17.78 cm), and had a series of notches 2-1/2 inches (6.4 cm) deep cut into the forward corners at 1-foot (30.48- cm) intervals to create steps leading in and out of the hatchway (Fig. 4-30). In profile, the notches are triangular in appearance and measure 3 inches (7.62 cm) wide at the base and approximately 8 inches (20.32 cm) high. Archaeological examples of stanchions such as these, referred to as "monkey ladders," or "monkey posts," are rare. The only other wrecks that were fitted with such stanchions (of which the author is aware) are the Joseph Keating-built *Alvin Clark* (1846) and an early-eighteenth century merchant ship excavated in New York City, known popularly as the "Ronson vessel."[34]

The hatchway's coaming tapers in width from 5-1/2 to 3 inches (14.00 to 7.62 cm) and extends 5 inches (12.70 cm) above the decking. The joints between the overlapping headledges and coaming pieces were secured with a single iron fastener in the same manner as the other hatchways.

Figure 4-30. One of three "monkey ladder" stanchions leading out of *Indiana*'s hold. (Photo by Kevin Crisman).

Interestingly, the headledge's outer face is concave, while the starboard coaming is made convex by aquarter-round molding 2 inches (5.08 cm) wide that was nailed to it. The starboard coaming piece's upper, inboard edge is notched in six places along its length to fit grating pieces 2-1/4 inch (5.72 cm) wide that originally spanned the hatchway's opening. The notches measure 3/4 inch (1.91 cm) by 2-1/4 inches (5.72 cm) and are 2-1/2 inches deep (6.4 cm). The ends of the grating pieces were supported by a single batten, 4 feet, 3-1/2 inches (1.31 cm) long, fastened on the inside edges of the coaming pieces. Two more batten pieces, secured to the inside face of each headledge and measuring 14-1/2 inches (36.8 cm) long, 2 inches (5.08 cm) wide, and 1-1/2 inches (3.80 cm) thick, also helped support the grating pieces.

Four of the six transverse deck beams located between the forward cargo hold's two hatchways are supported from below by single stanchions, positioned along the centerline of *Indiana*'s hull. Molded 4 inches (10.16 cm) and sided 5 inches (12.70 cm), the stanchions are located under TDB 22, 23, 24, and 27. The stanchion heads were secured to the underside of the transverse deck beams with a single iron spike toenailed through the head of the stanchion and into the deckbeam.

Possible Steering Chain Hatchway. Twelve feet, 6 inches (3.81 m) forward of Forward Hold Hatchway No. 2, centered over the longitudinal axis of *Indiana*'s hull, is a small rectangular hatchway measuring 9 inches (22.86 cm) wide and 2 feet, 3 inches (68.58 cm) long that is surrounded by a coaming 3 inches (7.62 cm) tall and wide. While the actual purpose of this small hatchway remains unknown, given its location (compare to the location of *Princeton*'s pilot house [Fig. 1-6]) and size, it may be the point where the steering chains from *Indiana*'s helm passed through the main deck before being directed aft towards the rudder. Alternatively, the opening may have been for the passage of a central hogging truss post.

Forward Hold Hatchway No. 1. The starboard coaming piece is all that is preserved from Forward Hold Hatchway No. 1, the forwardmost of two large cargo hatchways leading down into the forward cargo hold. The hatchway was originally located 22 feet, 3 inches (6.78 m) forward of Forward Hold Hatchway No. 2, and 87 feet (26.52 cm) forward of the sternpost. Forward Hold Hatchway No. 1's dimensions and construction are virtually identical to those of No. 2. As with the remains of Forward Hold Hatchway No. 2, enough information was preserved in Hatchway No. 1's coaming piece and the partially intact deck beams (TDB 28 and TDB 30) that framed its forward and after ends to reconstruct No. 1's original dimensions and assembly. The deck beams framing the forward and after ends of hatchway No. 1, TDB 28 and TDB 30, are sided 8-1/4 inches (20.96 cm) and 11 inches (27.94 cm) respectively. The half-beam located between them, TDB 29, is sided 9 inches (22.86 cm).

An additional similarity between the two hatches is the presence of a second monkey ladder stanchion, centered beneath TDB 28 at the after edge of hatchway No. 1. This slightly larger monkey ladder stanchion is molded 4-1/2 inches (11.4 cm) and sided 8 inches (20.32 cm). The notched steps cut into its forward face are spaced 1 foot, 3 inches (38.10 cm) apart. These triangular notches are 11 inches (27.94 cm) high, 3 inches (7.62 cm) wide, and 2-1/2 inches (6.4 cm) deep at their bases. Unlike hatchway No. 2, the stanchion supporting the deck beam under hatchway No. 1's forward edge (TDB 30) was preserved. It measures 5-1/2 inches (14 cm) molded and 7-1/2 inches (19.10 cm) sided. Approximately 4 feet (1.22 cm) ahead of this stanchion is the last of the deck beam stanchions preserved in *Indiana*'s hull. This stanchion, 4 inches (10.16 cm) molded and 4-1/2 inches (11.4 cm) sided, is centered under TDB 31.

Deck Planking

Indiana's deck planking (sawn from white pine) measured 2 inches (5.08 cm) thick and 3-7/8 to 8-3/4 inches (5.3 to 22.23 cm) wide. Immediately abaft the fireroom companionway, where the planking strake widths were recorded, 48 of the original 52 to 54 strakes are partially preserved across the deck. However, the waterways and several adjoining strakes are absent from both sides of the hull at this point. In fact, the waterways are absent from the deck everywhere except in a single location on the starboard side of the hull opposite the engine hatchway.

Indiana's waterways are composed of two edge-fastened strakes 2-1/2 inches (6.4 cm) thick. The inboard and outboard waterway strakes respectively measured 5 and 7 inches (12.7 and 17.78 cm) wide (see Fig. 4-27). In addition to its edge-fastening to the outboard waterway strake, the inboard waterway strake is also square-fastened to the deck beams and the heads of the sponson guard's diagonal braces. The outboard waterway strake is square-fastened to the deck beams, the heads of the diagonal braces for the sponson guards, and the inboard guard timber. The outboard waterway strake is also square-fastened along its outer edge to the outboard guard timber.

All the decking strakes run parallel to the longitudinal centerline of the hull and none are nibbed at their ends. Individual planks comprising each decking strake vary in length and are butt-joined. At the butts the planks are square-fastened to the transverse deck beams with two spikes per plank per deck beam. Elsewhere the fasteners are staggered and planks are secured to the deck beams with two spikes per beam. The layout of the planking does not appear to conform to any particular pattern (i.e., four planks between parallel butts), although a minimum spacing of one strake between butts was maintained.

Fantail Decking and Associated Features. At the fantail wreckage, thirteen planks from the main deck, measuring 2 inches (5.08 cm) thick and 5 to 6 inches (12.70 to 15.24 cm) wide, lie exposed above the sand (Fig. 4-31). The heavy counter timber measuring 1 foot (30.48 cm) square in section and 14 feet 9 inches (4.50 m) long bisects the deck longitudinally. Resting on top of the sternpost and extending abaft the stern, this heavy counter timber originally cantilevered aft of the sternpost and supported most of the fantail's weight. The upper face of the forward end of the fantail timber is stepped and mortised (Fig. 4-32). The timber's 2-inch- (5.08-cm-) deep upper step provided a recessed surface for securing the after end of a central deck plank so that it was flush with the upper face of the fantail timber. A mortise 3-1/2 inches (8.9 cm) wide by 11 inches (27.94 cm) long, whose function remains unclear, is carved into the step's upper face. A second, lower step, also cut into the upper face of the fantail timber's forward end, allowed it to fit beneath the large transverse deck beam (TDB 1) located approximately 8 feet (2.44 m) forward of the sternpost.

A massive, transverse wooden cleat, measuring 7 feet, 8-1/2 inches (2.3 m) from tip to tip, is fastened to the deck with two iron U-bolts (Fig. 4-33). Historical accounts indicate that this cleat was used periodically for towing purposes.[35]

Immediately abaft this cleat is the displaced upper terminus of the hanger-bearing. The upper end of the U-shaped hanger bearing consists of two iron rods (1-1/2 inches [3.8 cm] in diameter and spaced approximately one foot [30.48 cm] apart) that pass up through the fantail deck on either side of the heavy longitudinal counter timber. A rectangular wooden bolster block (4 inches [10.16 cm] thick and one foot, 9-1/2 inches [24.1 cm] long) and a 3/4-inch- (1.91-cm-) thick rectangular iron washer plate are secured over the threaded upper ends of the hanger bearing rods by a two 2-inch (5.08-cm) iron nuts, one screwed onto the top of each of the hanger bearing rods. These nuts could be turned to adjust the tension on the rods and the amount of support they gave to the propeller shaft.

Both the cleat and the top of the hanger bearing are positioned immediately forward of a wooden hawse hole 10 inches wide (25.40 cm) and 2 feet, 9 inches (83.82 cm) long that is centered above the vessel's centerline at the base of the fantail bulwarks. The surviving 3-foot- (1-m-) tall fantail

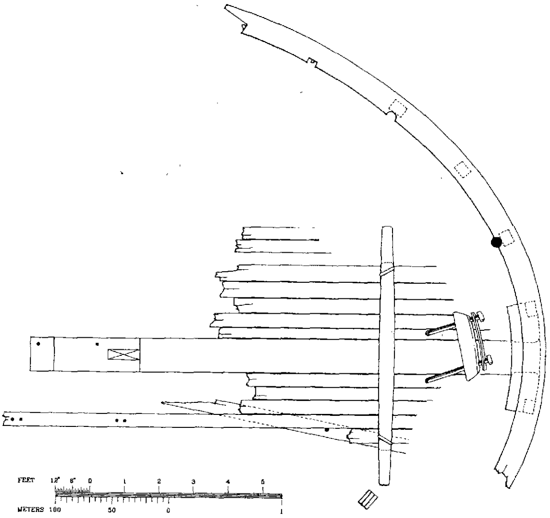


Figure 4-31. Plan view of *Indiana*'s fantail wreckage. (Drawing by Peter Hentschel).

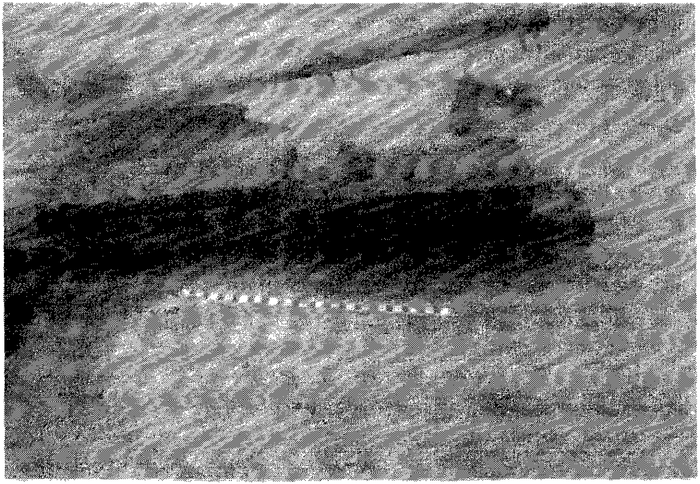


Figure 4-32. The forward end of the counter timber is stepped to fit under the heavy, aftermost transverse deck beam (TDB 1). (Photo by Peter Hentschel).

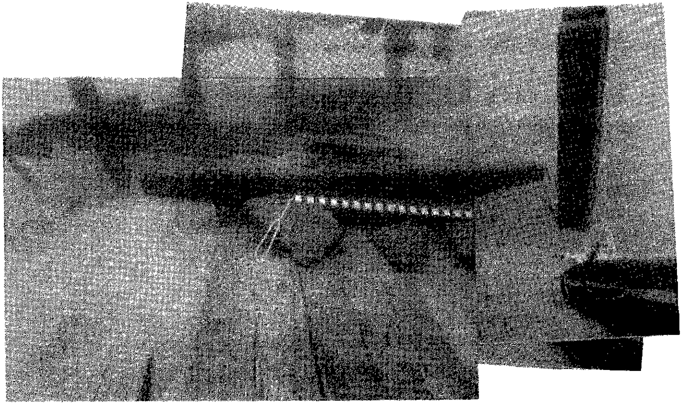


Figure 4-33. *Indiana*'s towing cleat. (Photos by Peter Hentschel).

bulwarks consisted of an oval main rail, 8 inches (20.32 cm) wide and 3-1/4 inches (8.2 cm) thick, five posts 3-1/2-by 4-1/2 inches (8.89 by 11.43 cm), and remnants of a 3/4-inch- (1.9-cm-) thick sheathing of a horizontal planking on their outboard surface. Short sections of iron chain are visible in two places on the fantail bulwarks. One section is wrapped several times around horizontal kevel that is fastened across the inboard faces of two bulwark stanchions on the fantail's starboard side. On the fantail's port side, a second length of iron chain is draped loosely over the main rail. The purpose of these chains is unknown. An iron tiller bar, 7 feet (2.13 m) long and 3-1/2 inches (8.89 cm) in diameter, was observed on the fantail wreckage when the wreck was discovered, but is now missing.

A single, upper deck support stanchion preserved among the fantail wreckage extends approximately 4 feet, 6 inches (1.37 m) above the cap rail and provides archaeological evidence that *Indiana* was indeed fitted with an upper deck (see Fig. 3-10). This upper deck would have been similar in appearance and arrangement to that of other contemporary Great Lakes propellers. Formed from a single turned timber, the stanchion is fastened to the inboard face of one of the five preserved starboard bulwarks stanchions and is fitted into a semi-circular notch carved into inboard edge of the cap rail. Similar notches in the bulwarks cap rail are visible at two other locations. Another vertical post, square in section with a tenon on its upper end, extends approximately 3 feet (1 m) above the fantail's decking. The function of this member is unknown, but it may represent the lowermost portion of a upper deck support stanchion.

The Upper Works

Evidence of the construction of *Indiana*'s upper works (i.e., the hull structure that extended above the main deck) was preserved on the main deck at the stern, in the detached fantail wreckage (described above), and in two large, broken sections of detached starboard bulwarks from *Indiana*'s main and upper decks that now lie in the sand along both sides of the hull (Figs. 4-34 and 4-35). These remains contained a number of interesting features, including a window, two gangways, several different types of stanchions, kevels, hawse holes, fairleads, handrails, and a lifeboat davit. No remains of the port side bulwarks were observed on the wreck site.

<u>Main Deck Bulwarks</u>

Indiana's main deck bulwarks consisted of lower and upper sections. The lower bulwarks

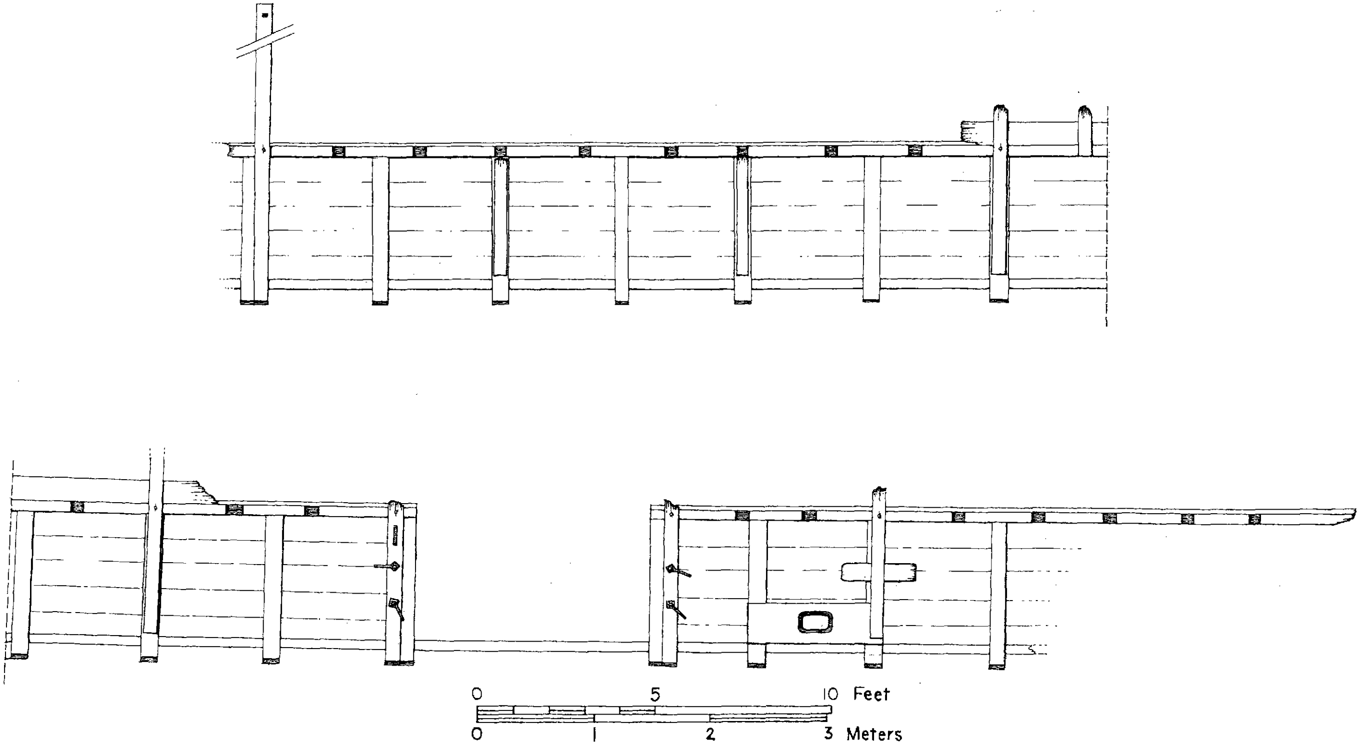


Figure 4-34. Upper works wreckage lying in the sand alongside *Indiana's* starboard side. (Drawing by David S. Robinson and Peter Hentschel).

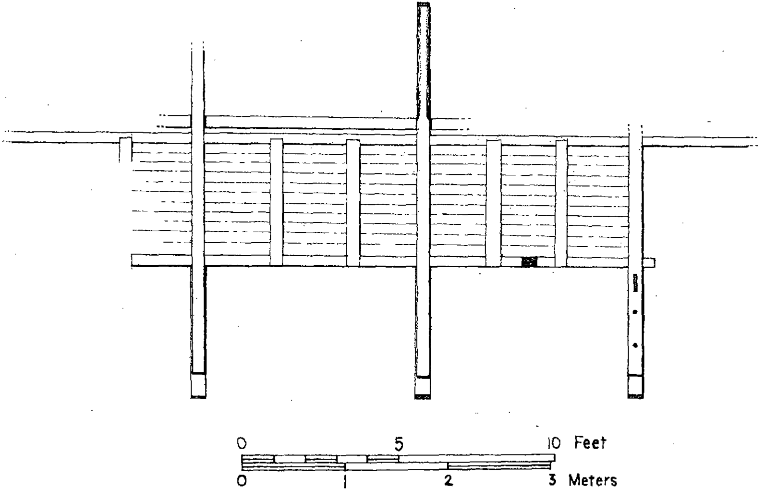


Figure 4-35. Upper works wreckage lying in the sand on *Indiana*'s port side. (Drawing by David S. Robinson and Peter Hentschel).

section extended to a height of approximately 3 feet (91.4 cm) above the main deck and were completely sheathed by 3/4-inch- (1.9-cm-) thick horizontal tongue-and-groove planking, 6 to 8 inches (15.24 to 20.32 cm) wide secured to an underlying framework of posts (4 inches [10.16 cm] square) spaced apart on 3 feet (91.44 cm) centers. The tenoned heels of these posts fit into mortises cut into the waterway strake. The top of the lower bulwarks section was defined by the main rail. This oval rail, 8 inches (20.32 cm) wide and 3-1/2 inches (8.25 cm) thick, originally extended from the sides of the stem aft along the full length of *Indiana*'s deck and wrapped completely around the perimeter of the elliptical fantail.

The 4-foot (1.21-m) space between the main rail and *Indiana*'s upper deck was open, except between two points on the hull located approximately 45 feet (13.7 m) abaft the stem and approximately 10 feet (3 m) forward of the sternpost where it was fully sheathed. This sheathed area above the main rail comprised the upper section of the main deck bulwarks. The upper section of the main deck bulwarks' sheathing measured 3/4 inch (1.9 cm) thick and 4 inches (10.16 cm) wide. The sheathing is fastened to a second set of posts, different from those of the lower section of main deck bulwarks, which are 4-inches- (10.16-cm-) square and are spaced at a regular interval of approximately 1 foot, 6 inches (45.72 cm) on center.

In the areas at the bow and stern where the space above the main rail was open, turned upper deck support stanchions were attached to the inboard face of every other post (a 6-foot [1.82 m] interval). In areas where the upper section of bulwarks were sheathed, the 4-inch- (10.16-cm-) square support stanchions for the upper deck were attached to the inboard face of every fourth post (a 6-foot [1.8-m] interval).

Two large sections of *Indiana*'s main deck bulwarks are preserved along both sides of the hull. The largest of these, preserved to a level just above the main rail, measures 79 feet, 8 inches (24.28 m) long and lies on the hull's starboard side flat and partially buried on the lake bed approximately 10 feet (3.05 m) away from the hull (see Fig. 4-34). Within this broken portion of the main deck bulwarks are preserved the lower half of the framing of a gangway door for loading cargo and passengers as well as hawse holes for the passage of mooring lines through the hull and a horizontal kevel. The absence of the upper section of the bulwarks suggests that most of it was carried away with the upper deck during the sinking.

The single gangway that is preserved in this large section of the starboard main deck bulwarks measures approximately 6 feet (1.83 m) across its width. Five iron gangway clamps or "dogs" are preserved in their original locations on the inboard faces of the vertical framing timbers that are located on both sides of the gangway. Approximately 2 feet, 6 inches (76.72 cm) forward of the gangway is located a single hawse hole. Immediately forward and above the hawse hole, a single horizontal kevel (6 inches wide [15.24 cm] and 2 feet [60.96 cm] long) is fastened securely to the bulwarks framing, sandwiched between the posts of the lower and upper sections of the bulwarks. This kevel provided a point of attachment for mooring lines that passed through the adjacent hawse hole.

A second smaller section of the main deck bulwarks, 37 feet, 2-1/2 inches (11.3 m) long, lies against the port side of *Indiana*'s hull (see Fig. 4-35). Unlike the lower section of bulwarks preserved in the sand on *Indiana*'s starboard side, the bulwarks wreckage on *Indiana*'s port side is from the upper section of bulwarks that extended above the main rail. Consequently, it contains several important construction features related to the upper deck that are not represented in the wreckage of the lower bulwarks. This bulwarks wreckage also presented one of the most puzzling aspects of *Indiana*'s wreck site.

Initially, this wreckage was believed to represent part of the port bulwarks because of its location on the port side of the hull. However, careful examination of the wreckage revealed that it was instead part of *Indiana*'s starboard main deck bulwarks. This surprising conclusion was based on the upright orientation of the bulwarks. Because they are upright, their exterior surface should be visible and facing out and away from the port side of the hull. However, this is not the case. Instead, it is the interior surface of the bulwarks that is exposed. For this to be possible, one of two events must have occurred: 1) the port bulwarks turned 180° when they were ripped from the hull and deposited on the lake bed; or 2) the upper portion of the starboard bulwarks was torn from the hull while *Indiana* was sinking and then settled alongside the hull's port side when it crashed down onto the lake bed. Of these two possibilities, the second scenario seems more likely.

This displaced portion of the upper section of the starboard bulwarks includes many of the same structural features as did the lower starboard bulwarks (i.e., main rail, posts, tongue-and-groove sheathing) and is essentially constructed in the same manner. However, there are some significant differences between them. These differences include: a second run of tongue-and-groove sheathing above the main rail, the framed opening of a window, a single post that extended above the level of *Indiana*'s upper deck, a deck beam from the upper deck, an upper deck wale, an upper deck waterway, an upper deck toe rail, a chamfered upper deck stanchion, a quarter-round molding on the top exterior of the upper bulwarks stringer, and an unidentifiable raised socket on the outboard edge of the upper deck.

Above the main rail, approximately 4 inches (10.16 cm) inboard of the sheathing on the lower half of the main deck bulwarks, the second section of tongue-and-groove sheathing is fastened to the more closely spaced posts of the upper section of the bulwarks. The seam between the main rail and the sheathing of the upper section of bulwarks is covered by a 5/8-inch (1.58 cm) quarter-round molding.

The gangway included in this upper section of the starboard main deck bulwarks contains both a gangway and a window. Extending from the main deck to the upper deck, the gangway opening measured 6 feet (1.83 m) wide and was originally 6 feet, 8 inches (2.03 m) tall. Approximately 6 feet (1.83 m) abaft the gangway is located a single rectangular bulwarks window that measured approximately 2 feet (60.96 cm) wide and 3 feet (91 cm) tall (Fig. 4-36). None of the window's glass or framework is preserved.

One of the more interesting features of the upper section of the main deck bulwarks is an intact post, preserved over its full length of 6 feet (1.83 m), that extends from a point 9 inches (22.86 cm) above the main deck to the underside of an upper deck transverse deck beam (Fig. 4-37). The outboard end of one of the upper deck's transverse deck beams (molded 3 inches [7.62 cm]) originally rested on and was supported by this post. The top three inches (7.62 cm) of the post's outboard face is recessed 1 inch (2.54 cm) to accept an upper deck "wale" 1-1/2 inches (3.8 cm) thick by 6 inches (15.24 cm) wide. An "upper deck clamp" is square-fastened to the inboard face of the intact post, so that the post is sandwiched between the upper deck clamp and upper deck wale. The upper deck planking, 2 inches (5.08 cm) thick and 4-1/2 inches (11.4 cm) wide, is fastened to the upper deck's deck beams and forms a solid connection between the upper deck and the main deck bulwark. The outboard edge of the decking is finished with a half-oval molding. A chamfered upper deck stanchion 3 inches (7.62 cm) square and approximately 2 feet, 6 inches (76.20 cm) tall is fastened to the upper deck directly over the upper vertical framing timber. The top of the stanchion is tenoned, perhaps to fit into a mortise cut into the underside of an upper deck bulwarks rail. One inch (2.54 cm) above the upper deck, a toe rail 1-inch (2.54-cm) thick by 3 inches (7.62 cm) wide is fastened to the outboard face of the upper deck bulwarks stanchion.

Figure 4-36. Upper works wreckage lying alongside *Indiana's* port side (note window opening). (Photo courtesy of the Smithsonian Institution, NMAH).

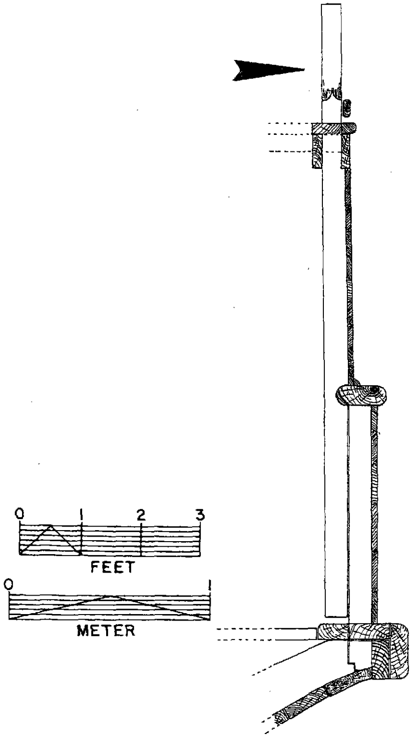


Figure 4-37. Upper deck bulwarks stanchion. (Drawing by Peter Hentschel and David S. Robinson).

Hogging Truss

The problem of "hogging" (the drooping of a vessel's ends) had long been a central problem inshipbuilding, but its solution was particularly difficult in wooden vessels with extreme length-to-breadth and length-to-depth ratios. In the case of the early screw propellers, such as *Indiana*, the weight of the engine, boiler, shaft, and propeller was concentrated in the stern where the hull was given a hollow run to maximize the propeller's efficiency. These two characteristics combined to accentuate the tendency of the stern to droop. Given these facts as well as the depth limitations and frequently rough sea conditions of the Great Lakes, extraordinary means were necessary to strengthen the shoal-draft hulls of wooden steam-vessels 150 feet in length (45.72 m).[36] Consequently, lake shipwrights of the middle nineteenth century turned to hogging truss technology as one of several ways to increase the longitudinal strength and rigidity of their steamers. Adopting the same type of truss systems employed on paddlewheel steamers, the trusses of early propellers utilized a combination of vertical and horizontal wooden beams that were united by iron rods or stays and integrated into the hull. After undergoing some modifications in form, the angular hog-frame or hog-truss took the form of a bow or arch, sweeping in an unbroken curve from one end of a vessel to the other (Fig. 4-38). This later bow-type of frame was nicknamed "Bishop" arch reportedly after the last name of the inventor.[37]

Composite wood and iron hogging trusses originated on Hudson River steamers during the late 1820s.[38] The first documented use of a hogging truss on steamboat was on the 1827 Hudson River steamer *North America* built by Robert L. Stevens (Fig. 4-39).[39] By the late 1830s combinations of angular-frame and bow-shaped hogging trusses were being employed on the steamers of Lake Champlain (Fig. 4-40).

While the composite wood frame and iron stay hogging trusses were effective, they were also heavy and cumbersome. To avoid the added weight and bulk of the framed trusses, builders of western steamers in the late 1840s began using a much simpler and lighter system of "hog chains" to provide longitudinal strength to their vessels.[40] The first documented use of such a system was on the Pittsburgh-Cincinnati packet *Brilliant* (361 tons) built in 1848.[41]

Hog chains consisted of a series of iron rods, ranging in size from one to 2-1/2 inches (2.54 to 6.4 cm) in diameter, that were connected end-to-end by turnbuckles and knuckle-joints and carried over a series of struts or masts with their ends secured to hull timbers at the bow and stern.[42] In addition to the hogging chains, western steamers of the period also employed "cross chains" that ran athwartships

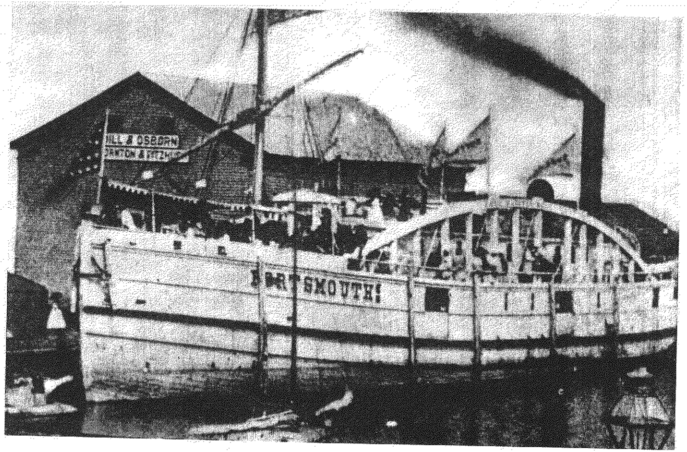


Figure 4-38. Great Lakes propeller *Portsmouth* (1852). Note the vessel's bow or "Bishop" arch truss. (Photo courtesy of C. Patrick Labadie).

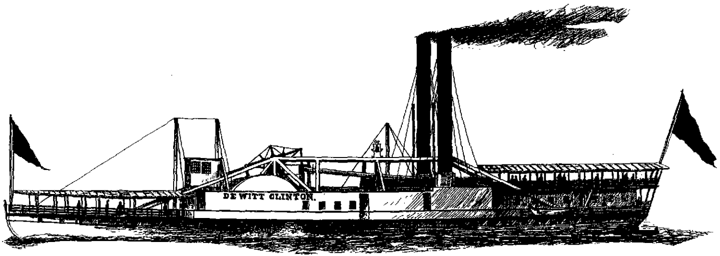


Figure 4-39. Hudson River steamer *De Witt Clinton* (1828), a contemporary of Stevens' *North America* (1827) was among the first steamers to be fitted with a hogging truss. (After Anderson, *Steamboats of the River Hudson*, 13).

Figure 4-40. Hogging trusses first appeared on Lake Champlain steamers, such as *Burlington* (1837), in the late 1830s. (Courtesy of the University of Vermont Archives, Lake Champlain Transportation Company Collection).

and passed over masts or "Sampson posts" raised from the main deck above the planksheer or from the keelson.[43] Unlike the more visually prominent framed trusses, this combined system of hog chains and cross chains was less obtrusive and extended into but not usually above a vessel's superstructure.[44]

Although the hog chains and braces were effective they also had their drawbacks. They required frequent adjustment and interfered with the physical arrangement of the boat, with the handling of freight, and with the convenience of passengers. They also did not entirely compensate for the weaknesses in the hull structure.[45] Furthermore, the Sampson posts that were employed in the early versions of the cross chain systems quickly went out of use, all but disappearing by the end of the 1850s, because of an inherent flaw in their design: the concentrated load on a single vertical timber tended to punch holes in the bottom of the boats in which they were installed.[46]

Indiana's archaeological remains suggest that it was fitted with some simple form of fore-and-aft hog chains and posts. Given *Indiana*'s hull length of nearly 150 feet (45.72 m) and its somewhat exaggerated length-to-breadth and depth-to-length ratios of 6.4:1 and 13.3:1, respectively, as compared to those of contemporary sailing vessels (4:1 and 10:1, respectively) it is not all surprising that some type of stiffening device was employed in the propeller's hull.[47]

Iron straps or "truss anchors" measuring 5 feet, 10-1/2 inches (1.79 m) long and 4 inches (10 cm) wide fastened to the exterior of both sides of *Indiana*'s hull at the stern immediately forward of the heavy TDB 1 (Fig. 4-41). Spiked through both the hull and ceiling planking, the forward ends of the truss anchors pass beneath an external hanging knee and through the main deck (Fig. 4-42). The forward ends of these truss anchor straps pass through the main deck and terminate in pinned joints that connect to iron truss rods or chains 1-3/4 inches (4.45 cm) in diameter that extend forward along the length of the main deck. The port chain at the stern is broken off approximately 4 feet (1.22 m) forward of its point of articulation with the truss anchor strap and the starboard chain extends forward approximately 30 feet (9.14 m) before ending in a break.

Two detached sections of chain lie across the deck (see Fig. 3-8). One section, oriented more-or-less fore-and-aft, extends 62 feet, 1-1/2 inches (18.9 m) aft from the forward edge of the boiler hatchway to the sand outboard of the forward terminus of the attached starboard chain. This section is composed of three shorter segments of chain connected by a knuckle joint (Fig. 4-43) and a turn-buckle (1 foot, 4-1/2 inches [41.91 cm] long) (Fig. 4-44). The turn-buckles provided a means of adjusting the tension of the truss, while the hinged knuckles allowed the chains to bend in different

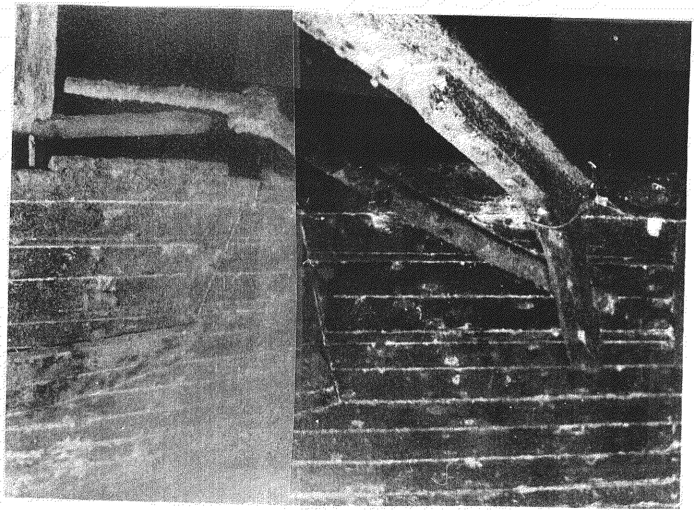


Figure 4-41. *Indiana's* port side after truss anchor. (Photo courtesy of the Smithsonian Institution, NMAH).

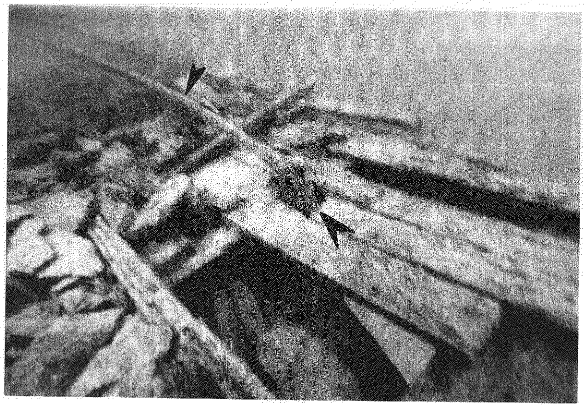


Figure 4-42. *Indiana's* starboard after truss anchor and chain passing up through the main deck. (Photo courtesy of the Smithsonian Institution, NMAH).

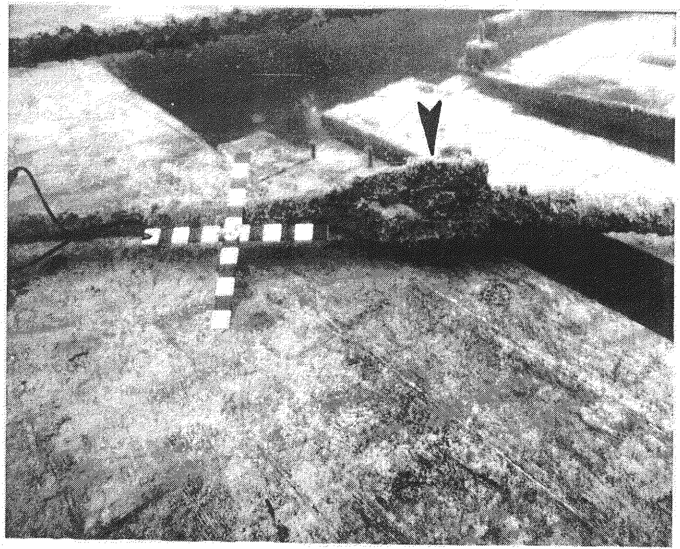


Figure 4-43. Knuckle joint in *Indiana*'s hogging chain. (Photo courtesy of the Smithsonian Institution, NMAH).

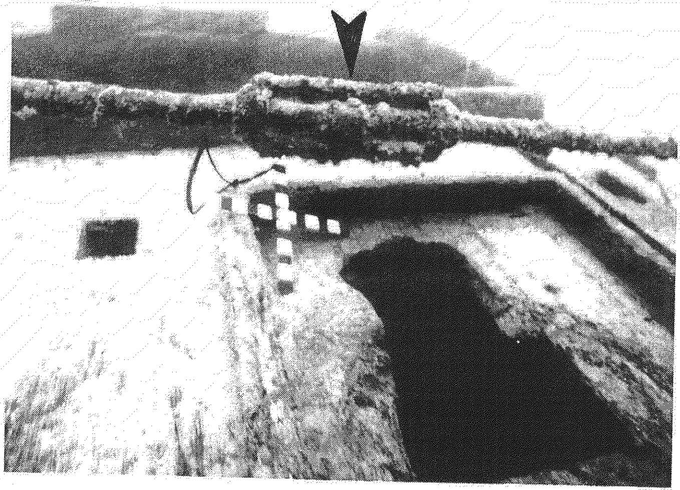


Figure 4-44. Turnbuckle in *Indiana*'s hogging chain. (Photo courtesy of the Smithsonian Institution, NMAH).

directions such as when they were passed over the top of a post. The second detached section of chain is draped athwartships across the deck between the engine and boiler hatchways; its starboard end isburied beneath the bulwarks wreckage. The exposed chain measured 34 feet, 10 inches (10.61 m) in length. This section of chain is also composed of three shorter segments of chain connected by knuckle and turn-buckle joints. Unlike the first section, however, the starboard end of this section of chain, just beyond the knuckle, appears to end in a truss anchor strap.

It appears that both of *Indiana*'s two hogging chains were passed over the two large wooden posts (spaced apart 19 feet, 3 inches [5.87 m]) located on each side of the engine hatchway (see page 265). The posts, which served a similar function as did the Sampson Posts described above, measured 9 inches (25.40 cm) square and extended above the main deck 10 feet, 7 inches (3.27 m) (Fig. 4-45). At the point where the posts meet the deck, their outboard faces are recessed so that half of the posts' width is supported by the clamp while the other half, which extends 4 feet, 7 inches (1.39 m) below the main deck, is fastened with six iron spikes to the inboard faces of *Indiana*'s ceiling.

Above the main deck, the corners of the posts are chamfered up to a point approximately 6 feet, 6 inches (2 m) above the main deck. The chamfering is interrupted for approximately 1 foot (30.48 cm) and then it resumes for two more feet (60.96 cm) before stopping one foot (30.48 cm) below the posts' upper termini. As with the chamfered stanchion preserved on the detached fantail, the point at which the chamfering stops briefly is believed to correspond with the location of *Indiana*'s upper deck. Based upon this interpretation, only about three feet (1 m) of the post would have been exposed above *Indiana*'s upper deck. The tops of the posts are notched with a 4-inch- (10.16 cm-) wide channel or saddle for the truss chains.

Presumably the chains passed over either a single central post or a second pair of posts near the bow. After passing over the(se) forward post(s) the chains would have angled downward and continued forward to the bow, where their forward ends would have been anchored to long iron straps fastened to the exterior of the hull at the level of the main deck (see page 265). The starboard forward truss anchor strap (located between TDB 39 and TBD 40) was preserved and accessible for documentation (Fig. 4-46). It is similar in both size (6 feet, 4 inches [1.93 m] long, 3-5/8 inches [9.2 cm] wide, and 1-1/4 inches [3.17 cm] thick) and construction to the stern truss anchor straps except for its sternward (rather than forward) angle and the eye (rather than a pinned joint) at its after end. Interestingly, the forward starboard truss anchor strap passes under the forward end of the starboard sponson guard. The eye

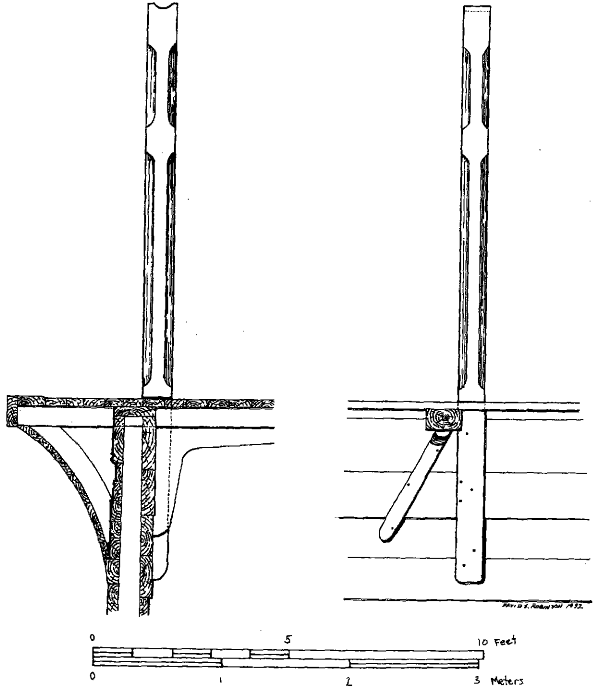


Figure 4-45. *Indiana's* port side queen post. (Drawing by David S. Robinson).

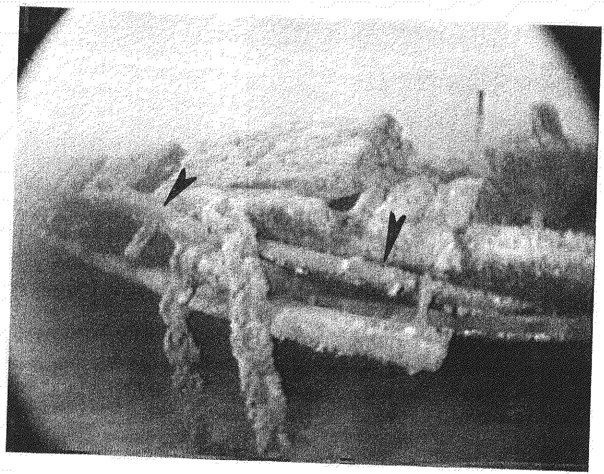


Figure 4-46. *Indiana*'s starboard forward truss anchor. (Digital image of underwater video footage recorded byThomas Alburn captured by Douglas Gann).

measured 2 inches wide and 6 inches (5.08 and 15.24 cm) long at the after end of the truss anchor; it is visibly distorted, presumably from years of being under tension.

The primitiveness of *Indiana*'s truss system make it one of the more interesting features on the wreck. In the late 1840s, truss technology on the Great Lakes, particularly the use of hogging chains, was still in its earliest stages of development. Despite their skills as craftsmen, the individuals who built *Indiana*'s truss were practical boatbuilders and mechanics who worked without the benefit of scientific knowledge and trained engineering skill in a trade that promoted proprietary secrecy. Any advancements that they made were largely the result of their own trial-and-error and experimentation. Given these considerations and the numerous examples of similar but improved hull-stiffening arrangements that appear on Great Lakes steamers and propellers built after *Indiana*, it seems likely that the elements described above represent a primitive form of truss system.

Deck Equipment

<u>Riding Bitts</u>

A pair of riding bitts, lying upside down in the sand, was found by divers among the disarticulated wreckage of *Indiana*'s forward deck about 3 feet (approximately 1 m) aft of the windlass (Fig. 4-47). These bitts were used for securing the anchor-cable in the days before windlasses displaced the capstan and chain took the place of hemp cable. Given the fact that *Indiana* had a chain anchor cable and was equipped with both a capstan and a windlass, the presence of these riding bitts is somewhat anachronistic, although *Indiana* may have had lighter anchors that still used rope cable. Their inclusion is especially interesting in light of an observation made by an officer on the Great Lakes propeller *Mineral Rock* in the report of *Indiana*'s loss that appeared in the 12 June 1858 issue of the *Lake Superior Miner*. The report states that *Mineral Rock*'s officers were able to identify the floating wreckage that they encountered while passing the area in which Indiana had sunk several days earlier as *Indiana*'s when they, "...noticed a winch different from those now in common use on such boats, and the precise kind as *Indiana* had." From this statement, it would appear that some of *Indiana*'s deck equipment, perhaps including the riding bitts, was out-dated by 1858 standards.

Indiana's forward riding bitts consist of two vertical posts or bitts, set 2 feet, 8-3/4 inches (83.19 cm) apart (face to face), that stood 2 feet, 11-1/2 inches (90.2 cm) above the main deck and are connected by a horizontal cross piece or bolster 8 inches (20.32 cm) molded and 5 inches (12.70 cm)

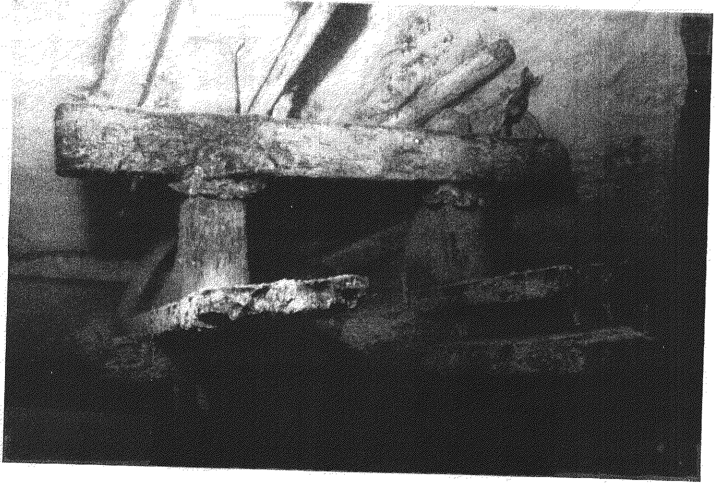


Figure 4-47. *Indiana's* forward riding bitts. (Photo by Kevin Crisman).

sided. The bitts are essentially square in cross section but taper from 7-1/2 inches (19.1 cm) at their heels to 6-1/2 inches (16.5 cm) at their heads. On the forward faces of the bitts are attached standing knees, intended to take most of the strain on the bitts (5 inches [12.70 cm] sided). On the bitts' after faces, the bolster is secured with two iron spikes per bitt 1 foot (30.48 cm) below the bitt heads. The portions of the bolster that extend beyond the outboard faces of the bitts are chamfered. The bottoms of the bitts abut the after face of a fragment of a transverse deck beam (possibly TDB 41) (sided 9 inches [22.86 cm] and molded 6-3/4 inches [17.15 cm]) and pass through extra-large deck planks 3-1/4 inches (8.26 cm) thick and one foot, 3-3/4 inches (40 cm) wide and short, thick underlying planks that are bolted to the undersides of the deck beams that are located forward and aft of the bitts. Of these two short thick planks, only the starboard one is preserved intact. It measured 4 3/8 inches (11.11 cm) thick, 1 foot, 1-1/2 inches (34.3 cm) wide, and 3 feet, 9-1/2 inches (1.2 m) long. Three 3/4 inch-diameter [1.91 cm] bolts at both ends of the short planks secure them to the undersides of the transverse deck beams. The sided dimensions of the lower ends of the bitts (5-1/2 inches [14 cm]), which pass through the short thick underlying planks, are reduced by 7/8 inch (2.21 cm) on each side.

Capstan

An iron capstan salvaged from *Indiana* by sport divers was donated to the Smithsonian, conserved, and put on display in the National Museum of American History's Hall of American Maritime Enterprise in 1984. Provenience information is lacking, but this manually operated capstan was probably recovered from the bow area of the wreck, where it had been originally mounted for hauling in *Indiana*'s anchors, sails, and sheets. The capstan was documented by the author in April of 1993.

The capstan's overall dimensions measured 3 feet, 1-1/2 inches (94 cm) in height and 2 feet, 4 inches (71.12 cm) in diameter at the base of the barrel and 1 foot, 9-3/4 (55.9 cm) inches in diameter at the drum head (Fig. 4-48). The capstan's drum head is 7-3/4 inches (20.3 cm) tall, and it is socketed with six holes, 2-1/2 inches (6.4 cm) square and 7 inches (17.78 cm) deep for its wooden capstan bars. The bars, typically made from hardwoods such as ash or hickory, were inserted into the holes to provide the leverage necessary to turn the capstan while under strain. The drum head is connected to the barrel by a 5-inch- (12.7-cm-) diameter spindle and six "S"-shaped legs, each of which are decorated with three embossed oak leaves (Fig. 4-49). The decorative upper rim of the capstan barrel also displays the

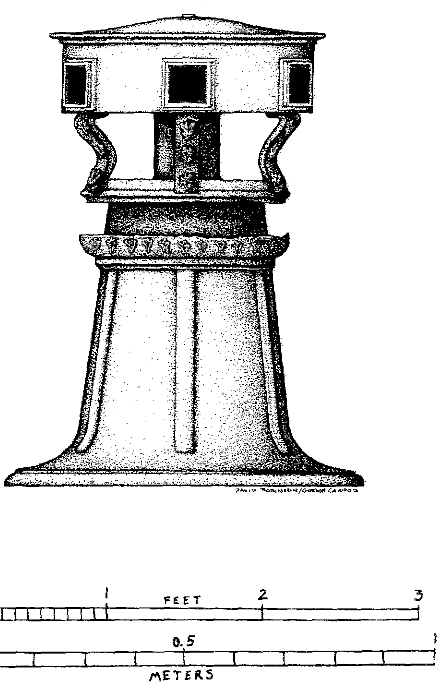


Figure 4-48 *Indiana*'s capstan. (Drawing by Gordon Cawood and David S. Robinson).

Figure 4-49. Decorative oak leaves embossed on capstan. (Photo by David S. Robinson).

embossed oak leaf decorations. The barrel has six 1-1/2-inch- (3.8-cm-) wide whelps, spaced 5-1/2 inches (14 cm) apart at the barrel head and 7-1/2 inches (19 cm) at the base, which provided gripping points for the hawsers or cable being hove-in.

While documenting the capstan, the author noted paint residue on all of the capstan's surfaces except the top of the drum head. Green paint residue, similar in color and appearance to the green paint found on portions of *Indiana*'s hull, was visible on the rim of the drum head where the capstan bars were inserted. From that point down to the capstan's base white paint residue was found.

One particularly interesting feature of the capstan is several nearly illegible embossed letters on the capstan's drum head we've assumed to be the name and location of its maker. To document this embossed text, the author made a graphite-on-paper rubbing of the text (see Fig. 2-8). Subsequent careful examination of the drum head and the rubbing produced the following text: "CL_VD,_H," and "_ _ CLE_LA_ _ &C°." As described in Chapter II, an 18 July 1849 entry in Ahira Cobb's ledger book documents a payment of $500 for a "proppeller [sic] engine" to Cleveland-based machinists John McClelland & Samuel L. Baker.[48] This entry, coupled with McClelland and Baker's business association with fellow Clevelander, Luman Parmalee, who appears to have designed *Indiana*'s boiler, suggests that *Indiana*'s engine, boiler, and deck machinery were supplied and installed by McClelland and his associates, Baker and Parmalee.[49] Thus, it seems likely that the capstan text actually reads "CL<u>E</u>VD,<u>O</u>H," and "<u>Mc</u>CLE<u>L</u>LAN<u>D</u> & C°"

Windlass

The intact remains of *Indiana*'s windlass and bitt lie on their starboard side, immediately abaft and attached to the stem assembly (Fig. 4-50). The iron windlass consists of two barrels mounted athwartships on a single, heavy wooden bitt. Both barrels are joined together on a single axle, and disc-shaped ratchets protrude at the bases of both barrels. Fore-and-aft oriented sockets for the windlass' stout wooden lever arms are positioned directly above each of the ratchets. The levers were offset approximately 90° from each other, so that the lever arms could be alternately raised and lowered to engage the ratchets during the windlass' operation. As a result of the up-and-down motion of the lever's arms, this particular type of windlass was called a "pumping windlass."[50] Master pawls, which acted as brakes, were attached to each lever immediately below their forward socket and continuously dropped into place on both ratchets as the levers were worked.[51] *Indiana*'s windlass was used to raise and lower

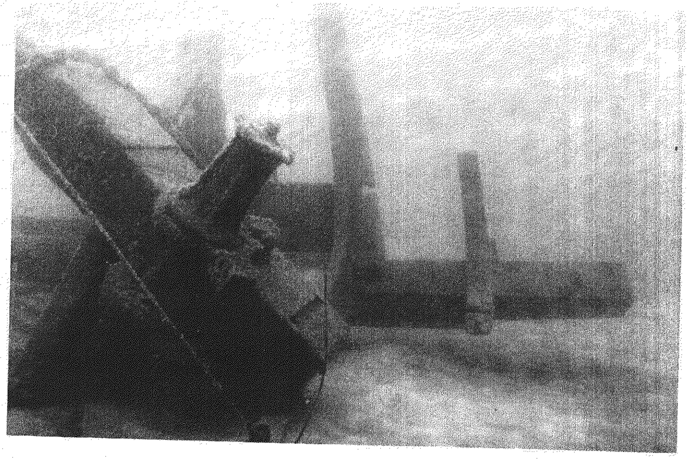


Figure 4-50. *Indiana*'s windlass and bitt (left foreground). *Indiana*'s stem assembly is also visible in the background (Photo courtesy of the Smithsonian Institution, NMAH).

the bower anchors. A length of anchor chain, still looped around the windlass's port barrel, extends out through the port side hawse hole and disappears into the sand.

Indiana's windlass bitt was fashioned from a single massive piece of white oak, 1 foot, 6 inches (45.72 cm) by 11 inches (27.94 cm) at its head and 15 feet, 1/4 inch (4.57 m) long. The bitt remains fastened to the after end of the triangular forward section of the main deck that is part of the stem assembly. An athwartships channel for the windlass's axle was cut into the bitt's after face, 1 foot, 5 inches (43.18 cm) below the head of the bitt. Four feet, 3-1/2 inches (1.3 m) beneath its head, the bitt's 11-inch (27.94 cm) athwartships dimension abruptly expands to 1 foot (30.48 cm), providing a 1-inch- (2.54-cm-) wide ledge on both sides of the bitt for the decking. The bitt's 1-foot- (30.48-cm-) wide dimension extends only a short distance down the length of the bitt before ending in a beveled edge, 5 feet, 10 inches (1.78 m) below the head of the bitt. From this point to the heel, the bitt tapers and the corners are chamfered. The end of the bitt terminates in a tenoned heel that apparently fitted into a mortise in the keelson.

Anchor

Indiana's bower anchor was also salvaged by divers and brought to the Smithsonian during the early 1980s. Today, the anchor is one of several items from *Indiana* that is exhibited in the Hall of American Maritime Enterprise at the National Museum of American History. In April 1993, the author visited the museum and recorded the anchor's construction and dimensions (Fig. 4-51).

The anchor has a total length of 6 feet, 5 inches (1.96 m), measured from the top of the shank to the anchor's crown. The shank itself has a measured length of 5 feet, 9 inches (1.75 m) from its top to the weld seam where it joins the arms. The diameter of the octagonal shank ranged between 4-1/4 and 4-7/8 inches (10.80 and 12.38 cm). The anchor's lifting ring, 11-1/2 inches (29.2 cm) in diameter, passes through an eye 2-3/8 inches (6.03 cm) in diameter at the top of the shank.

The anchor arms' breadth measured 4 feet, 5 inches (1.35 m) across from bill to bill. The flukes were fabricated from rolled iron one inch (2.54 cm) thick and measured one foot, 6-1/2 inches (47.00 cm) long and one foot, 2-1/2 inches (36.8 cm) wide. The bills extended 5 inches (12.70 cm) beyond the outside edge of the fluke.

The anchor's 8-foot- (2.44-m-) long stock consists of two pieces of wood, sandwiched together around the shank. The diameter of the stock measured 11-1/2 inches (29.2 cm) at the shank and tapers

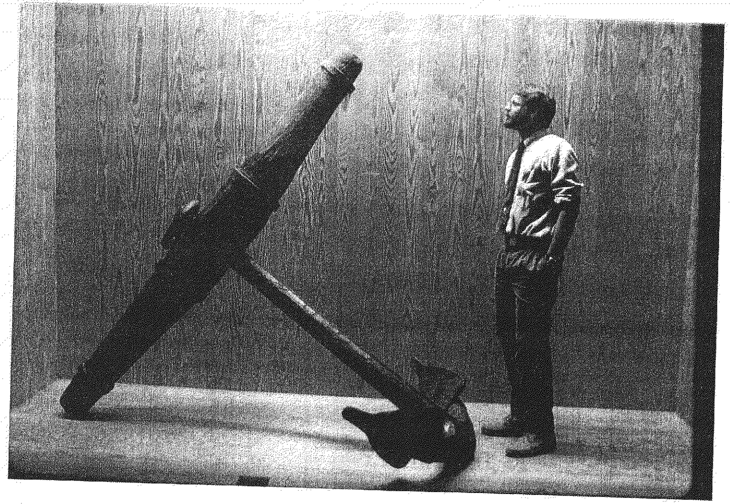


Figure 4-51. Dr. Crisman examining *Indiana*'s wooden-stocked anchor on exhibition at the Smithsonian Institution, NMAH. (Photo by David S. Robinson).

to 5 inches (12.70 cm) at the ends of the stock. The two halves of the stock are held together by four iron bands, measuring 3/8 of an inch (0.95 cm) thick and 1-7/8 to 2 inches (4.67 to 5.08 cm) wide. Square-headed nails are toed-in against the outside edges of the two inner hoops to prevent slippage.

Paint residue was observed in several places on the anchor's surface. Silver paint was visible on the anchor's metal components, and green paint, matching the color of green paint that was recorded on *Indiana*'s hull, was noted on the wooden stock. Drops of red paint were also noted. This paint is not necessarily an original feature. It may instead have been applied to the anchor after its recovery during the years before it came to the Smithsonian, while it was on display at the Great Lakes Museum Ship *Valley Camp* in Sault Sainte Marie, Michigan.

Cargo Winches

Manually-powered cargo winches were found at each of the two forward hold hatchways (Fig. 4-52). There is also evidence (e.g., raised sockets in the deck immediately abaft the hatchway) that a third cargo winch was once attached to the deck adjacent to the after hold. These hand-powered deck winches consisted of two vertical wooden legs, 3 inches (7.62 cm) thick, 8-1/2 inches (21.6 cm) wide, and 7 feet, 9 inches (2.36 m) long, connected together at one end by a horizontal wooden cross-member, through which passed the winch's legs. The cross-member measured 10 feet, 8 inches (3.25 m) long and 4 inches (10.16 cm) thick. The cross-member's width tapered from 7 inches (17.78 cm) at the uprights to 5 inches (12.7 cm) at the ends of its arms. Located between the two vertical legs are a barrel and three axles that are fitted with spur gears. A hand crank for turning the barrel was preserved on one of the winches as was a length of chain that remains wrapped around the barrel. These winches were used to move barrels of cargo in and out of the hold.

Starboard Stern-Quarter Lifeboat Davit

According to accounts of *Indiana*'s loss its crew and passengers escaped from the rapidly sinking propeller in two lifeboats. During the 1992 field season, a single, detached davit for one of these lifeboats was discovered lying partially buried in the sand next to the disarticulated starboard bulwarks off *Indiana*'s starboard stern quarter. A large portion of the davit was uncovered and recorded in detail (Fig. 4-53).

The documented portion of the davit consists of a heavy, wooden davit post and the base of a

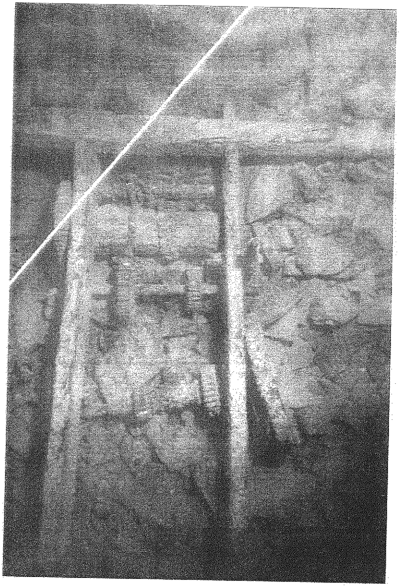


Figure 4-52. One of *Indiana*'s two extant cargo winches. (Photo courtesy of the Smithsonian Institution, NMAH).

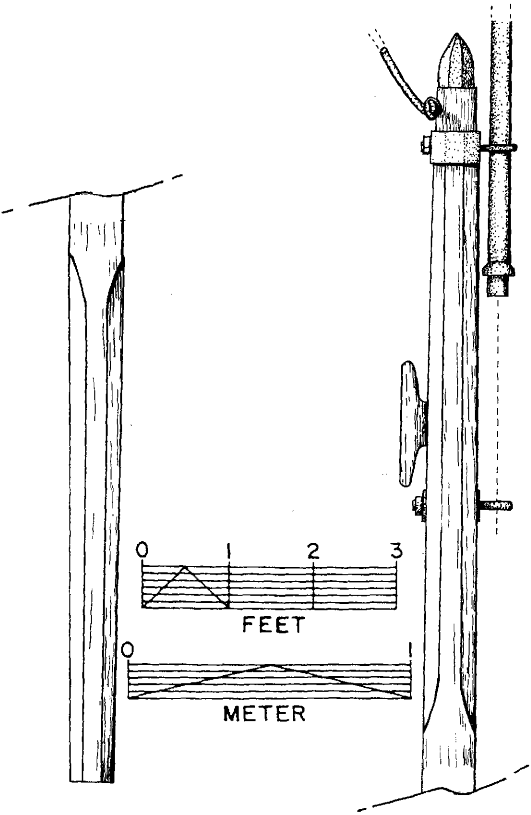


Figure 4-52. Starboard stern-quarter lifeboat davit. (Drawing by David S. Robinson and Peter Hentschel).

iron davit arm. The davit post, 7 inches (17.78 cm) square, once extended to an overall height of 15 feet, 3 inches (4.65 m) above the level of the main deck. The top 8 inches (20.32 cm) of the post were carved into a decorative pointed finial. The base of the davit post appears to have been stepped into a raised mortise on the main deck. The corners of the davit post are chamfered from the level of the main deck to a point approximately 6 feet (1.83 m) above it where the post becomes square in section for 1 foot, 5 inches (43.18 cm) before becoming chamfered again. This interruption in chamfering follows the same pattern of chamfering that was documented on the fantail stanchion and the hogging truss posts and provides additional archaeological evidence for the location of *Indiana*'s upper deck approximately 7 feet (2.13 m) above the main deck.

The iron davit arm that extends from the post appears to have been preserved intact over its full length, but time limitations prevented exposing and documenting more than 30 inches (76.2 cm) of its length. The base of the davit arm was secured in an iron eyebolt or socket that allowed the davit arm to pivot outboard for deployment of the lifeboat. The position of this eyebolt on the davit post indicates that the base of the davit arm would have been located 10 feet (3.05 m) above the main deck and approximately 3 feet (91.44 cm) above *Indiana*'s upper deck where the lifeboat would have been stowed. The davit arm passes through a second eyebolt four feet, 2 inches (1.27 m) above the lower one that is fastened through the davit post. A short length of small-diameter iron rod with a broken hook-end is secured to the side of the davit post between the upper-most eyebolt and the base of the carved finial. This rod fragment may have been a stay for stabilizing the top of the davit post. Eleven-1/2 inches (29.2 cm) above the lower davit arm eyebolt on the opposite or inboard side of the davit post is a large wooden cleat (1 foot, 6 inches [45.72 cm] long) for securing the line that was reeved through the block at the end of the davit arm and attached to *Indiana*'s starboard lifeboat.

Propulsion Machinery

As described in Chapters I and II, *Indiana*'s propulsion machinery was the primary focus of the Smithsonian's salvage expeditions of the late 1970s and early 1980s. Following its recovery, *Indiana*'s power plant was supposed to be conserved and exhibited in the National Museum of American History. Unfortunately, as has all too often has been the case, this plan proved later to be logistically and financially impossible for the museum to complete. Consequently, all of *Indiana*'s recovered propulsion machinery, except for the propeller and a small number of other items, are warehoused in the museum's

Silver Hill, Maryland storage facility.

To date, little or nothing has been done to stabilize any of these historically significant objects or to create adequate storage containers for them (Fig. 4-54). The first comprehensive inventory of all of the *Indiana* artifacts was prepared by the Smithsonian's Dr. Paul Johnston and John Stine in 1993.[52] *Indiana*'s boiler has been stored out-of-doors, unprotected from the elements, for nearly two decades. The cumulative adverse affects of the museum's handling of these items have manifested themselves in several ways. As expected, wooden and ferrous metal artifact components have suffered the worst. The wooden framework of *Indiana*'s engine, which was in excellent condition when recovered in 1979, has been allowed to dry out untreated and now displays obvious signs of permanent irreversible damage. Individual timbers comprising the frame have shrunk and are now cracked and distorted. Exposure to atmospheric oxygen has blackened and checked the unpainted surfaces of the frame, giving the wood the false appearance of having been exposed to fire. The wooden handles of several shovels recovered from *Indiana*'s hold have deteriorated to the point that they crumble when touched. Corrosion of the ferrous metal components of the engine, boiler, shovel blades, etc., has been accelerated by exposure to atmospheric oxygen and fluctuations in ambient moisture and continues unabated. The boiler's long-term exposure to atmospheric oxygen, moisture, chlorides, and corrosive urban pollutants will eventually lead to its destruction. Clearly, the neglect of these unique artifacts is a situation that should be remedied immediately. If the Smithsonian is incapable of providing the care and facilities required to maintain the *Indiana* artifacts in its possession, then the artifacts should be transferred to another curatorial agency. Even if the Smithsonian stabilizes and provides adequate storage for the *Indiana* artifacts, an appropriate venue for displaying the propulsion plant should be sought so that the original goals of the Smithsonian's salvage campaign may finally be met.

To their credit, the Smithsonian has sponsored two studies focusing on *Indiana*'s power plant (see Chapter II). The first of these investigations was undertaken between 1981 and 1991 by consulting architect Richard K. Anderson, Jr.[53] The purpose of Anderson's study was to document the construction and operation of *Indiana*'s power plant (i.e., the boiler and engine). A second study was undertaken in 1984 by Frederick Hocker, as a summer intern at the Smithsonian.[54] The mission of Hocker's research was to identify the builder of the various components comprising *Indiana*'s propulsion plant. Unfortunately, the absence of makers' marks or builder's plates on *Indiana*'s engine or boiler prevented conclusive identification of a source for *Indiana*'s machinery. However, Hocker's work produced a

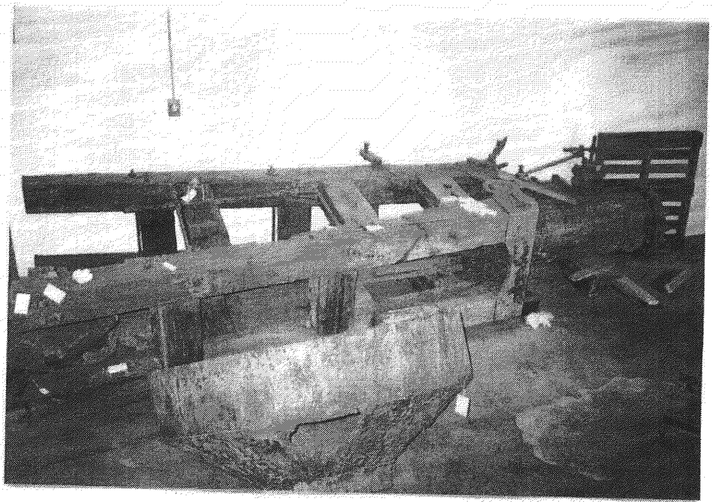


Figure 4-54. *Indiana's* unconserved engine and detached boiler smoke casing in the Smithsonian Institution's off-site storage facility in Silver Hill, Maryland. (Photo by David S. Robinson).

valuable body of information identifying middle nineteenth century steam engine manufacturers in the Great Lakes region which allowed him to rule out a number of potential sources for *Indiana*'s propulsion machinery.

As part of the archival research that was undertaken for this thesis, in December of 1994, the author conducted an exhaustive page-by-page review of every issue of the *Journal of the Franklin Institute* published during the 40-year period between 1830 and 1870. The purpose of this research was to obtain information on the technological development of screw propulsion, so that *Indiana* could be placed in a technological context.

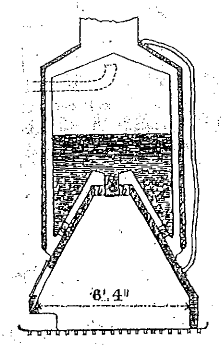
The *Journal* was the best place to initiate this research for several reasons. First, the Franklin Institute's publication was one of the few scientific/technical journals of the time that was wholly dedicated to examining and commenting on all new inventions offered to the patent office.[55] Second, the Franklin Institute was in Philadelphia, where commercially viable screw propulsion was introduced into the United States by John Ericsson in 1839. And third, by the late 1840s, Philadelphia was the East Coast's leading center of screw propulsion technological development and production.[56]

While conducting this research, the author was fortunate enough to discover an 1854 article describing both the design and source of *Indiana*'s boiler.[57] Data generated from this research and from the previous investigations provided the basis for the following discussion on the design, construction, and origin of *Indiana*'s propulsion machinery. The reader should refer to Anderson's 1991 manuscript report and 1992 addendum for more a detailed description and analyses of the components comprising *Indiana*'s power plant.[58]

The Boiler

Indiana was one of the first steam vessels fitted with a unique form of boiler, known locally on the lakes as a "bee-hive boiler" (Fig. 4-55).[59] The bee-hive, or "conical vertical boiler," as it was referred to in the Official Inspector's Reports, was introduced in 1847, when the 259-ton Great Lakes propeller *Boston* was fitted with such a boiler in Cleveland by its designer and builder Luman Parmalee.[60] Although Parmalee never obtained exclusive patent rights to his invention, he is credited with constructing most or all of the bee-hive boilers that were employed on the lakes.[61]

Initially, some individuals believed that the bee-hive boiler's unique design was destined to become a troublesome failure.[62] From the outset, the practical application of the boiler quickly showed



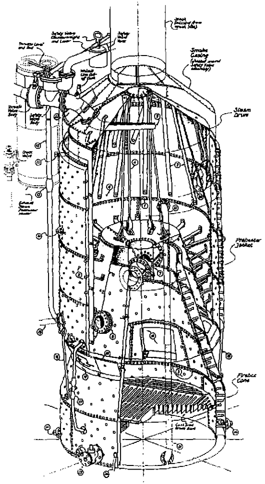


Figure 4-55. Luman Parmalee's "bee-hive" boiler and *Indiana*'s boiler. From Stetson, "The Bee-Hive Boiler of Lake Erie," 356, and Anderson, "The Propulsion Plant of the Propeller-Ship *Indiana*," n.p.).

that this was not to be the case. The boiler was a success due to its greater efficiency, safety, compactness, fuel economy, and durability when compared to its predecessors. The bee-hive design provided a more efficient heating surface than boiler types of similar dimensions and reportedly experienced little evaporation. Its large, unobstructed water surface allowed what was then rarely obtained in other upright boilers: near-perfect separation of the vapor from the water, with a much smaller percentage of mechanically suspended particulate than in any of the ordinary forms of upright boilers.[63]

The form and proportion of the bee-hive boiler also allowed very considerable fluctuations in water level without exposing any of the boiler's surfaces to the direct action of the fires in its furnace. By effectively preventing the boiler's exterior surfaces from overheating through the use of a water-filled jacket, the risk of igniting nearby woodwork was reduced significantly. This innovation represented an important improvement in boiler safety, given the fact that overheated boilers were a principal cause of fires on board steamboats.[64] Of course, overheating would not have been as serious a threat had the owners and operators of Great Lakes steamboats adopted the technique used universally on oceanic steamers of insulating their boilers with a layer of hair felt.[65] On middle nineteenth century steam vessels of the Great Lakes, however, insulating boilers was not a common practice.[66]

In terms of economy and durability, bee-hive boilers reportedly performed well. Vessels fitted with them were said to consume less than half the amount of fuel needed by their sidewheel counterparts, averaging just three-fourths to one cord of hardwood per hour.[67] These boilers lasted a long time, too. For example, after seven years of continuous service between Cleveland and Ogdensburgh, *Boston*'s bee-hive boiler's repairs totaled a mere $250.[68] Further evidence of the durability of the bee-hive design is illustrated by the comments of Thomas D. Stetson, author of the article, "The Bee-Hive Boilers of Lake Erie," that appeared in the *Journal of the Franklin Institute* in 1854. In the article, he remarks:

> In the fresh clear waters of the lakes, these boilers have been uniformly successful, and although difficult of repairs, may very naturally be inferred from the novelty of the form, and the whole might be, for various theoretical considerations, pronounced necessarily short-lived and troublesome, the experience of the few years it has been in use, seems to indicate a rather unlooked-for durability, and the style has won itself a degree of local popularity which might, perhaps, be more widely extended.[69]

Diligent archival research has thus far not yielded any other contemporary descriptions of the bee-hive boilers. Stetson's report provides the only detailed information pertaining to its design, operation, performance, and the vernacular terminology that was used to describe its various components.

By 1854, 11 propellers, most of which were built in Cleveland, were fitted with Parmalee's bee-hive boiler.[70] Apparently, *Indiana* was only the second vessel to be fitted with the new invention. Launched in the spring of 1848, *Indiana* probably received its boiler late in the winter of 1847 or early in 1848. Two more of the boilers were built and installed in 1849, one in the 340-ton propeller *Troy* and the other in the 450-ton propeller *Niagara.* Both vessels were built at Cleveland. Also included among the 11 vessels fitted with bee-hive boilers prior to 1854 were: *Ogdensburgh* (1851), *Prairie State* (1851), *Michigan* (1852), *Forest Queen* (1853), and *Westmoreland* (1853).[71]

Dimensions of these boilers ranged between 4 feet, 6 inches (1.37 m) to 7 feet, 4 inches (2.24 m) in diameter and 10 to 17 feet (3.05 to 5.18 m) in height.[72] Fire surface area and grate surface area in the boilers' furnaces was between 570 and 700 square feet (52.97 and 65.06 ct) and 28.3 and 38.5 square feet (2.6 and 3.6 ct), respectively.[73] To produce an adequate number of revolutions in the propeller shaft, a moderately high-pressured steam was required by the propeller's direct-acting engines.[74] The bee-hive boilers produced steam at pressures of 68 to 80 psi (47,810.8 to 56,248.0 kgsm) in such volume that use of the throttle valve was unnecessary.[75] The $2,250 cost of a bee-hive boiler in 1854 was, as Stetson asserts, much higher than the 1849 price, due to the increased cost of materials.[76]

As informative as Stetson's article is, there is no substitute for having an actual bee-hive boiler to study. Anderson's 1991 and 1992 reports documenting *Indiana*'s bee-hive boiler provides researchers with a wealth of data that is simply not available from the historic record.[77] The following description of *Indiana*'s boiler summarizes the information presented in Anderson's manuscript and drawings and includes several of the author's own observations regarding *Indiana*'s fuel and fireroom.[78] Contemporaneous terminology for some of the boiler's components is derived from Stetson.[79] The reader may find it helpful to refer to the illustrations of the boiler featured in Figs. 2-27 and 2-28.

Indiana's boiler has a measured height of 15 feet, 7-5/8 inches (4.8 m) and a diameter of 7 feet, 3/4 inch (2.13 m). Its weight is estimated at 6 tons when dry and 11 tons when filled with water and in operation.[80] The boiler produced steam at pressures calculated to be between 76 to 84 psi (53,435.6 to 59,060.4 kgsm), with an average working pressure of 80 psi (56,248 kgsm) at a saturated steam temperature of 309 to 317° F (153.89 to 158.33° C).[81] Significant bulging observed in the plates comprising the steam drum indicates that the pressures at which the boiler was routinely operated approached the extreme limit of the boiler plates' breaking point.[82]

Indiana's primary fuel was apparently wood, although coal also seems to have been used.[83] Firewood and a small amount of coal observed by the author in *Indiana*'s machinery space indicates that its fuel was stored in the hold while its fires burned. Coal is visible in the recesses of the hull's interior below the firewood and was concentrated around the area of the boiler. Lightly charred wood, discovered in *Indiana*'s furnace after the boiler was brought to the surface and examined, indicates that the vessel's fireman had stoked its fires just prior to the sinking (Fig. 4-56). Archival research has revealed that most steam vessels on the lakes commonly burned coal as fuel during upbound voyages and used wooden fuel for trips headed downbound.[84]

Indiana's boiler consists of four principal components: 1) a firebox or "furnace" enclosed within a truncated conical, water-filled, double-walled membrane and divided into a cylindrical "lower shell" and a conical "main shell"; 2) a large, water-filled steam drum or "upper shell" positioned directly above and partially surrounding the top of the furnace's main shell; 3) the feedwater pre-heater jacket or "water jacket" which is also a thin, water-filled, double-walled membrane, attached at its base to the furnace's lower shell and extending upwards to completely enclose the upper shell or steam drum; and 4) a smoke casing that sits on top of the boiler and was originally connected to the smoke pipe. The smoke pipe is missing and apparently broke off during the sinking. The smoke pipe may be among the items comprising a relatively small concentration of scattered debris lying approximately 300 yards (274.32 m) east of *Indiana*'s hull (see Fig. 3-9 [Feature D]).

The Engine

Although much smaller than the massive 60- to 70-ton, low-pressure steam "walking-beam" engines of contemporary sidewheel steamers, *Indiana*'s economic, relatively simple, direct acting steam engine was larger and more powerful than the compact power-plants of the first generation propeller-driven steamboats which were placed far in the stern and reportedly occupied an area of only approximately 6 square feet (0.56 ct).[85] *Indiana*'s engine consists of two principal components: a single vertical cylinder assembly and a heavily constructed wooden support frame (see Figs. 2-26, 2-28). The overall height of the engine measured 18 feet, 2-5/8 inches (5.5 m). In the fore-and-aft elevations, the engine frame's legs spread apart towards their bottoms reaching a maximum breadth of 7 feet, 3/4 inch (2.13 m). Conversely, in the port and starboard elevations, the frame maintains a constant breadth of 3

Figure 4-56. Unburned wood fuel inside the firebox of *Indiana*'s boiler indicated that the fire was stoked immediately prior to the sinking event. (Photo courtesy of the Smithsonian Institution, NMAH).

feet, 3-1/2 inches (1 m).

The engine's cylinder block was assembled from numerous iron castings, bolted together, andwas fitted with a double-acting piston of 1 foot, 6-3/8 inches (47 cm) bore, and 3 feet, 4-7/8-inch- (1.04-m-) stroke. The cylinder assembly was bolted to an iron bed plate measuring 3 feet, 4 inches (1.02 m) square. The engine bed plate is bolted to the top of the engine's 13 feet, 5-1/4 inches- (4.1 m-) tall wooden engine frame. None of the castings bore any identification information or builder's plates.

A cast iron valve chest, bolted to the middle of the cylinder, contained two valve chambers for a slide valve and a rotary valve. The valves were driven independently by wrought iron rods that extended from rocking shaft levers mounted on the engine frame's port side. These rocking shaft levers were driven by hook-ended rods that extended from eccentrics mounted on the crankshaft, outside the after face of the engine frame. The slide valve controlled the motion of the engine and had to be engaged to start the engine and to keep it running and was disengaged to stop or reverse the engine. After the engagement of the slide valve and once *Indiana* was underway, the rotary valve was engaged and operated as a sort of throttle, supplying small bursts of steam to the slide valve at varying pressures depending on how its timing was set.

The vertical motion of the engine's piston was transferred to a cast iron cross- head which ran between two cast iron cross-head guides, measuring 4 feet, 1-1/4 inches (1.25 m) long, bolted to the interior faces of the forward and after sides of the wooden engine frame legs. The cross-head's vertical motion was in turn transferred to a feedwater pump for transmitting water to the boiler via an exhaust steam feedwater preheater and to the main connecting rod, an iron forging 9 feet, 1-1/2 inches (2.8 m) long. The main rod's lower end was attached to a journal on the cast iron disc flywheel, 3 feet, 10 inches (1.17 m) in diameter. The flywheel acted as a crank, turning the reciprocating motion of the rod into rotary motion. The wrought iron crankshaft (6 feet, 3 inches [1.91 m] long and 8-3/4 inches [22.23 cm] in diameter) attached to the after or forward face of the flywheel which was fitted with three eccentrics, one each for the slide valve, rotary valve, and the bilge pump; all were engaged and disengaged manually. Interestingly, the engine had no reverse eccentric (*Indiana*'s engine also lacked a condenser, had no visible provisions for lubrication, and was not insulated). To deliver forward motion to *Indiana*'s propeller, both the slide and rotary valves were engaged to their respective eccentrics. To reverse the engine, both valves had to be disconnected from the eccentrics and the slide valve operated manually using a handle at the level of the cylinder baseplate. On the after end of the crankshaft is a forged iron flange, 1 foot, 7-5/8 inches (49.5 cm) in diameter, for coupling with the propeller shaft. The shaft joint was secured with six bolts, 1-11/16-inch- (4.27-cm-)-diameter bolts, spaced evenly around the flange.

The engine frame was constructed from four timber legs, each measuring 9 inches (22.86 cm) by 1 foot (30.48 cm), secured together with three heavy cross timbers per side. One-1/2-inch- (3.8-cm-) diameter wrought iron tie-rods bind the engine frame together vertically and horizontally. Four 1-1/4-inch- (3.18-cm-) diameter tie rods helped to secure the engine to *Indiana*'s hull. The frame legs were painted green from the main deck level, 7 feet, 10 inches (2.39 m) above the toes of the legs, up to the point where the cast iron cylinder assembly was attached. The engine frame's four legs were secured to two sets of heavy foundation timbers running athwartships under the forward and after sides of the engine frame. The outboard toes of the engine frame's legs were let into the tops of foundation timbers approximately 1-1/2 inches (3.8 cm) to prevent the legs from spreading apart. The after foundation timber also acted as a base for the main bearing block and the hand-driven feed pump, which were bolted to it. The cross-head pump was secured to the forward foundation timber.

The engine foundation timbers remain in their original location in the hull and were documented during the 1991 to 1993 underwater archaeological field campaigns. The two parallel sets of engine foundation timbers extend across the full interior breadth (18 feet, 3 inches [5.56 m]) of *Indiana*'s hull (Fig. 4-57). The foundation timbers consist of two pairs of heavy timbers stacked one atop the other. The dimensions of the lower and upper timbers in the forward pair were molded 1 foot, 3 inches (38.10 cm) and 1 foot, 5 inches (45.72 cm), respectively; both were sided 1 foot, 1 inch (33.02 cm). The dimensions of the after pair were slightly different from the forward engine foundation timbers. The lower timber was molded 1 foot, 2 inches (35.56 cm) and the upper was 1 foot 5 inches (43.18 cm). The sided dimensions of the timbers were, respectively, 1 foot, 2 inches (35.56 cm) and one foot (30.48 cm).

A standing knee 4-1/2 inches thick (11.4 cm) is fastened to the after faces of the after pair of engine foundation timbers and to the top of the keelson. The purpose of this knee was to stabilize the after engine foundation timbers and prevent them from being displaced by the forces of thrust on the propeller shaft. The knee's lower, horizontal arm extends three feet, 1/4 inch (92.08 cm) along the top of the keelson, while the vertical arm of the knee reaches upwards 1 foot, 9 inches (53.34 cm). The width of the knee ranges from 5 inches (12.70 cm) near the ends of the arms to one foot, 1/2 inch (31.8

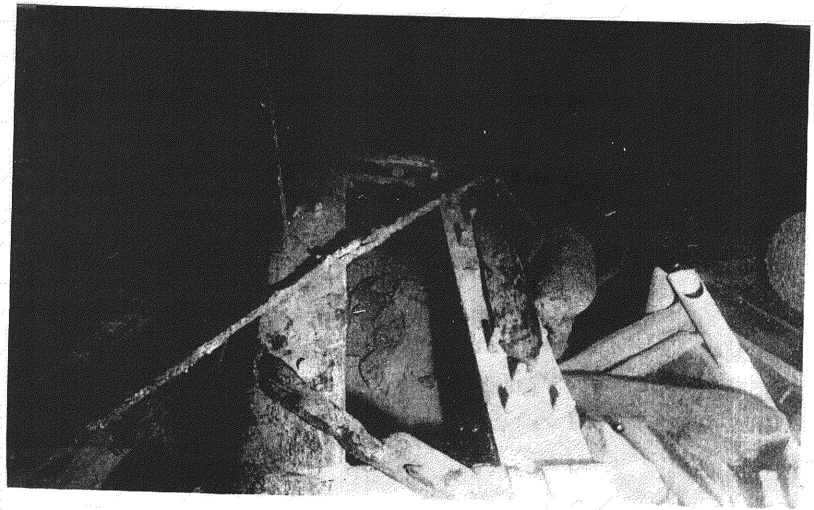


Figure 4-57. *Indiana*'s engine bed timbers. (Photo courtesy of the Smithsonian Institution, NMAH).

cm) at the knee's throat. It is secured in place by six iron drift bolts.

Initial inspection of *Indiana*'s engine when it was discovered revealed that the throttle was closed and the drop hooks were disconnected from the valves. Thus, *Indiana*'s engine had been shut down prior to the sinking. The engine was probably shut down immediately after a major problem was discovered.[86]

The Propeller

Removed from the wreck in 1979 during the Smithsonian's first expedition, *Indiana*'s propeller was conserved, reconstructed, and put on display in the National Museum of American History's Hall of American Maritime Enterprise in the early 1980s (Fig. 4-58). In the fall of 1991, Dr. Johnston recorded some basic descriptive information on the propeller, which the author had requested while working on a preliminary reconstruction of *Indiana*. According to Dr. Johnston, the propeller was a four-bladed left-hand propeller, with a diameter of 9 feet, 7-3/4 inches (2.94 m).[87] The propeller is of composite construction, with a cast iron flanged hub and rolled iron blades (Fig. 4-59). The hub's outside diameter measured 1 foot, 3-3/16 inches (38.58 cm); the inner diameter measured 8-3/16 inches (20.80 cm). Four arms radiate outward from the hub's outer edge to a distance of 2 feet (60.96 cm). At the end of each arm is bolted a blade that is held in place by two staggered rows of eleven bolts, 1 inch (2.54 cm) in diameter (five on the inside row and six on the outer row).

The propeller was designed by Richard F. Loper (1802-1880) of Philadelphia and manufactured by Spang & Company (1845-1858) of Pittsburgh, at that time among the largest manufacturers of iron products in the country.[88] Contemporary sources note that the Loper propeller was referred commonly to as the "Philadelphia Wheel" on the lakes, after the home of the inventor, and was, "the style universally in vogue," with "more of these kind of propellers...employed on vessels in the United States than any other."[89] Loper licensed rights to the Philadelphia-based firm of Reanie, Neafie & Company, builders of marine steam engines and propellers, who in turn had made business arrangements with a number of firms on the lakes for use of Loper's design.[90]

Damages to the Stern That Contributed to *Indiana*'s Loss

From the beginning of the archaeological investigations at *Indiana*'s wreck site, it was hoped that evidence could be found to determine the exact cause of *Indiana*'s loss. Contemporary newspapers

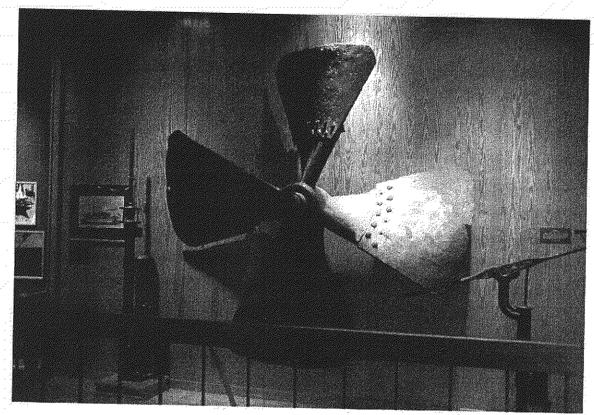


Figure 4-58. *Indiana's* conserved propeller (with replica blade) on exhibition in the Smithsonian Institution, NMAH. (Photo by David S. Robinson).

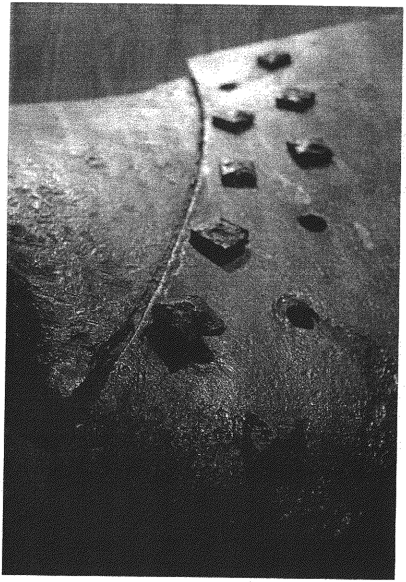


Figure 4-59. *Indiana*'s rolled iron blades were bolted to the flanged arms of the propeller's cast iron hub. Note the missing bolts. (Photo by David S. Robinson).

attributed *Indiana*s loss to a structural failure of the propeller shaft's watertight through-hull fitting, which ultimately led to the splitting of the sternpost:

> ...her stuffing box, or stern pipe, burst, probably from over heating, which caused the splitting of her stern post, and she immediately commenced filling... (*Cleveland Morning Leader* 14 June 1858);
>
> ...she broke the stuffing box of her shaft, and this occasioned the splitting of her sternpost, when she began to fill very fast... (*Detroit Daily Free Press* 12 June 1858);
>
> ...the stuffing box, or 'sleeve' through which the propeller shaft passes through the stern, burst. In a short time her stern post split, when she filled rapidly and sank... (*Painesville Telegraph* 17 June 1858).

The overheating and damage of propeller shaft bearings from friction was a common problem that plagued the designers of early propellers until after the mid-1850s when water cooled, lignum vitae-lined bearings were adopted (Fig. 4-60).[91] In his 1861 *Notes on Screw Propulsion: Its Rise and Progress*, U.S. Navy Commander, W. M. Walker, noted that the problem of overheating bearings in screw-propelled steamboats was so severe that, if not for the advent of water-cooled wooden linings, "some of the most competent engineers...would have been compelled to abandon the use of the screw in heavy ships."[92] In an 11 June 1858 article in the *Cleveland Morning Leader* the wearing and heating of stuffing boxes and outside journals were identified as the "most prejudicial, most frequent, and most difficult [problems] to repair." The writer of the article attributed the wearing and overheating to imbalances in the propellers.

Although damage to the inner and outer sternposts and the stern tube bearing was clearly evident during field investigations and seems to confirm the historical record, the precise sequence of events that caused this damage remains a mystery. Observed damage includes the split inner sternpost, two gouged areas on the outer sternpost, a cracked stern tube bearing, and a propeller blade wedged in the base of the stern post (Figs. 4-61, 4-62, and 4-63). When *Indiana* was discovered, the propeller was broken off its shaft and lying in the sand several feet (2-3 m) aft and starboard of the stern. The hanger bearing, which cradled the end of the propeller shaft and helped stabilize it, was broken from its struts but still attached to the shaft end. The split in the inner sternpost measures 8 inches (20.32 cm) wide at the head and extends down the middle of the inner sternpost to an undetermined point somewhere near its base, below the accumulated sediments and immovable debris inside the hull (see Fig. 4-61).

The two gouges on the upper half of the outer sternpost consist of one barely noticeable 3-inch

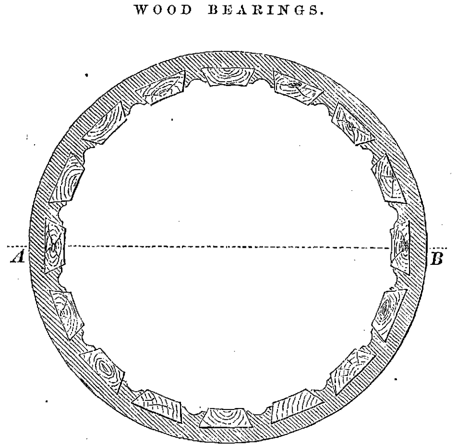


Figure 4-60. The advent of water-cooled *Lignum vitae* wood bearings represented a significant improvement over their metallic predecessors. (From Walker, *Notes on Screw Propulsion: Its Rise and Progress*, 44).

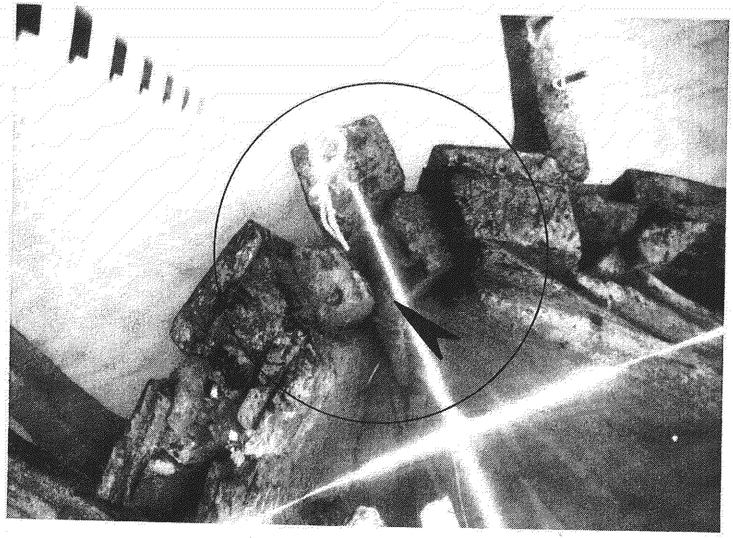


Figure 4-61. Viewed from above, *Indiana*'s split inner stern post is clearly visible. (Photo courtesy of the Smithsonian Institution, NMAH).

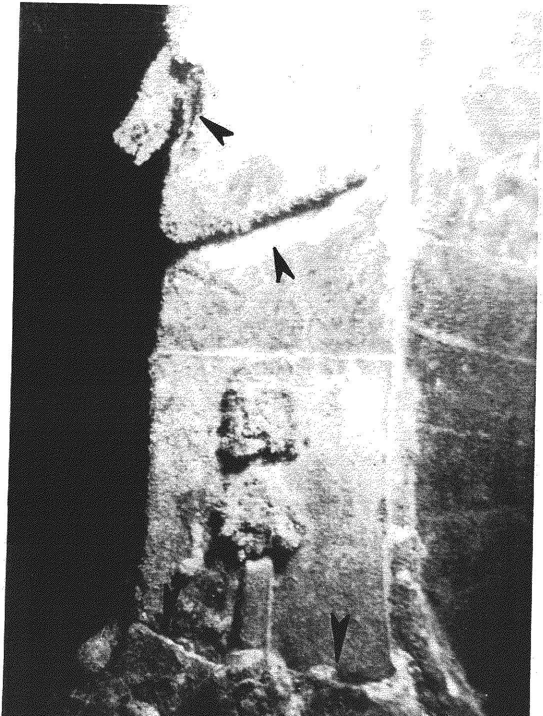


Figure 4-62. Damages to *Indiana*'s stern post (gouges) and stern tube bearing (crack). (Photo courtesy of the Smithsonian Institution, NMAH).

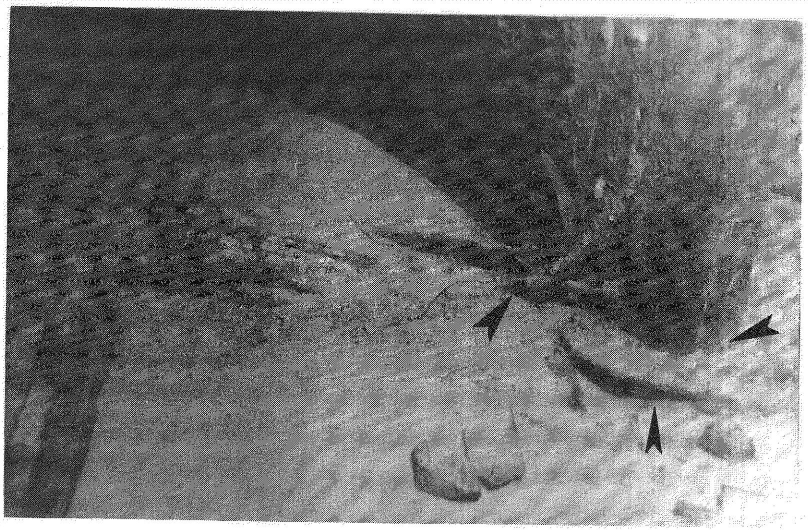


Figure 4-63. The leading tip of *Indiana*'s broken propeller blade visible protruding up from the sand at the base of the stern post. Note the displaced shaft boss reinforcement strap and the vertical flange on the after face of the post through which the blade sliced. (Photo courtesy of the Smithsonian Institution, NMAH).

(7.62-cm) chunk of wood missing from the after face of the sternpost. Below it a crescentic gouge 3 to 4 inches (7.62 to 10.16 cm) deep arcs across the after face and port corner of the post. Both gouges appear to have been caused by the still-spinning propeller striking the post.

Indiana's propeller was missing one of its four blades when it was first seen in 1972. Near the end of the 1992 field season the broken blade was discovered wedged firmly in the hull at the foot of the sternpost. Attempts to free it from the hull proved futile. The blade appears to have struck the hull from the starboard side at a nearly horizontal angle, roughly perpendicular to the normal orientation of a ship's spinning propeller. As the blade sliced into and through the solid oak timber, it also cut cleanly through the iron rudder skeg flange at the base of the post and emerged on the port side, displacing one of the propeller shaft boss's port-side iron reinforcement straps (see Fig. 4-63). Careful examination of the stern tube bearing revealed a large crack across the upper half of the bearing flange and a number of other problems, including missing bolts and additional cracks in the body of the bearing, all of which may have contributed or were perhaps the result of poor maintenance (see Fig. 4-62). The vertical split in the inner sternpost apparently occurred after one of *Indiana*'s propeller blades broke partly away, across some of the bolt holes in the hub flange, and then flailed about long enough to strike and become lodged in the post after coming completely loose. The resulting vibration from the heavy, unbalanced screw probably added to the damage done by the blade and caused the stern tube bearing to crack and the stern post to split.

As the blade passed through this part of the hull, it sheered through an iron reinforcement strap 1 inch (2.54 cm) thick fastened to the starboard side of the outer sternpost and keel, and sliced through an iron "L"-bracket 1 inch (2.54 cm) thick that connected the after face of the outer sternpost to the rudder skeg. The blade also displaced the 1-inch (2.54 cm) thick iron reinforcement strap on the port side and destroyed the portion of the keel below the sternpost. The force with which the blade struck the outer sternpost's starboard side sheered the propeller off the shaft, split the inner sternpost, cracked the outer shaft gland bearing, and pushed the outer post away from hood ends of the starboard hull planking, opening the rabbeted joint between them. A torrent of water poured through the gap between the sternpost and hull planking, rapidly filled *Indiana*'s hull, and caused it to settle to the guards in less than 15 minutes.

When compared to the construction of the Great Lakes propellers of the early 1840s, it is immediately apparent that *Indiana*'s design and construction are markedly different. The most important of these differences are *Indiana*'s comparatively large size, its improved power plant and propulsion system, the placement of the power plant relatively far forward in the hull, the presence of an upper deck, the fineness of its run (to be discussed in the next chapter), the employment of a primitive form of a hull-strengthening truss system, and the inclusion of fully-sheathed sponson guards on the sides of its hull. The employment of both a truss and sheathed sponson guards appears to be atypical of contemporary Great Lakes screw-propelled steamboats of the 1840s. This combination of differences represent the best efforts of *Indiana*'s builder and owners to create and maintain one of the most complex structures of its time and operate it in the most cost-efficient manner possible and were unique to *Indiana*.

Notes: Chapter IV

1. Donna Christensen, "Results from the Analyses of Wood Samples Removed from *Indiana*'s Hull During the 1991 Field Campaign" (unpublished manuscript on file at the National Museum of American History, Division of Transportation, Smithsonian Institution, Washington, DC, 1992), n.p.; Harry A. Alden, "Results from Analyses of Wood Samples Removed from *Indiana*'s Hull During the 1992 Field Campaign" (unpublished manuscript on file at the National Museum of American History, Division of Transportation, Smithsonian Institution, Washington, DC, 1992), n.p; Melvin J. Wachowiak, Jr., "Wood Analyses Report for Wood Samples Removed from *Indiana*'s Hull During the 1993 Field Campaign" (unpublished manuscript on file at the National Museum of American History, Division of Transportation, Smithsonian Institution, Washington, DC, 1994), n.p.

2. Cammie S. Campbell, "Results from the Analyses of Paint Samples Removed from *Indiana*'s Hull During the 1992 Field Campaign" (unpublished manuscript on file at the National Museum of American History, Division of Transportation, Smithsonian Institution, Washington, DC, 1992), n.p.

3. Cammie S. Campbell, "Results from the Analysis of Hull Caulking Samples Removed from *Indiana*'s Hull During the 1992 Field Campaign" (unpublished manuscript on file at the National Museum of American History, Division of Transportation, Smithsonian Institution, Washington, DC, 1993), n.p.

4. Treenails were commonly used during the mid-nineteenth century to fasten together frame components and to secure outer planking and ceiling to the frames. Board of Lake Underwriters, *Proceedings of the Board of Marine Inspectors of the Association of Lake Underwriters, Held at Buffalo*, August, 1856 (Buffalo, NY, 1856), 4; Board of Lake Underwriters, *Rules Relative to the Construction of Lake Sail and Steam Vessels Adopted by the Board of Lake Underwriters, 1866* (Buffalo, NY, 1866), 3; William L. Crothers, *The American-Built Clipper Ship, 1850-1856: Characteristics, Construction, and Details* (Camden, ME, 1997), 61-67.

5. Kevin J. Crisman, Personal Communication; Frederick M. Hocker, Personal Communication; Crothers, *ibid.*, 65.

6. Crothers, *ibid.*, 65, 66.

7. *Ibid.*, 68.

8. *Ibid.*, 60.

9. According to Mills, one of the trends in shipbuilding on the Great Lakes "...a few years after 1850 was...the extension of joiner work on the forward main deck to the stem of the vessel, all the steamboats to that time having been open forward of a point about twenty or thirty feet from the wheel-boxes." James Cooke Mills, *Our Inland Seas: Their Shipping & Commerce for Three Centuries* (Cleveland, OH, 1976 [1910]), 148.

10. Crothers, *ibid.*, 352, 370.

11. *Ibid.*

12. Charles G. Davis, *The Built-Up Ship Model* (Salem, MA, 1933), 73, 74.

13. Wachowiak, *ibid.*, 3.

14. T. C. McCutcheon, Jr., "*Alvin Clark*: An Unfinished Voyage," *Wooden Boat Magazine*, vol. 52, no. 3 (1983), 58.

15. The problem of excessive vibration in screw-propelled steamboats is addressed in G. S. Graham, "The Transition from Paddle Wheel to Screw Propeller," *Mariner's Mirror*, vol. 44, no. 1 (February 1958), 44-46; Cedric Ridgely-Nevitt, *American Steamships on the Atlantic* (Newark, DE, 1983), 188, 190; William Still, Gordon P. Watts, and Bradley Rogers, "Steam Navigation and the United States," in Robert Gardiner and Basil Greenhill, eds., *The Advent of Steam: The Merchant Steamship before 1900* (Annapolis, MD, 1993), 71; and Basil Greenhill, "Steam Before the Screw," in Robert Gardiner and Basil Greenhill, eds., *The Advent of Steam: The Merchant Steamship before 1900* (Annapolis, MD, 1993), 21, 22.

16. Ridgely-Nevitt, *ibid.*, 189-191.

17. Richard A. Gould, "Bird Key Harbor Brick Wreck (FOJE) 1990 Fieldwork," in Larry E. Murphy, ed., *Dry Tortugas National Park Submerged Cultural Resources Assessment* (Santa Fe, NM, 1993), 339, 340.

18. *Ibid.*, 340.

19. John Penn, "On Wood Bearings for Screw Propeller Shafts," *Journal of the Franklin Institute*, ser. 3, vol. 32 (1856), 148-156.

20. Thomas Richard Guppy, "Description of the Great Britain Iron Steam Ship, with Screw Propeller; with an Account of the Trial Voyages," *Journal of the Franklin Institute*, ser. 3, vol. 11 (1846), 10.

21. Howard I. Chapelle, *Boatbuilding* (New York, NY, 1941), 50.

22. *Ibid.*, 51.

23. *Ibid.*

24. Crothers, *ibid.*, 152.

25. Alan L. Bates, *The Western Rivers Steamboat Cyclopædium* (Leonia, NJ, 1968), 23, 30, 116, 118; John Wolcott Dayton, *Steamboat Days* (New York, NY, 1939), 15; William A. McKewen and Alice Lewis, *Encyclopedia of Nautical Knowledge* (Centreville, MD, 1992 [1953]), 378, 524.

26. McKewen and Lewis, *ibid.*, 524; *Webster's Ninth New Collegiate Dictionary* (Springfield, MA, 1988), 1140.

27. Louis C. Hunter, *Steamboats on the Western Rivers: An Economic and Technological History* (New York, NY, 1993 [1949]), 91.

28. *Ibid.*; Ridgely-Nevitt, *ibid.*, 25.

29. Dayton, *ibid.*, 15.

30. C. Patrick Labadie, *Submerged Cultural Resources Study: Pictured Rocks National Seashore* (Santa Fe, 1989), 23.

31. Hunter, *ibid.*, 93.

32. *Ibid.*

33. *Ibid.*

34. McCutcheon, *ibid.*, 58; Warren Reiss, Personal Communication.

35. There are two documented instances when *Indiana* was observed towing other vessels. Mr. Stone, first officer of the steamer *Louisiana*, witnessed *Indiana* towing two canal boats, bound up, at the Manitou Islands on 12 August 1848 (*The Buffalo Morning Express*, 17 August 1848), and *The Lake Superior Miner* for 12 June 1858 noted that *Indiana* was seen towing the schooner *M. L. Sargent* through the canal locks at Sault Sainte Marie. Towing was a commonly performed task for screw-propelled steamboats, and a trade for which they were designed. Donald R. Dohrmann, *Screw Propulsion in American Lake and Coastal Steam Navigation 1840-1860, a Case Study in the Diffusion of Technological Innovation* (New Haven, CT, Yale University, unpublished dissertation, 1976), 7; Rick Neilson, "The First Propellers at Kingston," *Fresh Water*, vol. 2, no. 2 (Autumn 1987), 4-8.

36. Daniel J. Lenihan, ed. *Submerged Cultural Resources Study: Isle Royale National Park* (Santa Fe, NM, 1987), 55.

37. Henry Hall, *Report on the Ship-Building Industry of the United States* (New York, NY, 1970 [1884]), 168.

38. John H. Morrison, *History of Steam Navigation* (New York, NY, 1958), 51.

39. *Ibid.*

40. Hunter, 94-100.

41. *Ibid.*, 96, 99.

42. *Ibid.*, 99.

43. *Ibid.*

44. *Ibid.*

45. *Ibid.*

46. Bates, *ibid.*, 29.

47. Hunter, *ibid.*, 95.

48. Ahira Cobb's great-grandson, Carl B. Cobb, owns Ahira Cobb's personal ledger and supplied the Smithsonian with Xeroxed copies of the portion of the ledger containing references to *Indiana*.

49. Thomas Drew Stetson, "The Bee-Hive Boiler of Lake Erie," *Journal of the Franklin Institute*, ser. 3, vol. 27 (1854), 356-358; *Cleveland Morning Leader*, 21 August 1854 and 3 May 1856.

50. McKewen and Lewis, *ibid.*, 605.

51. *Ibid.*

52. Paul F. Johnston and John L. Stine, "*Indiana* Shipwreck Materials" (unpublished manuscript on file at the National Museum of American History, Division of Transportation, Smithsonian Institution, Washington, DC, 1993), n.p.

53. Richard K. Anderson, Jr., "The Propulsion Plant of the Propeller Ship *Indiana*: Notes on its

Construction and Operation Based on Field Measurements and Examinations" (unpublished manuscript on file at the National Museum of American History, Division of Transportation, Smithsonian Institution, Washington, DC, 1991), 1.

54. Frederick Hocker, "*Indiana's* Engine Builder" (unpublished manuscript on file at the National Museum of American History, Division of Transportation, Smithsonian Institution, Washington, DC, 1984).

55. The Franklin Institute was created in Philadelphia in 1824 to bridge the gap between scientific theorists and "mechnicians" in an age of secrecy in the arts and trades. Mechanics' institutes, which were proliferating in Great Britain at that time, were also becoming increasingly common in America. Unlike other mechanics' institutes and philosophical societies, however, the Franklin Institute was unique: it was a weld of "dirty-fingernail" people (the mechnicians) and the gentry of Philadelphia whose founders, "...sought to make it a focal point and clearing-house for information of all kinds." One of the major elements of the institute was its journal, which was published to stimulate national pride in American manufactures, provide mechnicians with news of the state of the mechanical arts and science, increase the awareness of the need for scientific method, and increase the pace of scientific progress. Descriptions of the latest patents were published in order "to lay open those stores of genius and skill of our countrymen which, although existing in the Patent Office, have hitherto been but very partially known." David Freeman Hawke, *Nuts and Bolts of the Past: A History of American Technology, 1776-1860* (New York, NY, 1988), 185-189.

56. Dohrmann, *ibid.*, 12, 15.

57. Stetson, *ibid.*

58. Anderson, Jr., *ibid.*; Richard K. Anderson, Jr., "Addenda/Corrections to 1991 *Indiana* Propulsion Plant Report" (unpublished manuscript on file at the National Museum of American History, Division of Transportation, Smithsonian Institution, Washington, DC, 1992).

59. Stetson, *ibid.*

60. *Ibid.*

61. *Ibid.*

62. *Ibid.*

63. *Ibid.*

64. Charles H. Haswell, "On the Cause and Frequency of Fire Occurring on Board of Steam Vessels of All Descriptions," *Journal of the Franklin Institute*, ser. 3, vol. 33 (1857), 291.

65. *Ibid.*, 289-294.

66. Haswell, *ibid.*, 290; Stetson, *ibid.*, 357.

67. Stetson, *ibid.*, 357.

68. *Ibid.*, 356.

69. *Ibid.*

70. *Ibid.*, 357.

71. *Ibid.*

72. *Ibid.*, 358.

73. *Ibid.*

74. Dohrmann, *ibid.*, 78, 79.

75. Stetson, *ibid.*, 357.

76. *Ibid.*

77. Anderson, *ibid.* (1991 and 1992).

78. *Ibid.*

79. Stetson, *ibid.*, 356-358.

80. Anderson, *ibid.* (1991), 1.

81. *Ibid.*, 2-4.

82. *Ibid.*; Stetson, *ibid.*, 357.

83. The first shipments of coal from newly opened mines in Ohio to the Lake Erie port city of Cleveland for use by steam vessels as fuel occurred in 1840, following the opening of the Pennsylvania and Ohio Canal. Although not immediately accepted by steamboat engineers and firemen, by 1845 coal had supplanted wood as a fuel source for steam vessels in operation on the lower lakes (i.e., Lakes Erie and Ontario). James M. Swank, *A History of the Manufacture of Iron in All Ages* (New York, NY, 1965), 310, 311. In 1853, Andrews specifically cited the accessibility of "coal of a very fine quality...at an average price of three dollars and a half per ton, and at many points a two and a half on the docks," as one of "two conditions [the other being voyages of less than three weeks long in duration], on which rests the availability of screw-steamers" and their great, regularly increasing adoption on the lakes. Israel D. Andrews, *Report on the Trade and Commerce of British North American Colonies, and Upon the Trade of the Great Lakes and Rivers* (Washington, DC, 1853), 50. Hunter includes a quote from Colonel William W. Mather's 1838 geological survey of Ohio, in which he describes the benefits of coal versus wood as a fuel source for steam vessels: "Many of our boats now use coal in preference to the best wood for a double reason, (viz.) that the fire can be kept more uniform and generate a greater quantity of steam; 2d, that the expense is much less. Ten to twelve bushels of coal produce the same power as a cord of the best wood. The space occupied by equivalent quantities of coal and wood is said to be about one to nine, and weight about one to three, and the labor of putting on board our boats, about one to four." The average price of coal on the Ohio River during the middle nineteenth century was ten cents per bushel and wood cost $2.50 per cord. Hunter notes that although coal had become a commonly-used fuel by 1850, few vessels depended entirely upon it, and instead burned both coal and wood when either was available. Hunter, *ibid.*, 268, 269.

84. Although archival information indicates that coal would have been the fuel of choice for steamboats operating on the lower lakes by the time of *Indiana*'s final voyage in 1858, wood fuel was discovered in *Indiana*'s fireroom and firebox, indicating that coal was perhaps used during upbound trips while wood would have been used on downbound voyages. *Ibid.*

85. Mills, *ibid.*, 129.

86. Paul Forsythe Johnston and David Stewart Robinson, "The wreck of the 1848 propeller Indiana: interim report," *International Journal of Nautical Archaeology and Underwater Exploration*, vol. 22, no. 3 (1993), 223.

87. Paul F. Johnston, Personal Communication.

88. Henry S. Spang entered into the iron business in Pittsburgh when he purchased the Etna Iron Works, in nearby Etna, PA in 1828 and founded the company Henry Spang & Son to roll bar iron from Juniata blooms. By 1845, Spang's Etna anthracite furnace (in Huntingdon, PA), Earl Farr charcoal furnace (in Berks County, PA, on the Schuykill River between Reading and Philadelphia) and Etna forge (also in Huntingdon) were employing more than 140 men and producing in excess of 1,700 tons of pig iron and 800 tons of bar iron per year. Between 1845 and 1858, during which time *Indiana*s propeller was manufactured, Spang's firm operated under the name "Spang & Co." In 1854, John W. Chalfant formed a connection with Spang & Co., and when Henry Spang retired from the business in 1858 the organization's name was changed to Spang, Chalfant & Co. John Chalfant's son, Henry, joined the firm in the 1899 and was appointed its president in 1902. Under the younger Chalfant's leadership, the firm grew into the third largest producer of steel tubular products in the United States with a capital stock of $17,500,000 and production capacity of 600,000 tons of pipe per year. Thomas Chambers, G. N. Eckert, and Samuel J. Reeves, "Iron and Coal Statistics: being Extracts from the Report of a Committee to the Iron and Coal Association of the State of Pennsylvania, 1846," *Journal of the Franklin Institute*, ser. 3, vol. 12 (1846), 125, 127, 128; Editors, *The National Cyclopædia of American Biography*, vol. 22 (New York, NY, 1932), 446, 447 (entries for John Weakley Chalfant and Henry Chalfant); Swank, *ibid.*, 299.

89. Donald Canney, *The Old Steam Navy: Frigates, Sloops, and Gunboats, 1815-1885*, vol. 1 (Annapolis, MD, 1990), 27; Cedric Ridgely-Nevitt, *American Steamships on the Atlantic* (Newark, DE, 1981), 202; *Buffalo Commercial Advertiser*, 16 January 1845; Robert Macfarlane, *History of Propellers and Steam Navigation, with Biographical Sketches of the Early Inventors* (New York, NY, 1851), 119, 120.

90. Dohrmann, *ibid.*, 76.

91. Penn, *ibid.*

92. W. M. Walker, *Notes on Screw Propulsion: Its Rise and Progress* (New York, NY, 1861), 44, 45.

CHAPTER V

THE ARCHAEOLOGICAL RECONSTRUCTION OF *INDIANA*

Introduction

In the previous chapter, the dimensions and assembly of the extant elements of *Indiana*'s hull, propulsion system, and deck machinery were described in detail. While these descriptive data were essential for understanding *Indiana*'s design and construction, they did not include the information on missing, badly damaged, or inaccessible portions of *Indiana*'s hull that was required for completing the study of the vessel. The forward two-thirds of *Indiana*'s hull are flattened and fragmentary, much of the framing and all of the bottom of the hull are obscured, the bow and stern deadwood are missing or inaccessible, and virtually all of the upper works are absent from the wreck. Consequently, to complete the picture of *Indiana*'s construction it was necessary to graphically "reconstruct" the shape and construction of these undocumented elements (i.e., the shape of the forward two-thirds of *Indiana*'s hull, the dimensions and construction of the keel, the bow and stern deadwood, and her upper works) using clues from both the hull and contemporary documentary sources.

Fortunately, many different places throughout *Indiana*'s hull offered direct or indirect evidence for much of the reconstruction of missing elements. Stanchions on the main deck, the detached fantail deck, and the starboard bulwarks indicated the height and location of *Indiana*'s missing upper deck. The pattern of fasteners in the hull planking marked the locations of otherwise obscured frames. Notches cut in the sheer and clamp provided the locations and sided dimensions of missing deck beams. Numerous other small but important clues (i.e., hatches, gangways, bulkheads, mortises, and impressions and stains in and on the wood) provided additional evidence used to piece together the giant puzzle of *Indiana*'s remains.

While *Indiana*'s hull provided the best clues for the reconstruction, it was necessary in some instances to turn to information contained in contemporary archival sources (i.e., narrative descriptions from newspapers, scantlings from inspection certificates, lines and construction plans, and photographic images) to complete certain aspects of the reconstruction. For reconstructing the lines of the forward two-thirds of *Indiana*'s hull, two contemporary American textual sources, W. H. King's 1849 *Lessons and Practical Notes on Steam, The Steam Engine, Propellers, etc., etc., For Young Engineers, Students, and Others*, and John W. Griffiths's 1854 *The Ship-Builders Manual, and Nautical Referee*, provided a general indication of the possible shape of *Indiana*'s hull.[1] Several contemporary pictorial sources provided additional details for reconstructing *Indiana*'s lines. These sources included circa 1860s photographs of two 1846 propellers, *Pocahontas* and *Globe* (Figs. 5-1 and 5-2), a body plan of the 1854 propeller *Oriental* (Fig. 5-3), and a full-breadth lines plan for the 1867 "sister" propellers *Maine* and *Oswegatchie* (Fig. 5-4).[2]

For estimating the dimensions of *Indiana*'s keel and other construction features that were not recorded archaeologically, the "Rules, &c. Relative to the Construction of Sail Vessels and Propellers to Class A1," included in the 1856 *Proceedings of the Board of Marine Inspectors of the Association of Lake Underwriters* proved very informative.[3] Because the specifications in this document represented ideal dimensions, materials, and manner of construction necessary for rating propellers of 50 to 1,000 tons "A1," they provided a wealth of important information on propeller construction during the middle 1850s.[4] Another document that provided similarly detailed construction information for propellers dating from the middle 1850s was a two-page 1857 *Lake Vessel Survey* report for the 1853 Great Lakes propeller *Kentucky* (Fig. 5-5).[5] This document is of particular interest because it records the actual, rather than ideal, dimensions of principal hull timbers in a screw-propelled Great Lakes vessel of approximately the same size and age as *Indiana*.

Archival information for reconstructing *Indiana*'s bow below the waterline proved more elusive. Some relevant comparative information was obtained from C. T. McCutcheon's drawings of the bow construction of the 1846 Joseph M. Keating-built schooner *Alvin Clark* (Fig. 5-6), Asa C. Keating's construction plans of the propellers *Maine* and *Oswegatchie* (mentioned above), William Webb's designs for middle and late nineteenth-century steam vessels, and William Crothers's depictions of the bow construction of mid-nineteenth-century American clipper ships.[6] Each of these sources provided clues about *Indiana*'s lower bow construction and the manner in which the recorded timbers fit together.

Not surprisingly, documentary evidence for reconstructing *Indiana*'s stern deadwood was as scarce as that for reconstructing the deadwood configuration of *Indiana*'s bow. Again, Asa Keating's construction plans for *Maine* and *Oswegatchie*, McCutcheon's drawings of *Alvin Clark*, Webb's steamboat drawings, and Crothers's construction plans for mid-nineteenth-century sailing vessels were consulted, as were early propeller designer John Ericsson's plans for the 1843 propeller-driven warship, *Princeton*, which appeared in Donald Canney's book, *The Old Steam Navy*.[7]

Reconstruction of *Indiana*'s upper works relied almost entirely on historical descriptions and

Figure 5-1. Circa 1860s photograph of the 1846 Great Lakes propeller *Pocahontas*. (Courtesy the Smithsonian Institution, NMAH).

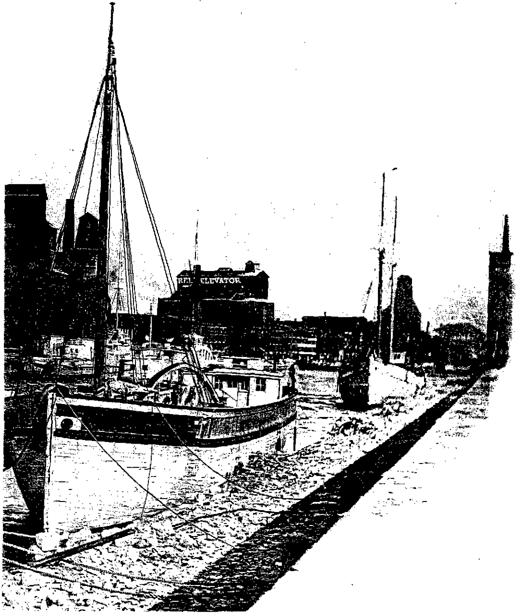


Figure 5-2. Circa 1860s photograph of the 1846 Great Lakes propeller *Globe* cut-down to a barge. (Courtesy of the Buffalo and Erie County Historical Society).

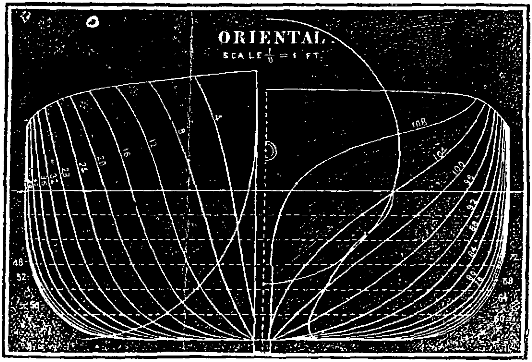


Figure 5-3. Body plan of the 1854 Great Lakes propeller *Oriental*. (From "Draught and Calculation of the Lake Propeller '*Oriental*'," *The Monthly Nautical Magazine*, 139).

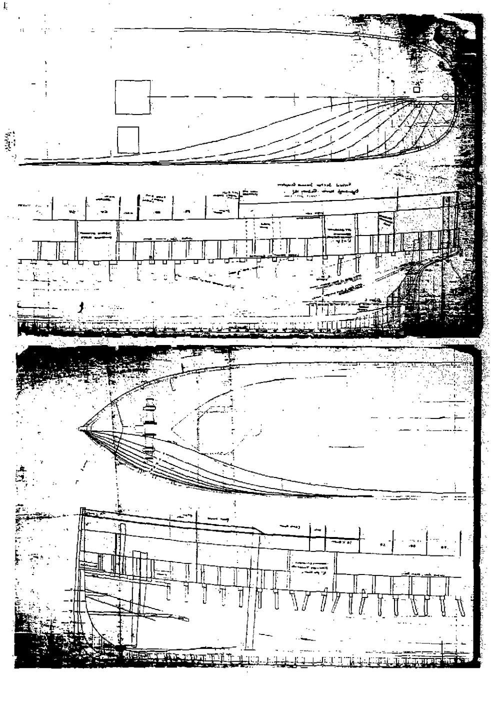


Figure 5-4. Full-breadth lines plan for the 1867 Great Lakes propellers *Maine* and *Oswegatchie*. (Plan courtesy of C. Patrick Labadie).

Survey, Made by .... at Oswego
21 March 1857, on the Propeller Kentucky
American Tonnage, 366 Built at Buffalo Launched in 1853
by G. S. Weeks Rebuilt at .... in 18
Length between Perpendiculars, 137 Beam, 25.6 Depth of hold, 11.2
Surveyed afloat or in Dock, afloat Model, good Ends, — Bottom, —
Owner, Fitzhugh & Littlejohn Residence, Oswego
Master, ... Residence, —

KIND OF TIMBER, DESCRIPTION, ETC.		DIMENSIONS OF TIMBER, FASTENINGS, ETC.
Stem, W. Oak	Stern Post, W. Oak	Keel-sided and moulded,
Transom,	Knight Heads,	Stem and Stern Post, do.,
Keel,	Floor Timbers,	Floor-sided, 12
Top Timbers,		Frames moulded at centre, 12
Keelson, Main,	Sister,	Frames moulded at Bilge, 9
Bilge Strakes,	Deck Clamps,	Frames moulded at top, 6
Shelf Piece,	Stringer,	Distance between centres, 24
Beams,	Carlins,	Are top Timbers doubled? yes
Knees, Tamarac	Breast Hooks, two Oak	M. Keelson sided and moulded, 12 X 13
Plank on Bottom, Oak	Sides, Oak	S. Keelsons, sided and moulded, —
Ceiling in Bottom,	Sides,	M. Transom, sided and moulded,
Arches Kind,	Kind,	Beams, sided and moulded, 10 & 11 X 7½
Centre-board case, —	Length, —	Space between beams, 26 in
Condition, —		Garboard strakes, thickness, 3 Bolted to keel, —
Large Anchor, 1400 lbs		Bottom Plank, thickness, 3
Large Chain, 1 1/16	75 fm	Plank on side, thickness, 3
Small Anchor, 784 lbs		Covering Board and Rail, 16 X 3½
Small Chain, 7/8	75 fm	Ceiling in Bottom, 3
Kedge,	Hawser, 7 in	Bilge Strakes, 30 X 5 Edge Bolted, —
Water-tight Bulkhead and slide, —		Ceiling on Sides, 3 Edge Bolted, —
Cabin Plates,	Secured,	Deck Clamps, 17 X 5
Bob Stays,	Set up,	Arches, Outside, — Inside, 30 X 3 / 14 X 3
Rigging,	Sails,	Beams kneed off by Diagonal knees
Was she Salted? yes		
Draft of Water light,	Loaded, 10 feet	Shelf-piece, — Stringer, —
Pumps, two iron	Cased,	How is she Fastened? square Butt Bolted, yes
Bilge Pumps,	Dead rise ¼ of beam, 7 in	Length of spike, 7–8
High or Low Pressure, high	Cylinder, 24 in	Size of Bolts, 5/8 — 3/4

What means to extinguish fires? All the law required

GENERAL REMARKS, Had had very large repair this spring 1851 —
Is now in good order and will do good service yet

Is .... well qualified to carry grain cargos, being ....

I would recommend the following valuation and classification:
Estimated CASH value, $ .... Class, A 2 For 5 years from month of April, 1853

....
Marine Inspector.

Figure 5-5. 1857 Lake Vessel Survey form for the 1853 Great Lakes propeller *Kentucky*. (From NARG-92, Records of the Office of the Quartermaster General: Water Transportation [1834-1900], Box 50, Steamer "Kentucky" Vessel Papers, Washington, DC).

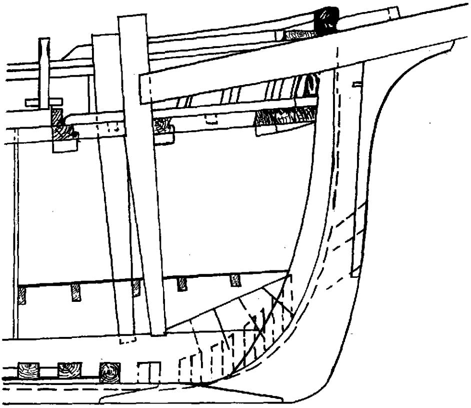


Figure 5-6. Bow construction of *Alvin Clark*. (After McCutcheon, "*Alvin Clark*: An Unfinished Voyage," 58).

pictorial evidence. Brief narrative descriptions of early Great Lakes propellers that appeared in newspapers published in Great Lakes ports during the 1840s and 1850s provided the largest volume of descriptive information on the general appearance of propellers from this period.[8] A narrative description and lithographic image (Fig. 5-7) of the 1845 Great Lakes propeller *Phoenix* was especially useful for reconstructing *Indiana*'s general layout, the configuration of her upper works, and the height of *Indiana*'s smoke pipe above the main deck.[9] Lithographic images of the propeller *Globe* (produced in 1847) (Fig. 5-8), an image of an archetypal propeller on an 1849 "Certificate of Inspectors" for the propeller *Independence* (Fig. 5-9), another image of a slightly different archetypal propeller on an 1859 Northern Transportation Company advertisement (Fig. 5-10), and a midships section drawing of a Great Lakes propeller dating from 1889 that bears a resemblance to the recorded archaeological remains of *Indiana*'s hull (including its sheathed sponson guards) were also examined (Fig. 5-11).[10]

Comparative evidence for the configuration of *Indiana*'s truss was obtained from a circa 1860s photograph of the 1852 sidewheel steamer *Huron*, which appears to have been fitted with a truss system of hogging chains and vertical wooden posts identical to that of *Indiana* (Fig. 5-12).[11]

As much information as possible about *Indiana*'s design and construction was gathered from the archaeological study of the vessel's remains and the reconstruction of its operational history from the archival record. Details from the above sources then helped to fill gaps in *Indiana*'s record, allowing a reasonably accurate reconstruction of *Indiana*'s internal and external appearance to be developed.

Hull Lines

Preparation of a set of lines drawings representing the three-dimensional shape of *Indiana*'s hull was the necessary first step in reconstructing *Indiana*'s hull form and construction (Fig. 5-13). Lines drawings provide a foundation or framework for graphically reassembling *Indiana*'s documented hull components. Also, once completed, *Indiana*'s lines could then be analyzed and compared with those of other propellers to determine the relative sophistication of *Indiana*'s design.

A completed set of hull lines consists of three different but interrelated views of the vessel which are typically depicted from below the plank-sheer. These views include: a sheer plan showing the vessel's profile along its length, a half-breadth plan depicting the hull as if viewed from above, and a body plan presenting an "end-on" view of the ship from both the bow and the stern. Each plan is drawn on a measured grid onto which are plotted a set of curved lines defining the shape of the hull from a

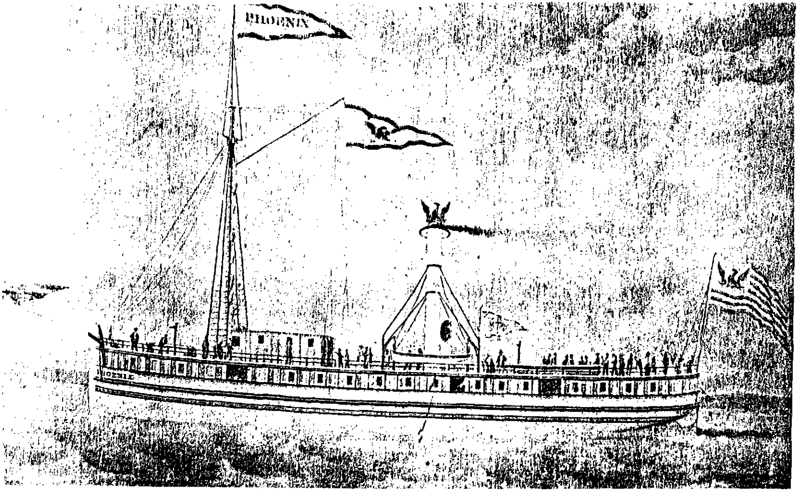


Figure 5-7. Great Lakes propeller *Phoenix* (1845). (Courtesy C. Patrick Labadie).

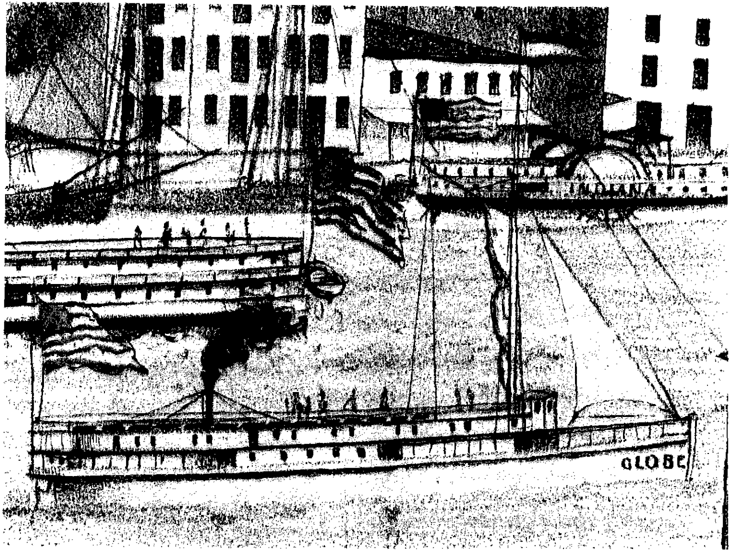


Figure 5-8. Edwin Whitefield's 1847 depiction of *Globe* prior to its conversion into a barge. (Courtesy of the Mariners' Museum).

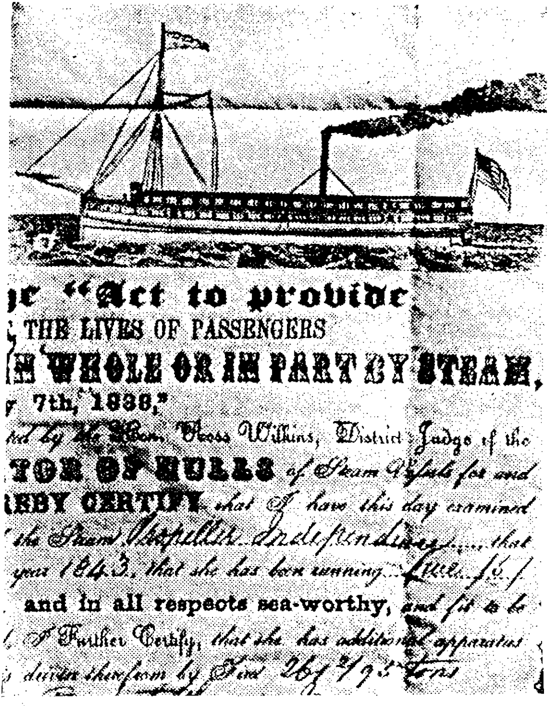


Figure 5-9. Pre-1849 depiction of an unidentified Great Lakes propeller. (Courtesy of C. Patrick Labadie).

Figure 5-10. Northern Transportation Company Propeller Line advertisement dating from 1859. (Courtesy of the Smithsonian Institution, NMAH).

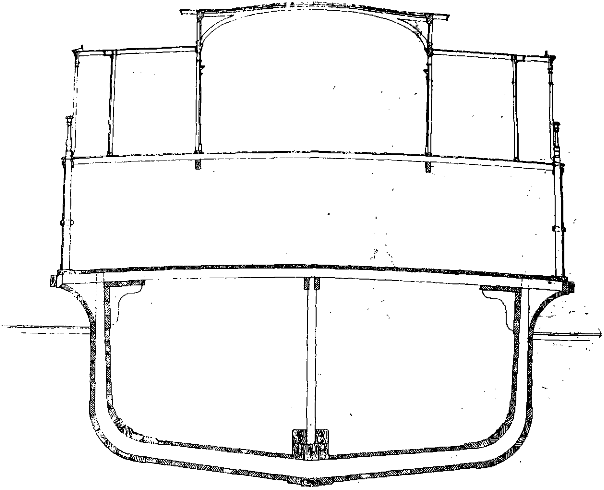


Figure 5-11. Midship section plan of an unidentified Great Lakes propeller dating from 1889. (Courtesy of C. Patrick Labadie).

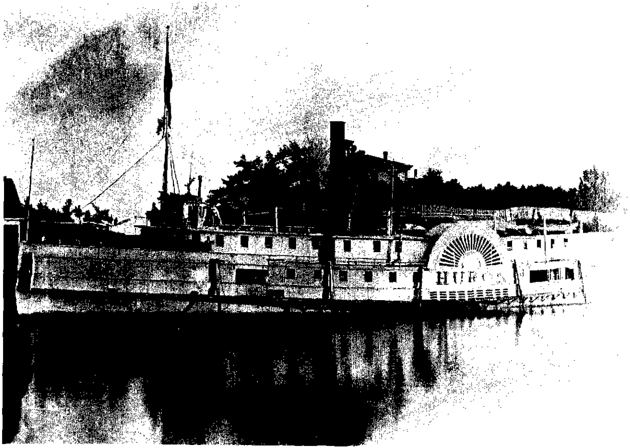


Figure 5-12. Great Lakes steamer *Huron* (1852). Note truss anchor at the vessel's bow and the configuration of truss rods and truss posts. (Photo courtesy of C. Patrick Labadie).

-INDIANA-

Built in 1848 at Vermilion, Ohio by Joseph M. Keating

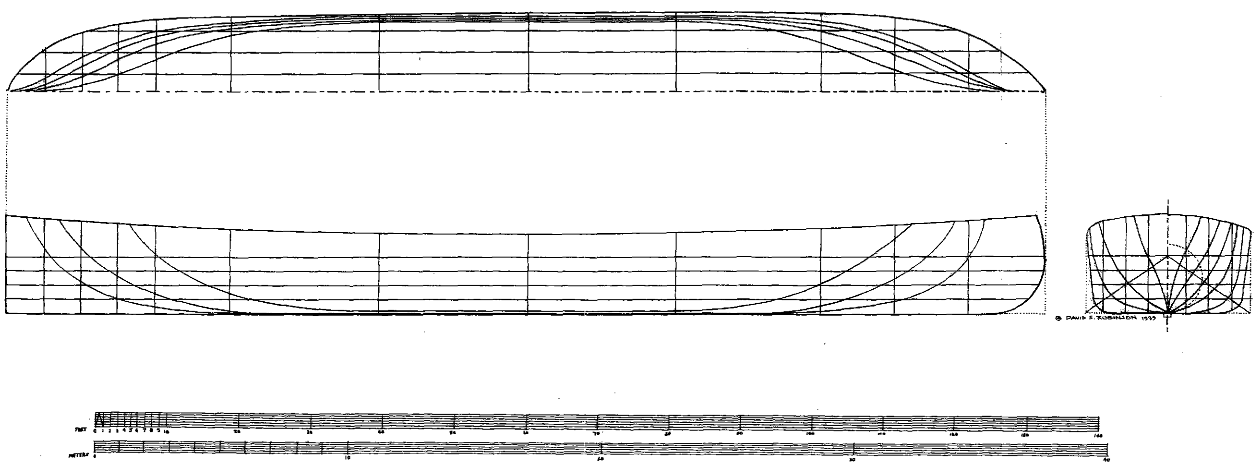


Figure 5-13. Reconstructed hull lines plan of the Great Lakes propeller *Indiana* (1848). (Drawing by David S. Robinson).

particular view. Ship lines are drawn fair and represent the idealized reconstructed hull form that was recorded during the project. In reality, *Indiana*'s built hull would not have been perfectly symmetrical. Instead, it would have exhibited signs of distortion caused by the natural variation of the wood and the hand processes used to work it. After construction, unequal distribution of the weight of *Indiana*'s machinery throughout her hull, the hull's own weight, and the destructive dynamics of the fluid environment in which the vessel was operated caused further deviation from the idealized shape. This range of transforming factors that acted upon the hull during its operational career, the damages that occurred during the sinking event, and the adverse affects of long-term (e.g., approximately 140 years) immersion all had to be taken into account while reconstructing *Indiana*'s lines.[12]

Primary evidence for reconstructing *Indiana*'s lines derived from measurements recorded underwater during the 1991 and 1993 archaeological field campaigns. These measurements included such dimensions as the overall length, width, and depth of *Indiana*'s preserved hull, the length of her stem and sternpost, the sweep of her preserved sheer, and six sections of hull curvatures. Although *Indiana*'s overall dimensions (i.e., length, breadth, and depth) were recorded in her enrollment papers, they were also documented archaeologically because, as Griffiths noted in 1854:

> So loose and indefinite is the present mode of measuring ships...the same ship may be measured by two men equally competent, and the difference in the results will be very material....[13]

Athwartships distances, the sweep of *Indiana*'s sheer, and depth-of-hold were measured to provide fixed points along the sheer from which the vessel's hull curvature could then be measured. *Indiana*'s hull curvature was recorded at arbitrarily chosen points along the hull located 5, 10, 15, 20, 30, and 50 feet (1.52, 3.05, 4.57, 6.10, 9.14, and 15.24 m) forward of *Indiana*'s sternpost. The sections at 5, 10, 15, and 20 feet (1.52, 3.05, 4.57, and 6.10 m) were recorded on the port side of the hull to avoid the sponson guard on the hull's starboard side. The 30- and 50-foot (9.14- and 15.24-m) sections had to be recorded on the starboard side of the hull to avoid immobile portions of *Indiana*'s bulwarks found leaning against the port side.

Because lines drawings produced at the time of a vessel's construction define the hull's "molded" shape, that is, its shape along the inner surfaces of the planking, the best place to record frame curvatures on a shipwreck is at the frame and planking interface on the inside the hull. Typically, the individual measurements comprising each curvature are recorded from the garboard rabbet along the keel to the top of the sheer. The location where a particular curvature is measured is then tied into the rest of the hull by recording its position along the length of the keel. In *Indiana*'s case, however, it was impossible to document the molded shape of the hull because of the intactness of *Indiana*'s ceiling and planking and the massive amount of immovable overburden inside *Indiana*'s hold. Thus, all of *Indiana*'s hull curvatures were measured on the exterior of the hull. Because of the hull's upright orientation, minimal deadrise, and the loose nature of the lake bed's sands, which could not be excavated with the limited equipment and time available during fieldwork, curvatures could only be measured from the sheer to the sandline at the turn of the bilge. Consequently, no complete sections of *Indiana*'s hull curvature were recorded. Furthermore, the profound distortion in the forward two-thirds of *Indiana*'s hull made it impractical to record any additional curvature measurements more than 50 feet (15.24 m) forward of the sternpost.

Given these limitations, the measurements of *Indiana*'s overall dimensions and hull curvatures represented just a starting point for drafting *Indiana*'s lines (Fig. 5-14). Because of the distortion of *Indiana*'s recorded curvatures and the absence of any archaeologically recorded curvature information for the bottom and forward two-thirds of *Indiana*'s hull, other sources depicting the lines of similar vessels were necessary for fairing the recorded curvatures and completing the reconstruction of *Indiana*'s lines.

Two contemporary textual sources dealing with the problem of designing an ideal hull form for screw-propelled vessels by W. H. King, an engineer in the U. S. Navy, and John W. Griffiths, one of America's first "modern" ship design theorists, contained important observations about the specific hull form requirements for screw-propelled vessels. In 1849, King observed:

> A very important element in the design of a screw vessel is to make the run very sharp - the lines fine - in order that the water may flow in solid at once, to fill the vacuity occasioned by the vessel's progress, or the propeller's revolutions.[14]

In 1854, Griffiths elaborated on King's observations and noted:

> There is a wide distinction in the [hull form] requirements of sidewheel steamers and propellers...the screw, as a propeller, also demands that the passing vessel should leave the water as nearly in an equilibriated [sic] state as possible; hence, we see that, for two reasons, the models of side-wheel steamers and screw propellers should be entirely different...in the vessel designed for side wheels...the greatest transverse hull section should be placed aft...[whereas] on the propeller...the greatest amount of resistance [or the greatest transverse section of the hull]...should be met on the bow...to form a draught [so that]...the convolution of the posterior resistance is greatly diminished and the screw serves more directly to propel the vessel in the line of her course [also]...the screw demands a long posterior part, while the wheel demands a long anterior part.[15]

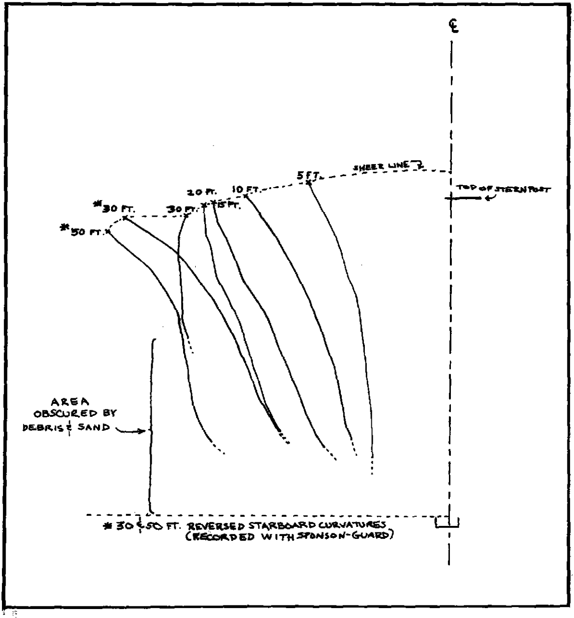


Figure 5-14. *Indiana's* hull curvatures depicted as recorded. (Drawing by David S. Robinson).

While neither of these sources provided a set of lines, they did indicate what constituted an ideal hull form for a screw-propelled vessel circa 1850.

A better source of information for completing the reconstruction of *Indiana*'s hull shape (and the earliest set of lines for a pre-1860s Great Lakes propeller) is a body plan of the mammoth *Oriental* (220 feet, 11 inches [67.36 m] long and 950 tons), built in 1854 by Bidwell and Banta (see Fig. 5-3).[16] Unlike *Indiana*, *Oriental* was built for freighting purposes only and was fitted with a transom stern to accommodate an extraordinarily large propeller, 22 feet (6.7 m) in diameter.[17] However, despite these obvious differences, the body plan of *Oriental* indicates that it and *Indiana* shared some basic similarities in their respective hull shapes, such as a relatively flat sheer and flat floors, full lines amidships, nearly vertical sides, and a fine (although slightly convex) entrance.[18]

Another important source of information for reconstructing *Indiana*'s lines are the plans for the Northern Transportation Company's sister propellers *Maine* and *Oswegatchie*, built in 1867 by the Company's prolific shipwright and superintendent of construction, Asa C. Keating (of no apparent relation to *Indiana*'s builder Joseph M. Keating; see Fig. 5-4).[19] In contrast to the huge freight-only *Oriental*, *Maine* and *Oswegatchie* (both 148 feet [45.11 m] long, 26 feet [7.92 m] wide, and 12 feet [3.66 m] deep) were nearly identical in size to *Indiana* and, also like *Indiana*, were designed for both freight and passenger service.[20] Asa Keating's full-breadth lines plan (see Fig. 5-4) depicts the propellers with a long, fine entrance, a slightly shorter, hollow run, and a full midships section. The floor is relatively flat and the turn-of-the-bilges is hard. The nearly vertical sides of the hull lack an overhanging guard and form a long deadflat amidships. The sheer is relatively flat except toward the bow. Both the dead flat and the shape of the after third of the depicted hull bear a close resemblance to the recorded curvatures of *Indiana*'s hull. However, half frames that extend far forward in *Indiana*'s bow and the absence of extensive deadwood in that area both suggest that *Maine* and *Oswegatchie*'s hulls were finer in entrance than *Indiana*.

Circa-1860s photographs of the 1846 propellers *Pocahontas* and *Globe* also provided some useful information for reconstructing *Indiana*'s lines. The photograph of *Pocahontas* (see Fig. 5-1) shows the propeller docked and waiting to be loaded at an unknown port. Although the pier obscures most of *Pocahontas*'s hull below the level of her main deck, her lightened starboard bow is clearly visible. From the vantage point of the photographer, the entrance at the waterline appears to be moderately long and full. The sheer, which is defined by a heavy guard projecting approximately 2 feet

(60.96 cm) beyond the nearly vertical side of *Pocahontas*'s hull, appears to be virtually flat. The photographs of *Globe* show her hull from both the bow (see Fig. 5-2) and stern while docked in Buffalo. Both photographs were taken after *Globe* had been cut down and converted into a barge. *Globe*'s entrance appears to be virtually identical to that of *Pocahontas*. Also like *Pocahontas*, the sides of *Globe*'s hull appear to be nearly vertical with a long dead flat amidships. However, *Globe*'s sheer is significantly more lively than *Pocahontas*'s, and the guards do not appear to extend beyond the limits of the hull except at the stern.

Although *Oriental*, *Maine*, and *Oswegatchie* were built more than a decade after *Indiana*, at a time when significant progress was being made in ship design theory, their lines provide the best comparative material available for reconstructing the shape of the forward two-thirds of *Indiana*'s hull. Notably, the existence of such plans indicates that lake shipwrights of the 1850s and 1860s were adopting more sophisticated techniques of naval architecture and applying them to their vessel designs. Also, the fact that the same set of lines was used to build both *Maine* and *Oswegatchie* strongly suggests that their hull form was a proven and successful design worthy of repeating.

Based on these and other contemporary sources of information, *Indiana* was obviously built at a critical point in the development of screw-propeller hull forms, when the specific requirements for the hull forms of such vessels were just beginning to be understood and addressed by contemporary designers and builders. This compilation of data has allowed reconstructions of *Indiana*'s lines and assembly as scale drawings.

No one source provided the information that was necessary to reconstruct the shape of the forward two-thirds of *Indiana*'s hull. Textual and contemporary pictorial sources, combined with archaeological data, provided enough information to hypothetically reconstruct the shape of *Indiana*'s hull. As reconstructed, *Indiana*'s hull measures 148 feet, 10 inches (45.36 m) in length from the after face of the sternpost to the forward face of the stem, 150 feet, 9 inches (45.94 m) on deck, and 155 feet (47.24 m) overall (not including rudder). *Indiana*'s reconstructed beam measures 23 feet (7.01 m) wide and 28 feet (8.5 m) with the guards. *Indiana*'s reconstructed depth-of-hold measures between a minimum of 10 feet, 3 inches (3.12 m) and a maximum of 11 feet, 6 inches (3.50 m). By comparison, *Indiana*'s dimensions recorded in the enrollment documents were 146 feet, 6 inches (44.8 m) in length (from the after face of the sternpost to the forward face of the stem), 23 feet (7.01 m) in breadth (without the guards), and 10 feet, 10 inches (3.3 m) depth of hold.

Indiana's reconstructed hull is long and narrow with a 6.4:1 length-to-breadth ratio. In contrast, most sailing ships built prior to 1850 did not often have a length-to-breadth ratio greater than 4:1.[21] The hull has been reconstructed with a nearly flat bottom with very little deadrise (7 inches [17.78 cm] at one-third the beam), hard round bilges, nearly vertical sides, and a relatively straight sheer that rises only slightly at the bow and stern. *Indiana*'s reconstructed keel is straight and her stem and sternpost are also straight, upright, and unadorned, although the curved leading edge of *Indiana*'s stem gave it the appearance of raking slightly aft. The sides of *Indiana*'s hull were nearly vertical and the addition of the sponson guard to the exterior of the hull provided a smooth transition between the overhanging deck and the sides. *Indiana*'s reconstructed bow below the water line has a fine, slightly convex, and moderately long entrance, but its damaged condition and the absence of comparable data make this reconstruction less reliable. The bow above the water line, at the level of the main deck, was moderately full. *Indiana*'s lines at the stern, based on the archaeological measurements of the existing hull, exhibited a long, very fine run that was slightly hollow at the after end. The design of *Indiana*'s run would have maximized the efficiency of her propeller and ensured a minimally disturbed flow of water into it. This design feature indicates that *Indiana*'s builder was cognizant of the newly discovered hull-form requirements for propeller-driven vessels.

Construction Plans

Indiana's architecture is represented in the construction drawings appearing in Fig. 5-15. The reconstruction of *Indiana* is substantiated by the large body of detailed archaeological data that was collected during the 1991 to 1993 field seasons, which demonstrates the assembly and configuration of *Indiana*'s surviving hull components up to the level of the main deck. Additional archaeological and historical data were utilized to fill in the architectural features that were missing from the site, such as the construction of the lower portions of the bow and stern and the general configuration and construction of *Indiana*'s upper works and sailing rig. The only primary documentary information regarding *Indiana*'s original appearance were her enrollment papers and two brief, yet illuminating, newspaper reports describing the portions of *Indiana*'s upper works that were visible to passing boats for several days after the sinking. Searches by the author for additional vessel documentation (e.g., Master Licenses, Builder's Certificates, Certificates of Inspection, etc.) at the Civil Reference Branch of the National Archives, Washington, D.C., and the National Archives Great Lakes Regional Reference

- INDIANA -

Built in 1848 at Vermilion, Ohio by Joseph M. Keating

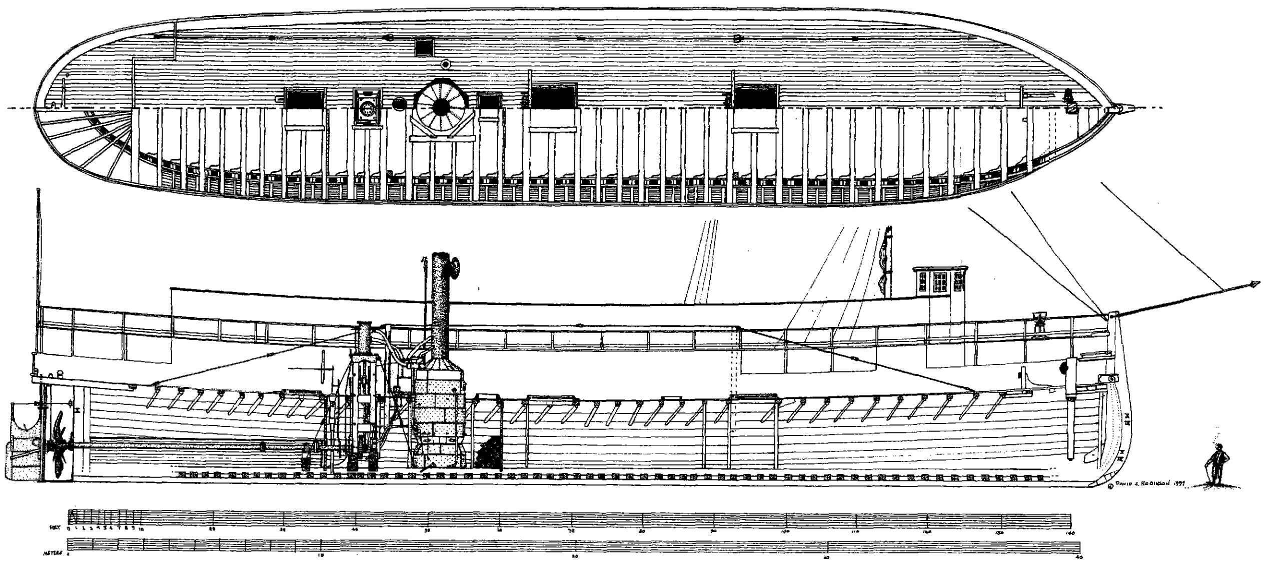


Figure 5-15. Reconstructed construction plan of the Great Lakes propeller *Indiana* (1848). (Drawing by David S. Robinson).

Branch in Chicago, Illinois, were unsuccessful due to the incompleteness of these records prior to the 1860s (as noted in Chapter I).

Indiana's enrollment documents provided valuable basic information concerning *Indiana*'s overall dimensions, number of masts, shape of the stem and stern, presence or absence of a figure-head or quarter galleries, and number of decks. However, the enrollment's dimensional data were of limited use for reconstruction purposes until it could be determined where on *Indiana*'s hull these measurements had been recorded. Fortunately, U. S. Custom House rules for measuring vessel dimensions are included in 1856 Board of Marine Inspectors of the Association of Lake Underwriters rules for constructing sail vessels and propellers.[22]

Based on these guidelines, it appears that inspectors measured *Indiana*'s 146-foot, 6-inch (44.7-m) registered length on deck, from the forward side of her stem to the after side of her stern post. Her 23-foot (7.01-m) registered beam was recorded to the outside of the hull planking on the exterior of the widest part of the hull, exclusive of the guards. *Indiana*'s 10-foot, 10-inch (3.3-m) measured depth of hold was taken between the ceiling alongside her main keelson to the underside of her decking. In addition to these dimensional data, *Indiana*'s enrollment papers also noted that it was built with a round stern, and had a plain stem, two decks, one mast, and no quarter galleries. At the time of her loss, *Indiana* was registered as having only one deck.

From these enrollment data, the author initially had the false impression that *Indiana*, fast approaching obsolescence at the age of ten years, had been converted from a two-decked combination passenger and package freighter to a single-decked, all freight vessel, destined to haul only bulk cargoes in the waning years of her career. However, both this initial theory and the deck information preserved in the enrollments were proven incorrect. The accumulation of archaeological and archival evidence indicated that *Indiana*'s deck configuration had not been altered during the course of her career.

The location of hooks on *Indiana*'s stem and the presence of upper deck support stanchions in *Indiana*'s fragmentary bulwarks provided archaeological evidence for the existence of a second, upper deck. This evidence was corroborated with eyewitness accounts of the sinking, which noted that lights visible for a long time after the boat sank were part of the "upper deck" that had "detached from the hull." Other vessels reported floating wreckage, described as "some 50 feet (15.24 m) of the upper deck, with two of the fenders thrown across it..." with "a winch different from those now in common use on such boats, and the precise kind as *Indiana* had."[23] Furthermore, *Indiana* was not engaged long-term to carry iron ore; it had been leased by the New York & Erie Railroad Line to provide liner service on a direct route between Buffalo and Detroit for the 1858 season. When business fell off due to the economic Panic of 1857, it was chartered by the Cleveland Iron Mining Company for "a week or two" to transport a single load of iron-ore from Marquette to Cleveland.[24] This historical information was critically important to the reconstruction because it corrected an error in the enrollments. Also, it filled a void in the archeological record and changed entirely the interpretation of the boat's character and appearance.

The reconstruction of *Indiana*'s keel is based on archaeological measurements and the Board of Marine Inspectors of the Association of Lake Underwriters' 1856 specifications for keels of propellers of *Indiana*'s tonnage. These specifications required a vessel of 350 tons to have a keel that is sided 1 foot, 1/2 inch (31.75 cm) and molded 9-3/4 inches (24.76 cm). Scarfs 5 feet, 6 inches (1.67 m) long are also specified for keels of a propeller of this size.[25] From the archaeological measurements it appears that the molded dimension of *Indiana*'s keel was virtually identical to the Board's recommendation and the sided dimension was 2-1/2 inches (6.35 cm) less than the recommended dimension.

Reconstructing *Indiana*'s bow and stern construction below the waterline was problematic because of the fragmentary and partially buried condition of the bow and the presence of intact hull planking that obscured the stern deadwood. C. T. McCutcheon's plans of the construction of the Joseph Keating-built *Alvin Clark* show a massive keelson, square frames that extend very far forward and astern in the hull, and single triangular pieces of deadwood in the bow and stern (see Fig. 5-6). Other information for the construction of the bow and stern came from William H. Webb's plans for contemporary steam vessels. Webb was an eminent and much imitated New York shipbuilder who designed primarily ocean-going vessels, including steamboats. His plans provided numerous examples of deadwood configurations in contemporary steam vessels. Perhaps the most helpful (and one of the only) sources of information for reconstructing the arrangement of *Indiana*'s stern deadwood were the construction plans for the world's first propeller-driven warship, *Princeton*, designed by John Ericsson and built in 1843.[26] Like *Indiana*, *Princeton* had an extremely fine run, so it seems possible that her deadwood configuration might have been somewhat similar to that of *Indiana*. Due to the near-total absence of data from *Indiana* and contemporary lake propellers, the reconstruction of *Indiana*'s stern deadwood must be considered hypothetical.

Certain aspects of *Indiana*'s interior arrangement below the main deck were evident in the archaeological evidence. However, the reconstructed arrangement and appearance of *Indiana*'s main and upper decks were based almost entirely on historical accounts and contemporary pictorial evidence. Information regarding the layout of *Indiana*'s interior spaces was gleaned from several newspaper articles that appeared in the *Daily National Pilot* of Buffalo between April and July of 1845 in which the architecture and arrangement of the propeller *Phoenix* (1845) are described.[27] These articles are of particular relevance to *Indiana*'s reconstruction because they list the attributes of the "new class of propeller vessels" that appeared on the Great Lakes during the late 1840s, of which *Indiana* was a member.[28]

Phoenix and *Indiana* were similar in general appearance and shared nearly identical dimensions in their length, breadth, and depth. *Phoenix* measured 145 feet (44.19 m) in length, 23 feet (7.01 m) in breadth (26 feet [7.92 m] including the guards), 10 feet (3.04 m) in depth, and 320 tons.[29] Both vessels were fitted with guards and each employed propellers of Loper's design. *Phoenix*, in fact, was the first of the Great Lakes propellers fitted with the Loper wheel. *Phoenix*'s upper works were described as follows:

> On her main deck she has two cabins, which are also separated by her engine room. The one aft, or gentlemen's cabin is fitted up with state rooms, and has berths for 30 passengers. The cabin is conveniently, neatly and elegantly furnished and finished. Her forward or steerage cabin is large and conveniently arranged expressly for emigrants and that class of passengers, and it is not excelled by any steamboat on the Lakes. It will, with the standing berths and sacking frames give good accommodation to 200 passengers. Connected with it is a large kitchen, having a cooking stove, pumps, &c., &c. Besides these two cabins, she has on her upper or promenade deck, a large saloon with eight berths, for cabin passengers; a wash room and a bar; with this she can, in her best cabin, well accommodate 40 passengers.[30]

The *Daily National Pilot* articles also provide the height of *Phoenix*'s smoke stack or "smoke pipe" above the main deck (33 feet [10.05 m]), a feature absent from *Indiana*'s archaeological remains.[31]

Perhaps the most significant of *Phoenix* and *Indiana*'s shared similarities was their difference from all other propellers built prior to 1845. This difference was the placement of their machinery nearly amidships, between their forward and after freight holds.[32] According to the writer of one of the 1845 articles, *Phoenix*'s arrangement differed from "all the propellers I have ever seen."[33]

The most useful sources of information for reconstructing the layout and external appearance of *Indiana*'s upper works were lithographs of several late-1840s propellers, all of which clearly represent second generation Great Lakes propellers. These illustrations include a circa 1847 lithograph of *Phoenix* (see Fig. 5-7), an 1847 lithograph of the propeller *Globe* (see Fig. 5-8), an 1849 illustration of an unidentified propeller on an Detroit, Michigan, Certificates of Inspection document for the 1843 propeller *Independence* (see Fig. 5-9), and an unidentified propeller in an 1859 Northern Transportation Company broadside advertisement (see Fig. 5-10).[34] Another illustration that proved helpful in reconstructing *Indiana*'s upper works was an amidships transverse section of a "Proposed Steamboat for Lake Michigan" prepared by F. W. Wheeler & Company, West Bay City, Michigan, and dated June 26, 1889 (see Fig. 5-11).[35] The illustration is unique for showing a planked sponson guard virtually identical to *Indiana*'s. The only apparent difference is that the sponson guard in the illustration seems to be an integral part of the hull, since the frame tops underlying the sponson guard are not planked like *Indiana*'s.

The synthesis of these data sources has produced a reconstruction of *Indiana* as a combination freight and passenger propeller that exhibits the defining features of the place and period in which it was built. *Indiana*'s construction features (e.g., an enlarged and improved hull design, a more powerful and efficient propulsion system, extensive upper works with greater accommodations for passengers, and a rudimentary truss system) reflect technological advances and economic trends that prevailed at the end of the 1840s when the vessel was built. While these features initially set *Indiana* apart from pre-1845 predecessors as a comparatively advanced form of early Great Lakes propeller, the very same features would contribute to the vessel's obsolescence only five years later as a consequence of subsequent advances in ship design and propulsion machinery technology, navigational improvements on the lakes, and a shift in the character of the lake trade from passenger and package freight transport to liner support of the Great Lakes' interregional railways and the transport of bulk cargoes.

Notes: Chapter V

1. W. H. King, *Lessons and Practical Notes on Steam, The Steam Engine, Propellers, etc., etc., For Young Engineers, Students, and Others* (New York, NY, 1849), 131; John W. Griffiths, *The Ship-Builders Manual and Nautical Referee*, vol. 1 (New York, NY, 1856), 100-111.

2. "Propeller *Pocahontas*" (Washington, DC, Smithsonian Institution, National Museum of American History, *Indiana* files, n.d); "Propeller *Globe*" (Buffalo, NY, Buffalo and Erie County Historical Society, Photograph Files: Buffalo Waterfront, circa 1860s); Editors, "Draught and Calculations of the Lake Propeller "Oriental," *The Monthly Nautical Magazine*, vol. 2 (May 1855), 139; Asa C. Keating, "Plans for Northern Transportation Company Propellers *Maine* and *Oswegatchie*" (Perrysburgh, OH, Institute for Great Lakes Research, American Shipbuilding Company Plans Collection).

3. Board of Lake Underwriters, *Proceedings of the Board of Marine Inspectors of the Association of Lake Underwriters, Held at Buffalo*, August, 1856 (Buffalo, NY, 1856).

4. The author's discovery of the 1856 Board of Lake Underwriters document during the course of research for this thesis was significant, because, as Labadie noted, it represents the earliest known published recommendations for the construction, classification, and navigation of Great Lakes "Sail Vessels and Propellers" of 50-1,000 tons of burden. C. Patrick Labadie, Personal Communication. Previously, researchers had utilized the Board's 1862 rules for the constructing "Lake Sail and Steam Vessels" as a source of comparative data. Board of Lake Underwriters, *Rules Relative to the Construction of Lake Sail and Steam Vessels Adopted by the Board of Lake Underwriters, 1866* (Buffalo, NY, 1866). While both the 1856 and 1866 Board of Lake Underwriters documents contain a considerable amount of detailed information regarding the materials, dimensions, and construction of propellers and sailing ships, these data represent the Board's "ideal" characteristics for vessels of this kind. In reality, the "as-built" materials, dimensions, and construction techniques of vessels could have differed significantly from those recommended by the Board. As Griffiths pointed out in 1854, "a consideration which influences by far the greatest number of ship-builders...and the very prevalent notion among ship-owners, [is] that cheapest is best...So long as a ship will insure for A No. 1, it matters little who builds her, so long as the price is reduced to its lowest terms. The very first consideration with ship-owners, is to obtain the greatest amount of internal capacity, corresponding to the smallest amount of registered tonnage, and at the same time a favorable report from the agent of the underwriters, who is generally selected from among the superannuated list of ship-masters." Griffiths, *ibid.*, vol. 2, 161.

5. "Lake Vessel Survey of the Propeller *Kentucky*" (Washington, DC, National Archives, Military Reference Branch, Record Group 92, Records of the Office of the Quartermaster General: Water Transportation (1834-1900), Box No. 50, Steamer *Kentucky* Vessel Papers, 21 March 1857).

6. C. T. McCutcheon, Jr., "*Alvin Clark*: An Unfinished Voyage," *Wooden Boat Magazine*, vol. 52, no. 3 (1983), 58; Keating, *ibid.*; William H. Webb, *Plans of wooden vessels selected as types from one hundred and fifty of various kinds and descriptions: from a fishing smack to the largest clipper ships and vessels of war, both sail and steam, built by Wm. H. Webb, in the city of New York, from the year 1840 to the year 1869* (New York, NY, 1897), n.p.; William L. Crothers, *The American-Built Clipper Ship, 1850-1856: Characteristics, Construction, Details* (Camden, ME, 1997), 129-137.

7. Keating, *ibid.*; McCutcheon, Jr., *ibid.*; Webb, *ibid.*; Crothers, *ibid.*; Donald L. Canney, *The Old Steam Navy: Frigates, Sloops, and Gunboats, 1815-1885* (Annapolis, MD, 1990), 23, 24.

8. The author is grateful to C. Patrick Labadie for providing him with (among many other items) numerous Xeroxed copies of transcribed newspaper descriptions of Great Lakes propellers from the 1840s and 1850s. Included among the more informative articles were descriptions of the following:

Hercules (1843): *Buffalo Daily Gazette*, 21 June 1843; *Detroit* (1845): *Daily National Pilot* (Buffalo), 5 May 1845; *Phoenix* (1845): *Daily National Pilot* (Buffalo), 1 May, 8 July, 12 July, 16 July, 26 July, 1845; *Princeton* (1845): *Daily National Pilot* (Buffalo), 27 August 1845; *Earl Cathcart* (1846): *News* (Kington, Ontario), 15 October 1846; *Ogontz* (1848): *Buffalo Commercial Advertiser & Journal*, 11 May 1848; *Petrel* (1848): *Buffalo Morning Express*, 23 May 1848; *Forest City* (1851): *Buffalo Morning Express*, 30 August 1851; *Buffalo* (1851): *Buffalo Morning Express*, 30 December 1850.

9. *Daily National Pilot*, 8 July, 16 July, 1845.

10. Edwin Whitefield, "View of Buffalo, N.Y., From The Old Light-House," *Nineteenth-Century North American Scenery*, Bettina A. Norton, ed. (New York, NY, 1977); Harlan Hatcher and Erich A. Walter, *A Pictorial History of the Great Lakes* (New York, NY, 1963), 68; "Northern Transportation Company's Propeller Line From Ogdensburgh to the West" (Xeroxed copy of 1859 advertisement, courtesy of C. Patrick Labadie); Midships cross-section drawing of, "Proposed Steamboat for Lake Michigan," for F. W. Wheeler & Co., West Bay City, Michigan, 26 June 1889 (Perrysburgh, OH, Institute for Great Lakes Research, American Ship Company Plans Collection).

11. Circa 1860s photograph of 1852 Great Lakes sidewheeler *Huron*, courtesy of C. Patrick Labadie.

12. Kevin J. Crisman, *The* Eagle*: An American Brig on Lake Champlain during the War of 1812* (Shelburne, VT and Annapolis, MD, 1987), 163, 164.

13. Griffiths, *ibid.*, vol. 1, 86, 87.

14. King, *ibid.*, 131.

15. Griffiths, *ibid.*, vol. 1, 101-104.

16. Editors, "Draught and Calculations of the Lake Propeller "Oriental," *The Monthly Nautical Magazine*, vol. 2 (May 1855), 139.

17. *Ibid.*, 139, 140.

18. *Ibid.*, 139.

19. A. C. Keating was perhaps the most prolific individual designer and builder of Great Lakes propellers. He is listed in newspaper accounts as Superintendent of Construction, Master Carpenter, or Designer of 14 Northern Transportation Company propellers: *Michigan (*1852), *Ogdensburgh* (1852), *Granite State* (1852), *Maine* (1862), *Lowell* (1865), *Brooklyn* (1866), *Oswegatchie* (1867), *St. Albans* (1868), *City of Concord* (1868), *City of Toledo* (1868), *Nashua* (1868), *Milwaukee* (1868), *Champlain* (1870), and *Garden City* (1873). C. Patrick Labadie, Personal Communication. Despite their sharing of the same surname and their mutual, proximal, and contemporary involvement in the shipbuilding trade of the Great Lakes, archival research conducted by the author and C. Patrick Labadie has thus far produced no evidence indicating a professional or familial relationship between the two men.

20. *Toledo Blade*, 21 August 1867.

21. Louis B. Hunter, *Steamboats on the Western Rivers: An Economic and Technological History* (New York, NY, 1993 [1949]), 95.

22. Board of Lake Underwriters, *ibid.*, 12.

23. *Lake Superior Miner*, 12 June 1858.

24. *Detroit Free Press*, 10 June 1858.

25. Board of Lake Underwriters (1856), *ibid.*, 14.

26. Canney, *ibid.*, 24.

27. *Daily National Pilot*, 1 May, 8 July, 12 July, 16 July, 26 July, 1845.

28. *Ibid.*

29. *Ibid.*, 8 July 1845.

30. *Ibid.*

31. *Ibid.*

32. *Ibid.*

33. *Ibid.*

34. "Northern Transportation Company's Propeller Line From Ogdensburgh to the West" (Xeroxed copy of 1859 advertisement, courtesy of C. Patrick Labadie).

35. Midships cross-section drawing of, "Proposed Steamboat for Lake Michigan," for F. W. Wheeler & Co., West Bay City, Michigan, 26 June 1889 (Perrysburgh, OH, Institute for Great Lakes Research, American Ship Company Plans Collection).

CHAPTER VI

CONCLUSION

During the ten years spanning *Indiana*'s operational career (1848-1858), the United States' frontier, the "Old Northwest," underwent a remarkable transformation from a "remote, boundless, and unsettled wilderness..." into "the star of the American empire."[1] It was during this period that trade on the Great Lakes developed into "the right arm of the nation's commerce..." and the "cradle of national wealth, prosperity, and progress," as unprecedented numbers of immigrants and merchandise flooded into the region from the east and vast quantities of agricultural produce and livestock were shipped from the west to markets in the eastern states.[2]

The unparalleled growth of the Great Lakes' passenger and freight trades during the 1840s and 1850s produced a sharp demand for fast, inexpensive, and reliable water transportation. Sidewheel steamers initially provided the quickest, most comfortable, and reliable mode of travel available on the lakes in the second quarter of the nineteenth century. Unlike sailing vessels, steamboats were not controlled by the vagaries of the wind, and could maintain a regular schedule of arrivals and departures. This latter capability was becoming increasingly important because of the artificial compression of time that was occurring in the mid-nineteenth century with the availability of even faster, year-round, scheduled rail travel and the nearly instantaneous trans-regional telegraph communications.

However, the Great Lakes unique marine environment placed constraints on sidewheel steamers that effectively prevented them from traveling between the lower and upper lakes, and made passage in and out of the lakes' small, shallow harbors difficult. Furthermore, the high costs related to building and operating sidewheel steamboats required an exceedingly large capital investment to cover those expenses. Despite the sidewheel steamboat's obvious advantages over wind-powered sailing vessels, there was still room for improvement in steamboat technology and design. Such an improvement arrived on the lakes in 1841 when Swedish inventor John Ericsson's stern-mounted screw-propellers were employed in the canal barges of Canada's Rideau waterway system and on the Welland canal schooners plying the lake waters between Oswego, New York, on Lake Ontario, and the ports of the upper lakes.

Inaugurating the first direct steamboat trade between Lake Erie and Lake Ontario, the early propeller-schooners filled an important niche in the commerce of the lakes and were an immediate financial success. Cheaper to build and operate than sidewheelers, the propeller-schooners could better navigate the narrow canals and cramped harbors around the lakes while providing the same regularly scheduled service as sidewheelers at a significantly reduced rate.[3] Although slower than sidewheelers, the more compact size of the propeller-schooners' engines provided more space for freight and passengers and consumed less fuel, giving them an additional advantage over their sidewheel counterparts.[4] Because of their suitability for the rapidly expanding trade on the Great Lakes, screw propulsion technology was adapted far more extensively these inland waters than anywhere else in the world.[5]

Within five years of the propeller-schooners' introduction, a new form of screw-propelled Great Lakes steamboat appeared. Although more varied in design, this second generation of Great Lakes propellers was generally larger, faster, and better-suited for the passenger trade. Based on the historical and archaeological evidence compiled during this study, *Indiana* is a representative example of a second generation Great Lakes screw-propelled steamboat.

At 146 feet, 6 inches (47.7 m) long and 23 feet (7.01 m) wide, *Indiana* was significantly larger than the first generation (pre-1845) propellers and, in fact, was too large to fit through the original Welland Canal. Furthermore, *Indiana*'s reduced sail rig, extensive upper works, plain stem, elliptical stern, overhanging guards, and improved propulsion machinery (placed close to amidships in the hull) set *Indiana* apart from the propeller-schooners. Unlike the first Great Lakes propellers, those of *Indiana*'s era (1845-1855) were designed to be equally competitive in both the passenger and package freight trades. This fact is evident in the marked increase in passenger accommodations of the second generation propellers.[6]

Although *Indiana* and her contemporaries were well-appointed for general service in both the passenger and freight trades, the establishment of continuous rail service between the eastern seaboard and Chicago in 1852, the economic depression that accompanied the financial Panic of 1857, and a dramatic reduction in emigration to the United States, brought the steamboats' formerly profitable lake passenger trade to an abrupt end by the late 1850s.[7] Consequently, the large, already-obsolete, first-class sidewheel steamers quickly diminished in number, while most propellers were relegated to carrying freight. The stock of propeller tonnage grew faster than did the stock of shipping tonnage as a whole, indicating propellers were playing a greater, although less independent, role in the shipping of the lakes by the late-1850s.

Indiana's employment by the New York & Erie Railroad and the carriage of a bulk cargo of iron-ore on its final voyage were harbingers of screw propulsion's future on the lakes. The rise in the stock in propeller tonnage was largely due to the increased use of propellers by the railroads to maintain a competitive advantage over other rail lines that provided service from the eastern seaboard to Chicago. The opening of the Lake Superior iron-ore trade in 1855 created a need for larger, stronger propellers with reinforced hulls that were purpose-built for the bulk-freight trades. By the middle to late 1850s, many of the propellers that were being constructed were in excess of 600 tons or nearly twice as large as *Indiana*. Thus, within seven years of its construction, *Indiana* was already becoming obsolete.

Indiana's operational history reflects important trends and shifts in the Great Lakes economy and commerce. Archaeological study of *Indiana*'s remains has revealed some of the significant morphological changes that occurred in the design of early Great Lakes propellers built between 1841 and 1855. Constructed during the most dynamic period of improvement and experimentation in early screw propulsion technology, *Indiana* exhibits a unique combination of old and new design and construction features that set it apart from the first generation of propellers. However, the same characteristics that set *Indiana* apart also contributed to its obsolescence and may have been partially responsible for *Indiana*'s premature demise.[8]

The historical and archaeological documentation of *Indiana* provides the first detailed record of the career and construction of an early Great Lakes propeller of *Indiana*'s age and type. This information will provide a useful comparative example for future research on similar vessels. Although *Indiana*'s career as a transporter of passengers and freight ended long ago, the vessel continues to move those who have been fortunate enough to stand on the deeply-submerged remains of *Indiana*'s ore-covered deck and imagine what it would have been like to have traveled on board this remarkable craft.

Notes: Chapter VI

1. James L. Barton, Commerce of the Lakes. *A Brief Sketch of the Commerce of the Great Northern and Western Lakes for a Series of Years; to Which is Added, an Account of the Business Done Through Buffalo on the Erie Canal, for the Years 1845 and 1846. Also, Remarks as to the True Canal Policy of the State of New York* (Buffalo, NY, 1847), 6, 7; Israel D. Andrews, *Report on the Trade and Commerce of the British North American Colonies and Upon the Trade of the Great Lakes and Rivers* (Washington, DC, 1853), 4.

2. Andrews, *ibid.*, 46; James L. Barton, *Lake Commerce. Letter to the Hon. Robert McClelland Chairman of the Committee on Commerce, in the U.S. House of Representatives in Relation to the Value and Importance of Commerce of the Great Western Lakes* (Buffalo, NY, 1846), 18; William Cronon, *Nature's Metropolis: Chicago and the Great West* (New York, NY, 1991), 29, 110; George Brown Tindall, *America: A Narrative History* (New York, NY, 1984), 452, 453; Douglass C. North, *The Economic Growth of the United States, 1790-1860* (Englewood Cliffs, NJ, 1961), 245; Marvin A. Rapp, *The Port of Buffalo, 1825-1880* (Durham, NC, Duke University, unpublished dissertation, 1947), 25.

3. Daniel J. Lenihan, ed., *Submerged Cultural Resources Study Isle Royale National Park* (Santa Fe, NM, 1987) 50-56.

4. *Ibid.*; H. A. Musham, "Early Great Lakes Steamboats: The First Propellers, 1841-1845," *American Neptune*, vol. 17 (April 1957), 89-106; Dohrmann, *ibid.*, 80-136.

5. Dohrmann, *ibid.*, 8-17.

6. Lenihan, *ibid.*, 53.

7. *Ibid.*, 37, 55.

8. *Indiana*'s greater hull length, long and fine run, overhanging elliptical stern, upper works, primitive truss, forward placement of the engine, larger engine size, and Loper propeller represented significant improvements over the first generation of Great Lakes propellers, which had comparatively smaller hulls with relatively short runs, little or no upper works, transom sterns, and Ericsson propellers powered by smaller and weaker engines that were positioned in the aftermost portion of their hulls. Such improvements led to a rapid increase in the size and cargo capacity of Great Lakes vessels, particularly screw-propelled vessels, after circa 1845. This trend continued. By the time *Indiana* was five years old, its hull was significantly smaller than those of most of the new propellers in operation on the lakes. While some features of *Indiana*'s hull were innovational for the late 1840s, they may have produced unforeseen negative concomitant secondary effects on the hull. For example, although *Indiana*'s long fine run would have improved the action of its propeller, it would have also reduced the stern's buoyancy and possibly caused *Indiana*'s after end to droop. Furthermore, the weight of *Indiana*'s overhanging elliptical stern would, presumably, have exacerbated this tendency. Although *Indiana*'s upper works would have enhanced its suitability for carriage of passengers, it would have been an unnecessary encumbrance for carrying heavy bulk cargoes such as iron ore. *Indiana*'s hull appears to have been fitted with a truss, but was a very rudimentary one in comparison with the heavier and more extensive trusses of similarly-sized propellers dating from the mid-1850s. The placement of *Indiana*'s engine, positioned relatively far forward in its hull, allowed for a long, fine run, but required extending significantly the length of the propeller shaft, thus making it far more vulnerable to damages resulting from flexion of the hull. Although *Indiana*'s composite construction wrought- and cast-iron model of the Loper propeller was a significant improvement over its Ericsson-designed predecessor, it was out-moded by yet another improved Loper-designed propeller, produced in 1852, just four years after *Indiana* was built.

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APPENDIX A

PARTIAL INVENTORY OF CARGOES CARRIED ANNUALLY BY *INDIANA*

CARGO/YEAR	1848	1849	1850	1851	1852	1853	1854	1855	1856	1857	1858
ALCOHOL (Barrels)									8		
ALE (Barrels)								9			
APPLES, DRIED (Sacks)									20		
ASHES (Casks)	82	123		149	27	261		51	53		
BACON (Barrels)						3		3	34		
BACON (Casks)											
BACON (Hogsheads)									2		
BALANCES (Boxes)					3						
BARRELS				66				19			
BEANS (Barrels)						15					15
BEEF (Barrels)	70	248				216		5			
BEEF, ICED (Barrels)						452					
BEER (Barrels)								1,900			
BLOCKS								197			

CARGO/YEAR	1848	1849	1850	1851	1852	1853	1854	1855	1856	1857	1858
BOOKS (Boxes)						22					
BOXES								55			
BRISKET (Barrels)						29					
BUTTER (Barrels)	2	4						2			
BUTTER (Kegs)	44			105	4	68		71	727		
CANDLES (Box)										1	
CANDY (Boxes)									9		
CASKS	1							2			
CASTINGS (Bundles)					35						
CASTINGS (Boxes)	3										
CASTINGS (Pieces)					294						
CHAIRS, RAILROAD					2,240						
COAL (Barrels)					3						
COAL, BULK (Tons)								254			
COAL TAR									62		
COFFEE (Bags)					28						
COFFIN BOTTOMS						400					

CARGO/YEAR	1848	1849	1850	1851	1852	1853	1854	1855	1856	1857	1858
COFFIN STUFFING (Boxes)						145					
COPPER (Sheets)									26		
COPPER ORE, BULK (Tons)							79.45				
DOOR SHIMS (Barrels)					26						
DOOR SHIMS (Boxes)					1,400						
EGGS (Barrels)					16	1		2	479		
EGGS (Kegs)								1			
FISH (Barrels)	129								135		
FISH (Pounds)										507	
FISHING POLES (Bundles)									40		
FLAX (Bales)									19		
FLAX SEED (Bags)								331			
FLOUR (Barrels)	11,329	8,948		14,120	16,544	12,460		16,105	55,029		480
FRUIT (Boxes)					8						
FRUIT (Packages)					32						

CARGO/YEAR	1848	1849	1850	1851	1852	1853	1854	1855	1856	1857	1858
FURNITURE, BULK (Boxes)					10						
FURS (Packages)					15						
GLASS (Boxes)					134			1	48		
GLASS (Packages)									210		
GOODS (Boxes)					2				9		
GREASE (Barrels)									9		
GRINDSTONES									25		
GRINDSTONES (Tons)									27		
HAIR (Bales)					27	9			48		
HAIR (Sacks)						145					
HAM (Barrels)						45		4	10		
HAM (Pieces)								206	16		
HAM SHOULDERS (Pieces)								120			
HAM SHOULDERS (Barrels)								26			
HARDWARE (Boxes)					7						
HARDWARE (Barrels)					12						
HARDWARE (Packages)					77						
HEMP (Bales)	6			26							

CARGO/YEAR	1848	1849	1850	1851	1852	1853	1854	1855	1856	1857	1858
HIDES	74	447		63	249	2,403		104	531		
HIDES (Bundles)	2							10			
HIDES, GREEN						600					
HOGS, LIVE		400		180	91	188		1,669	618		
INSTRUMENTS (Boxes)					17						
IRON (Bars)					32				16		
IRON (Bundles)					14			78	1,379		
IRON, GALVANIZED					2						
IRON ORE , BULK (Tons)							307.80				
IRON, PIG, BULK (Tons)									25		
IRON, SCRAP (Casks)									8		
JACK SCREW								1			
LARD (Barrels)		600				17		224	659		
LARD (Kegs)	8				530			73	52		
LEATHER (Rolls)	13			3	40	38					
MACHINERY (Pieces)					3						
MACHINERY (Tons)						15					
MARBLE (Pieces)					5						

CARGO/YEAR	1848	1849	1850	1851	1852	1853	1854	1855	1856	1857	1858
MATS (Bales)								17			
MEAL (Barrels)									580		
MELONS (Casks)									8		
MELONS (Hogsheads)									4		
MERCHANDISE (Boxes)					2	3		12	3		
MERCHANDISE (Pounds)									11,640		
MERCHANDISE (Packages)						6,609		765			
MERCHANDISE (Tons)				80					577	602	
MINERALS (Boxes)		4									
NAILS (Kegs)									60		
NUTS (Barrels)						1		1			
OATS (Bushels)	1,800	760		14,604		2,108		23,491			
OIL (Barrels)					65	74		12	353		
OIL SALT								286			
PAINT (Barrels)				8							
PAPER (Bundles)						15		36	22		
PEACHES (Barrel)						1					
PELTS (Bales)					8						
PELTS (Barrels)		8									

CARGO/YEAR	1848	1849	1850	1851	1852	1853	1854	1855	1856	1857	1858
PELTS (Bundles)						15		36			
PLATES, SAUCE									60		
PORK (Barrels)	306	15				580		990	495		
PORK (Casks)				3							
POTATOES (Bags)								545			150
POTATOES (Barrels)								3			
POTATOES (Bushels)	110	13		260	20						
POTATOES (Sacks)					12						
PRODUCE (Box)								1			
RAGS (Bales)				348							
RIFLE, BARRELS (Box)					1						
RUMPS, (Barrels)									68		
RYE (Bags)								18	812		
SAFE, IRON					1						
SALT (Barrels)	398										
SEED (Bags)								15	146		
SEED (Bundles)					12						
SEED (Barrels)		23				3		8	28		
SEED (Casks)									76		
SEED, TIMOTHY								65			

CARGO/YEAR	1848	1849	1850	1851	1852	1853	1854	1855	1856	1857	1858
SHEEP						99					
SHOES (Boxes)					116						
SHOULDERS (Barrels)						2			25		
SHOULDERS (Casks)									10		
SKINS						55					
SKINS (Bales)									33		
SKINS (Bundles)	2	1			1						
SODA ASH (Barrels)					2						
SOFA					1						
STARCH (Boxes)									3,343		
SUGAR (Barrels)		111							2		
TALLOW		65				84		1	10		
THRESHING MACHINE						1					
TIN (Boxes)					42						
TOBACCO (Barrels)									1		
TOBACCO (Boxes)					73	45					
TOBACCO (Butts)									20		
TOBACCO (Hogsheads)									29		
TOBACCO (Packages)									10		

CARGO/YEAR	1848	1849	1850	1851	1852	1853	1854	1855	1856	1857	1858
TRUNKS				2							
VARNISH (Barrels)						4					
VEGETABLES (Barrels)									5		
VEGETABLES (Boxes)									2		
VENISON (Box)								1			
WAGONS					3						
WALKING BEAM (For Steam Engine)	1										
WAX (Barrels)						2		8	1		
WAX (Casks)	2										
WAX (Sacks)								4			
WHEAT (Bags)								905			
WHEAT (Bushels)	14,850	4,798		8,260	96,017	86,400		25,484			2,500
WHISKEY (Barrels)				150	120	120		1,112	1,896		
WINE (Barrels)									6		
WINE (Casks)								25			
WINES, HIGH (Casks)		38									
WOOL (Bales)	225	3		334	485	208		152	524		
WOOL (Sacks)								1			

APPENDIX B

RESULTS OF WOOD, PAINT, AND "CAULKING" ANALYSES

In the following appendix are presented the results from the analyses of samples of wood, paint, and a material originally believed to be caulking that were recovered from *Indiana*'s hull during the 1991-1993 field investigations. These analyses were completed by researchers from the Center for Wood Anatomy Research, U.S. Forest Products Laboratory, Madison, Wisconsin, and the Conservation Analytical Laboratory, Smithsonian Institution, Washington, D.C.

1991 WOOD SAMPLES ANALYSES REPORT

NAUTICAL ARCHAEOLOGY PROGRAM
DEPARTMENT OF ANTHROPOLOGY
Texas A&M University
College Station, Texas 77843-4352
(409) 845-6398 Tele.
(409) 845-6399 FAX

Dec. 6, 1991

Donna Christianson
Center for Wood Anatomy Research
Forest Products Laboratory
One Gifford Pinchot Drive
Madison, WI 53705-2398

Dear Ms. Christianson,

Please find enclosed 8 wood samples that I hope you might be able to identify for me. These samples were taken from a mid-19th century shipwreck in Lake Superior, Michigan.

The samples are labeled numerically on the side of each film canister. I have enclosed a sheet for you to fill in accordingly. If it is possible, I would like to have the samples returned to me. Please feel free to forward any postage charges to me.

Thank you very much for your time and effort. Your prompt attention to this matter will be greatly appreciated.

Sincerely,

David S. Robinson
Masters Candidate
Nautical Archaeology Program
Texas A&M University

See identifications as shown on attached list. Samples are returned within as requested.

***INDIANA* WOOD SAMPLES**
(from 1991 field season)

Sample Number	Wood Type
STEM — I-91-A	oak (Quercus) of the white oak group
PLANKING — I-91-B	oak (Quercus) of the white oak group
FRAME — I-91-C	oak (Quercus) of the white oak group
CEILING — I-91-D	oak (Quercus) of the white oak group
DECK BEAM — I-91-E	oak (Quercus) of the white oak group
KEEL — I-91-F	oak (Quercus) of the white oak group
DECKING — I-91-G	pine (Pinus) of the white pine group
STERN POST — I-91-H	oak (Quercus) of the white oak group.

IDENTIFIED BY Donna J Christensen
3/31/92
Center For Wood Anatomy Research
U. S. Forest Products Laboratory
Madison, WI 53705

1992 WOOD SAMPLES ANALYSES REPORT

1992 WOOD SAMPLES FROM INDIANA SHIPWRECK

Return To:

DR. PAUL F. JOHNSTON
NMAH-5010/MRC 628
SMITHSONIAN INSTITUTION
WASHINGTON, DC 20560

SAMPLE IDENTIFICATION	WOOD TYPE
(1) Sampson Post ✓	White Oak Group
(2) Dagger Knee ✓	White Oak Group
(3) Starboard Bulwark Frame ✓	White Oak Group
(4) Starboard Bulwark Tongue & Groove ✓	White Pine Group
(5) Sponson Frame	White Oak Group
(6) Sponson Planking ✓	White Oak Group

IDENTIFIED BY
Center For Wood Anatomy Research
U. S. Forest Products Laboratory
Madison, WI 53705

Harry A. Alden
11/16/92

1993 WOOD SAMPLES ANALYSES REPORT

CONSERVATION ANALYTICAL LABORATORY
SMITHSONIAN INSTITUTION WASHINGTON D.C. 20560-0001

WOOD ANALYSIS REPORT (1993 INDIANA Samples)

CAL #: 5447
OBJECT: twenty-three wood specimens
ACCESSION #:
RESPONSIBLE DIV, DEPT, PERSON: NMAH, Div. Trans.,Cur. Maritime History, Paul Johnston
EXAMINING CONSERVATOR: Melvin J. Wachowiak, Jr.
DATE OF EXAMINATION: complete 3 March 1994

ANALYSIS: WHITE OAK GROUP (samples 1-23, inclusive)

Family: *Fagaceae*
Genus: *Quercus*
Species Group: *Leucobalanus*
Species: *not scientifically possible at this time*
(see discussion below)

GROSS FEATURES: porous, conspicuous growth rings, abrupt transition from early-wood to late-wood (ring-porous), very wide rays

MICROSCOPIC FEATURES:

VESSELS: solitary pores, tyloses abundant, mean tangential diameter=)200μ, latewood pores in radial arrangement, latewood pores small, thick-walled and irregularly shaped
RAYS: two sizes: uniseriate and very wide (+10-seriate), homocellular
PARENCHYMA: apotracheal, uniseriate banded in latewood

DISCUSSION:
Oak species are the most abundant in the U.S., and among the most widespread. The species of the White Oak Group cannot be separated on the basis of their anatomy.

Each sample was examined macroscopically and microscopically. After removal from water as received, the samples were placed in isopropanol solution in individual jars. This may prevent degradation which would continue in water.

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SAMPLE LOCATION	WOOD TYPE
1. Keel	WHITE OAK GROUP
2. Aft edge, aft opening hatch coaming	WHITE OAK GROUP
3. Stbd. #1 Counter knee	WHITE OAK GROUP
4. Aft port boiler opening deck beam stanchion	WHITE OAK GROUP
5. Stbd. #1 Counter knee	WHITE OAK GROUP
6. Port stern, top: clamp	WHITE OAK GROUP
7. Fantail stanchion	WHITE OAK GROUP
8. Fantail rail	WHITE OAK GROUP
9. Fantail cleat	WHITE OAK GROUP
10. Stbd. frame #78: chock between deck beams	WHITE OAK GROUP
11. Stbd. frame #38 floor heavily degraded	WHITE OAK GROUP
12. Frame futtock	WHITE OAK GROUP
13. Middle breast hook short rays; sapwood degraded	WHITE OAK GROUP
14. Bottom Breast hook degradation not related to heartwood zone	WHITE OAK GROUP
15. Top breast hook	WHITE OAK GROUP
16. Windlass bitt	WHITE OAK GROUP
17. Portside stem deadwood slow growth, many small knots; juvenile heart, branch or sapling possible	WHITE OAK GROUP
18. Inner stem	WHITE OAK GROUP
19. Outer stem	WHITE OAK GROUP
20. Inner sternpost	WHITE OAK GROUP
22. Port aft deck beam very slow growth	WHITE OAK GROUP

?

ATTACHMENT: PRINT-OUT OF COMPUTERIZED WOOD ANALYSIS

```
---------------------------------------------------------------------
unknown #  1 - CAL5447.17
number of misses allowed =   0
search of NORTH AMERICAN HARDWOODS =**->    1 possible IDs found

 definition of this unknown :

   6 Perforations Simple * present *
  14 Tyloses Abundant * present *
  22 Mean T.D. > 200 um * present *
  33 Rays 2 Distinct Widths * present *
  34 Rays Homogeneous * present *
  45 Predom. Apotracheal * present *
  51 Banded Parenchyma * present *
  85 Ring Porous * present *

.....................................................................

possible IDs follow:

FAG QUERCUS (WHITE OAKS-LATEWOOD PORES ANGULAR,VERY SMALL)

   1 Exclusively Solitary
   3 Radial or Oblique
   6 Perforations Simple
  14 Tyloses Abundant
  22 Mean T.D. > 200 um
  24 Thick Walled Fibers
  26 Tracheids
  28 Commonly > 1mm High
  31 Commonly > 10-Seriate
  33 Rays 2 Distinct Widths
  34 Rays Homogeneous
  43 Commonly > 12/mm
  44 Pits to Vessels Large
  45 Predom. Apotracheal
  46 Diffuse
  48 Vasicentric
  51 Banded Parenchyma
  52 Bands 1-Seriate
  62 Crystals - Chambered Cells
  80 North America
  84 Growth Rings Present
  85 Ring Porous
  87 Straw / Light Brown
  88 Dark Brown
```

45 Predom. Apotracheal
46 Diffuse
48 Vasicentric
51 Banded Parenchyma
52 Bands 1-Seriate
54 Bands >= 6/mm
62 Crystals - Chambered Cells
80 North America
84 Growth Rings Present
85 Ring Porous
87 Straw / Light Brown
89 Red / Pink / Purple

FAG QUERCUS (WHITE OAKS-LATEWOOD PORES ANGULAR,VERY SMALL)

1 Exclusively Solitary
3 Radial or Oblique
6 Perforations Simple
14 Tyloses Abundant
22 Mean T.D. > 200 um
24 Thick Walled Fibers
26 Tracheids
28 Commonly > 1mm High
31 Commonly > 10-Seriate
33 Rays 2 Distinct Widths
34 Rays Homogeneous
43 Commonly > 12/mm
44 Pits to Vessels Large
45 Predom. Apotracheal
46 Diffuse
48 Vasicentric
51 Banded Parenchyma
52 Bands 1-Seriate
62 Crystals - Chambered Cells
80 North America
84 Growth Rings Present
85 Ring Porous
87 Straw / Light Brown
88 Dark Brown

1992 PAINT SAMPLES ANALYSES REPORT

SMITHSONIAN INSTITUTION

CONSERVATION ANALYTICAL LABORATORY

Museum Support Center - Washington, D.C. 20560

PHONE (301) 238-3077
FAX (301) 238-3709

December 7, 1992

Dear Dr. Johnston:

Enclosed are the Scanning Electron Microscopy/Energy Dispersive Analysis (SEM/EDA), Fourier Transform Infrared (FT-IR), X-ray Diffraction (XRD), and Gas Chromatography (GC) results for the Indiana samples. Due to construction in the laboratory, fiber analysis will be done at a later date. The analyses indicate that the white paint from the hull contains lead carbonate [$Pb_3(CO)_2$], barite, barium sulfate [$BaSO_4$] and a drying oil; the caulking contains lead carbonate [$Pb_3(CO)_2$], barite [$BaSO_4$], quartz [SiO_2] and a drying oil; and the green paint coaming contains barite [$BaSO_4$], quartz [SiO_2], lead carbonate [$Pb_3(CO)_2$], lead chromate [$PbCrO_4$] mixed with prussian blue {$Fe_4[Fe(CN)_6]_3$} to give chrome green, and possibly arsenic as emerald green [$Cu(C_2H_3O_2)_2 \cdot 3Cu(AsO_2)_2$], copper oxalate [$CuC_2O_4$], and a drying oil.

If you have any questions regarding any of the analyses, please do not hesitate to give Dr. Charles S. Tumosa a call at 301-238-3019. Thank you very much for your patience.

Sincerely,

Camie S. Campbell

1992 "CAULKING" SAMPLE ANALYSES REPORT

SMITHSONIAN INSTITUTION

CONSERVATION ANALYTICAL LABORATORY

Museum Support Center · Washington, D.C. 20560

PHONE (301) 238-3077
FAX (301) 238-3709

April 26, 1993

Dear Dr. Johnston:

Enclosed you shall find the fiber analysis for the ship's, **Indiana**, caulking. Please forgive the delay. As I stated, renovation of the furniture laboratory caused the delay.

If you have any questions regarding any of the analyses, please do not hesitate to give Dr. Charles S. Tumosa a call at 301-238-3019. Thank you very much for your patience.

Sincerely,

Camie S. Campbell

EXAMINATION AND TREATMENT PROPOSAL

FURNITURE CONSERVATION
CONSERVATION ANALYTICAL LABORATORY
SMITHSONIAN INSTITUTION

CAL # 5395
OBJECT: ship's caulking, *Indiana*
FABRICATOR: built in Vermillion, OH
DATE/PERIOD: circa 1848
PRIMARY MATERIALS: unknown (see CAL Analytical Services Group report)
RESPONSIBLE DIV, DEPT, PERSON: NMAH, Transportation, Maritime History, Paul F. Johnson
OWNER: Smithsonian Institution
EXAMINING CONSERVATOR: Melvin J. Wachowiak, Jr.
DATE OF EXAMINATION: 18 April 1993

DESCRIPTION

STRUCTURE:
These samples display the same basic morphology. The whitish matrix is aligned along a longitudinal axis. Cross-sections show a layered structure, though not quite concentrically arrayed. There is no indication of whether the layers were all formed during a single fabrication process, or multi-step, or subsequent repairs.

Ultra-violet light microscopy (UVM) indicates distinct zones of auto-fluorescence. The presence of organic binder is the most likely reason for the auto-fluorescence.

Several samples were examined using the stereo microscope. Samples were selected by three methods. 1) After all contents of the sample container were briefly examined under the stereo microscope, those samples exhibiting fibers on them were segregated. These fibers were removed from the matrix and examined using a compound microscope at up to 400X magnified.

2) Fragments were selected at random, broken open and examined under magnification for presence for fibers. None were found by this method.

3) Fragments were selected at random, embedded and examined under magnification for presence for fibers. These samples were embedded in polyester resin and polished with abrasive to produce a flat cross-section. Of the four samples embedded, only one held fibers (two).

Fibers were not found in abundance. Those found were of several types, including wood and other plant, and possibly hair. Fibers were not found in appreciable aggregate in any of the samples.

SURFACE:

The surface of the fragments were often darker than the interior, and sometimes coated with some type of fiber. Because these fibers are on the exterior of fragments, it is assumed that they became attached after fabrication--and more likely, after the sinking.

DISCUSSION

The request for services was for identification of fibers used in the caulking. During the course of this investigation, no systematic distribution of fibers in the matrix was observed. It is difficult to imagine that the matrix would not serve to protect the interior, especially given the good state of preservation of the fibers found. This does not mean that they were never present, however.

The search for fibers was both systematic and random, but fibers were rarely encountered. The caulking in this case may have been a putty without fibers.

VITA

David Stewart Robinson received his Bachelor of Arts degree with honors in Anthropology and Art Studio from the University of Rhode Island in 1990. Upon completion of his graduate coursework at Texas A&M University in 1992, Mr. Robinson was employed as an archaeological consultant by the Lake Champlain Maritime Museum (LCMM), at Basin Harbor, Vermont, and then by R. Christopher Goodwin & Associates, Inc. (RCGA), a Frederick, Maryland-based cultural resources management firm. In 1993, Mr. Robinson became a full-time associate with RCGA and in 1997 was appointed Director of the firm's Nautical Archaeology Division. Between 1995-1998, he served also as RCGA's Diving Safety Officer and Director of Conservation. In 1998, Mr. Robinson returned to the LCMM, where he is the Department Head of the LCMM's Nautical Archaeology Program and Director of the LCMM's conservation laboratory. Mr. Robinson may be reached at 456 Round Barn Road, Ferrisburgh, Vermont, 05456.