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New York District

ASSESSMENT OF POTENTIAL WRECK IN AMBROSE CHANNEL TO DETERMINE HISTORIC SIGNIFICANCE AND UNDERTAKE SELECTED RECORDATION OF REMAINS ENCOUNTERED IN CONNECTION WITH THE NEW YORK AND NEW JERSEY HARBOR NAVIGATION PROJECT

PREPARED FOR:

U.S. Army Corps of Engineers
New York District
New York, New York

UNDER SUBCONTRACT TO:

Great Lakes Dredge
and Dock, Inc.
Oak Brook, Illinois

PREPARED BY:

Panamerican Consultants, Inc.
Memphis, Tennessee

1082

FINAL REPORT

APRIL 2008

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Authored by:
Andrew Lydecker

Prepared for:
U.S. Army Corps of Engineers, New York District

**Contract No. W912DS-05-C-0018
Mod A00001, R0002**

Under Subcontract to:
**Great Lakes Dock and Dredge Co.
2122 York Road
Oak Brook, Illinois 60523**

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APRIL 2008

ABSTRACT

From May 1–3, 2007, Panamerican Consultants, Inc., of Memphis, Tennessee, under subcontract to Great Lakes Dredge and Dock, performed an archaeological investigation of a potential wreck site in Ambrose Channel, New York Harbor. The investigation was undertaken in response to the Scope of Work entitled *Scope of Work to Dive at Potential Wreck in Ambrose Channel to Determine Historic Significance and Undertake Selected Recordation of Remains Encountered In Connection with the New York and New Jersey Harbor Navigation Study* and conducted under Contract W912DS-05-C-0018, Mod A00001, R0002. It was performed in accordance with Section 106 of the Historic Preservation Act of 1966 as amended through 1992, and the Advisory Council on Historic Preservation Guidelines for the Protection of Cultural and Historic Properties (36 CFR 800).

In 2006, during preparations for dredging the Ambrose Channel, hydrographic data revealed the presence of what appeared to be a wreck on the edge of the channel. Multi-beam bathymetry revealed a significant mass of material extending from the upper edge of the channel slope to approximately 300 feet into the channel. Diver investigations revealed the presence of articulated iron plating. Preliminary assessment suggested this site to be the RMS *Fort Victoria*, sunk in 1929 after a collision with the SS *Algonquin*.

The purpose of the investigation was threefold. First, the site was examined using sidescan sonar, magnetometer, and subbottom profiler to determine the full extent of the site, including the location of any potential buried or separated sections of wreckage that may be in the vicinity. Second, the site was examined by divers from RanDive equipped with high-resolution video to examine areas determined from the remote sensing data to contain articulated structure. Third, historic background research was undertaken to determine the likelihood the vessel represents the Fort Victoria and to assess the site for historical significance.

The remote sensing survey identified and recorded the site in data from all three sensors. Remote sensing data revealed the presence of articulated wreckage extending in a north-northeast to south-southwest direction, with a large amount of disarticulated wreckage in the southern 1/3 of the site. Wreckage appears to be confined to the wreck site proper, with no large sections separate from the wreck apparent in the sidescan, magnetic, or seismic data. Three areas were chosen for diver investigation based on the remote sensing data, including two sections of articulated wreckage and one area of disarticulated wreckage. Investigations of the articulated sections of the wreck revealed it likely to be hull components of an iron or steel hulled vessel with overlapping riveted hull plating and Z-bar framing, indicating a construction date of late nineteenth century to early twentieth century. The remaining hull section appears to represent a side of the vessel, and is fairly well intact from the gunwale to the turn of the bilge. It remains undetermined which direction the bow and stern are oriented. The investigation of the disarticulated section of the wreck revealed the presence of large amounts of jumbled and twisted iron sections, with little or no discernible structure. A large amount of artifactual material was observed in this area, including bottles and bottle fragments, china, porcelain, and stoneware—several specimens were recovered for diagnostic and identification purposes, including pieces of identifiable First Class china service.

Determinations based on examination of the historical background, remote sensing data, visual inspection, and analysis of diagnostic artifacts indicate that the wreck site in question represents a late-nineteenth-century or early-twentieth-century passenger vessel with a riveted steel hull. Wreck database analysis indicates the only vessel of this type within a 5-mile radius of the current project site is the RMS *Fort Victoria*.

The RMS *Fort Victoria* is representative of the apex of riveted steel-hulled steamships. The wreck of the *Fort Victoria* is also likely to yield historical information regarding shipboard life in the early "Golden Age" of ocean-going passenger liners through study of the portable artifacts. However, several factors diminish its value with respect to American history. First, the value of the vessel as a historic resource is diminished significantly due the factors surrounding the development of its current state, including having been blasted and wire-dragged as a hazard to navigation. As well, the RMS *Fort Victoria* is a British vessel of Scottish construction, and not significantly linked with events in American history. These, combined with its location in an active navigation channel, do not justify the expense of additional investigations. The site is therefore not considered eligible for listing on the National Register of Historic Places.

ACKNOWLEDGEMENTS

A number of people and organizations played major roles in the completion of this project. The author would like to thank Great Lakes Dredge and Dock and the U.S. Army Corps of Engineers for the opportunity to conduct this research, specifically Lynn Neitfeld, Chris Gunsten, and Johan Von Bladel. The folks at Miller Launch and the crews of the *Marquerite Miller* and *Sorenson Miller* deserve thanks for the use of their well-kept vessels and excellent crews and boat handling. RanDive and the project dive crew are thanked for their hard and invaluable work in providing dive services for the project. Survey Equipment Services provided the subbottom profiler equipment, and Marine Sonic Technology is thanked for the loan of a sidescan sonar towfish. Panamerican personnel to be thanked are the field crew, including Andy Lydecker and Michael Faught, along with in-house personnel Kate Gilow and Jessie Flanders for report editing and preparation.

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1. INTRODUCTION

From May 1–3, 2007, Panamerican Consultants, Inc, of Memphis, Tennessee, under subcontract to Great Lakes Dredge and Dock, performed an archaeological investigation of a potential wreck site in Ambrose Channel, New York Harbor. The investigation was undertaken in response to the Scope of Work entitled *Scope of Work to Dive at Potential Wreck in Ambrose Channel to Determine Historic Significance and Undertake Selected Recordation of Remains Encountered In Connection with the New York and New Jersey Harbor Navigation Study* and conducted under Contract W912DS-05-C-0018, Mod A00001, R0002. It was performed in accordance with Section 106 of the Historic Preservation Act of 1966 as amended through 1992, and the Advisory Council on Historic Preservation Guidelines for the Protection of Cultural and Historic Properties (36 CFR 800).

PURPOSE OF THE PROJECT

In 2006, during preparations for dredging the Ambrose Channel, hydrographic data revealed the presence of what appeared to be a wreck on the edge of the channel (Figure 1-01). Multi-beam bathymetry revealed a significant mass of material extending from the upper edge of the channel slope to approximately 300 feet into the channel (Figure 1-02). Diver investigations revealed the presence of articulated iron plating. Preliminary assessment suggested this site to be the RMS *Fort Victoria*, sunk in 1929 after a collision with the SS *Algonquin*.

The purpose of the investigation was threefold. First, the site was examined using sidescan sonar, magnetometer, and subbottom profiler to determine the full extent of the site, including the location of any potential buried or separated sections of wreckage that may be in the vicinity. Second, the site was examined by divers from RanDive equipped with high-resolution video to examine areas determined from the remote sensing data to contain articulated structure. Third, historic background research was undertaken to determine the likelihood the vessel represents the Fort Victoria and to assess the site for historical significance.

The survey was accomplished using the survey vessel *Marguerite Miller* and the dive vessel *Sorenson Miller*. Instrumentation included a Marine Magnetics SeaSpy marine magnetometer, a Marine Sonic Technology sidescan sonar, and an Edgetech SB-424 subbottom profiler. Navigational capabilities were provided by a Trimble GPS receiver coupled with Hypack navigation software.

PROJECT FINDINGS

The remote sensing survey identified and recorded the site in data from all three sensors. Remote sensing data revealed the presence of articulated wreckage extending in a north-northeast to south-southwest direction, with a large amount of disarticulated wreckage in the southern 1/3 of the site. Wreckage appears to be confined to the wreck site proper, with no large sections separate from the wreck apparent in the sidescan, magnetic, or seismic data. Three areas were chosen for diver investigation based on the remote sensing data, including two sections of articulated wreckage and one area of disarticulated wreckage. Investigations of the articulated sections of the wreck revealed it to likely be hull components of an iron- or steel-hulled vessel with overlapping riveted hull plating and Z-bar framing, indicating a construction date of late nineteenth century to the early twentieth century. The remaining hull section appears to represent a side of the vessel, and is fairly well intact from the gunwale to the turn of the bilge. It remains undetermined which direction the bow and stern are oriented. The investigation of the disarticulated section of the wreck revealed the presence of large amounts of jumbled and twisted iron section, with little or no discernible structure. A large amount of artifactual material was observed in this area, including bottles and bottle fragments, china, porcelain, and stoneware—

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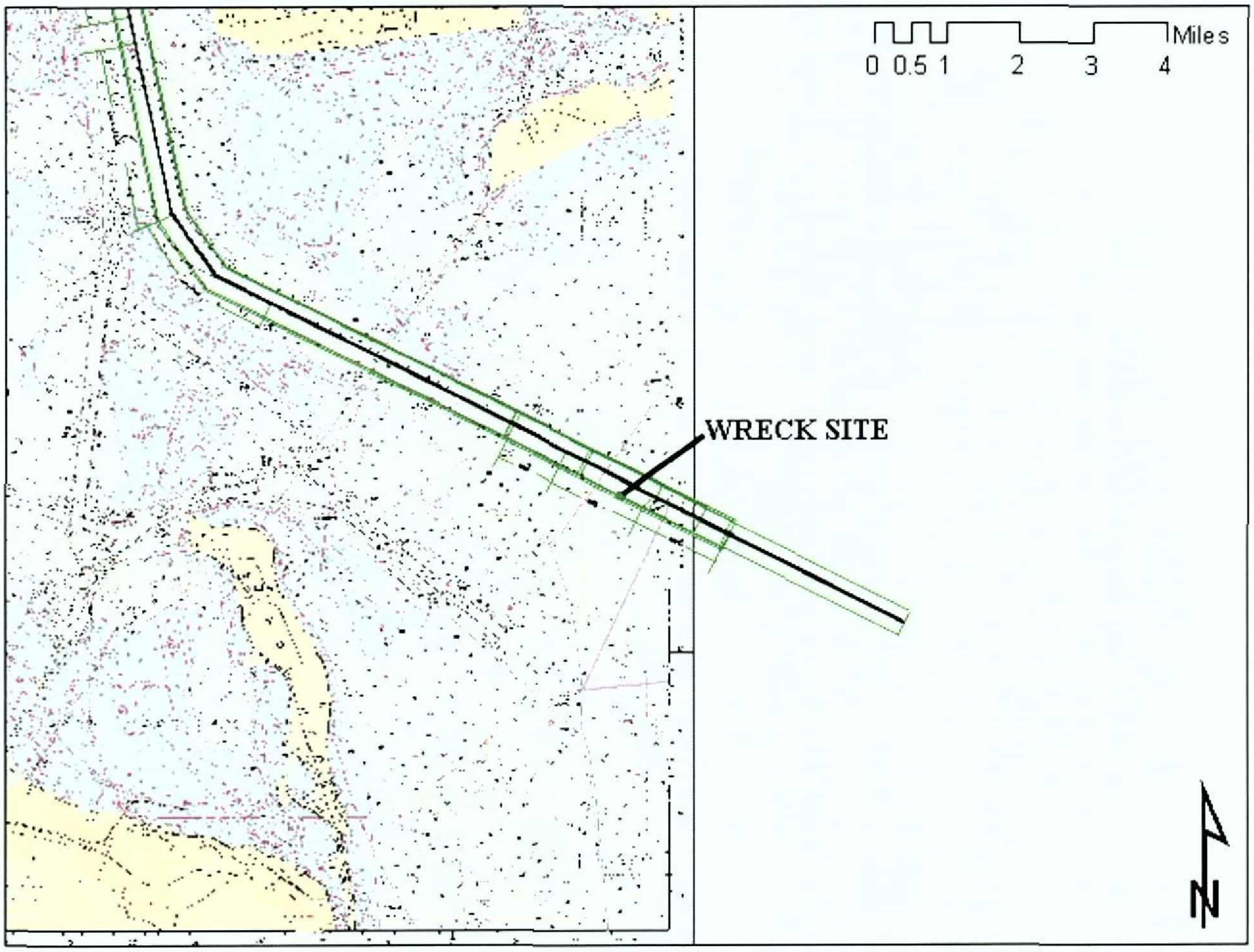


Figure 1-01. Project area.

Conclusions and Recommendations

Determinations based on examination of the historical background, remote sensing data, visual inspection, and analysis of diagnostic artifacts indicate that the wreck site in question represents a late-nineteenth-century or early-twentieth-century passenger vessel with a riveted steel hull. Wreck database analysis indicates the only vessel of this type within a 5-mile radius of the current project site is the RMS *Fort Victoria*.

The RMS *Fort Victoria* is representative of the apex of riveted steel-hulled steamships. The wreck of the *Fort Victoria* is also likely to yield historical information regarding shipboard life in the early "Golden Age" of ocean-going passenger liners through study of the portable artifacts. However, several factors diminish its value with respect to American history. First, the value of the vessel as a historic resource is diminished significantly due the factors surrounding the development of its current state, including having been blasted and wire-dragged as a hazard to navigation. As well, the RMS *Fort Victoria* is a British vessel of Scottish construction, and not significantly linked with events in American history. These, combined with its location in an active navigation channel, do not justify the expense of additional investigations. The site is therefore not considered eligible for listing on the National Register of Historic Places.

Normally, properties found potentially eligible, eligible, or listed on the NRHP must be considered within the framework of the proposed action. Relative to the assessment of project effect, it is quite clear that the *Fort Victoria* wreck site will be adversely affected by the current dredging activities. Usually, avoidance by project impacts on any historic property is the best preservative measure for that property, and avoidance should be the first option discussed by the managing agencies. However, if no alternatives to the proposed project are possible and the site cannot be avoided by dredging plans, a determination of adverse impact to the property should be made by the managing agencies. Subsequently, additional investigations of the property should be warranted in order to mitigate those adverse effects. However, since the RMS *Fort Victoria* is not considered historically significant due to its highly eroded nature and its primary association with British history, no further investigation is warranted or recommended.

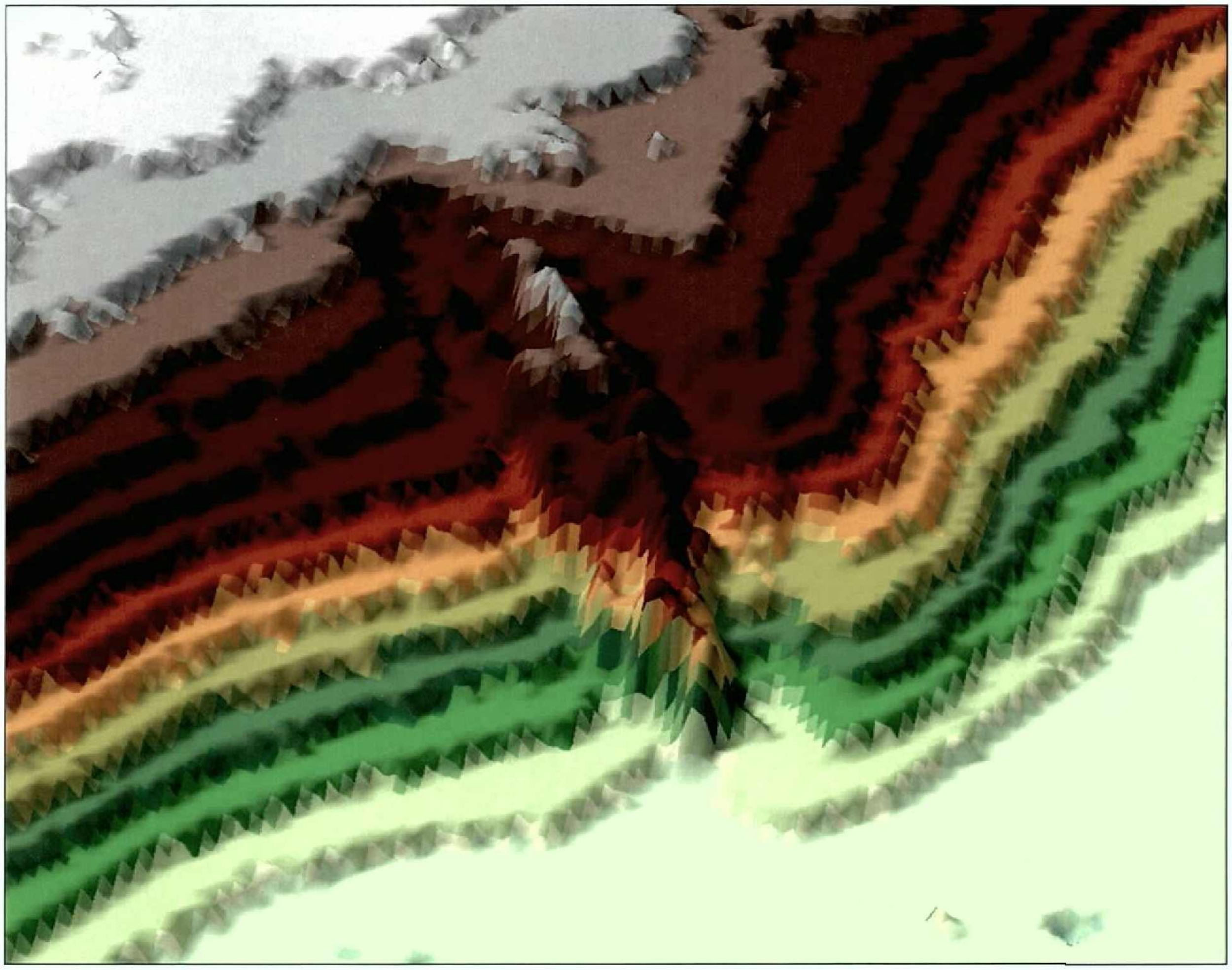


Figure 1-02. Multi-beam bathymetric image of the current project site.

2. BACKGROUND RESEARCH

Background research was undertaken prior to and subsequent to the field investigation. This research included a search of known wreck sites in the area, previous archaeological investigations, and historical background of the RMS *Fort Victoria*.

LITERATURE REVIEW

Several official sources are usually consulted in the search for known archaeological sites and previously surveyed areas: the Lytle-Holdcamper list, the NOAA Automated Wreck and Obstruction Information System (AWOIS), and various regional publications by Daniel Berg and Gary Gentile. Lytle-Holdcamper does not apply, as the last year it covers is 1890. Of all the regional publications (Gentile 1988, 1996; Berg and Berg 1990, 1993; Berg et al. 1993; and Sheard 1998), none mention any wrecks not listed in the AWOIS list, and only Gentile 1988 mentions the *Fort Victoria* (pg 55). All available data was included since the reliability and the completeness of information, including location coordinates, varies between data sources.

The most comprehensive source of shipwrecks for the United States is the NOAA Automated Wrecks and Obstructions Information System (AWOIS). This list can be accessed from the Internet at http://anchor.ncd.noaa.gov/awois/search.cfm. An interactive page appears and queries the user for information to aid in the search of shipwrecks such as name, navigation chart, or coordinates. An examination of two regions lying between 40° 23' and 40° 34' North latitude and 74° 00' and 74° 19' West longitude lists 56 wreck sites or obstructions in the vicinity of the survey area (Figure 2-01, Table 2-01).

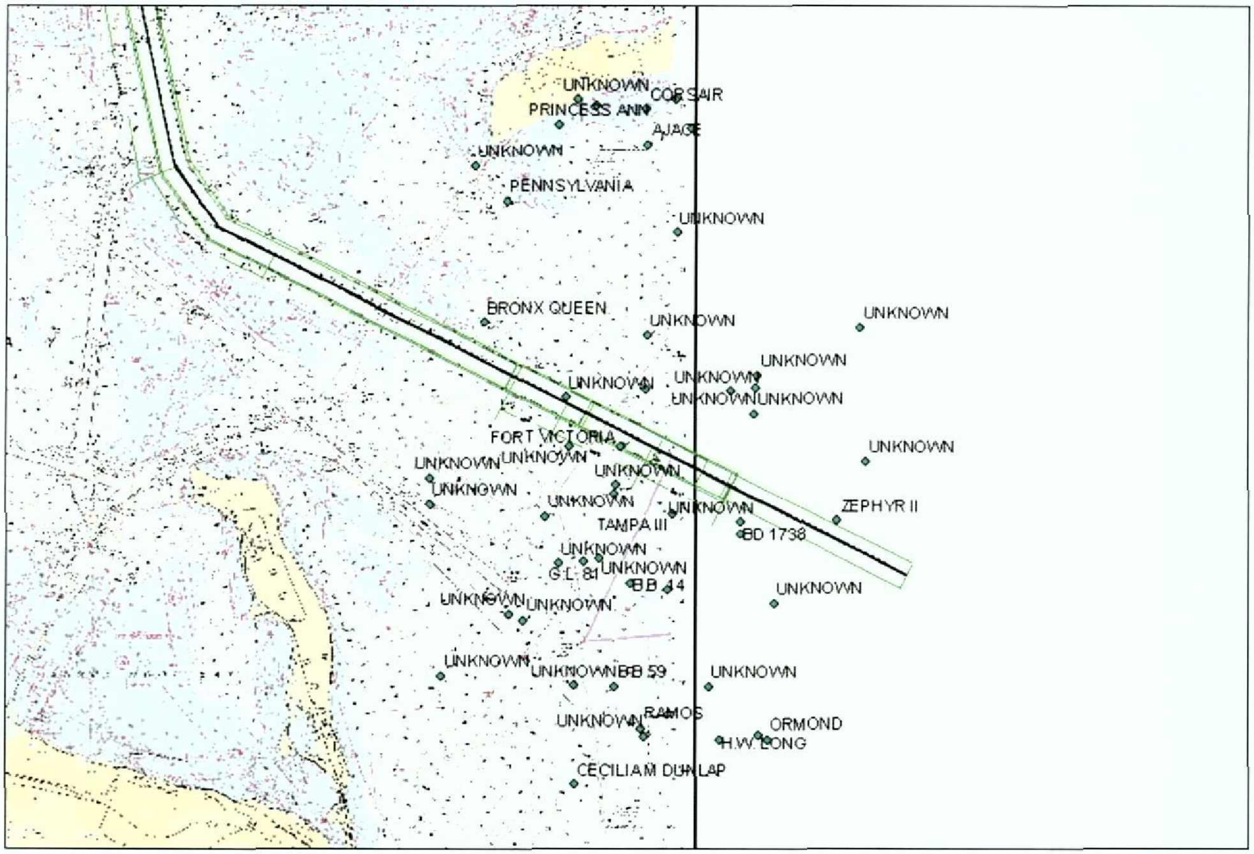


Figure 2-01. Map showing locations of wrecks in Table 2-01.

Table 2-01. Vessels lost within a five-mile radius of the current project site.

ID	Vessel	Depth	Year	LATDEC	LONDEC	Description
701	*H.W. LONG*	63		40.42280556	-73.88046667	tug, 53 ft.
747	unknown	0		40.45010556	-73.86624444	35-ft. fishing vessel
748	*ZEPHYR II*	0	1974	40.46677222	-73.84957778	51-ft. fishing vessel
751	unknown	42	1950	40.47227222	-73.90791389	dump scow B.B. 14
1582	*CECILIA M DUNLAP*	0	1931	40.41371944	-73.91846944	barge
1588	unknown	67	ca. 1955	40.42351944	-73.90005833	tug; sunk by marine casualty
1592	*RAMOS*	59	1933	40.42505278	-73.90108889	240-ft. long wooden vessel, 1208 GT
1595	*PENTLAND FIRTH*	52	1942	40.42387778	-73.87006944	patrol, 900 GT; sunk 9/19/42 by marine casualty
1596	*ORMOND*	58		40.42292222	-73.86784722	40×90-ft. wooden coal barge
1599	*B.B.59*	48	1924	40.43343889	-73.90791389	mudscow
1605	unknown	0	1925	40.45288333	-73.89402222	mudscow
1606	*B.B. 14*	63	1925	40.45411111	-73.90405556	mudscow B.B. 14
1612	*G.L. 81*	0	1936	40.45843889	-73.91624722	barge
1614	unknown	0	1945	40.45927222	-73.91208056	scow
1619	*BD 1738*	52	1946	40.46425556	-73.87505556	derrick barge, sunk 1946 by marine casualty
1623	*TAMPA III*	46		40.46821944	-73.89296944	90 GT; 72.3-ft. long fishing vessel
1625	unknown	0		40.47538333	-73.95652500	dump scow
1626	*FORT VICTORIA*	47	1929	40.48192500	-73.90626111	*FORT VICTORIA*
1627	unknown	0	1918	40.47871667	-73.84180000	coal barge
1634	unknown	0		40.49343889	-73.89958056	unknown wreckage
1641	unknown	0	ca. 1940	40.49371667	-73.87068889	USS *TURNER*
2454	unknown	0	ca. 1967	40.43566111	-73.95346944	barge
2458	unknown	0		40.47010556	-73.95652500	barge
2704	*PENNSYLVANIA*	0		40.53131944	-73.93598056	*not determined*
2710	unknown	0		40.53843889	-73.94458056	nothing
4296	unknown	60		40.43357222	-73.91834444	corner section of a brick building, 9 ft. long, 4 ft. wide
4301	unknown	0		40.55205000	-73.91763611	50×18-ft. barge, with crane visible
4439	unknown	47		40.48843889	-73.87124444	temporary hang
4440	unknown	44		40.49293889	-73.87741111	possibly wreckage of USS *Turner*
4441	unknown	41		40.49610556	-73.87041111	possibly wreckage of USS *Turner*
7470	*BLACK WARRIOR*	0		40.54616944	-73.88780556	unknown
7510	unknown	29		40.50421667	-73.89942778	dump site
7511	unknown	49		40.49174722	-73.92061667	fiberglass-hulled vessel
7702	*ROBERT A. SNOW*	0		40.55083889	-73.91257778	unknown
7713	*PRINCESS ANN*	0		40.54695833	-73.92258611	unknown
7719	*AJACE*	0		40.54286389	-73.89918056	unknown
7720	*CORNELIA SOULE*	0		40.55212778	-73.89179444	unknown
7786	unknown	0		40.46653889	-73.87491667	
7932	unknown	50		40.47406111	-73.90731389	shipyard debris including barge
7942	unknown	41		40.50576667	-73.84335000	scuttled wooden drydock
8083	unknown	39		40.44803889	-73.93570556	steel wreckage of undetermined nature
8084	unknown	44		40.44692500	-73.93175278	45-ft. steel wreck
8087	unknown	47		40.46763611	-73.92605833	large wooden ship or barge
8088	unknown	15		40.48196667	-73.91976111	undetermined buried wreckage

ID	Vessel	Depth	Year	LATDEC	LONDEC	Description
9707	*BRONX QUEEN*	0	1989	40.50694444	-73.94222222	wooden fishing vessel
9724	unknown	0	1996	40.52500000	-73.89166667	25-ft. wellcraft
9768	unknown	53		40.4334306	-73.88316944	250' × 50' wooden vessel
13255	*CORSAIR*	0		40.55010556	-73.89958056	cabin cruiser
13776	unknown	14		40.45816389	-73.92274167	deteriorated wreck

PREVIOUS INVESTIGATIONS

In 2001, Panamerican Consultants surveyed the edges of Ambrose Channel as part of the New York Harbor Navigation Study (Figure 2-02) (Lydecker 2001). The survey, consisting of a 50-foot wide area to either side of the channel, located numerous targets, including the current target, which was included as Target 89. It was determined potentially eligible based on the analysis of collected magnetic data, and recommended for further investigation and assessment.

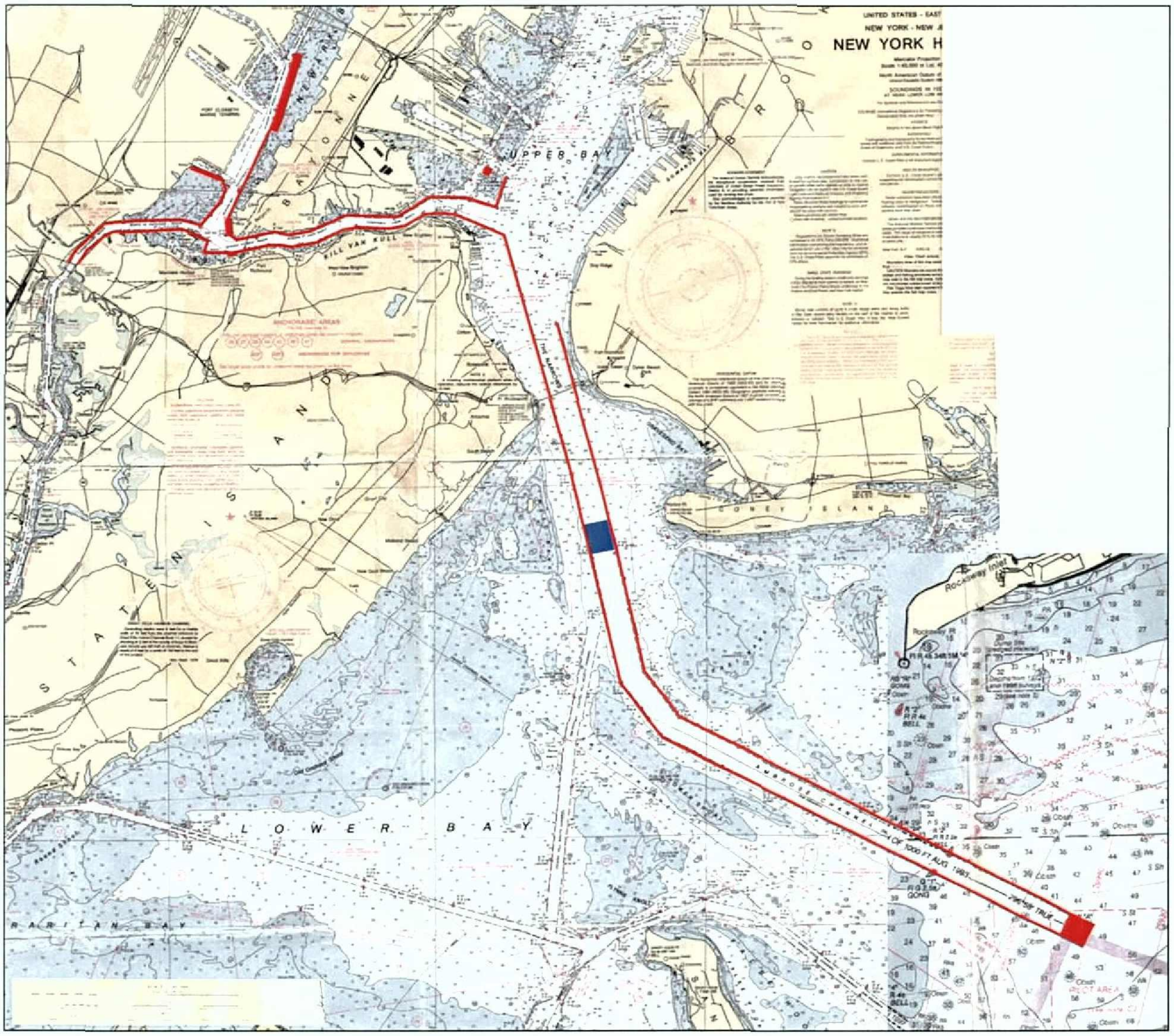


Figure 2-02. Areas surveyed by Panamerican *in 2001*.

In 2002, Panamerican returned to investigate 39 targets that were recommended for further investigation in 2001 (Lydecker 2002). Divers investigating the site reported large amounts of disarticulated metal with no discernible structure and no artifactual material. The site was determined to be non-significant and no further work was recommended.

HISTORICAL BACKGROUND OF RMS FORT VICTORIA

THE EVOLUTION OF THE IRON-HULLED STEAMSHIP

At the dawn of the nineteenth century, the merchant ships vital to the ever-growing global economy looked more or less the same as they had for the previous three hundred years. However, by the century's end the world's mercantile fleets had undergone dramatic changes, and the nature of these new ships as well as the nature and scope of international commerce, was strikingly different. Two fundamental changes characterized the development of modern mercantile shipping in the nineteenth century: iron (and later steel) ships replaced wooden ones, and steamships replaced sailing vessels. These two phenomena were related to and dependent on each other, as iron and steam mutually reinforced each other in the maritime world just as they did in other nineteenth-century industries.

Two other technological innovations had to occur before the great shipping revolution could take place. The iron-hulled steamship could not have become a viable alternative to merchant sail until a propulsion system without the inherent weaknesses of the paddlewheel was developed, and until a truly fuel-efficient, compact marine steam engine was put into use. Throughout the first three quarters of the nineteenth century, British, and to a lesser degree American, engineers and innovators grappled with and solved these problems in a setting of unprecedented industrial development and economic expansion. By the time of *Fort Victoria*'s construction in 1913, Britain had been transformed into the world's undisputed center of shipping and shipbuilding, international freight rates were plummeting, and the iron-hulled screw-propelled steamship became firmly established as the most efficient and profitable vessel for use in the international overseas carrying trade.

What follows is a detailed discussion outlining the historical evolution of iron shipbuilding, screw propulsion, high-pressure boiler technology, and the compound marine steam engine. *Fort Victoria*, built by William Beard, in Scotland in 1872, is an excellent representative of the late-nineteenth-century British-built screw steamer, and her designers incorporated all of these major innovations that had been developed throughout the first three quarters of the century.

The Development of Iron Shipbuilding and the British Iron Shipbuilding Industry

The use of iron in the shipbuilding industry began in the late eighteenth century, as developments in iron production led to innovative applications for this material. What would prove to be one of the most important innovations was the puddling process for producing wrought iron, and the subsequent grooved rolls, which allowed the production of iron plate and bar, both developed by Henry Cort in 1784. These technologies allowed for the much easier and faster manufacturing of a much higher quality iron, and were "absolutely necessary before metal shipbuilding materials could become commercially available" (Corlett 1990:21).

British engineers put these processes towards a practical application within two years, when iron plates were used for steam engine boilers for the mining industry. The first iron-hulled vessels appeared shortly thereafter, as a July 28, 1787 Birmingham newspaper attests:

> A few days ago, a boat built of English iron by J. Wilkinson, Esq. of Bradley Forge, came up our canal to this town. . .It is nearly of equal dimensions with other boats employed upon the canal being 70ft long and 6ft 8in wide. The thickness of the plates with which it is made is about 5/16th of an inch and it is put together with rivets like copper or fire engine boilers, but the stem and sternposts are wood and the gunwale lined with the same (Corlett 1990:23).

Not surprisingly, skeptics of this new technology were many, though the boat's designer John Wilkinson boasted, "my iron boat...answers all my expectations and has convinced the unbelievers who were 999 in every 1,000" (Corlett 1990:24). The use of iron canal barges spread rapidly after Wilkinson's pioneering example, and eventually iron vessels were seen in other contexts. The first iron-hulled craft intended for marine waters was a small pleasure boat built near Birmingham by Joshua Horton, and launched in the Mersey in 1815. This was followed in 1818 by the *Vulcan*, built near Glasgow for service on the Forth & Clyde, which marked the beginning of a long tradition of iron shipbuilding in Scotland. This vessel became an early example of the utility and longevity of iron vessels, remaining in service for nearly fifty years (Corlett 1990:24).

One of the landmarks in the early development of iron shipbuilding was the launching of the *Aaron Manby*, which in April 1822 became the first iron steamship to ply the open sea. Her owners, who held a patent on iron steamboats, had the satisfaction of operating her on a successful run from London to Paris in June 1828. While a technical success (she was still in good condition as late as 1849) she would prove to be a financial loss for her backers (Greenhill 1993:22). Britain's second iron steam vessel was built by the Horseley Company in 1823-1825. She successfully worked the River Shannon in Ireland for some thirty years (Corlett 1990:24).

Despite recognized advantages in strength, durability, and the reduction of weight, wasted space, and danger from fire, it would be some time before iron-hulled ships would be regularly seen at sea. It is not surprising that the most successful of the pre-1830 iron-hulled vessels were intended for canals and inland waterways, as these types were not hampered by what would prove to be the two most pervasive problems for iron ships at sea: compass deviation and bottom fouling. Other technical problems were comparatively minor and soon overcome. For example, severe and potentially cargo-damaging condensation inside the hold could be prevented by adequate ventilation (MacGregor 1952:69), and outer hull corrosion at the waterline was mitigated through the liberal use of white lead paint (Greenhill 1993:23).

However, the problem of bottom fouling would not be solved so easily. While shipworms could not damage the iron hull, barnacles and other sea growth seriously impeded the vessel's speed (Thiesen 2000:92; Greenhill 1993:23). This had been solved in wooden ships through the use of copper alloy hull sheathing, but this technique would not work on iron hulls, as the dissimilar metals in salt water suffered disastrous electrolytic deterioration. Bottom fouling was not a serious problem for smaller ships plying short routes along European coasts, but it became serious as ships became larger and sailing distances increased. Despite decades of technological progress, a solution seemed elusive, and as late as 1870 the Peninsular & Oriental Steamship Company spent some £70,000 each year to keep their ships' bottoms clean (Corlett 1990:38). Until the advent of modern anti-fouling paints, this problem remained unsolved and iron ships remained, in the words of Lord Clarence Page, "almost as foul as lawyer's wigs" (Corlett 1990:38).

One evolutionary offshoot of the iron ship that developed in response to the fouling problem was the composite ship. This was a vessel with interior iron members—usually frames, knees, keel, stem, and sternpost—but with wooden hull planking, and copper-alloy sheathing. These were cheaper to build than wooden ships, and had many of the same advantages over wooden hulls that iron ones did. The first well-engineered attempt to utilize a complete iron framework in a wooden hull was made in 1849 by John Jordan of L.H. Macintyre & Co. of Liverpool (MacGregor 1952:142; Clark 1910:322), and by the 1850s and 1860s composite construction became immensely popular. However, even reinforced wooden hulls proved unsuitable for steam engines (for reasons detailed below), and after the Suez Canal opened in 1869 competition from iron steamers with compound engines curtailed the construction of composite vessels (Sexton 1991:59).

The problem of compass deviation, due to the distortion of the earth's magnetic field by the iron hull, proved less challenging than that of fouling. At first this phenomenon crippled effective navigation and posed a serious impediment towards the adoption of iron-hulled vessels by both the naval and mercantile fleets (Thiesen 2000:92). By the end of the 1830s, though, the compass deviation problem had been overcome, or at least overcome to a degree that made iron ships on the open ocean an acceptable insurance risk. William Laird & Sons initiated experiments as early as 1835, conducting field tests on the iron paddle steamer *Garry Owen* on the River Shannon. These led to further trials by the company in 1838 onboard the 580-ton paddle steamer *Rainbow* (built the prior year). This experiment was led by the Astronomer Royal, Professor George Airy, who used a binnacle equipped with magnets and iron correctors to offset the iron hull's magnetic distortion. His report, published in the Royal Society *Transactions* the following year, led to a general acceptance of this new device for use on iron ships (Greenhill 1993:24). One of the more dynamic results of these experiments was the decision by the Great Western Steamship Company (whose Managing Director had been on board the *Rainbow*) to build its first iron-hulled steamship, the *Great Britain*, whose impact on iron shipbuilding was enormous.

The *Great Britain* is arguably one of the most historically significant ships ever built, and is traditionally labeled the world's first modern ship (Corlett 1990). Built between 1839 and 1843, she exemplified all of the advantages of iron ship construction. The most striking of these was size; the *Great Britain* was an unprecedented 3,270-ton, 289-foot long (88.1 meters) vessel with a breadth of 50 feet, 6 inches (15.4 meters) and depth in hold of 32 feet, 6 inches (9.9 meters). Iron ships could not only be built larger, but the greater strength to weight ratio of iron meant that they could increase size while at the same time decrease both weight and thickness, resulting in cargo capacities of up to 50 percent greater than similar-sized wooden vessels (Pollard and Robertson 1979:14). The *Great Britain*, for example, had some 24,000 cubic feet more hull space than she would have had she been made of wood, and she weighed some 600 tons less (Corlett 1990:195).

She was also the first iron ship to be driven by a screw propeller. These successful implementations of new technologies impressed other shipbuilders of the day; one of the most noted, Jonathan Grantham, wrote in 1858 that her construction "was at the time the boldest effort in iron shipbuilding, and formed a most remarkable feature in the history of this science" (Greenhill 1993:25). The *Great Britain* gave a dynamic impetus to the widespread adoption of both screw propulsion and iron construction, and her many years of successful service (especially after surviving an 1846 stranding with only minor repairs), "probably did more than anything else to convince the shipbuilding and shipping fraternities that iron was a practical material for large ships" (Corlett 1990:194).

This convincing demonstration came at a time when iron was becoming available in the British Isles in quantities, qualities, and at prices that made iron shipbuilding more and more economically viable. Timber, which had for centuries been scarce in England, was considerably more expensive than coal and iron, whose prices began to fall steadily throughout the nineteenth century. In England the price of iron dropped some 40 percent between the 1860s and 1890s (Harley 1970:263) and, while delayed, similar price declines were seen across the Atlantic: in an 1884 report to the U.S. Congress it was stated that iron ships cost $10 to $20 per ton less to build than wooden ones (Hall 1884:196).

Abundant sources of timber in North America, however, kept wooden ships cheaper to build than iron vessels in American shipyards as late as the 1850s. It soon became apparent, though, that wooden construction was incompatible with the steam engines—especially those using the new screw propellers—that were now rapidly proliferating in the world's merchant fleets. A wooden ship was made up of literally hundreds or even thousands of individual timbers, held together with fasteners made of wood, iron, or copper alloy. She was, therefore, a flexible structure. While flexibility could be well suited for weathering the stresses of wind and wave, the vibrations caused by steam machinery had disastrous effects on wooden hulls. Long propeller shafts in wooden vessels could become misaligned in severe weather, when reliable propulsion was most critical. This also tended to occur in drydocks or tidal berths due to the stresses on the hull, unless repair crews took the precaution of loosening the bolts that secured the engine to the bedplate (Thiesen 2000:91). Their inherent lack of torsional strength also meant that wooden vessels tended to hog or sag over time, a factor that was compounded when such a ship was fitted with heavy engines and boilers.

Therefore, steamships came to be built almost exclusively of iron, even while builders of sailing ships continued to construct wood or composite hulls. Shipbuilders improved and refined their techniques as more iron steamships were built, but early iron vessels followed a modified form of traditional wooden shipbuilding (Thiesen 2000:99-100; McCarthy 2000:8). Thus, transverse iron frames were laid upon a longitudinal iron keel, and further strength was provided by longitudinal keelsons and stringers along with transverse deck beams (Figures 2-03 and 2-04). Iron plates were then riveted onto the iron framework and to each other to form a rigid and waterproof outer shell. Frames, deck beams, and indeed all hull members other than the flat plates were made of angle-irons or angle-bars:

> These are long bars of iron rolled in the shape of the letter L, or like two pieces placed at right angles. . .An angle-iron makes two sides of a box, the top and one side. It is thus able to bend in two directions. Were the ribs of the ship made of solid iron bars of the same size, they would be immensely heavy, and it would be nearly impossible to bend them into the required shapes. The angle-iron is nearly as strong, and may be readily moulded into any shape (*Harper's New Monthly Magazine* 1878:645, 647).

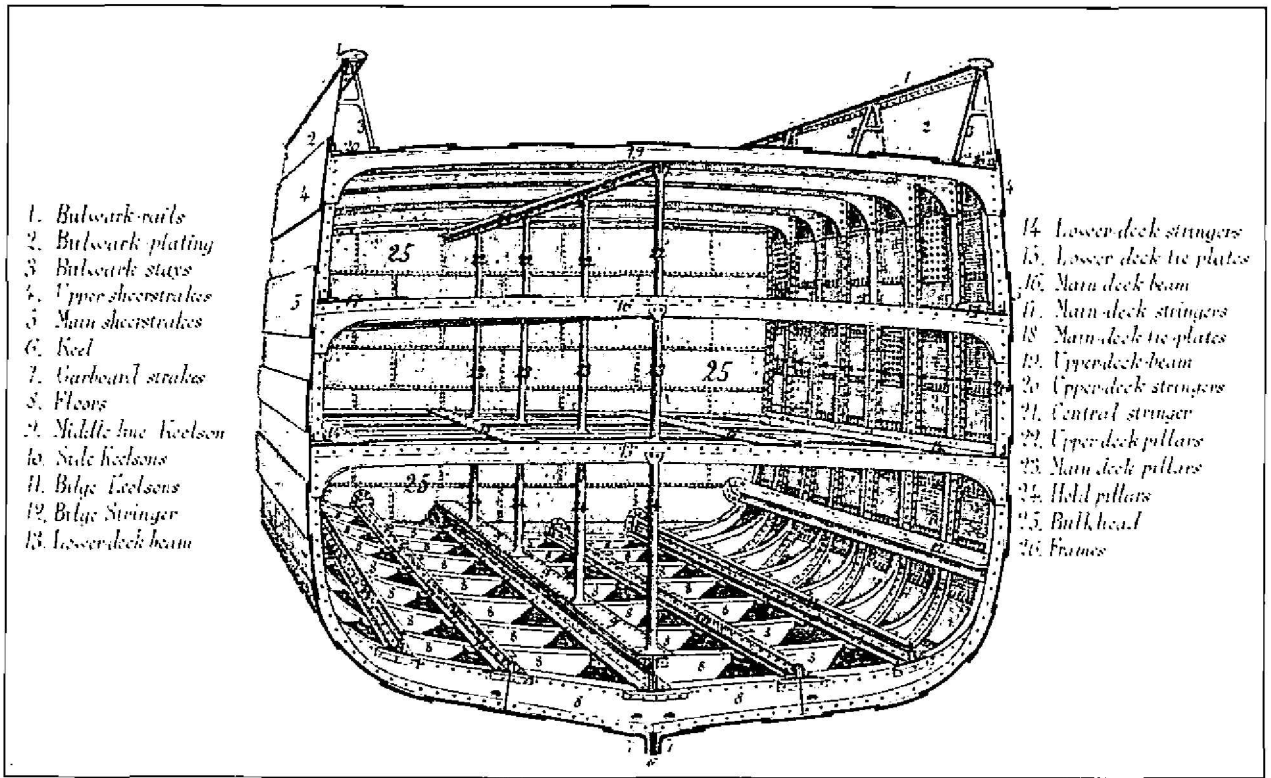


Figure 2-03. Interior view of the midship body of a three-decked iron steamship. Note the various internal framing members, the bar keel, the "in and out" outer hull plating, and the watertight iron plate bulkhead. The site investigated as the *Fort Victoria* displayed many of these features (as presented in Paasch 1890).

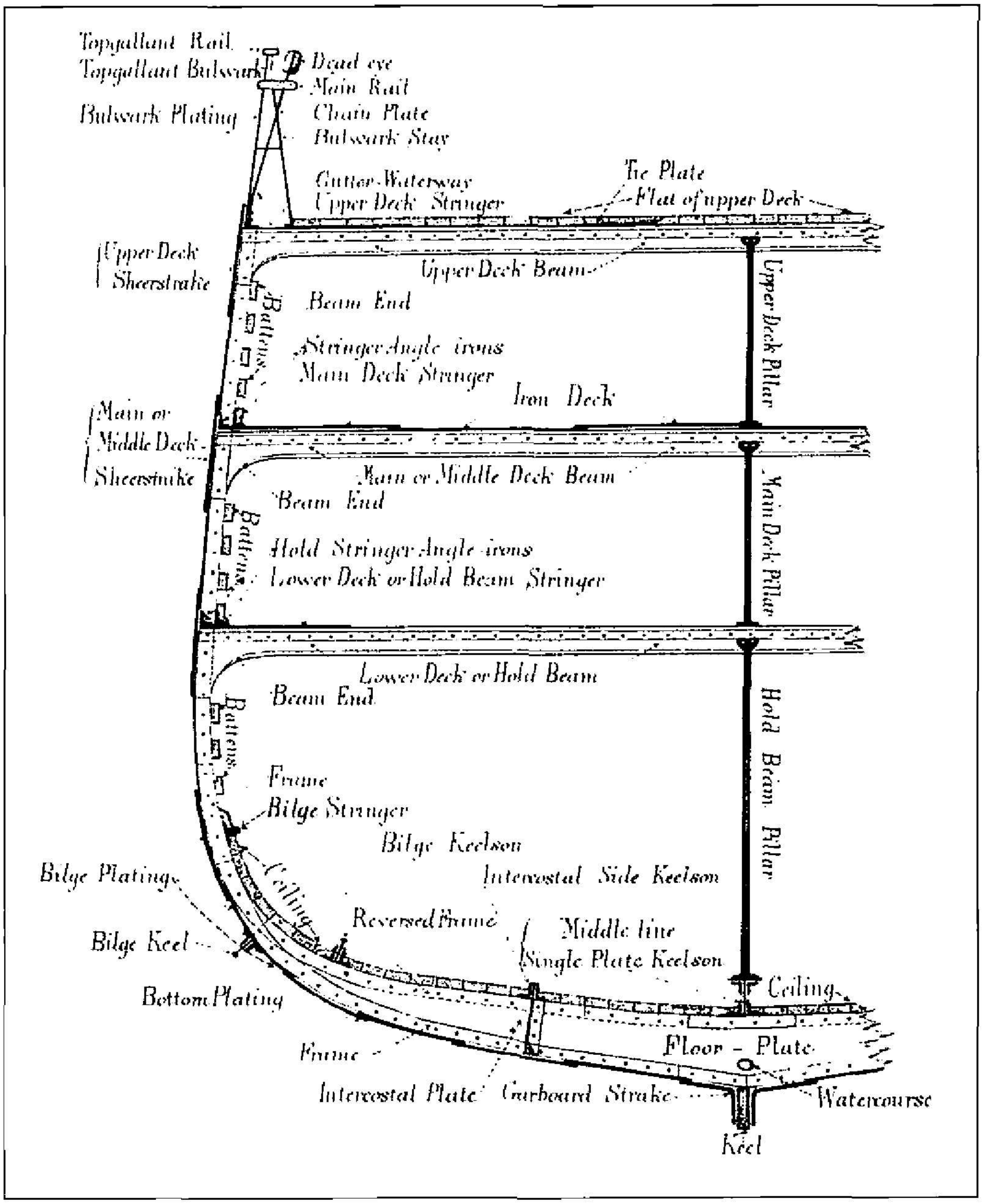


Figure 2-04. Midship section of an iron ship. Note the "in and out" outer hull plating, bar keel, and various internal framing members (as presented in Paasch 1890).

Early iron ships, like their wooden predecessors, were built with protruding keels "despite the fact [they] failed to serve a purpose" (Thiesen 2000:100). Some shipwrights (such as those who built the *Great Britain*) were so convinced of the importance of the protruding keel that false keels of wood were bolted along the bottom of the hull (Corlett 1990:30). Shipbuilders continued to experiment with a variety of often-complex keel designs, which eventually evolved into two simplified versions: the bar keel and the flush plate keel (Figure 2-05). The former was simply a massive, rectangular, external bar that ran longitudinally along the bottom centerline and supported the floors (lowermost framing members). Like traditional wooden keels, it protruded from the ship's bottom (Figure 2-05, E). The hull plates in the garboard stake (the row closest to the keel) typically were bent downwards upon contact with the keel so as to be riveted directly to its sides. Lloyd's endorsed a variation of the bar keel in their 1850 Rules, which mandated either a single or double keelson situated on top of the floors (Figure 2-05, F). This arrangement was quite reminiscent of wooden keel/keelson assemblies, but was less suited for iron hull construction and proved to lack strength to adequately prevent tripping (sideways collapse) in the floors (Corlett 1990:30).

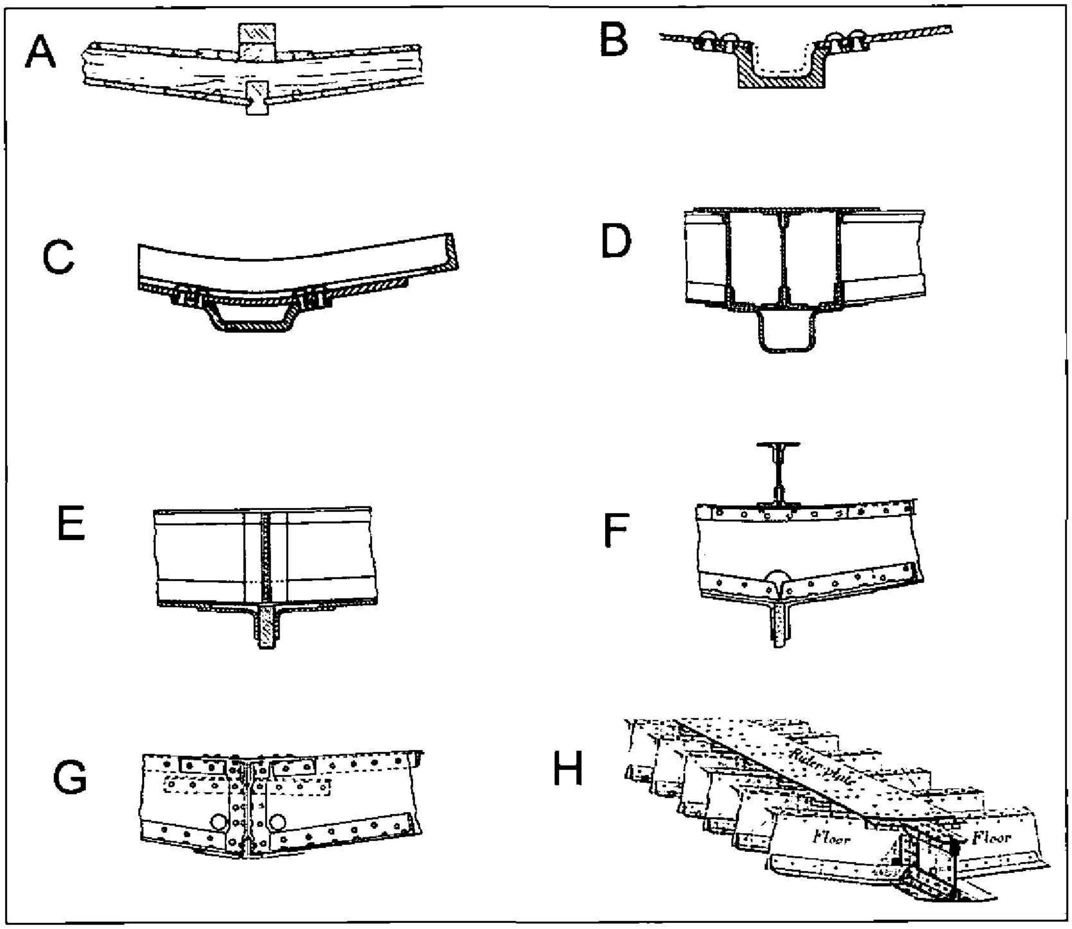


Figure 2-05. The evolution of the keel in iron ship construction: a) traditional wooden keel assembly; b) an early patented iron keel; c) an external iron keel; d) an external iron keel with internal member to incorporate longitudinal strength; e) simple bar keel; f) variation of bar keel endorsed by Lloyd's with middle line keelson; g) the flush plate keel, which eventually became standard, still seen on modern vessels; h) isometric view of a flush plate keel assembly, with frames and rider plate (a-g, as presented in Corlett 1990:30-31: *h*, as presented in Paasch 1890:Plate 38).

The later type, the flush plate keel, consisted of an internal, vertical, longitudinal member, to which was attached from below a continuous, longitudinal exterior plate that was flush with the bottom. This lower keel section overlapped the garboard strakes of hull plating—sandwiching them between itself and the inner member and floors—but did not protrude from the bottom like a traditional wooden keel (Figure 2-05, G). The interior vertical member ran the entire length of the ship, situated along the vessel's centerline and flanked by open floors, which were affixed to its sides by rivets (Figure 2-05, H). An upper keel member, in cross section an upside-down version of the lower member, was riveted to the central piece from above, sandwiching the floors from above. Thus the three-piece keel, when assembled, formed an I-beam shape in cross section. This form of keel, still seen in modern vessels, became universal practice for mercantile and naval ships (Corlett 1990:30).

After the keel and framing members were erected, the hull plates were riveted into place. These were typically "a little more than one yard wide, and from two to four yards long, and three-fourths of an inch thick" (*Harper's New Monthly Magazine* 1878:647). Like other aspects of iron ship construction, the arrangement of hull plating evolved over the course of the nineteenth century (Figure 2-06). The earliest method, used on the first iron naval ship (*Dover*, 1839), consisted of plates butted side to side so the exterior hull surface was flush (Figure 2-06, A). The plates did not overlap, and therefore could not be riveted to each other, so the butt joins were secured by internal butt straps. Usually, the edges of these internal straps were in turn strengthened by another series of straps (Corlett 1990:27). A later variation of flush plating (Figure 2-06, B) was introduced by a builder named Seaton in 1852, and was often used on early ironclads such as HMS *Warrior* (1861). This system used longitudinal exterior straps to reinforce seams between strakes (Corlett 1990:29).

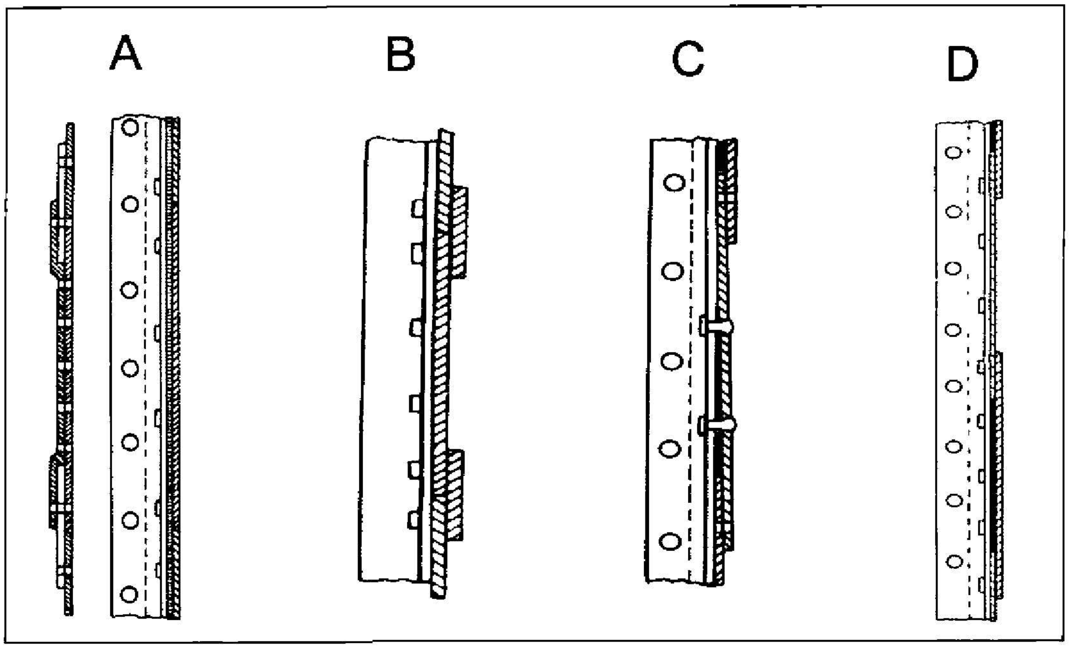


Figure 2-06. The evolution of hull plate attachment: a) flush butted shell plating; b) later version of flush plating, with external straps, often used on early ironclads; c) clinker laid shell plating; d) "in and out" plating (as presented in Corlett 1990:27, 29).

The second method of plating was that used on the *Great Britain*. This technique was known as clinker-laid shell plating, and was similar in form to the overlapping hull planks in a clinker-built wooden vessel (Figure 2-06, C). Iron plates overlapped each other and were riveted to each other as well as to the interior frames. Because the overlap necessitated that each plate was set at a slight angle, tapered filler pieces—called liners—were placed to fill the gap between each plate and the hull. While constituting a considerable additional expense, these liners made clinker construction a much easier process than the flush method, and utilized far fewer rivets. The clinker-built hulls were also much easier to repair (Corlett 1990:27-28).

A simpler and more economical system was introduced by Scott Russell and J.R. Napier, and it soon became generally adopted by shipbuilders. This is the so-called "in and out" arrangement, where each alternate strake of plating is attached directly to the frames, and the intermediate rows are overlapped on top of it, with a flat liner inserted to fill in the space beneath (Figure 2-06, D; see also Figures 2-03 and 2-04). This method creates hulls with a very distinctive pattern of alternating raised and lowered strakes of plating (Figure 2-07). Internal butt straps continued to be used to strengthen the seams between individual plates, as they were on the clinker-laid hull. The in-and-out method gained rapid popularity because it required only half the amount of liners used on a clinker-built hull, and they did not have to be tapered. This style of hull plating, which was used on *Fort Victoria*, remained the standard in iron and later steel shipbuilding until the advent of welding in the middle of the twentieth century (Corlett 1990:28-29).

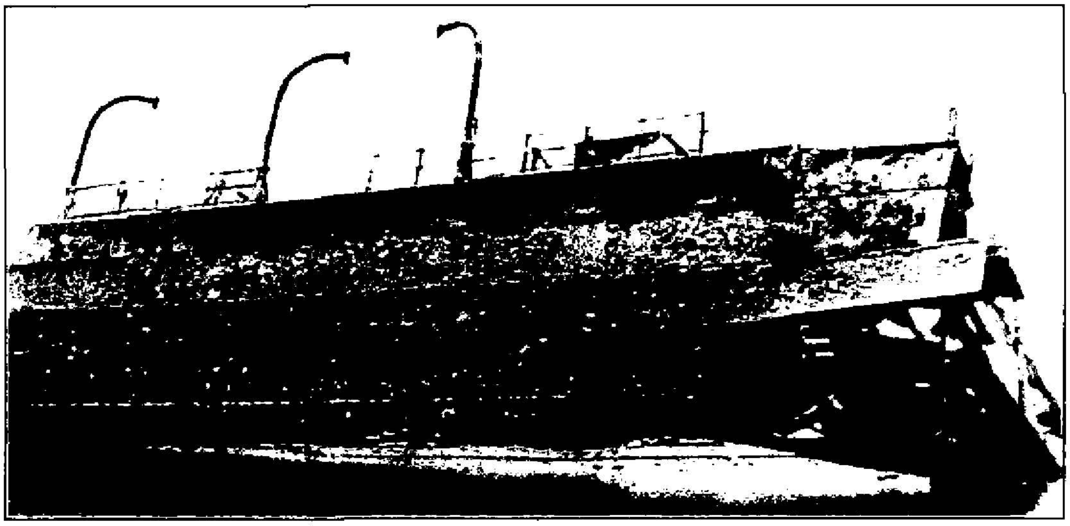


Figure 2-07. Wreck of the iron-hulled SS *Colic*, built in 1895 and lost near Derby, Australia. The distinctive "in and out" hull plating arrangement, similar to *Fort Victoria's*, is clearly visible (as presented in McCarthy 2000:Figure 3).

By the middle of the century, most of the construction features that would be common on later iron ships had been introduced. Many of these were unique to iron vessels, having no precedent in traditional European-style wooden shipbuilding. Watertight bulkheads, never before utilized on merchant ships, were first installed on the *Garry Owen* in 1834. Their inventor, Charles Wye Williams, strongly urged their general use in a paper presented to the British Association, and by the 1850s they were a legal requirement of the Board of Trade (Corlett 1990:25, 34). In addition, in the late 1830s a longitudinal system of framing was developed, quite contrary to anything ever seen in wooden ship construction. In this arrangement, frames, instead of lying perpendicular to the keel, are parallel with it and thus afford longitudinal strength to the hull. This was used to a limited degree in the *Great Britain*, and a much more extensive and sophisticated system was put to use in her descendant, the *Great Eastern*, launched in 1858 (Corlett 1990:25, 197). The *Great Eastern* also featured a complete cellular inner bottom that extended up her sides and provided an unprecedented degree of safety for the time. These kinds of innovations, along with the British shipping industry's vigorous application of regulations and enforcement, helped give Britain her commanding technological lead and would set the stage for the ascendancy of the iron ship.

In fact, despite the steadily increasing numbers of iron steamships, the first half of the nineteenth century remained primarily a wooden sailing ship era. Up to the 1850s, Britain's great competitor, the U.S., had been driving the industry with its cheap timber resources, fast sailing craft (notably the famous clipper ships), and well-organized packet lines (Pollard and Robertson 1979:9). Actually, in 1854 and 1855 alone America produced more ships than Great Britain and Canada combined (Harley 1970:262). But Britain's early lead during the transition from sail to steam and her undisputed expertise in engineering and metallurgy would launch her to a premier spot as the leader of global shipbuilding within a few decades of the appropriately named *Great Britain*'s launching. Iron tonnage production accelerated rapidly in the second half of the century: in 1850 just 10 percent of new British tonnage was iron, in 1860, 30 percent; and in 1870, 60 percent (Corlett 1990:196-197). Steam tonnage grew even faster, from 26 percent in 1850 to 80 percent in 1860.

When America's shipping and shipbuilding suddenly declined during the Civil War, Britain came to virtually monopolize the industry (Pollard and Robertson 1979:10-12). With the advent of effective compound steam engines later in the 1860s and the opening of the Suez Canal at the close of that decade, the wooden-hulled sailing ship was finally and irreversibly doomed to obsolescence, and Britain's role as the maker of the world's ships was assured.

As the benefits of iron as a building material ushered changes in the size and complexity of ships, the latter half of the nineteenth century witnessed the transformation of shipyards from small, local, and skill-based firms to massive industrial centers run by technologically innovative businesses (Arnold 2000:1) (Figure 2-08). These new yards employed hundreds or even thousands of unskilled and skilled laborers, who used an increasing variety of machines and steam-powered tools (Pollard and Robertson 1979:13). Shipyards began to subdivide labor into even more specialized tasks, so that between the Civil War and World War I the labor division for the construction of a typical iron hull went from 9 to 48 distinct occupations, including a diverse range of specialized iron workers (Thiesen 2000:106).

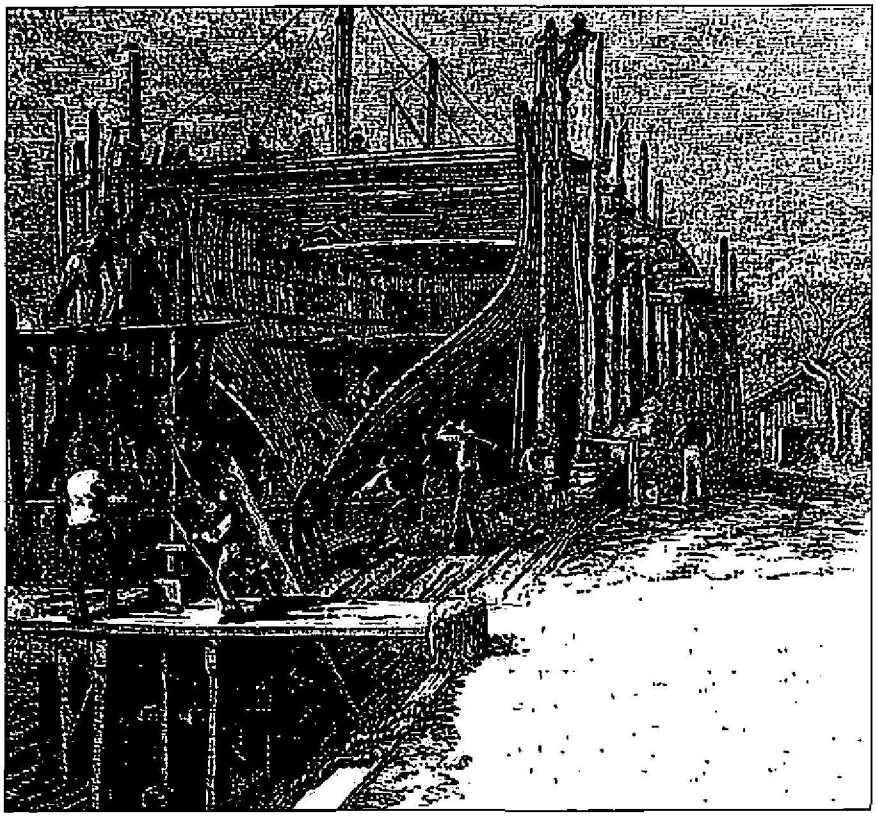


Figure 2-08. 1878 engraving of an iron ship on the ways at a large shipyard. *Fort Victoria*, built at the Beard yard on the Clyde, Scotland, would have been constructed in this manner (as presented in *Harper's New Monthly Magazine* 1878:641).

These changes made a crucial impact on shipyards throughout the British Isles—notably those of the Tyne, Tees, Mersey, and Thames—but especially on the Scottish shipbuilding region known as the Clyde, whose 35 shipyards included the builders of *Willochra*, William Beard and Co.

This Clyde shipbuilding district, named after its location along the Clyde River near Glasgow, became the foremost iron shipbuilding center of the late nineteenth century and was frequently divided into the Lower Clyde (Greenock, Port Glasgow, and Dumbarton) and the Upper Clyde (Glasgow and its suburbs). Beard is located approximately five miles from Glasgow, placing the yard in the Upper Clyde district. Though a limited degree of wooden ships were built on the Clyde through the early nineteenth century, the ascendance of the iron shipbuilding industry ushered in a new prosperity for the region. This was due in large part to local factors such as access to coal and iron, as well as the ready availability of engineering skill developed from the cross-channel steamer trades to Ireland and Liverpool. The area also benefited from extensive dredging in the early part of the century, which widened the river, secured its banks, and increased its depths, allowing the navigation of the largest steam liners (Pollard and Robertson 1979:60-62). By 1876, more iron ships were built on the Clyde than in the rest of the world combined (Lindsay 1884:70, 592-593).

By the time of *Willochra*'s launching, even the most ardent critics of iron ships had come to realize that this technology was not only here to stay, but would one day completely displace the traditional wooden sailing ship. The iron steamship was seen as something akin to an embodiment of Manifest Destiny at sea, a triumph of man's newfound technology over thousands of years of reliance on wind and waves. This attitude, along with an almost celebratory excitement over the rapidity of progress and the future potential of this revolutionary technology, is captured in the following passage, again by the unknown writer for *Harper's New Monthly Magazine*:

> England became great and rich through her ships. She has put her faith in iron, at first because she had no wood, and chiefly because she thinks it better than wood. Ships are, indeed, wrecked, be they of wood or iron, but the iron ship holds the greatest chances for safety either on the open sea or cast ashore. Many an iron vessel has been weeks and months aground where a wooden ship in the same position would not have lived to float again. Wooden ships have a known limit to their lives. It is yet to be determined how long an iron ship will last. It is only a trifle over forty years since the first iron ships were launched, and some of the earlier vessels are still in use. Iron ship-building is an art so new that there is no standard by which to compare iron with wood (1878:652-653).

The Introduction and Development of the Screw Propeller

Basil Greenhill (1993:11-12) has divided the history of the steamship into three distinct stages. In each stage, steam technology progressed to a point at which a plateau was reached, when it appeared that steam at sea had reached its practical limits. The start of each new stage was marked with a technical breakthrough, a concept or invention so profound that when applied to new vessels all previous types were rendered obsolete. The first stage was the era of the paddle steamer, which, by the 1840s, had reached a kind of dead end. While suited for inland transport and auxiliary purposes, the paddlewheel steamer was, as Greenhill (1993:11) states,

> ...incapable of development for either merchant shipping or naval purposes beyond a point at which only limited and somewhat specialised *(sic)* usage was possible. The paddle steamer was never going to play a significant part in the world's carrying trade, nor was she even in her largest and most powerful forms a substitute for the sailing ship of the line . . .

The breakthrough that marked the end of the paddlewheel era and the start of Greenhill's second stage was the screw propeller. Screw-propelled vessels driven by simple expansion engines would overcome all of the problems created by paddlewheels at sea, and, as explained above, would provide impetus for the shift from wooden to iron hulls. The screw propeller, which made its first deep-sea appearance in 1840, would remain the most important innovation in shipping until the advent of the compound steam engine in the mid-1860s.

The paddle steamer was unsuitable for both sea transport and as a warship for a number of reasons. The foremost of these was decried in 1852 by Robert Murray (109-110) in his

Rudimentary Treatise on Marine Engines: "Variable Immersion [is the] Great Objection To The Paddle Wheel." What he meant was that the paddle wheel was designed to work at a certain water depth for optimum performance. But the very nature of a merchant steamer meant that, as coals, stores, and water were consumed, and cargo was on- and offloaded, her draught would vary, and with it the immersion depth of her paddles. Therefore paddle steamships could only operate at maximum efficiency for very limited portions of their voyage. For example, during an Atlantic crossing coal consumption on the *Great Western* caused her paddle wheels to lose three feet of immersion (Griffiths 1985:47). This problem could be alleviated, to a certain degree, by reefing the paddlewheel floats (the boards that actually pushed the water). This meant physically detaching the floats and securing them closer to or further away from the hub of the wheel so as to alter their depth of immersion (Whittier 1987:36). But reefing, while easy enough in river waters, could prove dangerous on the open sea, and especially difficult for the small crews typical of a merchantman.

Performance was also critically hampered when operating a paddle steamer in heavy seas, as Greenhill (1993:16) has pointed out:

> [A]s the paddle vessel rolled, one paddle or the other was immersed too deep or too shallow or out of the water altogether, and the system was working at half, or less than half, efficiency. It is obvious that the vessel had to roll very little to bring about a situation in which neither paddle was working at anywhere near its optimum efficiency, even though the vessel was loaded to an ideal draught in still water. With a strong wind on the beam and the windward paddle almost out of the water the lee wheel constantly drove her up into the wind. In these circumstances a paddle steamer, carrying excessive weather helm, could become almost uncontrollable.

As if these crippling problems were not bad enough, paddlewheelers had very poor steering capabilities at low speeds, and, due to the nature of paddle hydrodynamics, their hulls had to be long and narrow, precluding them from bulk cargo trades (Greenhill 1993:16-17). Needless to say, many engineers were seeking an alternative to the paddle wheel, and when the technical breakthroughs were made that proved screw propulsion a success, it gained widespread popularity almost immediately.

The idea of screw propulsion is a very old one. The screw pump, attributed to Archimedes, dates to the second century B.C. It used a rotating helix inside a tube to drive water from a lower to a higher level (Corlett 1993:3). Windmills used a similar principle to grind grain as early as the twelfth century. By the seventeenth century men of science were aware that a screw, in theory, could propel a ship, and a manually driven screw was used in this manner, though rather ineffectually, before the close of the eighteenth century.

At the start of the nineteenth century many American and British inventors were tinkering with screw propellers, with varying degrees of success. In general, there were two problems facing these early engineers: lack of an adequate power source, and lack of any theoretical understanding of the action of propellers. The advent of the steam engine, of course, would solve the first, but useful theories of screw propulsion would not be developed until the mid-1860s, a period when almost all sea-going steamers already were equipped with screws! This forced propeller designers up through that time to rely on trial and error, accident, and engineering insight.

Sir Marc Brunel, whose son would eventually design the propeller-driven *Great Britain*, conducted tests with screw-propelled models in the 1820s. The two most important pioneers, however, were Captain John Ericsson (who would become famous for designing the USS *Monitor*) and the future Director of the Science Museum, Francis Petitt Smith (Corlett 1990:46). While the former would prove more influential to American and Continental builders, Smith's designs would be very important in Britain. Both men would take out patents on screw propellers in 1836, and construct screw-driven ships in 1838 (Smith's *Archimedes*) and 1839 (Ericsson's *Robert F. Stockton*), respectively.

Smith's design featured a key element: *Archimedes*' screw was placed in front of its rudder, protruding from an aperture in the hull's deadwood (Figure 2-09). This design, unlike Ericsson's, which placed the screw abaft the rudder, provided remarkable maneuverability—even in fierce headwinds—because the screw race impinged directly upon the rudder. This position also allows the screw to take advantage of the slower water in the hull's wake, which significantly improves efficiency (Corlett 1990:46).

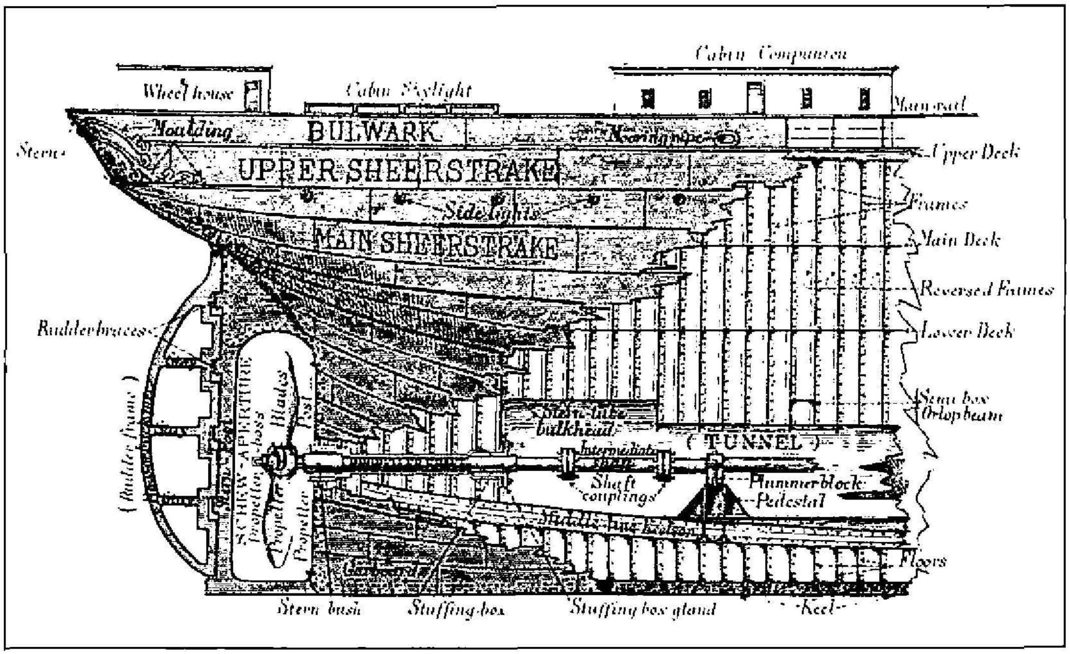


Figure 2-09. The most efficient position of the screw propeller is within an aperture in the deadwood directly in front of the rudder. This design was first proved effective in 1838 by Smith on the *Archimedes*. This illustration shows the after-body of a much later screw steamer, similar to *Manuela*, depicting the arrangement of the propeller shaft inside the hull (as presented in Paasch 1890).

In 1840, *Archimedes* underwent trials where she competed with Dover Mail Steam paddle packets. The government-appointed overseer declared, "[T]he propelling power of the screw is equal if not superior to that of the ordinary paddle wheel. Mr. Smith's invention may be considered completely successful" (Corlett 1990:48). The *Archimedes* subsequently circumnavigated England and Scotland at an average speed of seven knots, and made the first recorded seagoing journey (from Plymouth to Oporto) in record time at 9.5 knots (Corlett 1993:87). She proved so successful that, in the same year, the Building Committee of the Great Western Steamship Company halted stern and engine construction of *Great Britain* in order to allow Brunel to investigate the possibility of installing a screw instead of paddlewheels. Brunel's trials and subsequent report constituted the "birth of a scientific approach to propeller design" (Corlett 1993:88), and the *Great Britain* would become the world's first screw-propelled iron steamship.

It has already been pointed out what a great influence the success of the *Great Britain* provided to iron shipbuilders; the same happened to those contemplating screw propulsion. By 1843, just three years after the *Archimedes*' sea trials, there were already at least a dozen ships in service equipped with screw propellers. Over the next two decades, experiments with propeller design produced a number of improvements (as well as an equal number of useless permutations). Notable innovations included Woodcroft's controllable pitch (via adjustable blades) propeller, a variety of high aspect ratio (of length to chord) screws, twin screw systems, and Arthur Rigg's efficiency-improving contra vanes. These and other developments, many of which contributed directly to modern propeller designs, are discussed in detail by Corlett (1993).

Two other developments, which proved essential before the screw could achieve its full potential, deserve mention here. The first was the invention of a stern gland, or stern tube bearing, which could solve the problem of keeping watertight the tube through which the rotating propeller shaft passed through the hull (Figure 2-10). Up until 1854 there were serious problems with wear on the non-lubricated, metal-to-metal surfaces involved. In that year, however, William Penn patented a gland that used adjustable inserts made from *lignum vitae*, a very hard and self-lubricating wood (McCarthy 2000:15). Penn's design was quite successful, became the standard in shipping for decades, and is still used to this day (Corlett 1993:99-100).

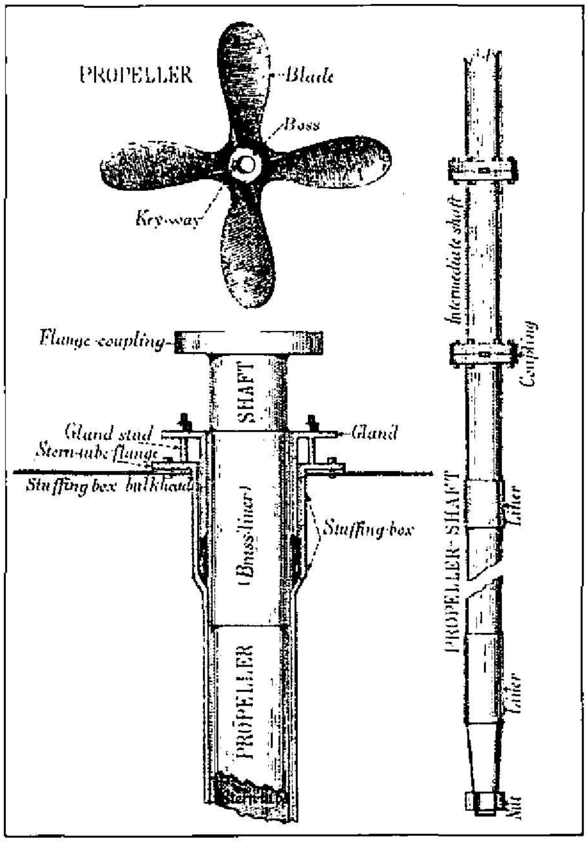


Figure 2-10. Propeller nomenclature, with detail view of stern tube and stern gland. The latter device, perfected in 1854, allowed the propeller shaft to rotate while keeping the stern tube watertight (as presented in Paasch 1885).

The second necessary innovation was the development of an effective thrust bearing. This became critical as engine power, and thus screw thrust, increased rapidly after 1840. What was needed was an efficient way to transfer the forward pushing force generated by the propeller back along its rotating shaft and to the hull of the ship itself. By the early 1850s the multi-collar type "thrust block" had been introduced (Figure 2-11).

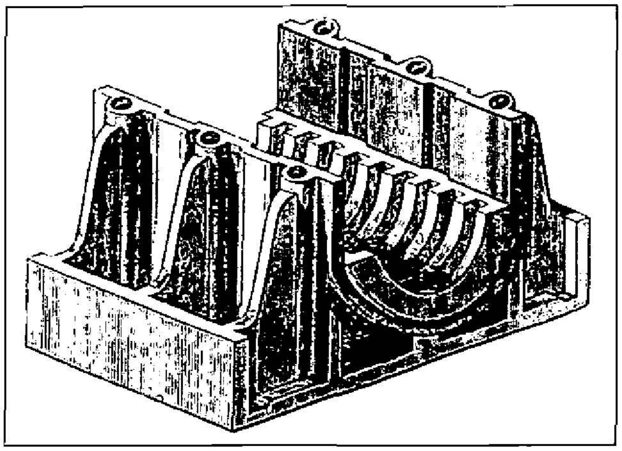


Figure 2-11. The standard multi-collared thrust block, which was solidly attached to the hull in order to accept the forward thrust of the propeller shaft. This particular example is from Brunel's *Great Eastern* (1858) (as presented in Corlett 1993:100).

This was initially developed by the William Penn & Co. of Greenwich—the same Penn who had solved the stern tube bearing problem—and it quickly became the industry standard. The thrust block, which was solidly attached to the structure of the hull, consisted of a series of adjustable collars in an oil-filled container (Corlett 1993:100; McCarthy 2000:15). It was used until thrusts became so high that a more sophisticated device was developed at the end of the nineteenth century.

Once these design problems had been solved, there were no more physical impediments to efficient screw propulsion, and it became the standard on all ocean-going steam vessels by 1865. Also at this time, valid propeller theory developed in earnest (Corlett 1993:102-104). After 1865, little was accomplished in propeller design other than minor refinements, at least through the end of the century. Another plateau of efficient steam power had been reached, and complete domination of merchant shipping by the iron-hulled screw steamer awaited only the impetus of high pressure boiler technology and fuel-efficient steam engines.

Marine Boilers, Condensers, and the Introduction of the Scotch Boiler

The third and final stage in Greenhill's (1993:11-12) scheme of steamship development is the era of the marine compound engine. This device, which used higher-pressure steam in order to expand it in two stages and thus gain more energy, dramatically cut fuel consumption, the number of furnaces, and the space needed for coalbunkers. This in turn made the screw-propelled iron steamship the most economically viable way to ship goods overseas, which would lead to the eventual demise of the merchant sailing ship.

But a workable compound engine could not exist without an initial steam pressure much higher than anything possible in the middle of the century. Advances in marine boiler making, then, from the 1850s to 1880s were of primary importance in the development of steam compounding. A steam boiler is simply a metal vessel in which water, through the heat released by the combustion of fuel, is converted into steam and raised to the required temperature necessary for use as the prime mover of machinery (Lyon and Hinds 1920:9). While steam-producing boilers had been used for land engines and water pumps since the 1600s, boiler technology of the first half of the nineteenth century was problematic in that it set the limits on marine engine efficiency; indeed, at almost any point in the nineteenth century more powerful engines could have been produced had improved boilers been available. Both material limitations and constructional difficulties hampered boiler design, significantly limiting both pressure and output (Griffiths 1993b:164). Significant technical developments occurred throughout the nineteenth century, which overcome these problems, leading to a reliable boiler design by the 1880s that would remain in use well into the mid-twentieth century. These innovations and various designs are well documented in the contemporary literature (cf. Burgh 1869, 1873; King 1870:171-192).

Many boilers in the early period of steam propulsion were crafted from copper (cf. Marestier 1957:32), a material that could not handle pressures much above one atmosphere (14.7 psi). The subsequent use of wrought iron was a promising innovation, but the flaws in the basic boiler design still hampered its ability to significantly increase pressure. Another detrimental factor was that during the first half of the nineteenth century the quality of iron, or copper for that matter, was variable and unpredictable, which necessitated lowered maximum operating pressures in order to minimize the risk of boiler explosions. Despite this practice, explosions did occasionally occur, sometimes with devastating loss of life, and these kinds of accidents were one of the basic impediments to the complete adoption of steam propulsion.

The earliest marine boilers differed little from the "kettle" types used on land, which were basically drums filled with water supported over an external fire by brickwork. The flue-type boiler was introduced by the 1820s. This type had flues through which hot gasses from the internal furnaces passed on their way through the boiler, thus greatly increasing the surface area for heat transfer, and thereby the evaporative rate (Griffiths 1993b:164). Even so, these more efficient flue boilers were still limited to relatively low steam pressures, usually no more than 12 psi. This was due to the basic design of the flue boiler; both the boiler shell and the flues themselves had flat surfaces which could not withstand higher pressures (Griffiths 1993b:165).

These problems were recognized and by the 1840s the tubular boiler superceded the flue boilers in popularity. In this boiler, the flues were replaced by large numbers of tubes, typically about three inches in diameter. These tubes allowed for an even greater degree of heat transfer surface area (Figure 2-12). The result was a more efficient heat extraction and evaporative rate from a boiler of smaller external dimensions, which in turn allowed for more cargo space on the vessel (Griffiths 1993b:165-166). But the outer shells of tubular boilers at this time were still box-shaped, which continued to limit the ability to generate higher steam pressures. The flat surfaces were supported by stays, which would have alleviated this problem to a certain degree, except for the inconsistent metal quality of the iron plates and riveted joints. Boiler pressures were still limited to about 10 psi above atmospheric in the 1840s and 20 psi in the 1850s (McCarthy 2000:19).

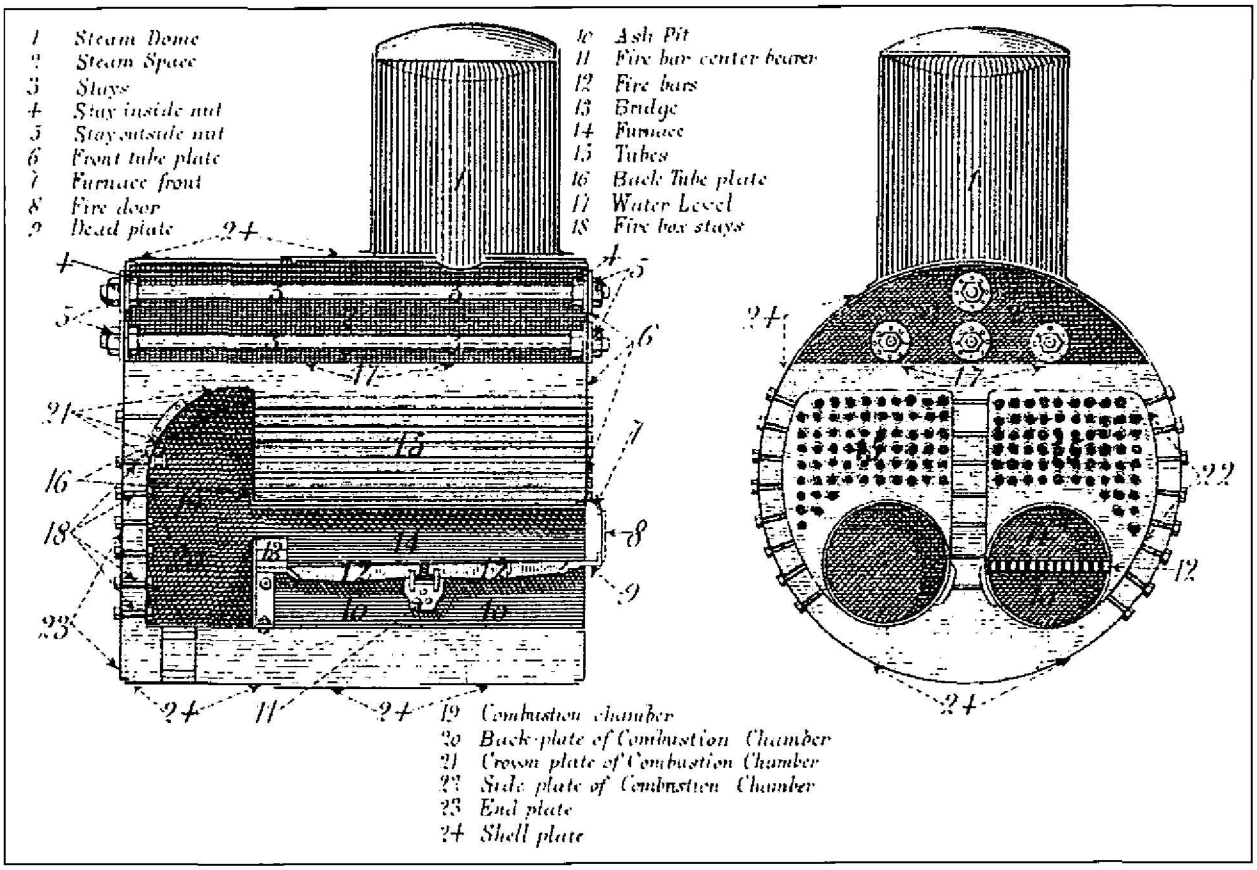


Figure 2-12. Boiler design and nomenclature. This illustration displays the side and front view of a tubular boiler, the former in cross-section in order to depict the tubes, furnace, combustion chamber, and other interior features (as presented in Paasch *1885*).

One major factor that compounded the flaws in boiler design and material was the fact that most marine boilers up until the early 1850s used seawater. While the ensuing steam itself was free of impurities, there are several inherent problems with the use of salt water to create high pressure steam. The first of these is that salt water takes more energy (and therefore more coal) to reach boiling point. As fresh water boils off, the remaining water becomes more saline, thereby further increasing the amount of fuel required to keep the water boiling and lowering the efficiency of steam production (McCarthy 2000:16-17). The second major issue is that the salt and calcium sulphate (sulphate of lime) in seawater precipitated onto the flues, tubes, grates, and other interior surfaces of the boiler. This created a hard and poorly conductive layer of salt scale which impeded heat transfer, required frequent (and thermally wasteful) "blow-downs," and reduced the working life of the boiler (McCarthy 2000:17; Griffiths 1993b:164).

The use of a surface condenser could have alleviated the problems associated with saltwater feed, but it was some time before this solution was practical. A condenser is a device that facilitates the recycling of exhaust steam by rapidly cooling it to make freshwater condensate, while at the same time creating a near vacuum in the pipes between it and the engine cylinders, which both increased usable power and reduced coal consumption (McCarthy 2000:17-18; Pirsson 1855). There were two basic types of condensers: the jet condenser, which cooled steam by passing a jet of cold seawater over it; and the surface condenser, which passed the steam through tubes cooled by circulating seawater. The former mixed the recycled fresh water condensate with seawater, which was then reused. The surface condenser, on the other hand, kept the salt and fresh water separate, preventing salt from entering the boiler and thus eliminating the aforementioned problems. But this system had a major defect: tallow and other engine lubricants would solidify in the surface condenser tubes, clogging their surfaces and creating blockages (Griffiths 1993b:163; McCarthy 2000:18). Therefore, jet condensers were the norm, along with the use of saltwater to make steam. Once heat-stable mineral oil lubricants were developed in the mid-1850s, however, surface condensers rapidly replaced the jet condenser and saltwater feed (cf. Pirsson 1855) which resulted in more efficient boilers and engines.

The 1860s finally saw changes in tubular boiler design that would lead to higher steam pressures. The basic boiler shape changed from box-like to oval, and finally to cylindrical. This last type would become universally known as the Scotch boiler, and by the late 1860s had proved to be so simple, reliable, and easy to maintain that it was rapidly on its way to becoming the dominant type (Figures 2-13 and 2-14).

The Scotch boiler is basically a cylindrical, multi-furnace fire-tube boiler in which the fire tubes, located above the furnace, bring hot gasses from a combustion chamber positioned at the rear of the furnace to a smokebox positioned at the front of the boiler. Water filled the volume of space that these fire tubes extended through, thereby creating a substantial amount of heating surface which increased the efficiency of the boiler (Griffiths 1997:66). The first Scotch-type boilers to have been installed on a seagoing ship are believed to be those in the *McGregor Laird*, built by Randolph, Elder & Company in 1862 (Griffiths 1993a:106). These particular boilers worked at the moderate pressures common at the time, but would lead to the development of high pressure Scotch boilers which would still be fitted into ships almost a full century later. The boilers fitted on the *McGregor Laird* (as were the ones installed on *Manuela*) were double-ended, which means there were furnaces at each end, with common combustion chambers for opposing furnaces.

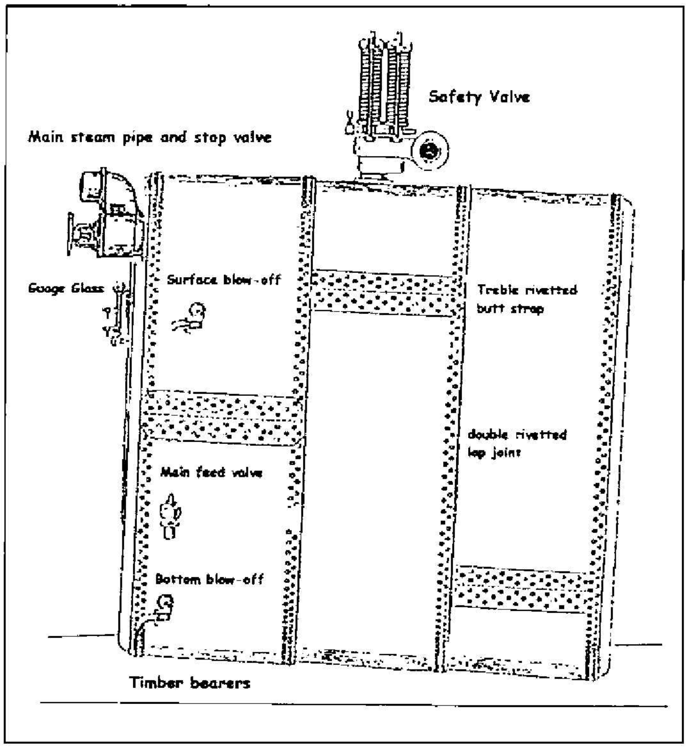


Figure 2-13. External side view of a typical late-nineteenth-century Scotch boiler, with a spring-operated safety valve (as presented in McCarthy 2000:Figure 8).

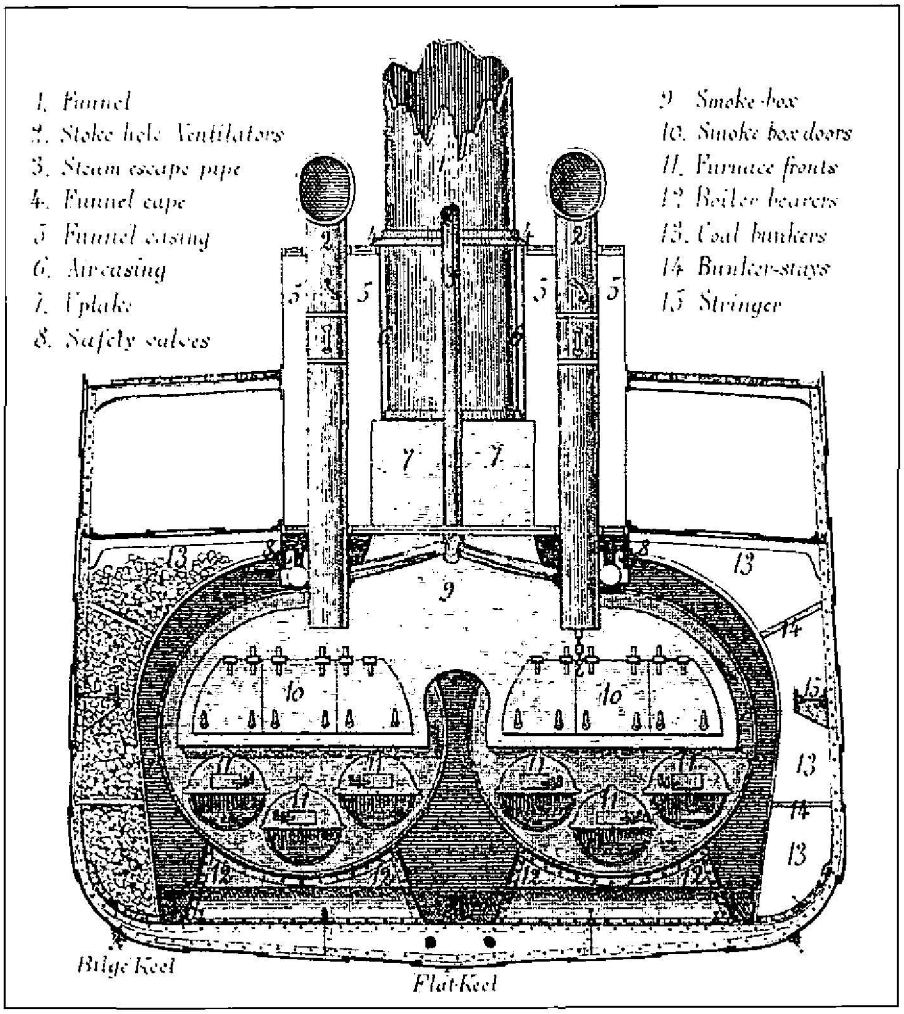


Figure 2-14. Midship section of an iron-hulled steamer, depicting the position of two Scotch boilers, coal bunkers, the funnel and ventilators, and related features (as presented in Paasch 1885).

The popularity of Scotch boilers can be attributed to aspects of both their manufacture and their operation. They required relatively simple construction methods for the period. Compared to other boiler designs, Scotch boilers tended to be rather small, economizing on shipboard space and allowing their manufacturers to use already-existing technologies for producing the shell plating for their fabrication. They were simple to operate, economical in their fuel consumption, and their designs allowed easy interior access for maintenance and repairs (Osbourne 1941:Section 7, pp. 18). The fire tubes in Scotch boilers were straight and manufactured in standard sizes, so they could be easily maintained and replacements were readily available in most ports. Their disadvantages included a tendency to generate steam slowly due to the large water volume they contained, and a corresponding delay when there was a change in steam demand from the pilothouse. Because of concerns over unequal contraction and expansion between parts of the boiler in direct contact with burning gases and those covered by water, heating the boiler was a very slow, gradual process. It could take ten hours or longer to raise steam, and cooling down the boiler took just as long (*International Library of Technology: Types of Marine Boilers* 1907:Section 9, pp. 54, 55).

A considerable amount of variation existed in Scotch boilers; they could be single or double-ended, and could carry multiple furnaces on either end. Regardless, by the 1870s the Scotch boiler had proved so superior in regards to simplicity, reliability, and ease of maintenance that most other types became outmoded. The Scotch boiler then became the dominant form of marine steam generation in the latter half of the nineteenth century (McCarthy 2000:19). When used in conjunction with the compound engine, as on the *Fort Victoria*, it proved ideal for long-haul cargo tramp steamers and played a key role in the displacement of the last generation of sailing vessels (Rowland 1970:136).

In addition to the design of the Scotch boiler, the 1870s saw an improvement in the consistency of strength in such materials as wrought iron and steel. While this progress was slow, boilermakers eventually became encouraged when steel proved to be reasonably consistent, and confident enough so that some 560 boilers were constructed out of steel during the years 1879-1881 (Griffiths 1993b:172). All of these factors—the introduction of better quality iron and then steel plates, the use of fresh water fed through surface condensers, and the adoption of the cylindrical or Scotch boiler—along with the introduction of corrugated furnaces in the early 1880s led to both an increase in running pressures and a greater degree of reliability and safety during the operation of these boilers. By the 1880s operating pressures of 100 psi were not uncommon.

Though by modern standards late-nineteenth-century boilers operated at relatively low pressures, the energy they produced was impressive. The Board of Trade, which controlled British shipping operations, enforced strict regulations regarding boiler construction and operation, including such aspects as plate thickness, rivet size and spacing, and stay positioning. Despite these safeguards, explosions did occur with drastic consequences, resulting in horrible scalding or death of anyone in the boiler or engine rooms (Griffiths 1993a:110-111). According to a contemporary source, the energy stored in a Scotch boiler at 100 pounds of pressure would be sufficient to propel it to a height of 3 1/2 miles in the event of an explosion (*A Textbook on Marine Engineering* 1897:480).

The Evolution of Marine Steam Engines and the Advent of Compounding

The achievement of boilers capable of high steam pressures coincided with, and was necessary for, the development of efficient compound engines. But this was just one of a series of technological factors, along with changes in empirical and theoretical knowledge, that culminated with the introduction of a practical compound marine steam engine in the 1860s. The compound engine, which used dual cylinders in order to expand steam in two stages, proved to be more compact and much more efficient than all of its predecessors. Its advantages of faster voyage times, greatly decreased coal consumption, greater space available for cargo, and smaller crews meant significantly higher profit margins, ensuring that the compound marine engine would become the dominant type in the merchant fleet until the introduction of the triple-expansion engine in the final two decades of the century.

Before compound engines were put into widespread use in the late 1860s and 1870s, steamships were driven by a wide variety of less efficient steam engines. In the 1840s the first propeller-driven ships came into use, and originally were powered by engines designed for the seagoing paddlewheelers, which they were steadily replacing. This practice, however, caused considerable problems; effective screw propeller performance required greater rotational speeds than those needed for paddle wheel propulsion (McCarthy 2000:12; Griffiths 1993b:167). For a time there was no option but to adapt these inferior engines, for as late as 1840 no marine steam engine capable of running more than 30 rpm had ever been constructed (Corlett 1990:61). Engineers compensated for this deficiency by using a series of gearing to increase the screw shaft speed. Such a "multiplying gear" arrangement, with a ratio of 2.95:1, was used on the *Great Britain* to produce a propeller drive speed of 53 rpm while its engine ran at 18 rpm (Corlett 1990:62-63). While these gearing systems were workable, they proved to be noisy, expensive, less than efficient, and prone to failure (Griffiths 1993b:167; McCarthy 2000:12).

Not surprisingly, engineers shied away from geared paddle engines, and this led in the 1850s to the development and widespread use of direct drive, simple expansion engines specifically built to drive high revolution screws. The British Admiralty, quick to see the advantages of propeller-driven ships, encouraged the design and construction of these engines throughout Great Britain. One of their requirements was that the machinery be situated completely below the waterline (to protect it from enemy fire), so most of the engines produced for both naval and mercantile ships (such as the *Great Eastern*, 1858) were horizontal in design (Griffiths 1993b:168). These typically operated at pressures of 20 to 25 psi and used jet condensers (McCarthy 2000:12-13). Although coal consumption was still higher than desired, the horizontal engines of the 1850s were much more compact and lighter than older geared paddle engines (Sennett and Oram 1918).

While horizontal engines—especially the direct drive, double trunk (or two-cylinder trunk), and return-connecting-rod varieties (McCarthy 2000:13-14)—continued to be favored by the Royal Navy until the end of the century, merchant ship owners gradually began to switch to vertically inverted direct drive engines. They were thus called because, unlike earlier vertical engines, their cylinders were positioned above the crankshaft. These had a number of practical advantages over horizontal types. Being upright and therefore more accessible, they were easier to maintain, and they also allowed room for coal bunkers at the sides of the engine rooms (McCarthy 2000:13; Griffiths 1993b:168). They also suffered less mechanical and heat loss than most of the horizontal designs, which meant better fuel efficiency. Horizontal trunk engines in particular were notorious for their prohibitively expensive coal consumption; it was estimated that they burned an average of four to five pounds (2 to 2.5 kgs) of coal per indicated-horsepower-hour (Corlett 1993:97).

The many examples described above illustrate the great variety of engine styles that were in use in the 1850s and 1860s. While the vertically inverted type became more or less the standard, there were still many variations as different engineers attempted to circumnavigate existing patents and avoid royalty payments.

In addition to these technological evolutions, the period leading up to the 1860s saw advances in both theoretical and empirical knowledge related to the problems of steam engine performance. The Second Law of Thermodynamics and a valid Theory of the Heat Engine were formulated, the true nature of heat was explained, the expansive working of steam was established, the reasons for the presence of cylinder condensation became understood, the importance of steamjacketing and superheating was realized, the relationship between temperature and pressure was understood, and the calculation of the mechanical equivalent of heat was established (Knauerhase 1967:615). The stage was thus set for the introduction of the compound engine.

The man usually credited with the invention of the successful compound engine, John Elder, did not really contribute any new knowledge with his design. He simply understood the implications of the recent developments in science and engineering, and applied them correctly to make dramatic improvements in engine efficiency. A comparison of twelve of Elder's compound engines built before 1860 with the various types of simple expansion engines in common use at the time demonstrated a reduction of 30 percent to 45 percent in coal consumption, a proportional reduction of coal handlers, and increases of up to 20 percent of available cargo space (Knauerhase 1967:616). His 1863 ship *Carnatic* consumed as little as two pounds (1 kg) of coal per indicated-horsepower-hour, compared to previous engines whose consumption ranged as high as 4.5 to 6.9 pounds (2.25 to 3.5 kgs) per ihp hour (Jarvis 1993:156; Knauerhase 1967:616; see also Harley 1970:264, Table 1). These were the earliest models; later compound engines running at higher pressures and utilizing Scotch boilers would prove even more efficient.

In order to understand why these engines were so much more efficient than their predecessors it is necessary to understand how compounding works. The principle of compounding refers to a system whereby steam is expanded in at least two stages, first in a high pressure cylinder and then in larger diameter, low pressure cylinders, thus increasing the amount of work derived from a set amount of steam (Gardiner and Greenhill 1993:183). The term compound engine, as used here, refers to machinery that utilizes two cylinders to expand steam in two stages; later versions used three and even four cylinders and stages, and were known as triple- and quadruple-expansion engines.

As steam expands in a cylinder the temperature inside the cylinder and that of the cylinder itself reduces—through the principle known as Charles' Law—and the greater the expansion, the greater the variance between inlet and outlet temperatures. If the cylinder temperature falls too much, part of the new steam entering for the next expansion condenses on the (relatively) cold surface of the cylinder wall and is unable to perform work on the piston (Griffiths 1993b:169). In order to minimize such condensation losses, the change in temperature must be restricted. The only way to do this is to restrict the pressure decrease by limiting the amount of expansion in the set amount of steam. As the compound engine successfully restricted the amount of expansion by utilizing two separate cylinders, it eliminated the chance of condensation in each cylinder by minimizing the temperature difference between inlet and exhaust.

A further advantage of compound engines was that the piston stroke length could be reduced by as much as one half the value needed in single stage engines (Griffiths 1993b:169). This not only allowed for much shorter, and therefore more compact, engine sizes, but also reduced problems with crankshafts due to shorter crank throws.

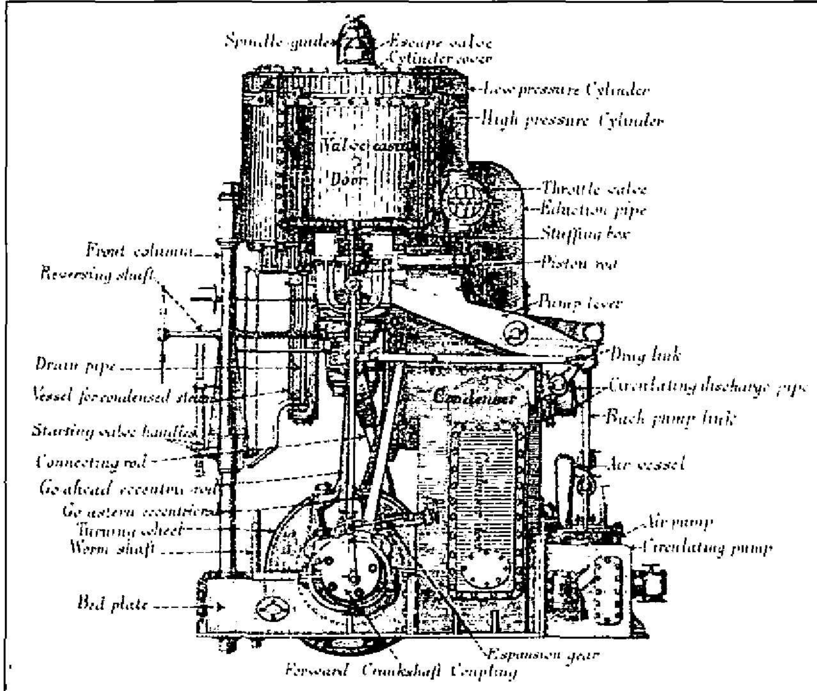


Figure 2-15. End view of a late-nineteenth-century two-cylinder compound engine (as presented in Paasch 1885).

Early in the development of the compound engine, there were many different designs in existence, with each builder having developed his own variation. In general, there were two basic designs, the simple compound and the receiver-compound. In each form, the steam enters the smaller diameter, high-pressure cylinder from the boiler, expands, and passes into the larger diameter, low-pressure cylinder. The steam, expanding further, finally exits into a condenser for re-circulation back into the boiler, or else is exhausted into the atmosphere. In the latter system, however, the steam passes into a chamber called a receiver before it enters the low-pressure cylinder from the high pressure one. The first engine design may have the cylinders situated side by side or in line, which means it may have either one or two sets of piston rods and cranks. The latter, or receiver-compound, engine always had two sets of piston rods and cranks, as its cylinders had to be side by side (*A Textbook on Marine Engineering* 1897:Section 10:53-54). Figure 2-15 depicts a typical compound engine with various elements labeled, from an 1885 marine dictionary. As stated before, at the time of Elder's invention the concept of compounding was not new, and indeed dates back to the infancy of the steam engine itself. One of the earliest engineers to experiment with compounding was John Hornblower, though the firm of Boulton & Watt already held patents on this technology (Griffiths 1993b:169). By the early nineteenth century, compound engines designed by Arthur Woolf were used in the British mining industry to drive water pumps. A number of engineers installed small specimens in ships in the 1830s and 1840s, though most proved less than successful. One of these early pioneers was Gerald Maurits Roentgen, who designed a compound marine engine in conjunction with high-pressure boilers in 1829. His engines saw only limited service on various European rivers, but his accomplishment deserves mention because, unlike Elder, his design was successful decades before the correct principles of the steam engine were fully understood (Knauerhase 1968:391-392).

Elder usually is given credit for introducing a practical compound engine to steam shipping. With Charles Randolph, he founded the ship- and engine building firm Randolph, Elder, and Company, which constructed the *Brandon* in 1854. She proved commercially successful and was soon followed by Pacific Steam Navigation Company's *Valparaiso* and *Inca* two years later (Guthrie 1971:119-126; Griffiths 1993b:169-170). Soon the commercial advantages of compound engines were realized, even by traditionally conservative shipyards, and became more common in the early 1860s. In 1862 the forward-thinking Elder even took out patents on triple- and quadruple-expansion engines, correctly anticipating these concepts, which would be perfected in the final decades of the nineteenth century.

Elder's credit of inventing the first commercially successful compound engine, however, has been challenged, most notably by Jarvis (1993). Elder's 1853 patent of a compound engine in conjunction with a screw propeller "was something of a false start," states Jarvis (1993:156), as his engine used low pressure boilers and therefore needed a considerable degree of superheat to benefit from the compounding process. Alfred Holt, on the other hand, in 1864 began experimenting with a compound engine in the ship *Cleator* (which worked at 60 psi, as opposed to Elder's 1862 *Carnatic* that operated at 26 psi). Higher operating pressures allowed compound engines to reach even greater levels of efficiency, and by 1870 it was said of Holt's Blue Funnel Line steamers (*Agamemnon*, *Ajax*, and *Achilles*, built in 1866), "the Steamers showing the results (in fact, as Mr. MacFarlane Gray stated, better than any he had in any case come across) are those of Mr. Holt, engaged in the China Trade, by which the saving has been from 23 tons to 14 [per day]" (Jarvis 1993:158).

Holt, more than any other individual, may claim responsibility for the widespread and rapid proliferation of the screw-propelled, compound engine-driven, iron-hulled vessel with eight to one beam-to-length ratio, an assemblage that constituted the world's first commercially viable long range steam cargo carriers, and which was sometimes referred to as the "Holt Standard" (Jarvis 1993:157). He also had the foresight or fortuitousness to build his ships on the eve of the opening of the Suez Canal. The Canal route, by which steamers could make a return voyage from the Orient some three months faster than competing sailing ships, brought the capabilities of the steamer to the world's attention, and catapulted it into the role of carrier of the world's trade after 1869.

BRIEF HISTORY OF THE RMS FORT VICTORIA

In 1910, the Adelaide Steamship Company of Adelaide, NSW, Australia, placed an order with William Beardmore and Company of Glasgow, Scotland, for two passenger liners to provide coastal service between Sydney and Fremantle. In March of 1911, ASS lost their liner *Yongala*, and immediately increased their order by a third vessel that was to become the steamship *Willochra*. The *Willochra*, 411.7 feet in length, 56.7 feet in the beam, with a 34.1-foot draft was 7,784 gross tons and 4,532 net tons burden, was equipped with a quadruple-expansion steam engine and twin screws (Figure 2-16). She was well appointed, with accommodations for 250 First Class, 120 Second Class, and 60 Third Class passengers (Figure 2-17). Completed in January of 1913 at the shipyard on the Clyde River, she departed for Australia, arriving in

Adelaide on April 1. The delivery of *Willochra* unfortunately coincided with a slump in the coastal trade, and she was taken to Kerocene Bay in Sydney Harbor, where she was laid up. She did not stay there very long, as she was immediately leased to the Union Steamship Company and placed on the New Zealand/San Francisco run opposite the similar sized steamer *Tahiti*.

Figure 2-16. SS *Willochra* ca. 1913.

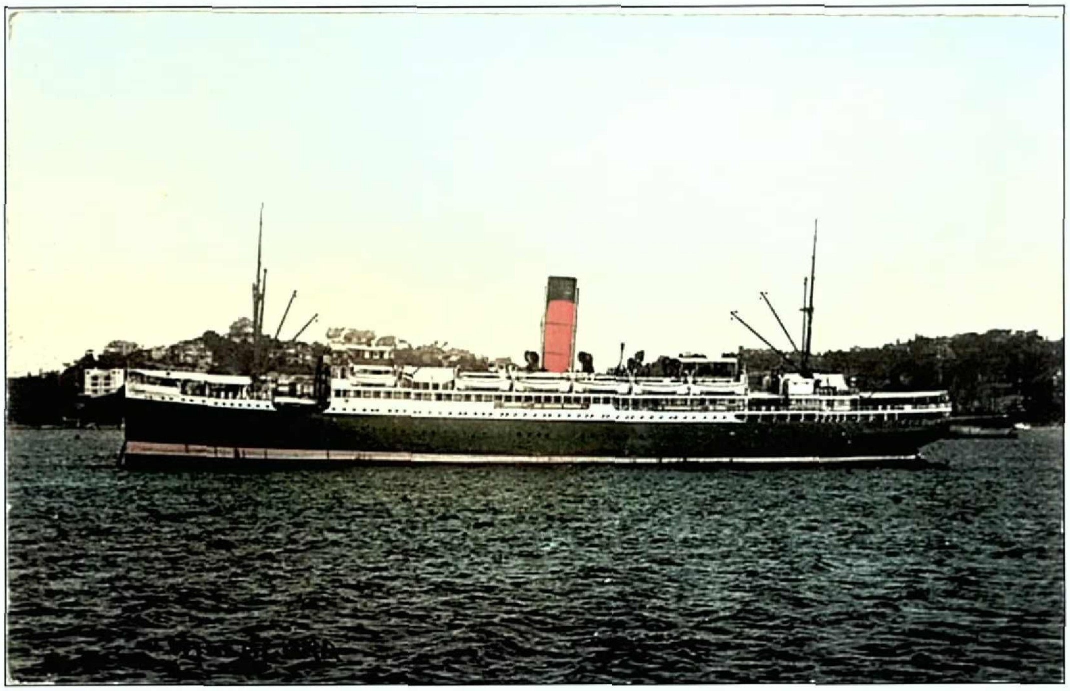


Figure 2-17. SS *Willochra* ca. 1913.

The vessel engaged in the trans-Pacific trade for about a year (Figure 2-18), when she was requisitioned by the government of New Zealand in November 1914 for conversion to a troop ship (Figures 2-19 and 2-20). From 1914 to 1917, she made eight voyages with New Zealand soldiers, including four to Egypt and four to Britain. In April 1917, she was transferred to British management and placed on the Atlantic troop run, bringing American soldiers to Europe. By the time the armistice was signed, she had only made two Atlantic voyages.

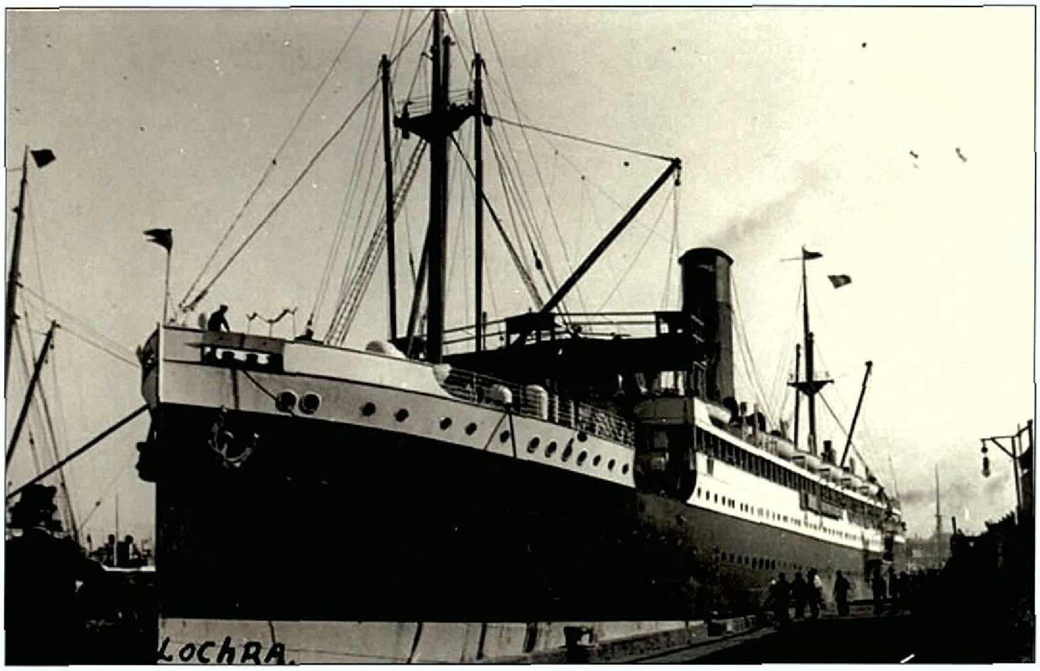


Figure 2-18. SS *Willochra* ca. 1913.

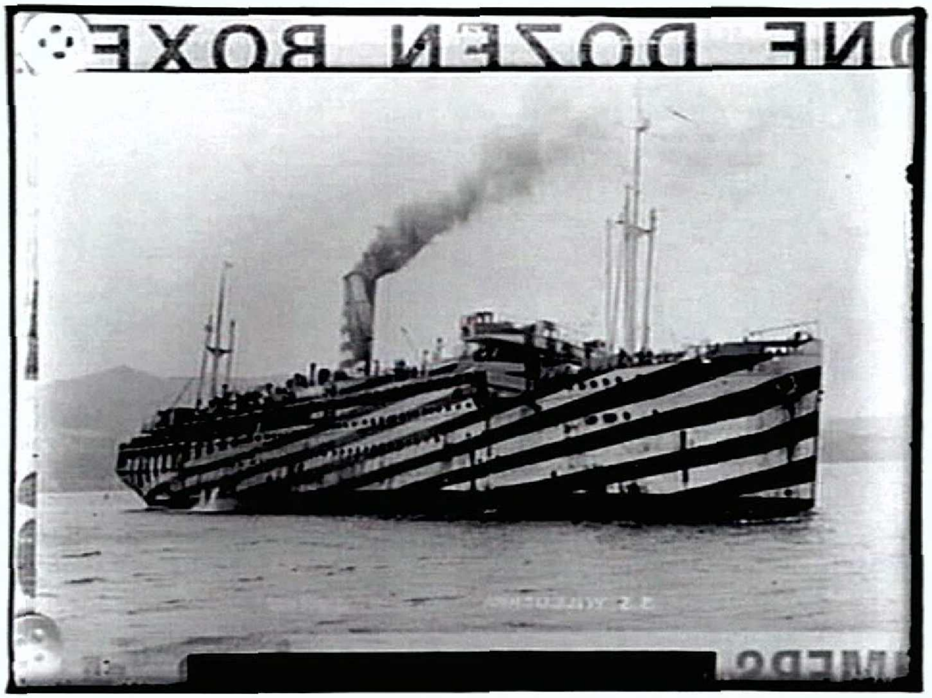


Figure 2-19. SS *Willochra* ca. 1915 as HMNZS *Willochra*.

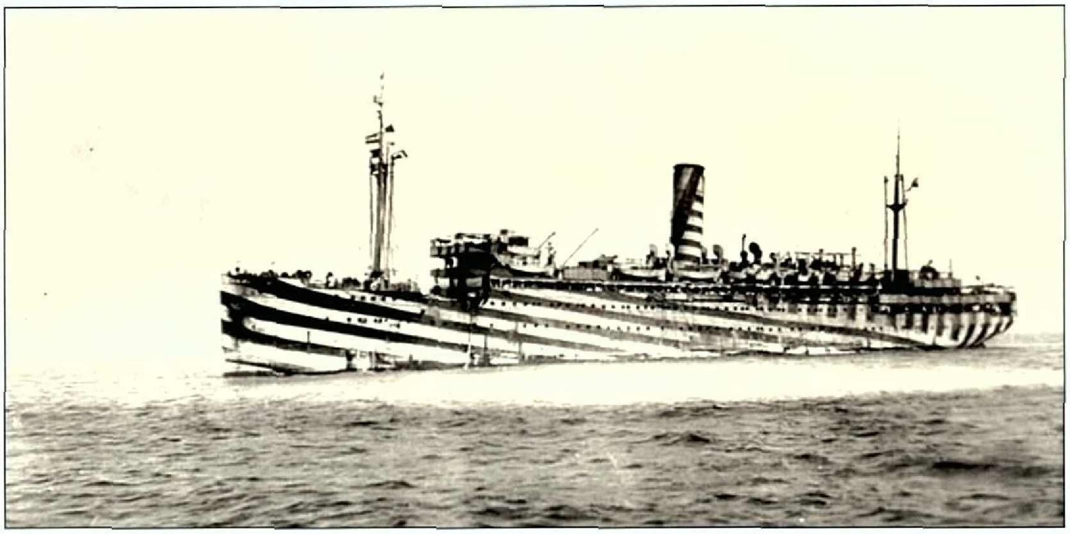
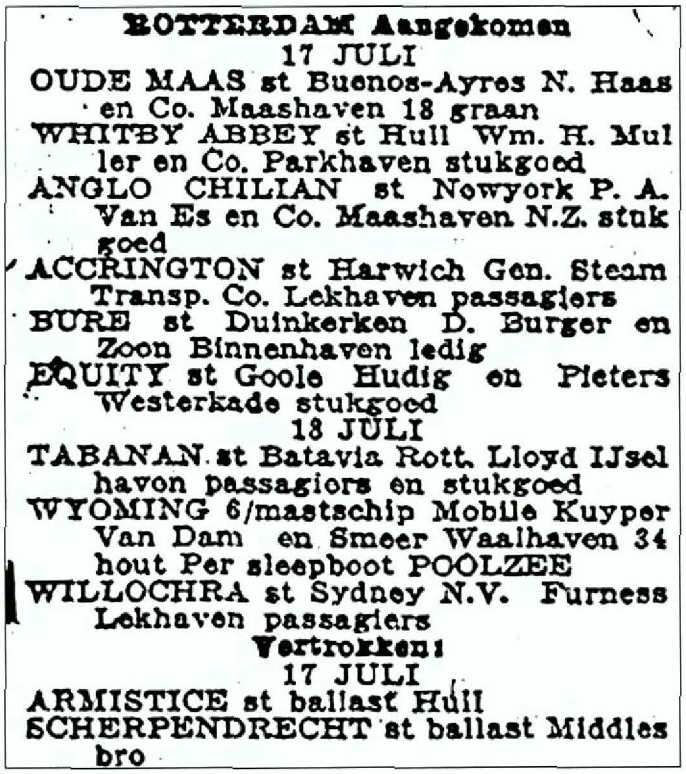


Figure 2-20. SS *Willochra* ca. 1916 as HMNZS *Willochra*.

Following the armistice, *Willochra* was placed on the North Sea run from Rotterdam to Hull (Figure 2-21), and then between Copenhagen and Leith, returning prisoners of war to their homelands. In February 1919, she left Southampton bound for New Zealand with returning New Zealand troops, arriving on April 14 (Figure 2-22). She returned to Plymouth, England, the following month carrying German citizens (Figure 2-23) where she remained until October 23, 1919, when she was released from her war service.



ROTTERDAM Aangekomen
17 JULI
OUDE MAAS st Buenos-Ayres N. Haas en Co. Maashaven 18 graan
WHITBY ABBEY st Hull Wm. H. Muller en Co. Parkhaven stukgoed
ANGLO CHILIAN st Newyork P. A. Van Es en Co. Maashaven N.Z. stukgoed
ACCRINGTON st Harwich Gen. Steam Transp. Co. Lekhaven passagiers
BURE st Duinkerken D. Burger en Zoon Binnenhaven ledig
EQUITY st Goole Hudig en Pieters Westerkade stukgoed
18 JULI
TABANAN st Batavia Rott. Lloyd IJselhaven passagiers en stukgoed
WYOMING 6/mastschip Mobile Kuyper Van Dam en Smeer Waalhaven 34 hout Per sleepboot POOLZEE
WILLOCHRA st Sydney N.V. Furness Lekhaven passagiers
Vertrokken:
17 JULI
ARMISTICE st ballast Hull
SCHERPENDRECHT st ballast Middlesbro

Figure 2-21. Clipping from Rotterdam's *Nieuwsblad*, of 19 July 1919, announcing the *Willochra's* arrival the previous day.

(Below) The transport SS *Willochra* leaving Southport, England, in early 1919 laden with New Zealand troops. Having recently played a key role bringing former British prisoners of war from Germany, the ship was en route for New Zealand where it collected New Zealand's prisoners of war who were bound for Germany. (Photo: *Auckland Weekly News*, 21/8/1919, p. 34)

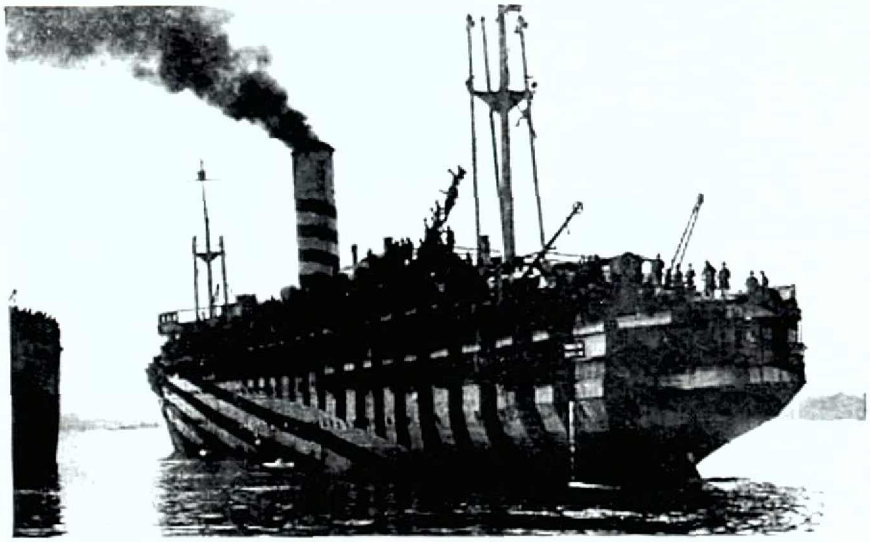


Figure 2-22. HMNZS *Willochra* leaving Southport bound for New Zealand carrying New Zealand soldiers (source: *Auckland Weekly News*, 8/21/1919. Pg 34).

Duitschers.

Het stoomschip Willochra is gisteravond uit Wellington in Australie, via Port Natal, alhier aangekomen. Aan boord bevinden zich ongeveer 900 uit Australie en Duitsch Afrika gezette Duitsche burgers. Zij ontschepen heden aan de Lekhaven.

Figure 2-23. "The steamship *Willochra* arrived here yesterday evening from Wellington and Australia via Port Natal. On board are approximately 900 German citizens who settled in Australia and German Africa who embarked in Lekhaven." Clipping from *Nieuwe Rotterdamse Courant* 19 July 1919.

Since she was under charter to the British Government from the Union Steamship Company, she was returned to that company rather than sold outright. However, due to changes in New Zealand passenger vessel regulations, she was deemed to be unprofitable by the Union Steamship Company for the trans-Pacific service, so she was returned to the Adelaide Steamship Company. Her owners made the same determination regarding profitability, so *Willochra* was sold to the Furness Group while still in her wartime colors.

The Furness Group intended to place her on the New York/Bermuda run. She underwent an extensive refit, with capacity increased to 380 First Class passengers and her boilers converted from coal to fuel oil (Figures 2-24, 2-25, 2-26). She was renamed RMS *Fort Victoria* after a Bermuda landmark. Registered in London under the ownership of the New York and Bermuda Steamship Company (known as the Furness Bermuda Line), she departed Liverpool for Boston on July 20, 1920. Accompanying the *Fort Victoria* was her sister ship *Fort St. George*. Also purchased from the Adelaide Steamship Company, she was another of the three vessels built alongside each other in 1913, and had been refit in a similar manner to the *Fort Victoria*. The two vessels were to run opposite each other on the New York–Bermuda run, offering for the first time a luxurious travel opportunity between the two places (Figures 2-27 to 2-34).

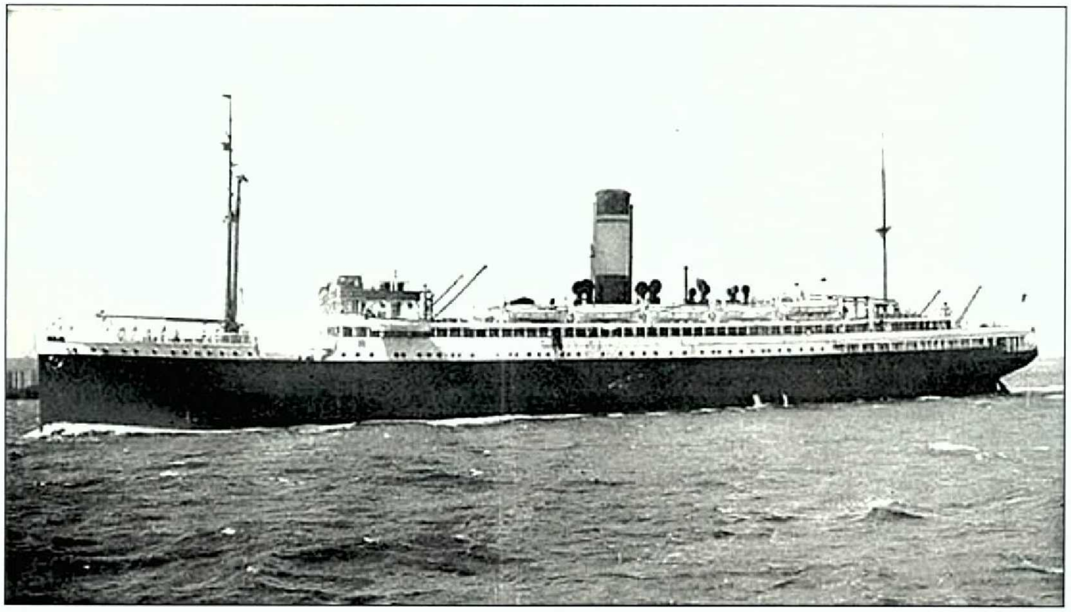


Figure 2-24. SS *Willochra* ca. 1920 after extensive refit and rechristening as SS *Fort Victoria*.

Figure 2-25. *Fort Victoria* ca. 1920 with Furness Bermuda Line colors.

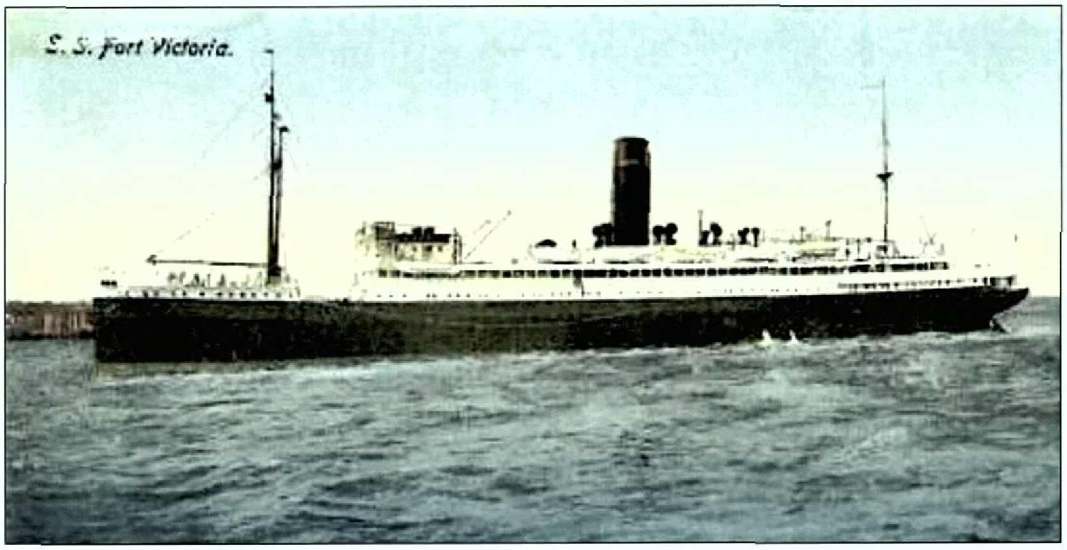


Figure 2-26. ***Fort Victoria*** **ca. 1920.**

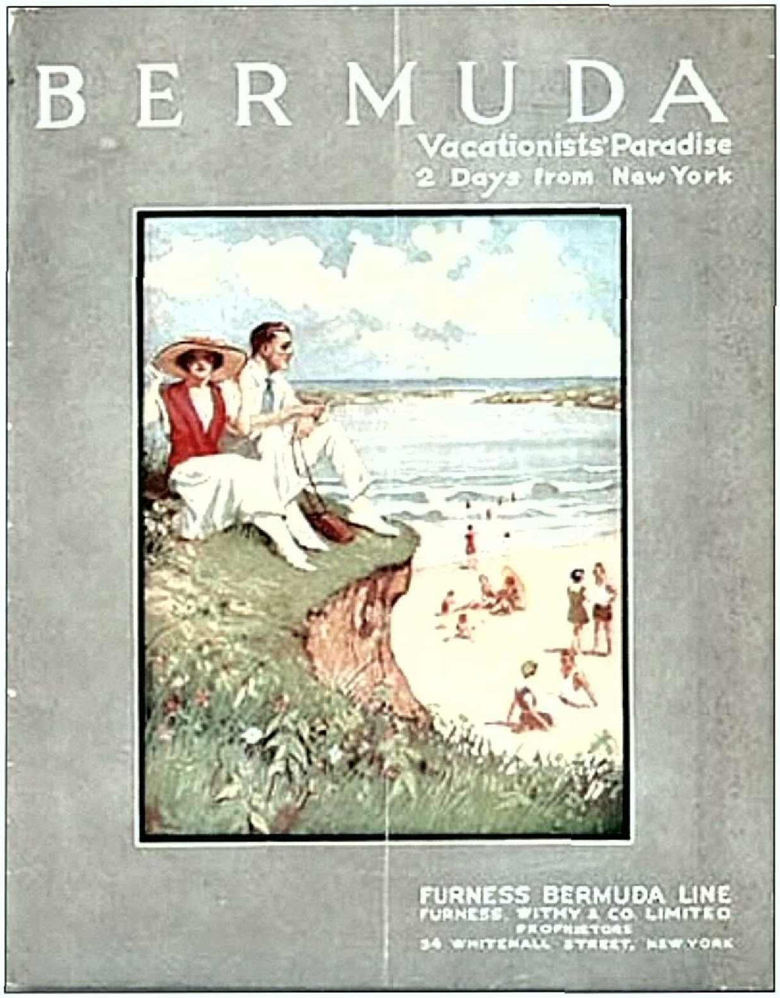
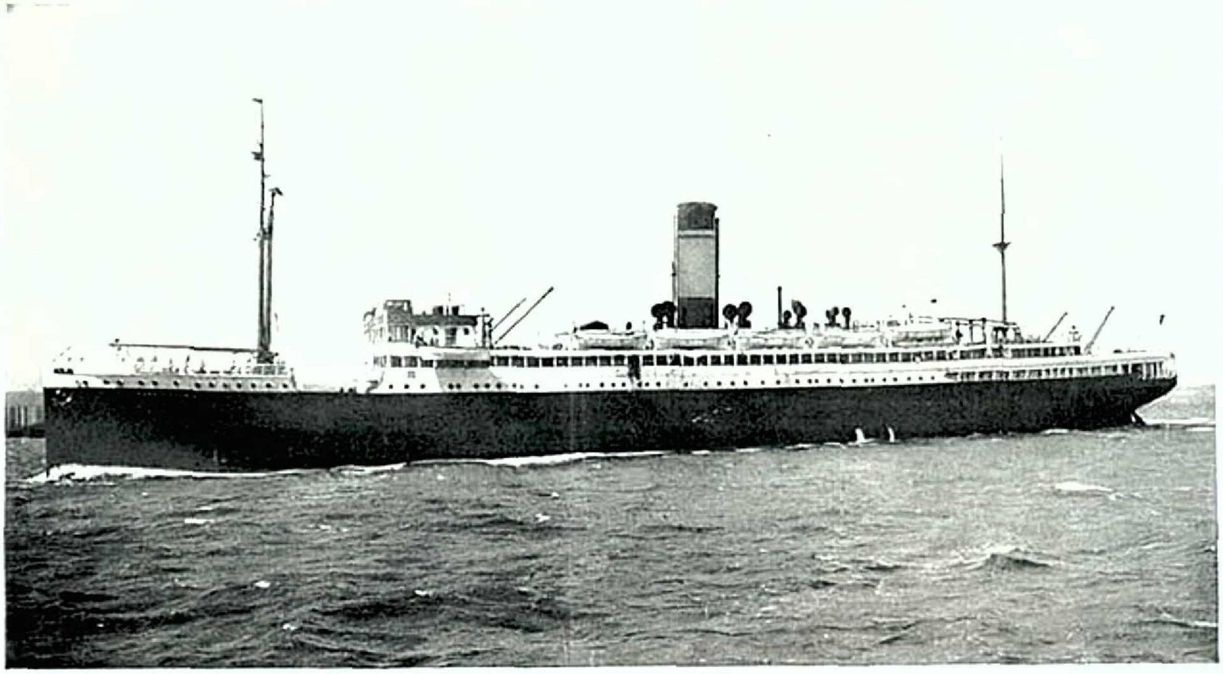


Figure 2-27. Cover of Furness Bermuda Line brochure advertising the new service.



TWIN-SCREW, 14,000 TON, OIL-BURNING S. S. "FORT VICTORIA" OF THE FURNESS BERMUDA LINE

BERMUDA STEAMSHIP SERVICE

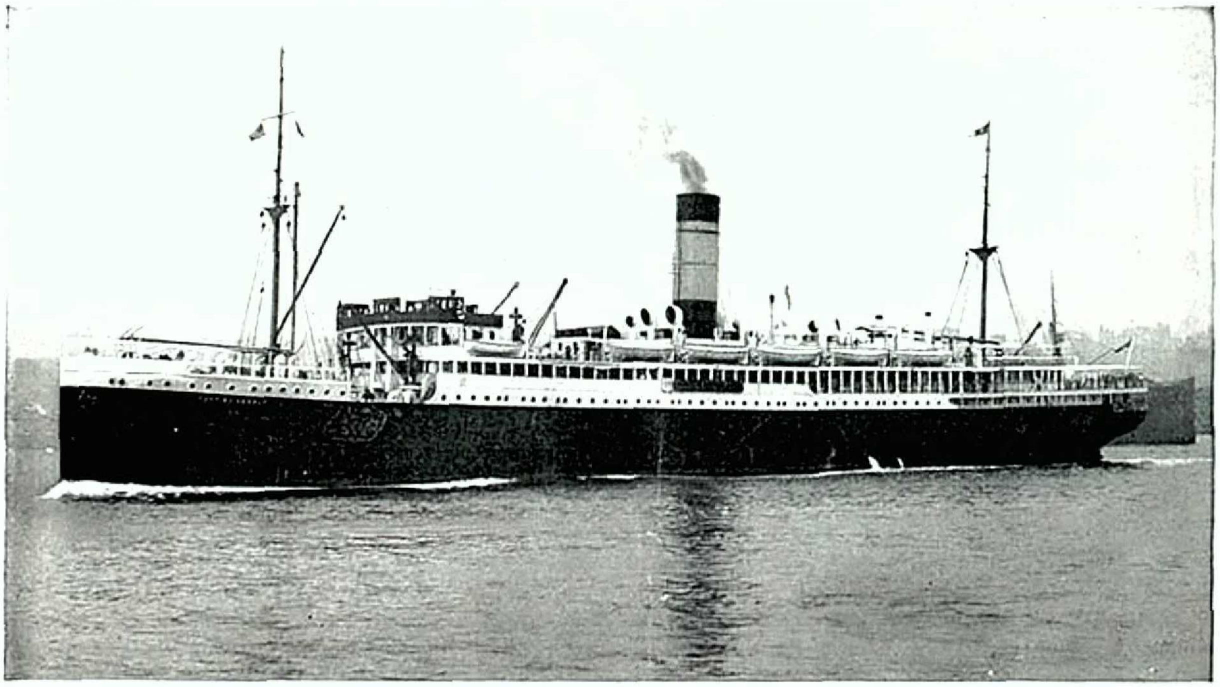
THE *palatial, twin-screw steamers,* S. S. "Fort Victoria" and S. S. "Fort St. George" of the Furness Bermuda Line, under contract with the Bermuda Government, which are now engaged in the New York-Bermuda route, are of the most advanced type, and their splendid accommodations and up-to-date equipment have done much to make the Bermuda trip such a popular one.

The ships are modern steel, twin-screw, oil-burning vessels, and are of the highest class at Lloyds. Each ship has accommodations for about 400 *first-class passengers, and* is strictly a first-class vessel. The state-rooms are comfortable and commodious, all fitted with electric lights, electric fans and running water. Many of the rooms are equipped with beds instead of the customary berths. For those who prefer more luxurious accommodations there are available a number of private suites containing sitting room, bedroom and bath, and also *a number of cabins* de luxe with private bath. The comfort of the passengers has received the fullest consideration, and the state-rooms on both vessels have an air of good taste and attractiveness which will appeal very strongly to discriminating travelers. Stewards and stewardesses are in attendance at all hours and are prepared to give passengers every possible attention.

Special attention has been given to the furnishing and equipment of the public rooms. All passengers like to spend a portion of the time on shipboard *in the music saloon and lounges*, and these are exceptionally roomy and attractive. The smoking rooms are handsomely and comfortably furnished. The dining saloons, in conformity with the best modern practice, are fitted with small tables. This feature will be particularly appreciated by tourists who are traveling in small parties of their own.

In the "Fort Victoria" and "Fort St. George" are exemplified a number of special features which are really new departures in ship construction. For instance, instead of the

Figure 2-28. Inside page of brochure in Figure 2-27 describing *Fort Victoria.*



TWIN-SCREW, 14,000 TON, OIL-BURNING S. S. "FORT ST. GEORGE," OF THE FURNESS BERMUDA LINE

small port-holes to which the ocean traveler is accustomed, these ships are fitted with windows on the upper decks, as will be noted from the accompanying illustrations. This is one of the many new features which have been introduced by the Furness-Bermuda Line to increase the comfort of passengers, and which help to place these ships in the front rank of their class.

The deck space is broad, allowing ample room for deck chairs and also for the pleasant promenade two or three times a day which most people find so invigorating. In the morning hours especially, an easy swing along the deck, filling one's lungs with the pure bracing sea air, brings a sense of exhilaration and physical well-being which is in itself a more than sufficient justification for the trip. A glance at the illustrations will show the broad attractive deck space. There are, of course, a number of deck games which can usually be found in full swing. The lounges, music saloon, smoking-room and verandah cafe are all situated on the promenade deck.

The verandah cafe, which vies in popularity with the lounge and other public rooms, is simply a lounging room out of doors, provided with comfortable wicker chairs and convenient tables, where passengers may have their favorite beverages. Here one can pass an occasional pleasant hour in good company, quite removed from the various activities of the ship.

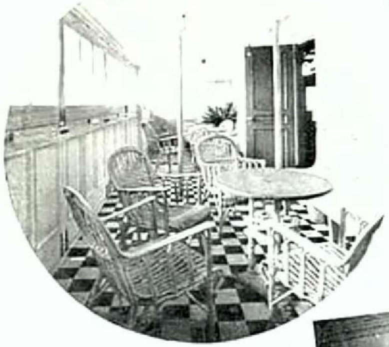
Sailings of the Furness Bermuda Line Steamers on the New York-Bermuda Route are twice weekly, leaving New York on Wednesdays and Saturdays and returning from Bermuda on Tuesdays and Saturdays. Tickets are interchangeable on either steamer, thus offering unequalled express service. The Furness Bermuda Line is under contract with the Bermuda Government and the ships of this Company are the only steamers in the New York-Bermuda service which land passengers direct at the Hamilton Dock without transfer by tender. Full particulars of rates, sailing dates and other information will be supplied on application to Furness Bermuda Line, 34 Whitehall Street, New York, or to any Local Steamship Ticket Agent.

Figure 2-29. Inside page of brochure in Figure 2-27 describing *Fort Victoria's* nearly identical sister ship *Fort St. George*.

Figure 2-30. Interior appointments of *Fort Victoria*.

Figure 2-31. Interior appointments of *Fort Victoria*.

SMOKING ROOM
S. S. "Fort St. George"



VERANDAH CAFE
S. S. "Fort St. George"

DINING ROOM
S. S. "Fort St. George"

Figure 2-32. Interior appointments of *Fort St. George*.

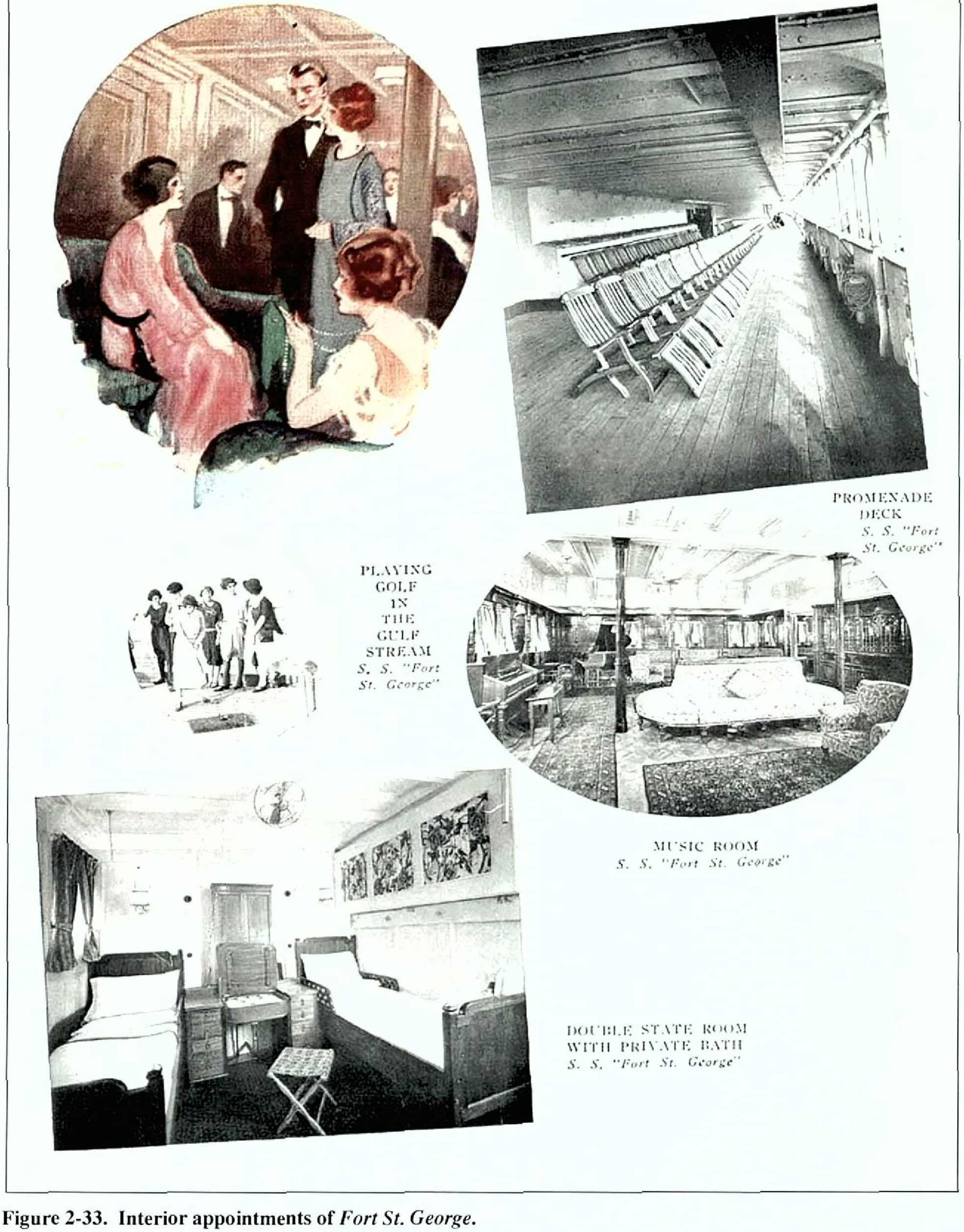
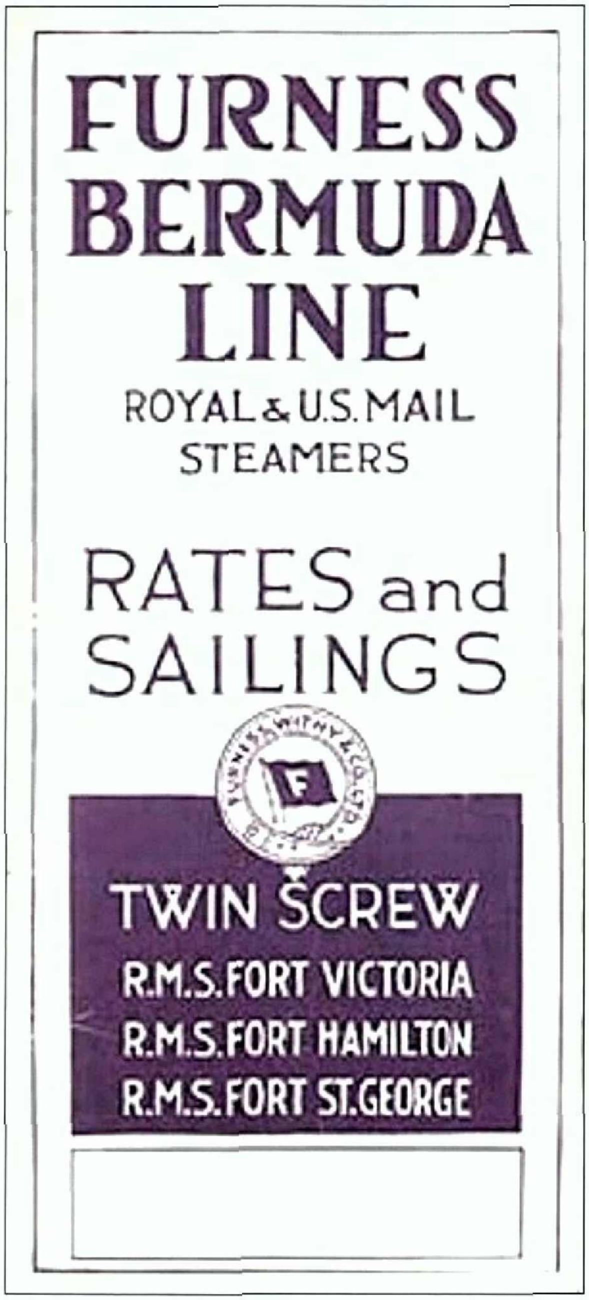


Figure 2-33. Interior appointments of *Fort St. George*.



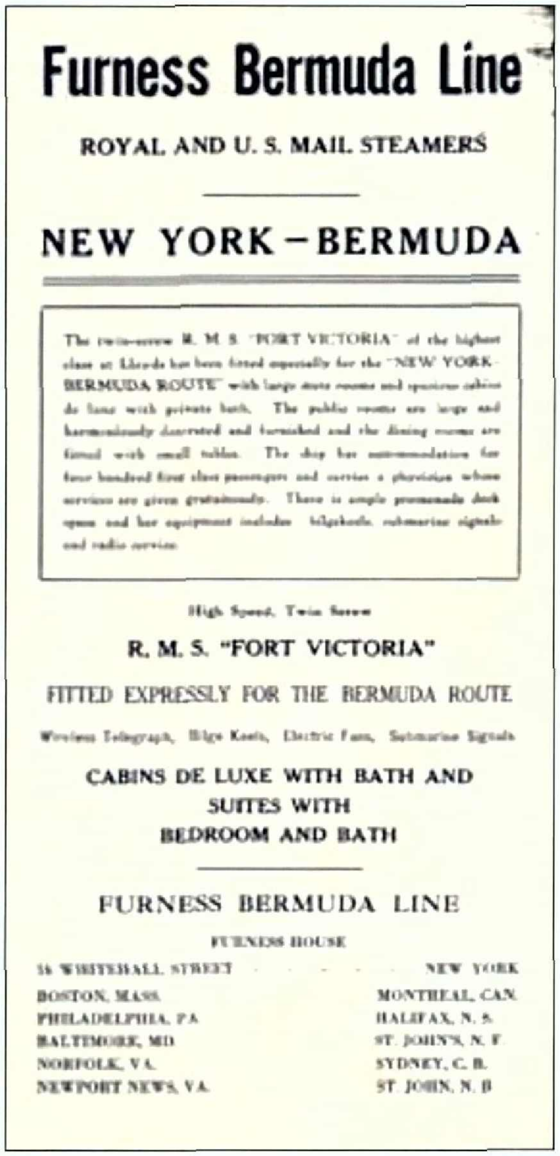
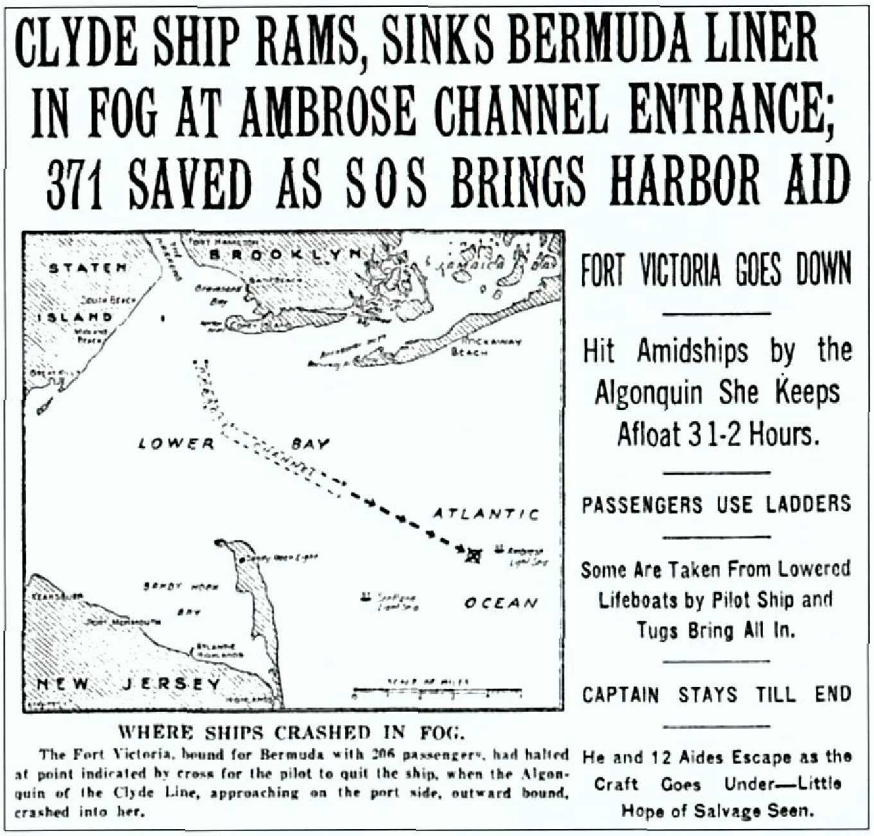


Figure 2-34. Furness Bermuda Line timetables, ca. 1922.

The New York/Bermuda run was a highly successful venture for the Furness Group. Carrying wealthy American tourists to the popular British colony, the *Fort Victoria* and her sister ships appeared set for a long career. However, on the morning of December 18, 1929, as she departed New York in a heavy fog, she collided with the American coastal steamer *Algonquin* (Figures 2-35 and 2-36). Although the crew and passengers escaped without serious injury, the *Fort Victoria* sank rapidly on her side in the middle of the channel. A serious hazard to navigation, she was dynamited with 20 tons of explosives and wire dragged to a clearance depth of 46 feet within a few years.



CLYDE SHIP RAMS, SINKS BERMUDA LINER IN FOG AT AMBROSE CHANNEL ENTRANCE; 371 SAVED AS SOS BRINGS HARBOR AID

WHERE SHIPS CRASHED IN FOG.

The Fort Victoria, bound for Bermuda with 206 passengers, had halted at point indicated by cross for the pilot to quit the ship, when the Algonquin of the Clyde Line, approaching on the port side, outward bound, crashed into her.

FORT VICTORIA GOES DOWN

Hit Amidships by the Algonquin She Keeps Afloat 3 1-2 Hours.

PASSENGERS USE LADDERS

Some Are Taken From Lowered Lifeboats by Pilot Ship and Tugs Bring All In.

CAPTAIN STAYS TILL END

He and 12 Aides Escape as the Craft Goes Under—Little Hope of Salvage Seen.

Figure 2-35. ***New York Times*** **article from 1929.**

Figure 2-36. SS *Algonquin* as a hospital ship in WWI.

3. INVESTIGATIVE PROCEDURES

As stated previously, the field investigation phase of the project was comprised of a an intensive remote sensing investigation utilizing a marine magnetometer, sidescan sonar, a subbottom profiler, and DGPS positioning followed by an assessment of the site by divers. The following chapter is a description of the equipment and methods were employed for these aspects of the investigation.

REMOTE SENSING SURVEY INVESTIGATIONS

Panamerican conducted archaeological survey fieldwork under the direction of Principal Investigator Andrew D.W. Lydecker, commencing on May 1, 2007. The archaeological field crew consisted of the principal investigator and Dr. Michael K. Faught. The project used equipment and procedures chosen specifically to meet the project requirements. The survey vessels *Marguerite Miller* and *Sorenson Miller* were used for the remote sensing survey and diving.

ENVIRONMENTAL CONDITIONS

The environmental conditions encountered during the project could probably be called typical for eastern New York during the early spring. Daytime temperatures ranged from 50 to 75 degrees Fahrenheit and sunny. Winds were typically out of the northwest, often creating 2- to 3-foot waves.

Commercial and pleasure vessel traffic was generally moderate. Heavy commercial vessels often passed near the survey areas, creating wave or magnetic interference, sometimes necessitating the rerunning of survey lines. Numerous pleasure boats were present, but did not present a problem.

REMOTE SENSING SURVEY EQUIPMENT

The remote sensing survey was conducted with equipment and procedures intended to facilitate the effective and efficient search for magnetic anomalies, acoustic, and seismic targets and to determine their exact location. The positioning system used was a Trimble Navigation DSM212H, Integrated 12-channel Global Positioning System (GPS), and Dual-channel MSK Beacon receiver for differential (DGPS) capabilities. Remote sensing instruments consisted of a Marine Magnetics SeaSpy marine magnetometer, Marine Sonic Technology dual frequency sidescan sonar, and an Edgetech SB-424 subbottom profiler. Data recorded for this project was recorded at one-second intervals. Survey lanes were placed at intervals not greater than 15 meters (50 feet).

DIFFERENTIAL GLOBAL POSITIONING SYSTEM

A primary consideration in the search for acoustic targets and magnetic anomalies is positioning. Accurate positioning is essential during the running of survey tracklines and also for returning to recorded locations for supplemental remote sensing operations or ground-truthing activities. These positioning functions were accomplished on this project through the use of a Trimble Navigation DSM212H global-based positioning system (Figure 3-01).

The 212H is a global positioning system that attains differential capabilities by internal integration with a Dual-channel MSK Beacon receiver. This electronic device interprets transmissions both from satellites in Earth's orbit and from a shore-based station, to provide accurate coordinate positioning data for survey. The Trimble system used here has been specifically designed for survey positioning. This positioning was provided through continuous real-time tracking of the moving survey vessel by utilizing corrected position data provided by an on-board GPS, which processed both satellite data and differential data transmitted from a shore-based GPS station utilizing Radio Technical Commission for Maritime Services (RTCM) 104 corrections. The shore-based differential station monitored the difference between the position that the shore-based receiver derived from satellite transmissions and that station's known position. Transmitting the differential that corrected the difference between received and known positions, the DGPS aboard the survey vessel constantly monitored the navigation beacon radio transmissions in order to provide a real-time correction to any variation between the satellite-derived and actual positions of the survey vessel. New York Long Island State Plane coordinates, based on the 1983 North American Datum (NAD 83) coordinate system, were used for this project.

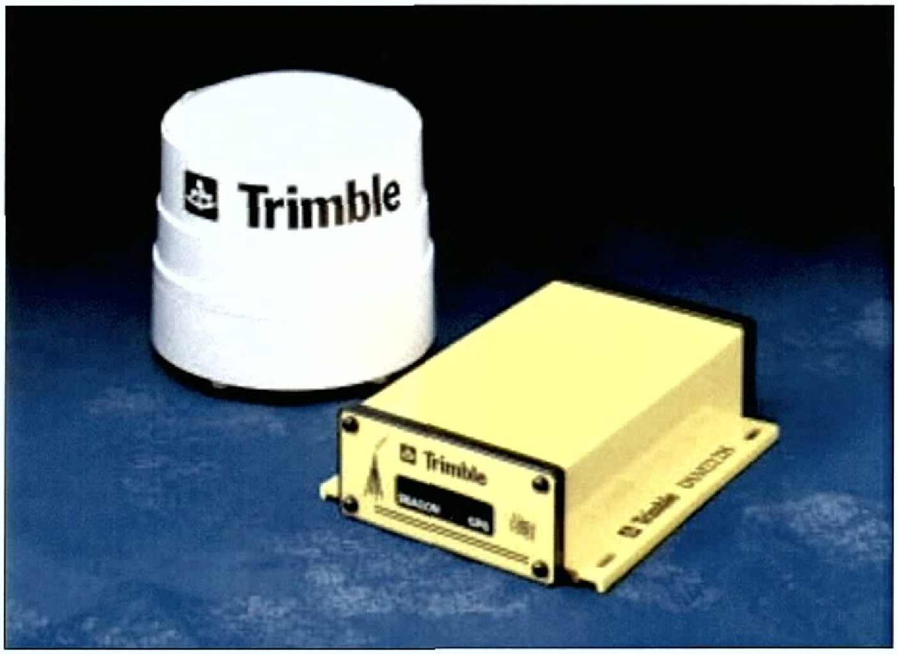


Figure 3-01. Trimble navigation DSM212H DGPS unit used during the project.

Both the satellite transmissions and the differential transmissions received from the shore-based navigation beacon were entered directly into a Sony Vaio laptop computer with an auxiliary display screen aboard the survey vessel. The computer and associated hardware and software calculated and displayed the corrected positioning coordinates every second and stored the data. The level of precision for the system is considered by the manufacturer "...to achieve positions accurate to the submeter level" (Trimble Navigation Limited 1998:1-10). Computer software (Hypack Max®) used to control data acquisition, was written and developed by Coastal Oceanographics, Inc. specifically for survey applications. Positioning information was stored on magnetic disk aboard the survey vessel.

All positioning coordinates are based upon the position of the antenna of the DGPS. Each of the remote sensing devices was oriented to the antenna, and their orientation, relative to the antenna, (known as a layback) was noted. This information is critical in the accurate positioning of targets during the data analysis phase of the project, and repositioning for any subsequent archaeological activities. The layback of the magnetometer sensor was 50 ft. aft and the layback for the sidescan sonar was 10 ft. aft (Figure 3-02).

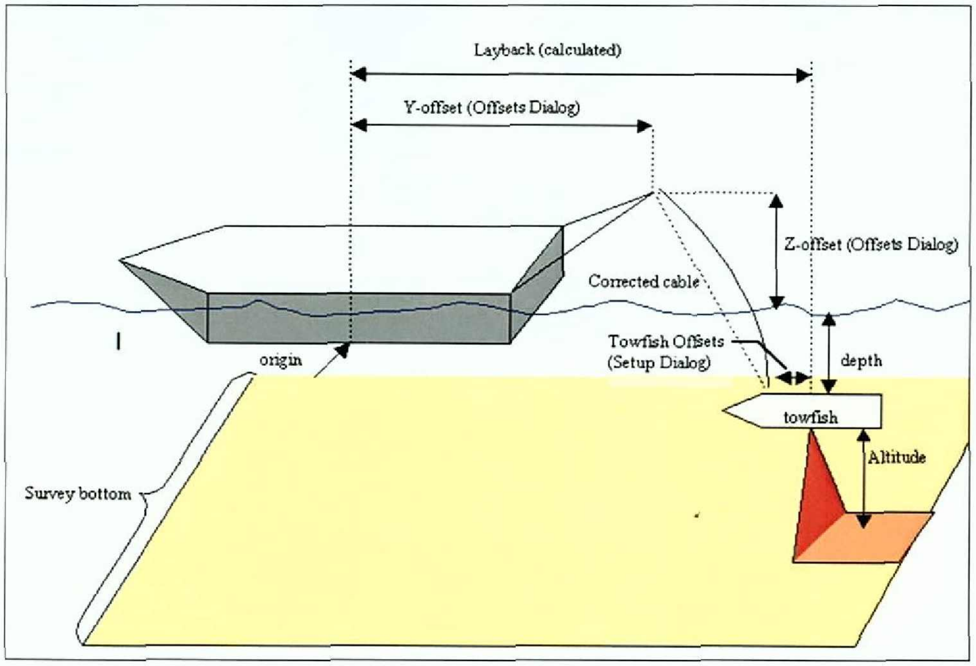


Figure 3-02. Equipment schematic illustrating layback (Courtesy of Coastal Oceanographics, Inc.).

MAGNETOMETER

The remote sensing instrument used to search for ferrous objects on or below the Sound floor of the survey area was a Marine Magnetics SeaSpy Overhauser magnetometer (Figure 3-03). The magnetometer is an instrument that measures the intensity of magnetic forces. The sensor measures and records both the Earth's ambient magnetic field and the presence of magnetic anomalies (deviations from the ambient background) generated by ferrous masses and various other sources. These measurements are recorded in gammas, the standard unit of magnetic intensity (equal to 0.00001 gauss). The SeaSpy is capable of sub-second repeatability, but data was collected at one-second intervals both digitally and graphically, providing a record of both the ambient field and the character and amplitude of anomalies encountered. This data was stored electronically in the navigation computer.

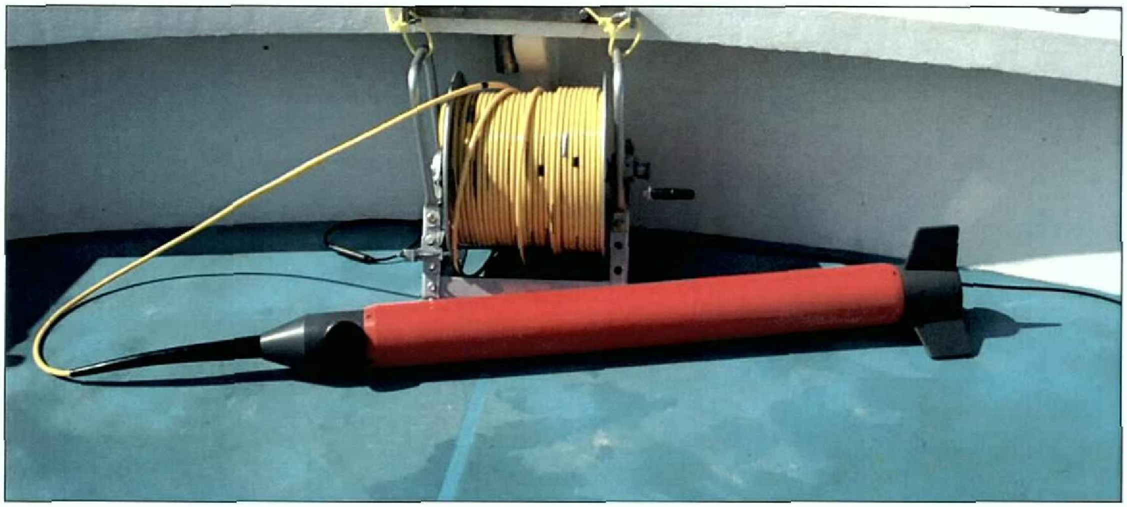


Figure 3-03. Marine Magnetics SeaSpy magnetometer.

The ability of the magnetometer to detect magnetic anomalies, the sources of which may be related to submerged cultural resources such as shipwrecks, has caused the instrument to become a principal remote sensing tool of marine archaeologists. While it is not possible to identify a specific ferrous source by its magnetic field, it is possible to predict shape, mass, and alignment characteristics of anomaly sources based on the magnetic field recorded. It should be noted that there are other sources, such as electrical magnetic fields surrounding power transmission lines, underground pipelines, navigation buoys, or metal bridges and structures, that may significantly affect magnetometer readings. Interpretation of magnetic data can provide an indication of the likelihood of the presence or absence of submerged cultural resources. Specifically, the ferrous components of submerged historic vessels tend to produce magnetic signatures that differ from those that are characteristic of isolated pieces of debris. While it is impossible to identify, specifically, the source of any anomaly, solely from the characteristics of its magnetic signature, this information, in conjunction with other data (historic accounts, use patterns of the area, diver inspection), other remote sensing technologies, and prior knowledge of similar targets, can lead to an accurate estimation.

For this project, the magnetometer was interfaced with a Dell laptop computer, utilizing Hypack® software applications for data storage and management. It was also interfaced with the positioning system, allowing positioning fix points to be integrated with each magnetometer data point.

Sidescan Sonar

The remote sensing instrument used to search for physical features on or above the bottom of Pamlico Sound was a Marine Sonic Technology (MST) Sea Scan sidescan sonar system (Figure 3-04). The sidescan sonar is an instrument that, through the transmission of dual fan-shaped pulses of sound and reception of reflected sound pulses, produces an acoustic image of the bottom. Under ideal circumstances, the sidescan sonar is capable of providing a near-photographic representation of the bottom on either side of the trackline of a survey vessel. The MST Sea Scan sidescan sonar unit used on this project was operated with an integrated single frequency 600 kHz towfish.

Figure 3-04. Marine Sonic Technology (MST) Sea Scan sidescan sonar system.

The Sea Scan PC has internal capability for removal of the water column from the instrument's video printout, as well as correction for slant range distortion. This sidescan sonar was utilized with the navigation system to provide manual marking of positioning fix points on the digital printout. Sidescan sonar data are useful in searching for the physical features indicative of submerged cultural resources. Specifically, the record is examined for features showing characteristics such as height above bottom, linearity, and structural form. Additionally, potential acoustic targets are checked for any locational match with the data derived from the simultaneous magnetometer survey.

SUBBOTTOM PROFILER

There are several types of subbottom profilers: sparkers, pingers, boomers, and chirp systems. Sparkers operate at the lowest frequencies and afford deep penetration but low-resolution. Boomers operate from 0.5 kHz to 5 kHz and they can penetrate to between 30 m and 100 m with resolution of 0.3 m to 1.0 m. Pingers operate from 3.5 kHz and 7 kHz and penetrate seabeds from a few meters to more than 50m depending on sediment consolidation, with resolution to about 0.3 m. CHIRP systems operate around a central frequency that is swept electronically across a range of frequencies between 3 kHz to 40 kHz and resolution can be on the order of 0.1 m in suitable near-seabed sediments.

The current project survey deployed an Edgetech 424 XSE-500 Shallow Tow X-Star System with topside processor and towfish (Figure 3-05). This Edgetech subbottom profiling system included a Model 3100-G Topside Processor with DISCOVER Subbottom Software and a 4-24 kHz SB-424 towfish.

Figure 3-05. The Edgetech subbottom processor and 424 towfish used in the survey.

PROJECT VESSELS

The survey vessel *Marguerite Miller*, a 45-foot crew boat powered by twin diesel engines, was employed for the initial survey (Figure 3-06), while the work vessel *Sorenson Miller*, a 130-foot work vessel, was employed during diving operations (Figure 3-07). The vessels conformed to all U.S. Coast Guard specifications according to class and have a full compliment of safety equipment. The vessels carried appropriate emergency supplies including life jackets, a spare parts kit, a tool kit, first aid materials, and potable water.

Figure 3-06. Survey vessel *Marguerite Miller*.

Figure 3-07. Dive vessel *Sorenson Miller*.

UNDERWATER VIDEO

All divers were recorded using a Kongsberg submersible video system (Figure 3-08). This system consists of a handheld diver video camera with the transmission cable integrated into the diver's umbilical. A topside monitor and controls allow the timekeeper to see the video and record comments, as well as control lighting.

Figure 3-08. Video system.

DIVE EQUIPMENT

Throughout the diving phase of the investigation, operations utilized surface-supplied air (SSA) due to its inherent safety and efficient operations. SSA provides direct diver-to-surface air and communication. The system contains two complete diving sets, each with a dive helmet and 200-foot surface-to-diver air supply umbilical, polypropylene rope safety line, communications cable, and pneumatic hose. The Kirby-Morgan Superlite 27 helmets (Figure 3-09) are equipped with speakers, microphones, regulators, and, at the air intake, a non-return safety valve. The communications components, regulators, and non-return safety valves of the dive masks are checked for proper functioning prior to each dive. In addition, divers using SSA wore safety equipment including a harness, quick-release attachments connecting the diver to the surface umbilical, a 50-cubic foot auxiliary air tank, quick-release weight belts, and protective gear including wet suits, boots, and gloves, which were worn during all diving operations.

A cascade air system for SSA diving provided no less than two 200-cubic feet 2100 PSI commercial K-bottles of certified breathing air. The system included a 50-cubic foot 3000 PSI backup cylinder worn by the diver and connected to the dive helmet as an emergency air source in the event of primary air failure. The diving supervisor monitored the air supply system during each dive to ensure correct air pressure. Air supply hoses consisted of Gates 33HB commercial dive hoses with a rated bursting pressure of at least 1000 PSI. A 3/8-inch polypropylene rope safety line secured the air supply hoses. The communications cable integrated into the diver umbilical included a 16-gauge four-conductor cable with oil resistant jacket. Video transmission cable for the diver-held video camera was integrated into the umbilical. The diver umbilicals consisted of Synflex 3630-4 × 1/4-inch 300 PSI working pressure pneumo hoses.

Dive length time corresponded to that prescribed by the standard Professional Association of Diving Instructors (PADI) SCUBA table.

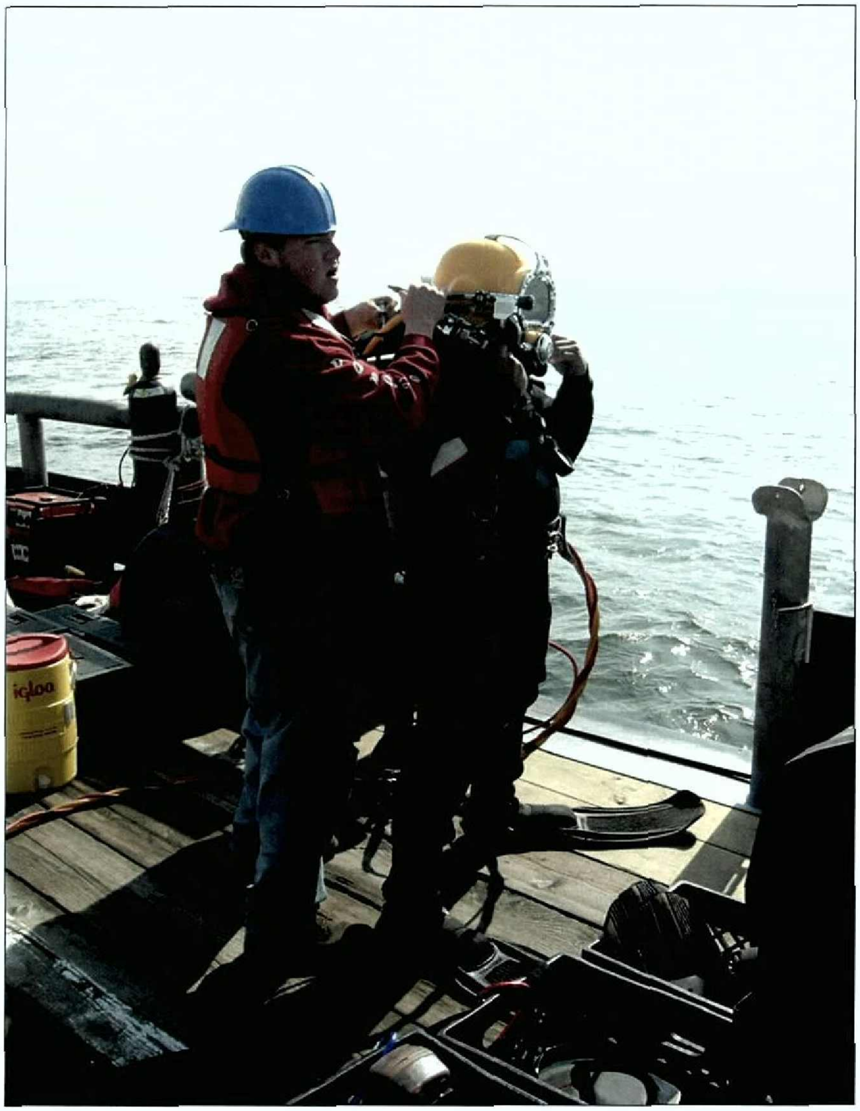


Figure 3-09. RanDive diver readies to go in the water.

Four dives were conducted on May 2 and 3, 2007. Much of the underwater work on the site consisted of examining the site with handheld video.

Survey Procedures

The remote sensing phase of this project began on May 1, 2007. Coordinates for the site as indicated by Great Lakes Dredge and Dock were entered into the navigation program Hypack® and pre-plotted tracklines were produced with 100-foot intervals depending on location (Figure 3-10). The magnetometer, sidescan sonar, subbottom profiler, and DGPS were installed and tested aboard the survey vessel, and the running of pre-plotted tracklines began. The helmsman viewed a video monitor linked to the DGPS and navigational computer to aid in directing the course of the vessel relative to the trackline. The monitor displayed the real-time position of the path of the survey vessel along the trackline (Figure 3-11). The speed of the survey vessel will be maintained at approximately four knots for the uniform acquisition of data.

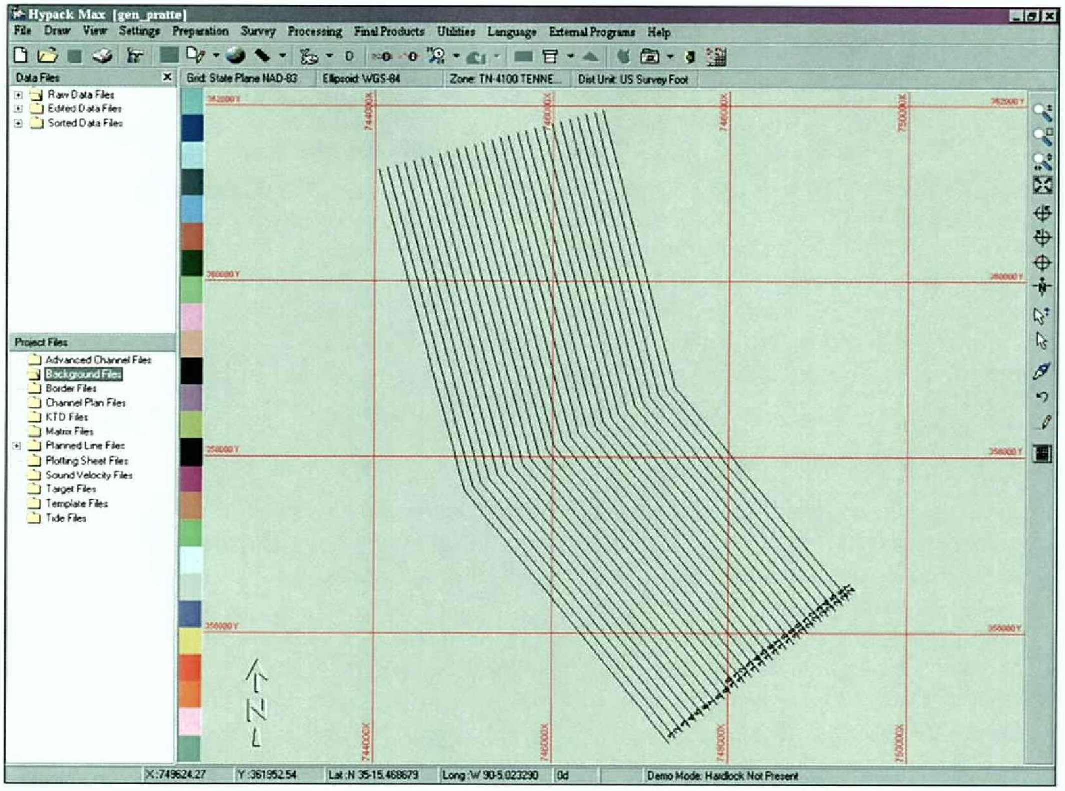


Figure 3-10. Example of pre-plotted trackline data for a survey area in Hypack® software.

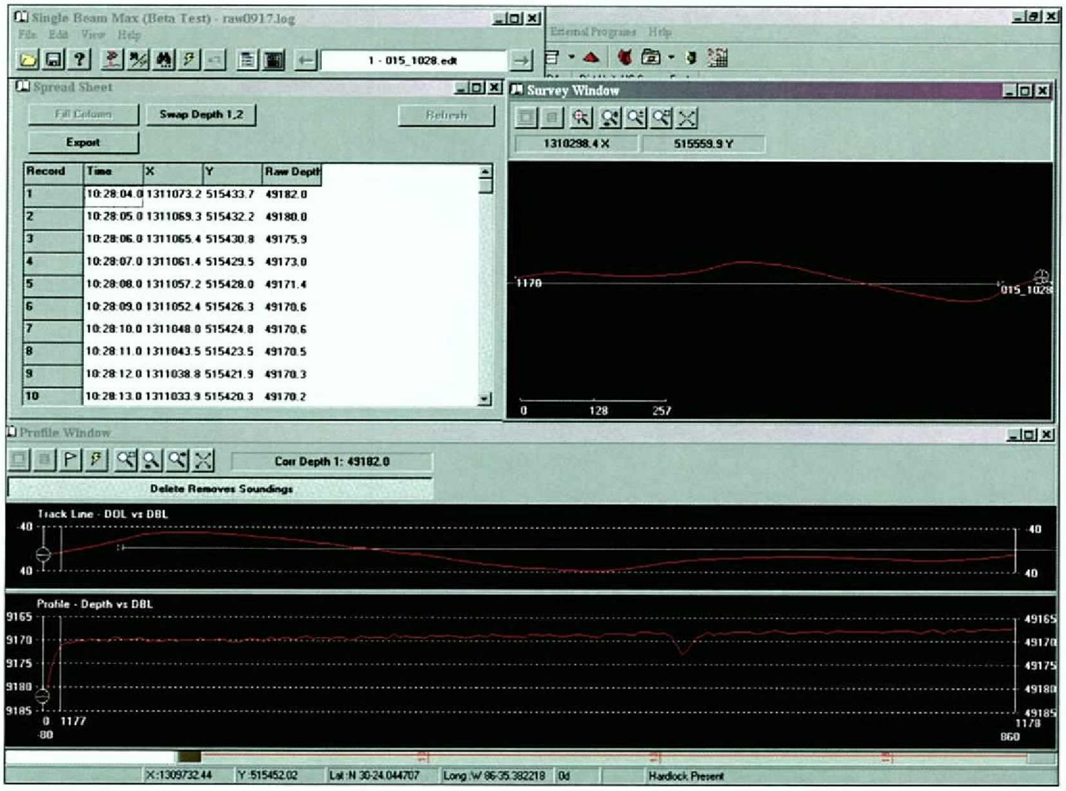


Figure 3-11. Example of real-time survey trackline and magnetic data in Hypack®. Top left window shows magnetic values and positioning; top right window as well as window immediately below shows overhead view for the trackline; bottom window shows magnetic deviation of the trackline.

The full project area was examined with the sidescan sonar and magnetometer where safely navigable. The survey vessel began each run outside the survey area. At the proper interval the vessel would turn parallel to the centerline and proceed down the next trackline. As the survey vessel maneuvered down each transect, the navigation system determined vessel position along the actual line of travel every second. These positioning points along the line traveled were recorded on computer floppy disk. During the running of a line, event marks were annotated on the sidescan printout at the start and end of the line and at any interesting featured noted during the survey.

The remote sensing survey phase of the project concluded on May 3, 2007, with the project area completely surveyed. Upon completion of the remote sensing survey, the data were reviewed. Sidescan and magnetometer features were prioritized as to possible significance by employing signal characteristics (e.g., spatial extent, structural features, etc.).

DATA ANALYSIS PROCEDURES

Upon completion of the remote sensing survey, the data was reviewed. This task essentially entailed the archaeologist and remote sensing specialist analyzing the previously acquired and processed data. Sidescan and subbottom features and magnetic anomalies were tabulated and prioritized as to possible significance by employing signal characteristics (e.g., spatial extent, structural features, etc.). Magnetic data was presented in a magnetic contour map(s) with trackline format. Specific sidescan targets are also located on the map and are illustrated and discussed individually. The magnetic anomalies and/or sidescan targets shown on the map(s) are sequentially numbered and tabulated as to location (Northing and Easting), as well as magnetic deviation. The contoured/labeled targets are then compared with strip chart records and attendant sidescan data. Each magnetic anomaly or sidescan target, described with the proper terminology and locational and positional information, is included. If any of the remote sensing targets correlated with any documentary evidence it was noted.

The evaluation of the potential cultural significance of targets was then conducted and was dependent on a variety of factors. These include the detected characteristics of the individual targets (e.g., magnetic anomaly strength and duration, and sidescan image configuration), association with other sidescan or magnetic targets on the same or adjacent lines, relationships to observable target sources such as channel buoys or pipeline crossings, as well as correlation to the historic record. Magnetic anomalies were evaluated and prioritized on the basis of amplitude or deflection intensity in concert with duration or spatial extent. Targets such as isolated sections of pipe can normally be immediately discarded as nonsignificant. Targets that were likely to represent potential historical shipwrecks or other potentially historic submerged resource were identified, and recommendations were made for subsequent avoidance or assessment by archaeological divers.

MAGNETOMETER ANALYSIS

Interpretation of data collected by the magnetometer is perhaps the most problematic to analyze. Magnetic anomalies are evaluated and prioritized on the basis of magnetic amplitude or deflection of gamma intensity in concert with duration or spatial extent; they are also correlated with sidescan targets. The problems of differentiating between modern debris and shipwrecks on the basis of remote sensing data have been discussed by a number of authors. This difficulty is particularly true in the case of magnetic data, and therefore it has received the most attention in the current body of literature dealing with the subject. Pearson and Saltus state, "even though a considerable body of magnetic signature data for shipwrecks is now available, it is impossible to positively associate any specific signature with a shipwreck or any other feature" (1990:32). There is no doubt that the only positive way to verify a magnetic source object is through physical examination. With that said, however, the size and complexity of a magnetic signature does provide a usable key for distinguishing between modern debris and shipwreck remains (see

Garrison et al. 1989; Irion et al. 1995; Pearson et al. 1993). Specifically, the magnetic signatures of most shipwrecks tend to be large in area and tend to display multiple magnetic peaks of differing amplitude.

The state of technology of iron-hulled or steam vessels may also be considered a factor in their potential for being detected by modern remote sensing techniques. The magnetometer detects ferrous objects that create deviations in the Earth's natural magnetic field. The greater the weight of iron in the remains of a shipwreck, the greater the likelihood the remains will be observed, at least theoretically. The mass of metal on iron-hulled or steam vessels is made up of the hull and/or boilers, pipes, valves, steam engines, hogging trusses and straps, deck gear, auxiliary engines, pumps, hoists, winches, and other pieces of equipment. As the state of steam technology advanced, boilers and engines got larger, and/or more were used for larger vessels. Larger locomotion systems contained more iron and therefore are more likely to have a detectable magnetic signature.

In a study of magnetic anomalies in the northern Gulf of Mexico, Garrison et al. (1989) indicate that a shipwreck signature will cover an area between 10,000 and 50,000 m^2. Applicable to the Gulf Coast and based on large vessel types, the study's findings are not totally relevant to wooden sailing vessels in the pre-steam era. However, criteria from the Garrison et al. (1989) study and others developed to identify the signatures of larger vessel types are applicable. Using the Garrison et al. (1989) study, as well as years of "practical experience," in an effort to assess potential significance of remote sensing targets, Pearson et al. (1991) developed general characteristics of magnetometer signatures most likely to represent shipwrecks. The report states, "the amplitude of magnetic anomalies associated with shipwrecks vary [*sic*] considerably, but, in general, the signature of large watercraft, or portions of watercraft, range from moderate to high intensity (>50 gamma) when the sensor is at distances of 20 ft. or so" (1991:70). Using a table of magnetic data from various sources as a base, the report goes on to state that "data suggest that at a distance of 20 ft. or less watercraft of moderate size are likely to produce a magnetic anomaly (this would be a complex signature, i.e., a cluster of dipoles and/or monopoles) greater than 80 or 90 ft. across the smallest dimension … " (Pearson et al. 1991:70).

While establishing baseline amounts of amplitude and duration reflective of the magnetic characteristics for a shipwreck site, the authors recognize "that a considerable amount of variability does occur" (1991:70). Generated in an effort to test the 50-gamma/80-foot criteria and determine amount of variability, Table 3-01 lists numerous shipwrecks as well as single- and multiple-source objects located by magnetic survey and verified by divers. All shipwrecks meet and surpass the 50-gamma/80-foot criteria, while all single-object readings, with the exception of the pipeline, fall below the criteria. However, the signature of the pipeline should show up as a linear feature on a magnetic contour map and not be confused with a single-source object. While the shipwrecks and single-source objects adhere to the 50-gamma/80-foot criteria, the multiple-source objects do not. If all targets listed on the table had to be prioritized as to potential significance based on the 50-gamma/80-foot criteria, the two multiple-source object targets would have to be classified as potentially significant.

Although data indicate the validity of employing the 50-gamma/80-foot criteria when assessing magnetic anomalies, other factors must be taken into account. Pearson and Hudson (1990) have argued that the past and recent use of a water body must be an important consideration in the interpretation of remote sensing data; in many cases it is the most important criterion. Unless remote sensing data, historical record, or specific environment (e.g., harbor entrance channel) provide compelling and overriding evidence to the contrary, it is believed that the history of use should be a primary consideration in interpretation. What constitutes "compelling evidence" is to some extent left to the discretion of the researcher; however, in settings where modern commercial traffic and historic use have been intensive, the presence of a large quantity of modern debris must be anticipated. In harbor, bay, or riverine situations with heavy traffic, this debris will be scattered along the channel right-of-way, although it may be concentrated at areas where traffic would slow or halt; it will appear on remote sensing surveys as discrete, small objects.

Table 3-01. Magnetic data from shipwrecks and non-significant sources.

Vessel (object)	Type & Size	Magnetic Deviation	Duration (feet)	Reference
Shipwrecks				
Tug	Wooden tug with machinery	-30257	176	Tuttle and Mitchell 1998
Mexico	288-ton wooden bark	1260	454	Tuttle and Mitchell 1998
J.D. Hinde	129-ft. wooden sternwheeler	573	110	Gearhart and Hoyt 1990
Utina	267-ft. wooden freighter of 238 tons	690	150	James and Pearson 1991; Pearson and Simmons 1995
King Phillip	182-ft. clipper of 1,194 tons	300	200	Gearhart 1991
Reporter	141-ft. schooner of 350 tons	165	160	Gearhart 1991
Mary Somers	iron-hulled, 967-ton sidewheeler	5000	400	Pearson et al. 1993
Gen. C.B. Comstock	177-ft. wooden hopper dredge	200	200	James et al. 1991
Mary	234-ft. iron sidewheeler	1180	200	Hoyt 1990
Columbus	138-ft. wooden-hulled, 416-ton Chesapeake sidewheeler	366	300+	Morrison et al. 1992
El Nuevo Constante	126-ft. wooden collier	65	250	Pearson et al. 1991
James Stockton	55-ft. wooden schooner	80	130	Pearson et al. 1991
Homer	148-ft. wooden sidewheeler	810	200	Pearson and Saltus 1993
Modern shrimp boat	segment, 27 × 5 ft.	350	90	Pearson et al. 1991
Confederate obstructions	numerous wooden vessels with machinery removed and filled with construction rubble	110	long duration	Irion and Bond 1984
Single-source Objects				
pipeline	18-in. diameter	1570	200	Duff 1996
anchor	6-ft. shaft	30	270	Pearson et al. 1991
iron anvil	150 lbs.	598	26	Pearson et al. 1991
engine block	modern gasoline	357	60	Rogers et al. 1990
steel drum	55 gallon	191	35	Rogers et al. 1990
pipe	8 ft. long × 3 in. diameter	121	40	Rogers et al. 1990
railroad rail segment	4-ft. section	216	40	Rogers et al. 1990
Multiple-source Objects				
anchor/wire rope	8-ft. modern stockless/large coil	910	140	Rogers et al. 1990
cable and chain	5 ft.	30	50	Pearson et al. 1991
scattered ferrous metal	14 × ft.	100	110	Pearson et al. 1991

(after Pearson et al. 1991)

Sidescan Analysis

By contrast, sidescan analysis is less problematic. The chief factors considered in analyzing sidescan data included linearity, height off bottom, size, associated magnetics, and environmental context. Since historic resources in the form of shipwrecks usually contain large amounts of ferrous compounds, sidescan targets with associated magnetic anomalies are of top importance. Targets with no associated magnetics usually turn out to be items such as rocks, trees, and other non-historic debris of no interest to the archaeologist. Also, since historic shipwrecks tend to be larger in size, smaller targets tend to be of less importance during data evaluation. In addition, the area in which the target is located can have a strong bearing on whether or not the target is selected for further work. If a target is found in an area with other known wreck sites, or an area determined to be high probability for the location of historic resources, it may be given more consideration than it would have otherwise. However, every situation, and every target located, is different, and all sidescan targets are evaluated on a case-by-case basis.

SUBBOTTOM PROFILER ANALYSIS

Subbottom profilers generate low frequency acoustic waves capable of penetrating the seabed and then reflect off boundaries or objects within the subsurface. These returns are received by hydrophone or hydrophone array operated in close proximity to the source. The data are then processed and reproduced as a cross section scaled in two-way travel time (the time taken for the pulse to travel from the source to the reflector and back to the receiver). This travel time can then be interpolated to depth in the current survey).

These seismic cross sections can be studied visually and the shapes and extent of reflectors used to identify bottom and subbottom profile characteristics. In general, high and low amplitude reflectors (light and dark returns) distinguish between stratigraphic beds; parabolic returns indicate point source objects of sufficient size to be sensed by the wavelength and frequency of the power source. Erosional or non-depositional contacts can be identified by discontinuities in extent, slope angle, and shape of the reflector returns. This latter fact is important when identifying drowned channels systems and other relict and buried fluvial system features (e.g., estuarine, tidal, lowland, upland areas around drainage features).

Seismic stratigraphy is a form of stratigraphic correlation. The reflection characteristics (e.g., as amplitude, continuity, wipeout [erosion] and bedform geometry) of regional unconformities and stratal surfaces are used to estimate rock or sediment properties, facies relationships, and some stratigraphic details to infer structural evolution and paleo-environmental histories (Mitchum et al. 1977, Vail et al. 1977).

There are five types of spurious signals that may cause confusion in the two dimensional records: direct arrivals from the sound source, water surface reflection, side echoes, reflection multiples, and point source reflections. Judicious analysis is required to suspect them. This is particularly true when the bottom or subbottom being traversed has considerable deformation or point source anomalies.

NATIONAL REGISTER OF HISTORIC PLACES EVALUATION

As stated in National Register Bulletin 15, *How to Apply the National Register Criteria for Evaluation* (National Park Service n.d.), and Bulletin 20, *Nominating Historic Vessels and Shipwrecks to the National Register of Historic Places* (National Park Service 1985), "the quality of significance in American history, architecture, archaeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association." To be considered significant and therefore eligible for nomination to the NRHP, the property must meet one or more of the four National Register criteria:

> A. Be associated with events that have made a significant contribution to the broad patterns of our history; or
>
> B. Be associated with the lives of persons significant in our past; or
>
> C. Embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic

> values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
>
> D. Yield, or likely to yield, information important in prehistory or history [National Park Service 1985:5-6].

Properties found potentially eligible, eligible, or listed on the NRHP must be considered within the framework of the proposed action. If adverse impact to such a property is possible, alternatives to the proposed action, i.e., avoidance, must be evaluated. If avoidance is not practical, additional activities relative to the evaluation of the resource may be required.

A vessel's significance, as stated in Bulletin 20, is based on a "representation of vessel type and (its) association with significant themes in American history and comparison with similar vessels" (National Park Service 1985:4). Of the five basic types of historic vessels which may be eligible for NRHP nomination as stated in National Register Bulletin 20, *Nominating Historic Vessels and Shipwrecks to the NRHP*, the vessels within our three project areas fall into two defined categories, "hulks" and "shipwrecks." Bulletin 20 defines hulks as "substantially intact vessels that are not afloat, such as abandoned or laid up craft that are on a mudflat, beach or other shoreline." "Shipwreck" is defined as "a submerged or buried vessel that has foundered, stranded, or wrecked. This includes vessels that exist as intact or scattered components on or in the sea bed, lakebed, river bed, mud flats, beaches, or other shorelines, excepting hulks" (National Park Service 1985:3). The significance of shipwrecks, as opposed to intact vessels (i.e., hulks), "requires that the wreck display sufficient integrity to address architectural, technological, and other research concerns" (Pearson and Simmons 1995:129).

The photographs and archival data presented here show selected features of site details and serve as an outline for NRHP evaluation. Specific recommendations are made in the *Conclusions and Recommendations* section of this report.

4. FIELD RESULTS AND INTERPRETATIONS

REMOTE SENSING RESULTS

The remote sensing phase of this project successfully collected magnetic, sidescan sonar, and subbottom profiler data in all safely navigable areas within the project area between May 1 and May 3, 2007. Magnetic and sidescan data was acquired on May 1, while the seismic data was acquired on May 2 and 3. The area of the target was completely covered by running the preplanned tracklines. In addition, several passes were made with both sidescan sonar and subbottom profiler in a northeast to southwest direction—along the length of the extant remains—in order to obtain images showing the entire wreck site. DGPS, magnetometer, sidescan, and subbottom profiler data were collected and digitally recorded on computer disk. Utilizing a 100-gamma contour interval, maps were generated from magnetometer and positioning data digitized during the survey and processed following completion of the fieldwork using the Single Beam Editor in Hypack.

Analysis revealed existing wreckage to be approximately 300 feet in length, oriented in a north-northeast to south-southwest direction. Wreckage appears to be concentrated in one area—no outliers or large separated sections of wreck were discovered during the survey.

MAGNETIC DATA

Magnetic data was collected on 20 lines surrounding the coordinates of the *Fort Victoria* wreck site (Figure 4-01), enabling the mapping of the complete magnetic anomaly associated with the wreck site, as well as the locating of any additional sections of wreck that may have been separated from the main site during salvage or clearing operations. Mapping of the magnetic data in a 100-gamma contour map (Figure 4-02) indicates the site exhibits a 3000+-gamma anomaly in a classic dipole form. A detail map (Figure 4-03) illustrates the positive (blue) and negative (red) poles of the anomaly. Figure 4-02 indicates the absence of other large anomalies indicative of separate pieces of wreckage in the survey area. Magnetic profiles for survey lines are presented in Appendix A.

Magnetic data was also collected over Target 13256. The goal regarding this target was to see if any wreckage existed and if so, to determine if that wreckage was related to the *Fort Victoria* site. Magnetic data was collected on two passes over the site (Figure 4-04). Both passes indicated no deviation from magnetic background readings, so no systematic survey was made to collect data to create a magnetic contour map. The magnetic profiles of the two survey lines are presented in Figures 4-05 and 4-06.

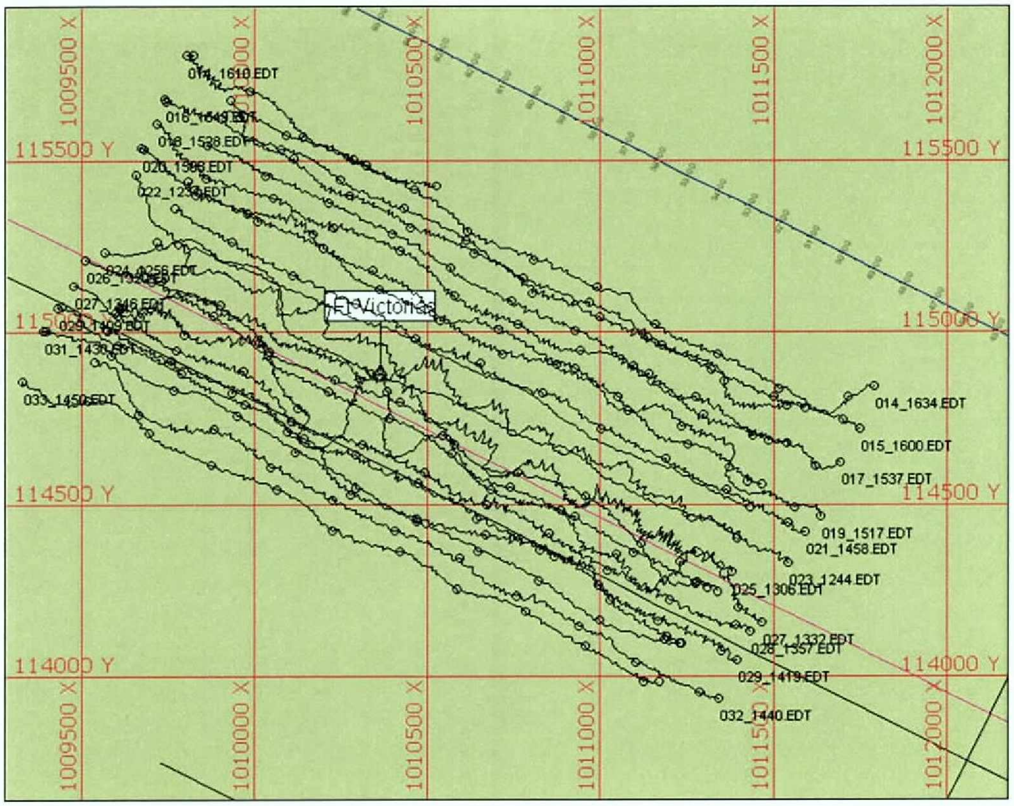


Figure 4-01. Post-plot magnetic data tracklines.

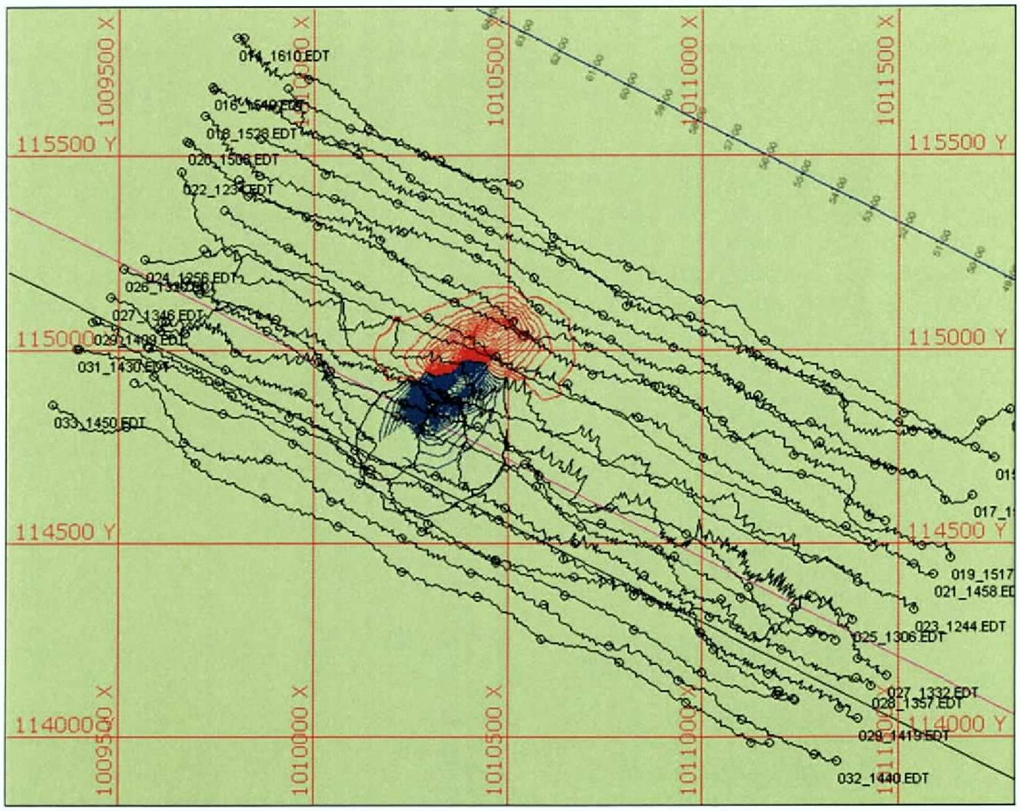


Figure 4-02. Magnetic contour map of the *Fort Victoria* site.

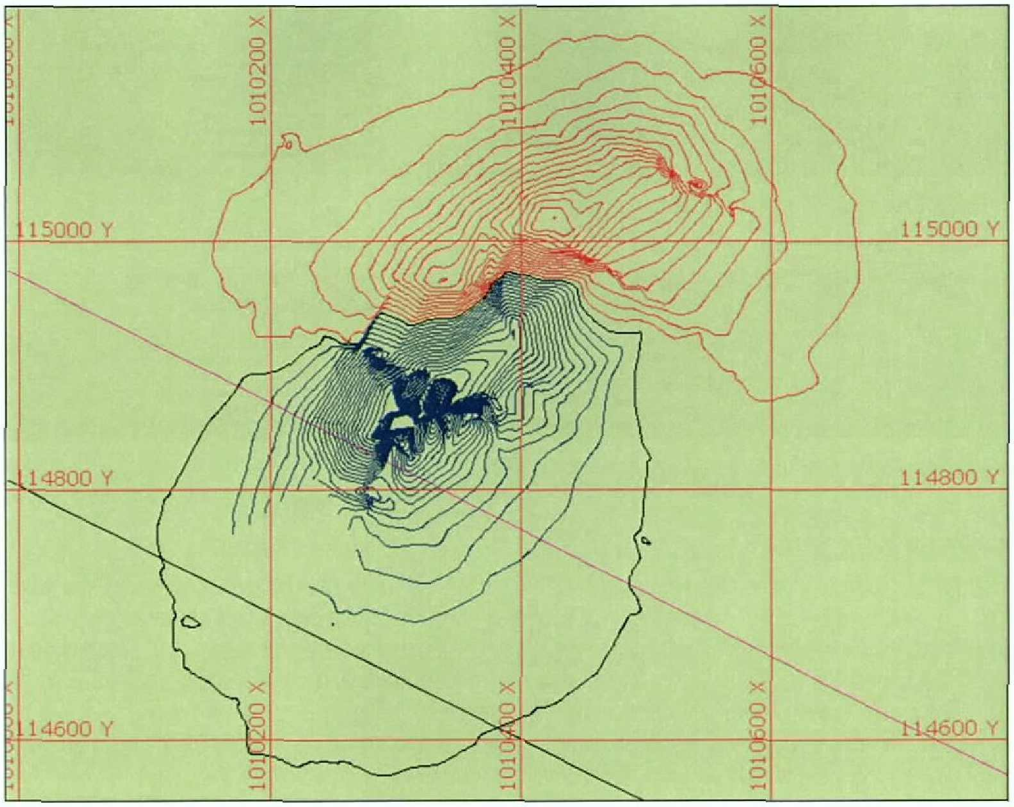


Figure 4-03. Magnetic contour map detail.

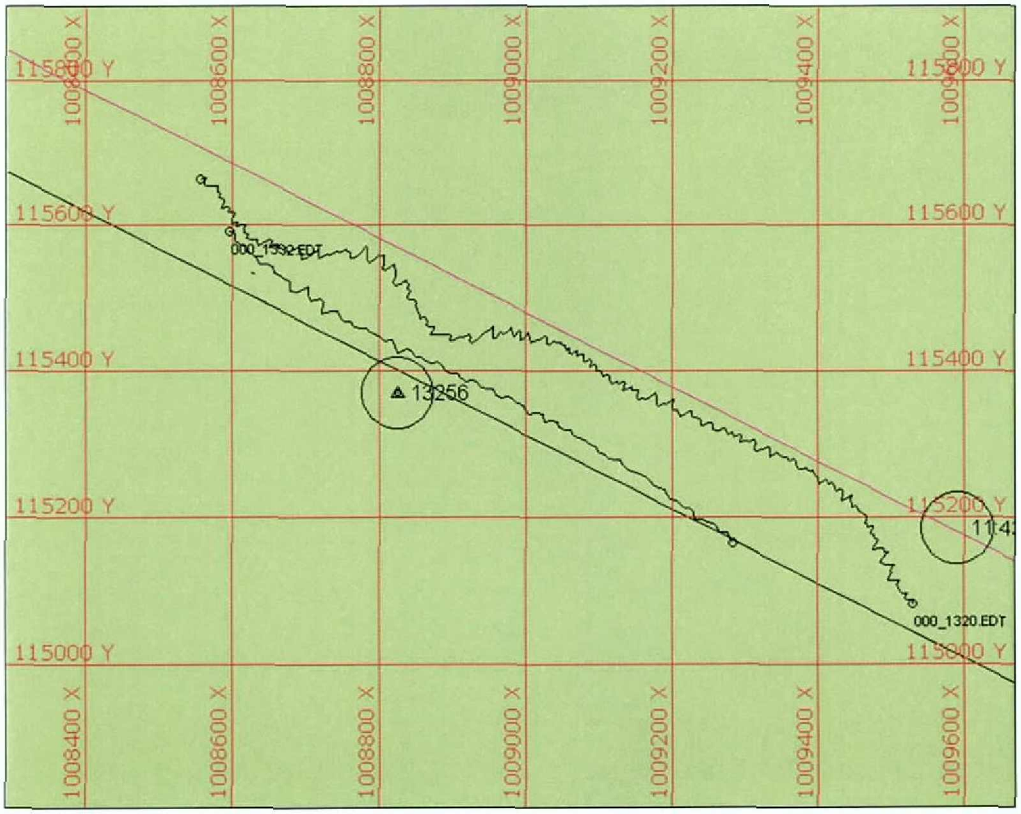


Figure 4-04. Post-plot magnetic tracklines for Target 13256.

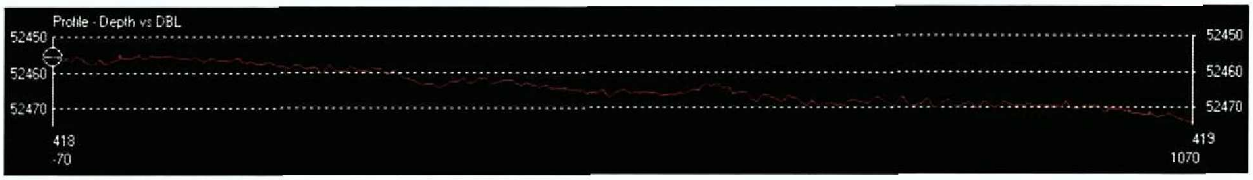


Figure 4-05. Magnetic profile of Line 1320, Target 13256.

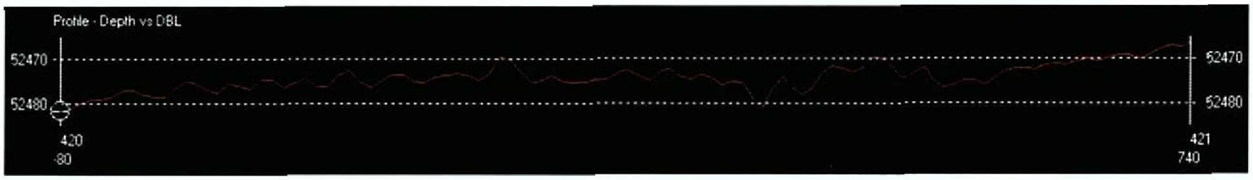


Figure 4-06. Magnetic profile of Line 1332, Target 13256.

SIDESCAN SONAR RESULTS

The sidescan sonar survey was run concurrently with the magnetic data collection, successfully covering the project area and including multiple overlap of adjacent transects. In addition, several passes were made along the north-south orientation of the wreck site to image the entire site at once (Figure 4-07). The acoustic images collected with the sidescan sonar revealed a large wreck site coinciding exactly with the magnetic contour data presented above (Figure 4-08). As revealed by the sidescan images, the site consists of a section of intact hull structure on the northern 2/3 of the site, with a large area of disarticulated debris to the south.

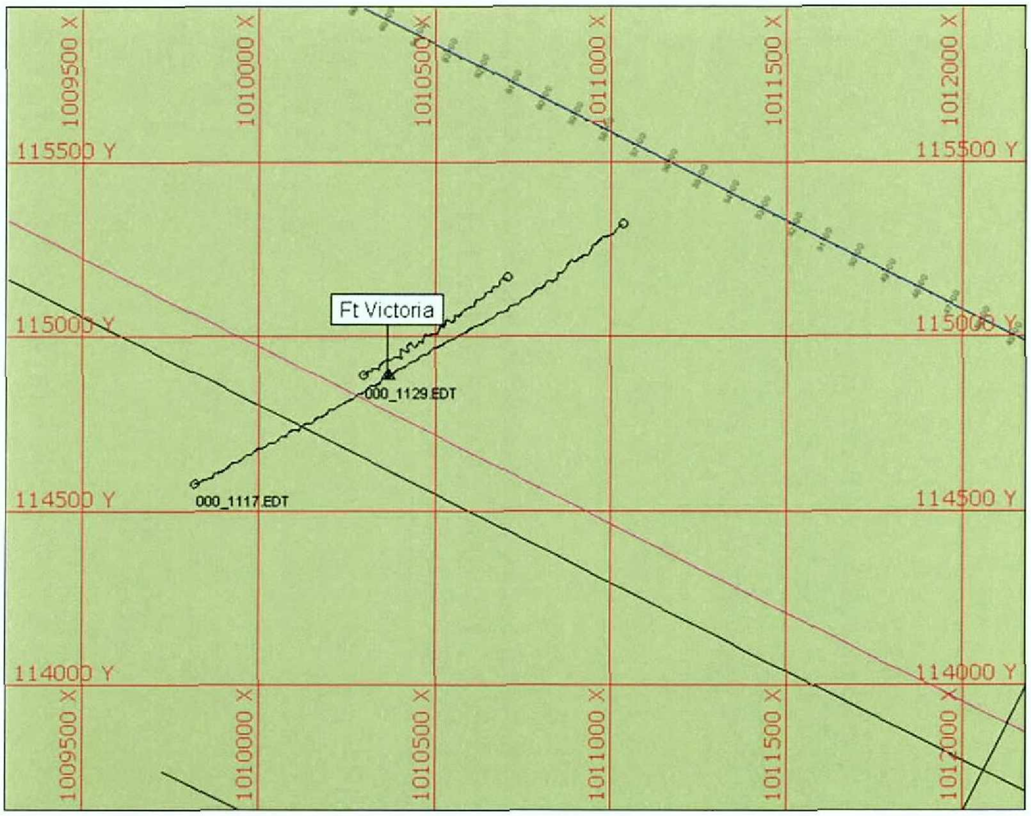


Figure 4-07. Sidescan sonar refinement tracklines.

Figure 4-08. Sidescan sonar image of wreck site. Note articulated structure on north (upper) end of image.

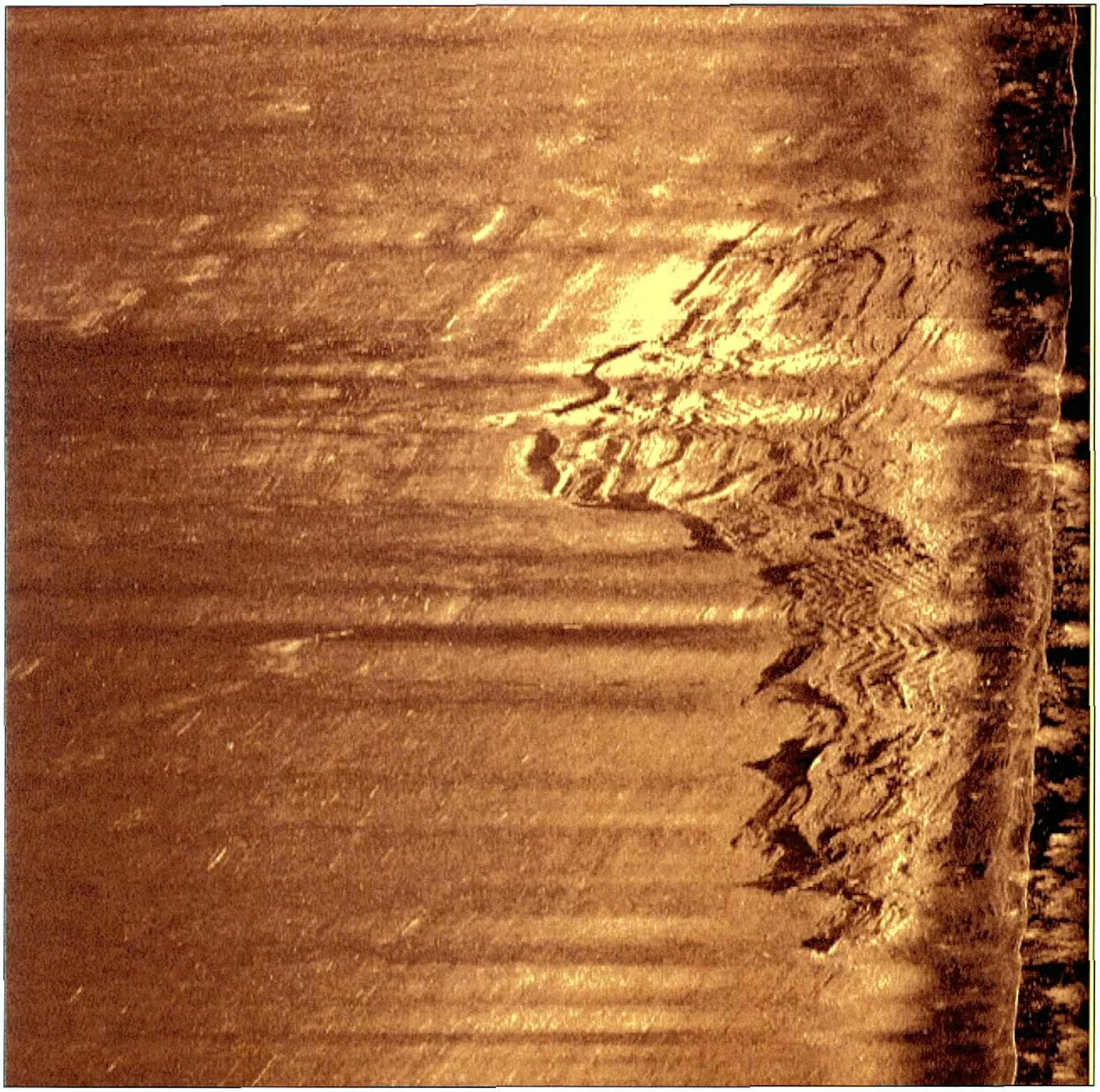


Figure 4-09. Sidescan sonar image detail showing intact vessel structure on north end and disarticulated structure on southern 1/3.

Analysis of the sidescan sonar data resulted in the selection of three areas for diver investigation, including two in the articulated portion of the wreck and one in the disarticulated section (Table 4-01, Figure 4-10).

Table 4-01. Sidescan sonar targets.

Target	Easting	Northing
SS1	1010411	114914
SS2	1010484	114974
SS3	1010328	114855

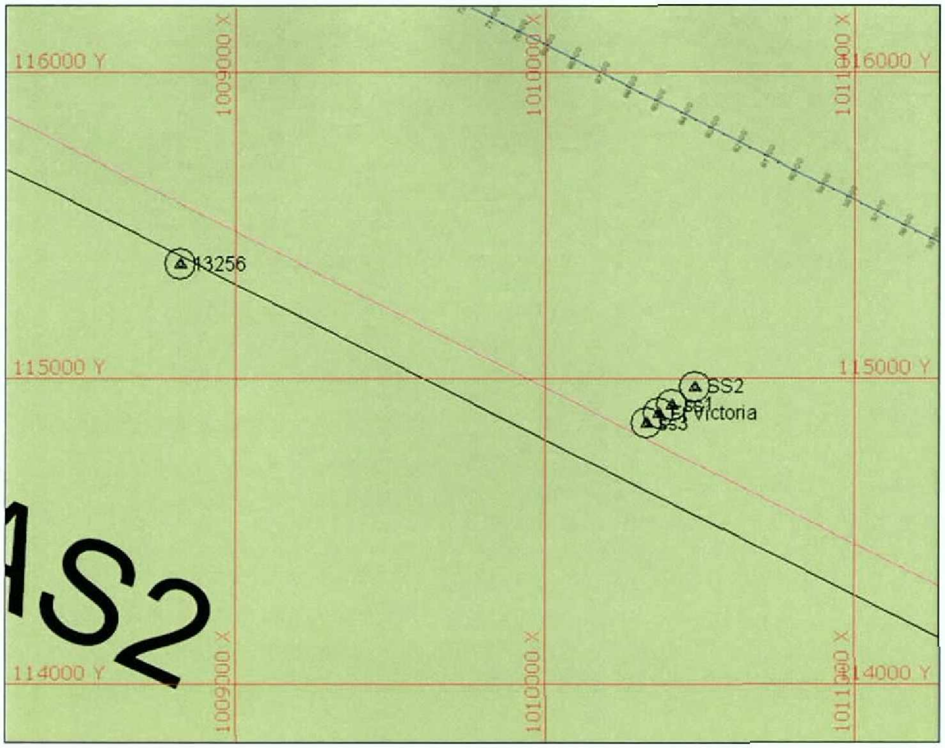


Figure 4-10. Sidescan sonar targets selected for diver investigation, shown here with original target coordinates.

Target 13256 was investigated with sidescan sonar as well. Two tracklines were run over the site (see Figure 4-04). Analysis of the data revealed a low target, located at the exact coordinates provided that appears to consist of sand and small boulders (Figure 4-11). Correlation with the magnetic data indicated the site has no magnetic signature and so is not likely associated with the *Fort Victoria* site.

SUBBOTTOM PROFILER SURVEY

Subbottom profile data was collected on May 2 and 3 along 12 lines oriented perpendicular to the wreck site and parallel to the channel (Figure 4-12). In addition, several lines parallel to the orientation of the wreck were run directly over the site to provide a longitudinal image of the wreck (Figures 4-13 and 4-14). A number of hard targets were detected with the subbottom profiler (Table 4-02, Figures 4-14, 4-15, 4-16), the largest grouping of which is not surprisingly located at the wreck site. Additional targets located some distance from the wreck site (as represented by Target 1645.2 in Figures 4-14, 4-15), when cross referenced with the magnetic data (Figure 4-17), were determined to have no magnetic signature and so are not likely to be associated with the *Fort Victoria* site. All subbottom line images are included in Appendix B.

Table 4-02. Subbottom profiler targets.

Target	Easting	Northing
1645.1	1010065	114967
1645.2	1010295	114906
1645.3	1010573	114549
1727.1	1011007	114308
1727.2	1010566	114569
1748.1	1011016	114296

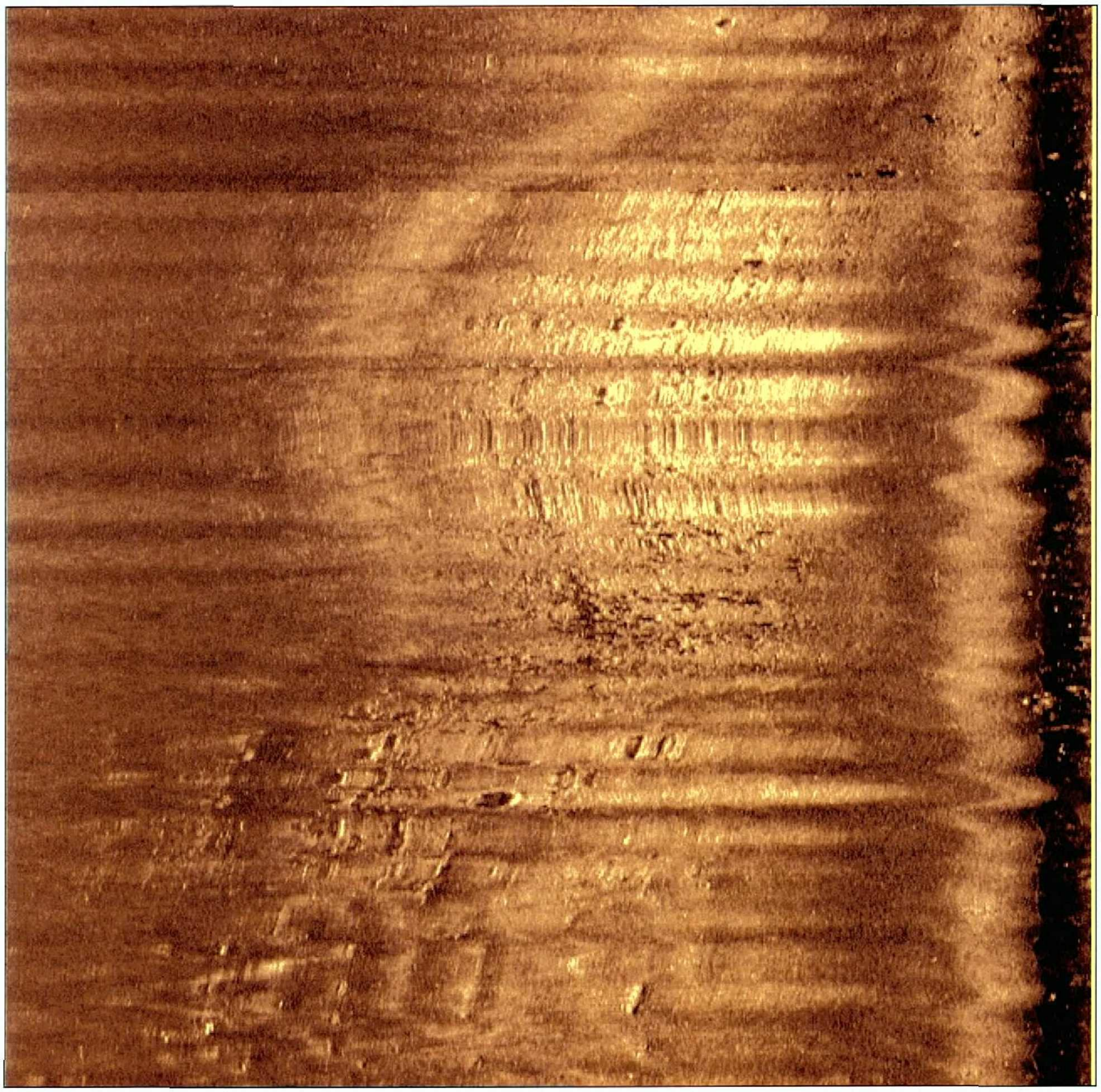


Figure 4-11. Sidescan sonar image of Target 12356.

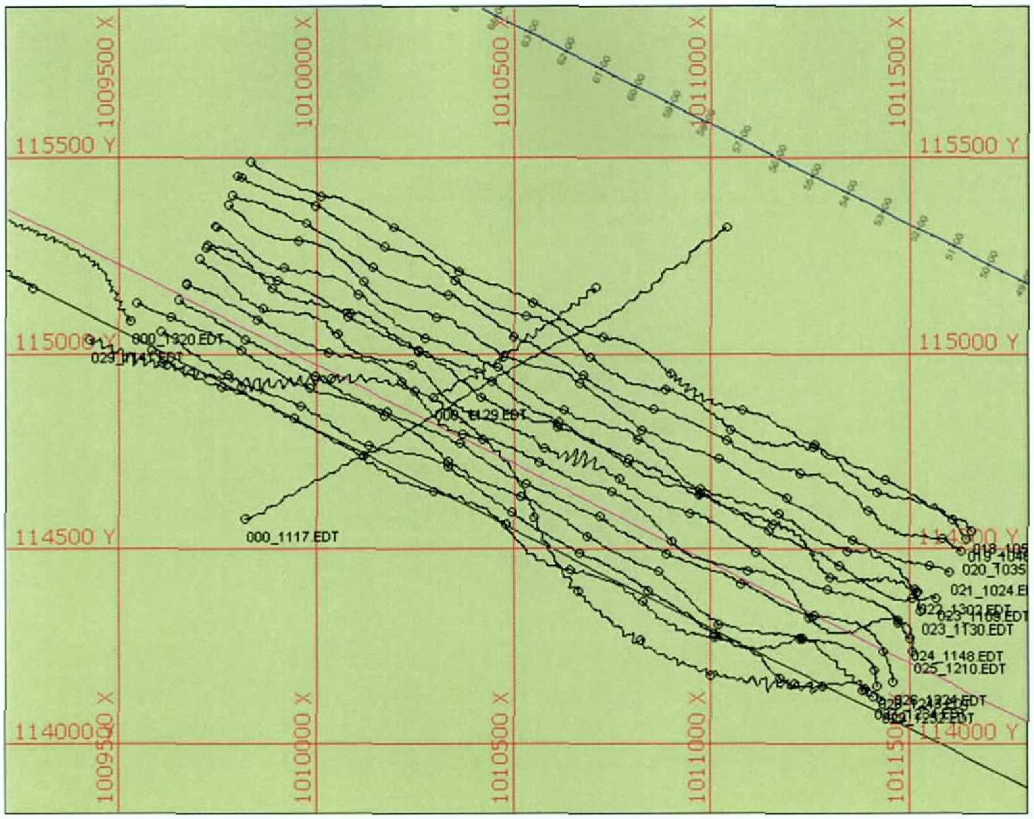


Figure 4-12. Post-plot subbottom profiler survey lines.

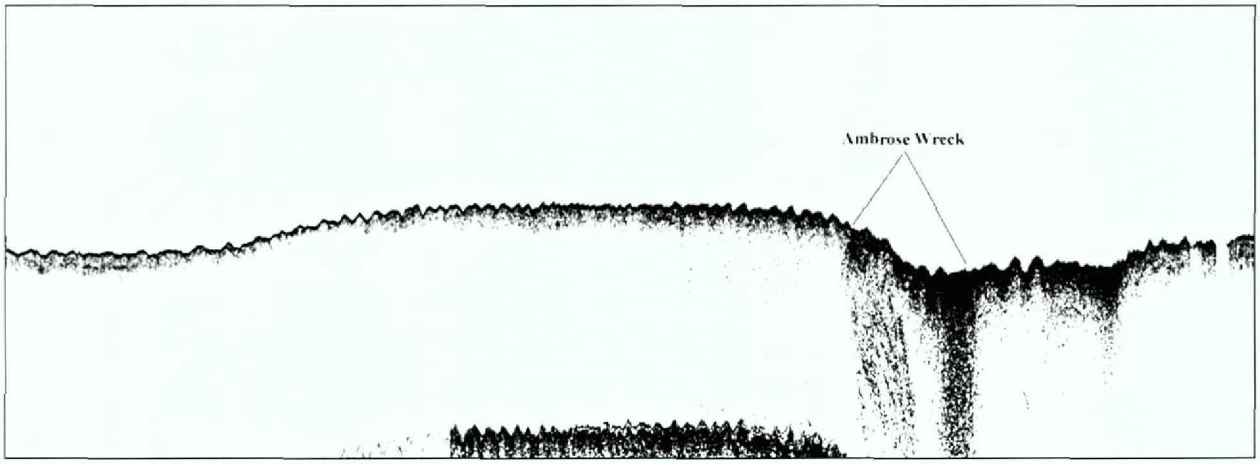


Figure 4-13. Subbottom line 1117 showing profile of wreck and navigation channel.

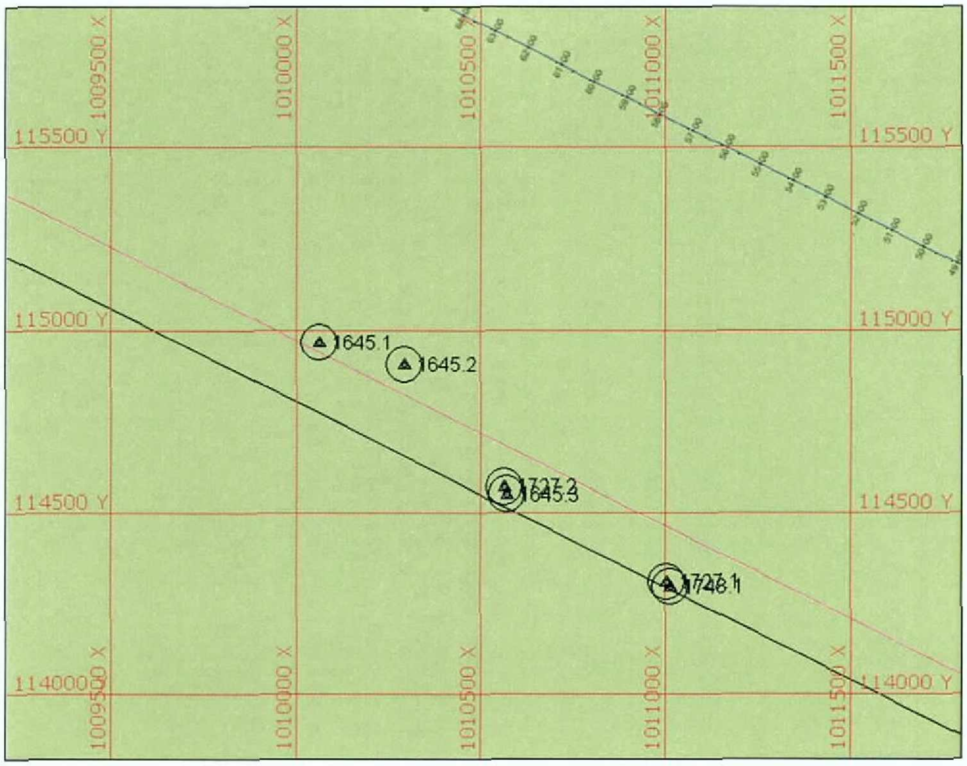


Figure 4-14. Subbottom profiler targets.

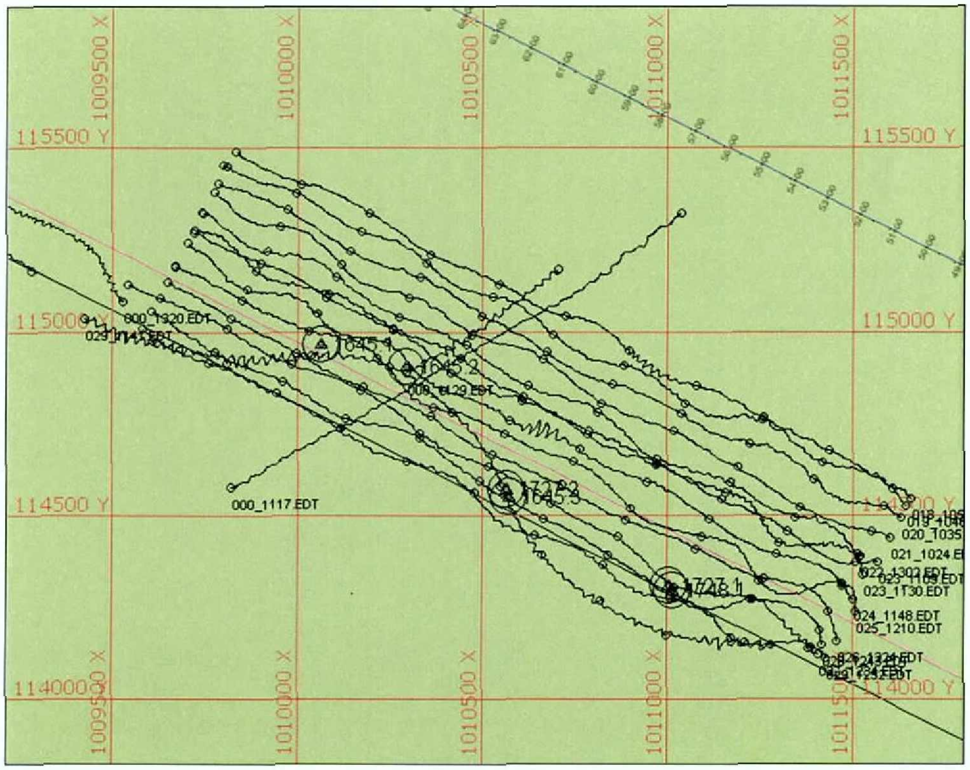


Figure 4-15. Subbottom profiler targets with survey tracklines.

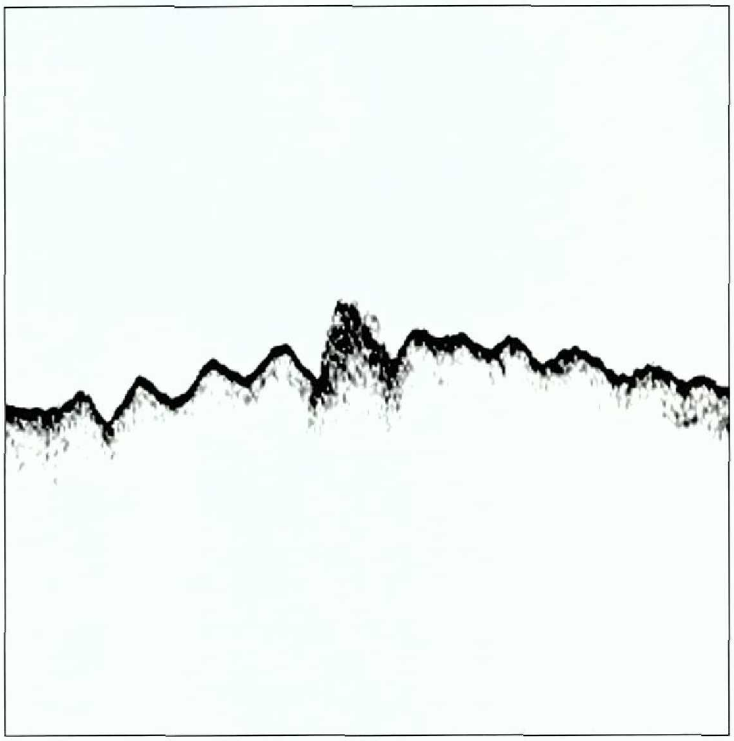


Figure 4-16. Subbottom target detail, line 1148, target 1645.2. This represents an E-W cross section of the wreck site.

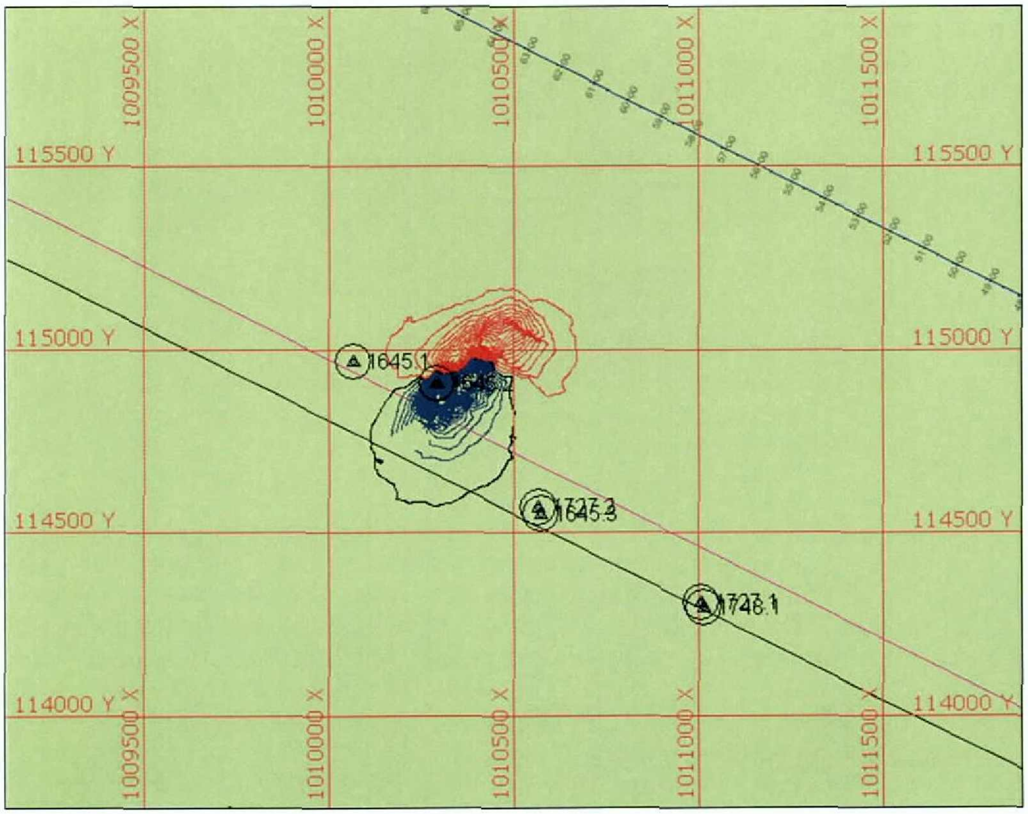


Figure 4-17. Magnetic contour map with subbottom profiler targets.

Target 13256 was also investigated with the subbottom profiler. Initial passes indicated a possible hard target only slightly distinguishable from the surrounding bottom, but generally inconclusive.

DIVER INVESTIGATION

Three areas (see Figure 4-11, Figure 4-18, and Table 4-01) were chosen for investigation by divers. The three areas were investigated on May 2 and 3, resulting in a visual inspection and video recording of approximately 60 percent of the exposed wreckage.

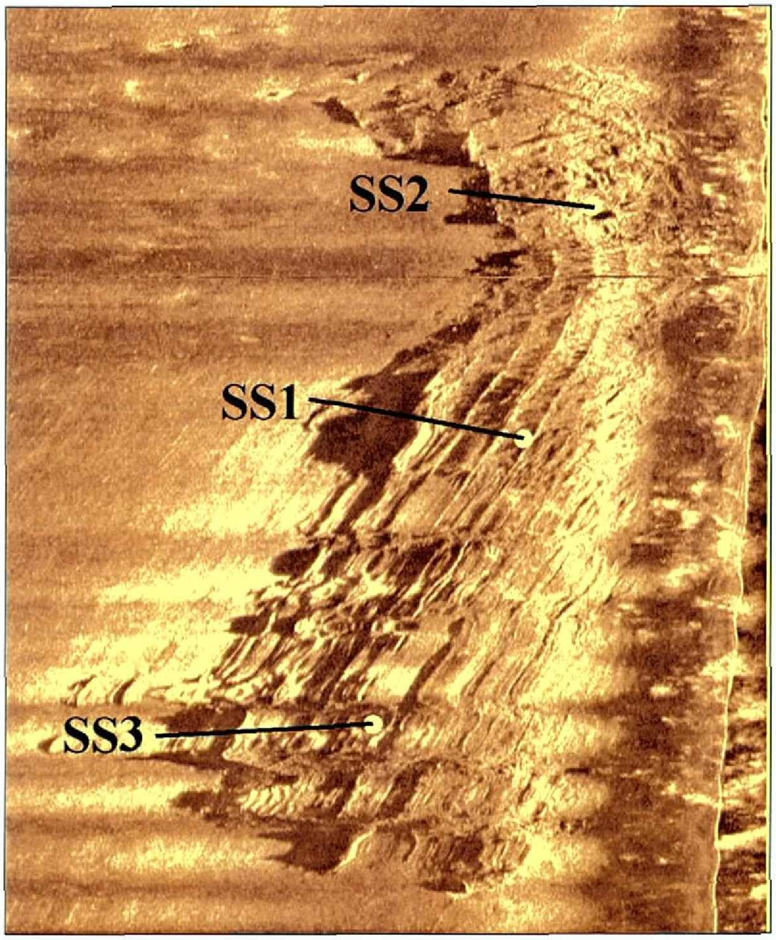


Figure 4-18. Sidescan image of wreck site showing location of targets dived.

SS1

Target SS1 was chosen as an area of apparent intact vessel structure. The area was characterized by very low relief and height off bottom with the exception of a few isolated features. Video feed from the diver confirmed the existence of intact Z-bar framing and overlapping riveted hull plating, indicating a vessel age of between 90-140 years. Also noted were an intact gunwale and deck support structures, along with several portholes, indicating the structure lying flat on the bottom represents the side of the vessel. Numerous artifacts were observed in the area, including broken stoneware, china, porcelain, and glass.

SS2

Target SS2 was chosen as an additional area of apparent intact vessel structure. The area was characterized by very low relief and height off bottom with the exception of a few isolated features on the western edge of the site. Video feed from the diver confirmed the existence of overlapping riveted hull plating. Numerous artifacts were observed including stoneware and glass.

SS3

Target SS3 was chosen for investigation as an area of apparent disarticulated debris. Diver investigation confirmed the area to be extremely disarticulated, with no discernable structure observed. The area was characterized by higher general relief and height off bottom than either SS1 or SS2. A considerable number of artifacts were observed and recovered for diagnostic purposes, including stoneware, china, porcelain, glass bottles and bottle fragments, and other items. The area appears to be the location of deck and hull structure removed from the wreck during the clearing process earlier in the twentieth century.

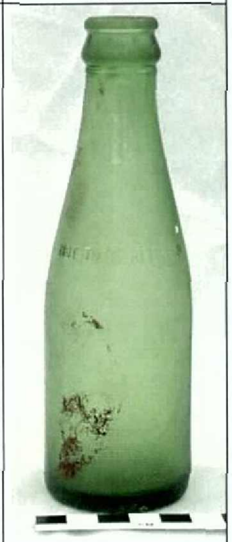
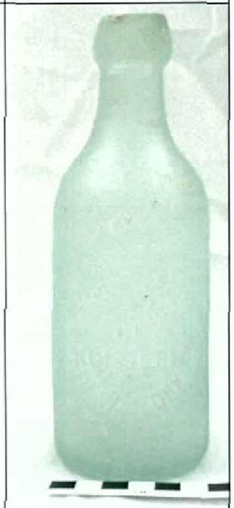
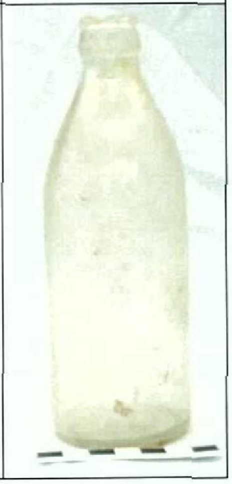
ARTIFACT DISCUSSION

A number of artifacts were recovered from the site for the purposes of aiding in the identification of the site. Although the 'Holy Grail' so to speak of artifacts is something with the ship's name on it, this seldom happens. What are primarily looked for are artifacts that place the site in some temporal context. Most beneficial are bottles, china, or stoneware with a certain pattern, all of which can generally be dated to a certain range of years. All date ranges of the assemblage place the site in a temporal range. This range can then be cross-referenced with known wreck sites or documented vessel losses in the area to narrow the field of prospective candidates. To this end, 11 bottles and bottle fragments, 2 restaurant ware sherds, 1 partial porcelain bowl, 1 partial china cup, and 1 miscellaneous piece of glass were recovered (Table 4-03).

Table 4-03. Diagnostic artifacts recovered from wreck site.

Type	Contents	Manufacturer	Identified Marks	Date	Description	Photo
Bottle	catsup	Owens Bottle Company, Toledo, Ohio	H.J. Heinz Co/255/PATD	1904-1929	H.J. Heinz Company introduced catsup in 1875. Since 1888 bottles have been embossed "H.J. Heinz Co.". ABM (automated bottle machine) lip indicates a post-1904 date of manufacture. Owens Bottle Company merged with Illinois Glass Company in 1929.	

Type	Contents	Manufacturer	Identified Marks	Date	Description	Photo
Bottle	Champagne	unknown	1/35	Post-1904	Deep pontil. ABM lip indicates post-1904 date of manufacture (DOM).	
Bottle	Champagne	unknown	None	Post-1904	Deep pontil. ABM lip indicates post-1904 DOM.	
Bottle	Beer	unknown	52/A4	Post-1904	ABM lip with crown cap indicates post-1904 DOM.	

Type	Contents	Manufacturer	Identified Marks	Date	Description	Photo
Bottle	Soda	Owens Illinois Glass Company	CONTENTS 7 FL OZS99 61 (factory mark)/ GK-1627	Post-1954	ABM lip with crown cap indicates post-1904 DOM. "I" in a circle logo indicates post-1954 DOM.	
Bottle	Mineral water	unknown	JOHN HAAG/ 417 E. 113th ST/ REGISTERED/ NEW YORK/ NOT TO BE SOLD	Early 1870s – ca. 1880	Three-piece mold indicates 1830s – 1905. Blob top indicates 1870-1880. Plate mold indicates pre 1910.	
Bottle	Soda	unknown	None	Post-1904		

Type	Contents	Manufacturer	Identified Marks	Date	Description	Photo
Restaurant ware		unknown	None	Early 20th century	Handle	
Crockery		unknown	None		Possible chamber pot or mixing bowl.	
						
Restaurant ware		unknown	None			
						
Restaurant ware		Multiple	RdNo. 117214/ RdNo. 324028	Post-1888	The nos. are English registry numbers identifying the body shape or decoration. The first no., issued 1888, protects the border pattern, and the second protects the scalloped edge; neither is present here. The pattern is known as "Crown" and was used on White Star Line and Red Star Line steamers, and others	

Type	Contents	Manufacturer	Identified Marks	Date	Description	Photo
						
Restaurant ware (coffee cup)	First Class Cabin service coffee	unknown	None		"Bird of Paradise" pattern. Used on many steamers in the early 20th century, including Furness Bermuda Line	
						

Diagnostic artifacts that were analyzed conform to what would be expected onboard an early-twentieth-century passenger steamer, and include items relating to consumption of food and beverages. Dates are not inconsistent with the 1913-1929 time period for the *Fort Victoria*, with three important exceptions. These exceptions either predate or post-date the date of wrecking, but as such do not contraindicate the identification of the vessel as the RMS *Fort Victoria*. There are alternative explanations for the presence of both the mineral water bottle (ca. 1870-1888) and the small green soda bottle (ca. post-1954), along with the English china piece. A datable artifact predating the wreck event could have been carried onboard by a passenger, or could have been present at the site before the wrecking event. It may even suggest the presence on the same site of another vessel, although no evidence of an additional vessel was seen in this case. A bottle that post-dates the wrecking event is not an uncommon find on a site of this nature, particularly one in open water that is a known site for commercial and recreational fishing. Indeed, a number of modern bottles were noted by divers on the site during diving operations. The most interesting of the three is the English china piece. Although the earlier of the two registry numbers dates to 1888, the pattern would have been manufactured during a date range beginning no earlier than that date, and may have continued for a considerable number of years. Indeed, the Crown pattern was used in the First Class dining room of the RMS *Titanic*.

5. CONCLUSIONS AND RECOMMENDATIONS

From May 1–3, 2007, Panamerican Consultants, Inc, of Memphis, Tennessee, under subcontract to Great Lakes Dredge and Dock, performed an archaeological investigation of a potential wreck site in Ambrose Channel, New York Harbor. The investigation was undertaken in response to the Scope of Work entitled *Scope of Work to Dive at Potential Wreck in Ambrose Channel to Determine Historic Significance and Undertake Selected Recordation of Remains Encountered In Connection with the New York and New Jersey Harbor Navigation Study* and conducted under Contract W912DS-05-C-0018, Mod A00001, R0002. It was performed in accordance with Section 106 of the Historic Preservation Act of 1966 as amended through 1992, and the Advisory Council on Historic Preservation Guidelines for the Protection of Cultural and Historic Properties (36 CFR 800).

The purpose of the investigation was threefold. First, the site was examined using sidescan sonar, magnetometer, and subbottom profiler to determine the full extent of the site, including the location of any potential buried or separated sections of wreckage that may be in the vicinity. Second, the site was examined by divers from RanDive equipped with high-resolution video to examine areas determined from the remote sensing data to contain articulated structure. Third, historic background research was undertaken to determine the likelihood the vessel represents the *Fort Victoria.*

Remote sensing data consisting of sidescan sonar, subbottom profiler, and magnetometer was collected between May 1 and May 3, 2007. The site was relocated, and a remote sensing investigation consisting of sidescan sonar, subbottom profiler, and magnetometer was performed in an area encompassing the wreck site. The site was visually inspected by divers and high-resolution video collected.

SITE IDENTIFICATION

Archival research coupled with data collected at the site indicate very strongly that the site represents the wreck of the RMS *Fort Victoria*, a passenger steamship of the Furness Bermuda Line, a subsidiary of Furness Withy, that was struck by an American coastal steamer on the night of November 13, 1929 while en route to Bermuda from New York. The following discussion includes all data including remote sensing, visual inspection, and archival.

WRECK CONDITION

Historical sources indicate the vessel sunk on its side in the Ambrose channel, in a roughly north-south orientation. The same sources indicate shortly afterward the vessel was cleared to 40+ feet as an extreme hazard to navigation. The clearing actions included dynamiting and wire dragging. Although sources do not indicate the direction in which the material was dragged, it stands to reason it would have been dragged to the south, out of the channel, or removed entirely.

The current project site is approximately 300 feet in length, oriented in a north-northwest direction. The northern 2/3 of the site is the fairly well intact side of a vessel, complete with deck components such as knees, lying flat or nearly flat on the bottom. The southern 1/3 of the vessel, which lies mostly on the slope of the channel, consists of a large flat pile of disarticulated hull and superstructure. This is consistent with what would be expected if a vessel were cleared and the debris dragged toward the edge of the channel. The articulated side of the vessel, which is lying flat on the bottom, is consistent with reports that the vessel sank on its side. The remaining hull structure along with the debris pile does not represent enough material for a 411-foot long steel vessel, suggesting vessel components were removed to a separate location.

Hull Construction

Hull construction of the vessel in question is consistent with iron and steel hull steamship construction of the late nineteenth century and early twentieth century. The site represents the remains of a steel-hulled vessel constructed of overlapping riveted hull plates. Hull framing consisted of riveted Z-bar frame construction.

Material Culture

The limited material culture items observed on and collected from the wreck for the purposes of diagnostics are indicative of what would be found on a passenger liner. Large numbers of bottles representing liquid consumables such as soda, beer, champagne, and mineral water, along with dining vessels made of china, stoneware, and porcelain, were apparent at various locations on the site. Most of the material culture observed is datable to the era of the *Fort Victoria* or earlier. The presence of limited exceptions to this, including a 1950s-era soda bottle, do not contradict the possibility this vessel represents the *Fort Victoria,* as many other modern objects were found in close proximity to the wreck, including beer cans. Such objects are often found on wreck sites and are the result of drift in or jetsam from fishing boats or other recreational vessels.

Archival Research

While the evidence above indicates the site represents an iron- or steel-hulled passenger vessel from the late nineteenth or early twentieth centuries, there is nothing to positively identify the vessel as the *Fort Victoria.* However, a search of the surrounding known wreck sites in a database such as AWOIS can eliminate many of them as possibilities based on what was found at the current site. For instance, a vessel listed as a "wooden barge," or a "51-foot wooden fishing vessel" can be eliminated from consideration. With that said, the obstruction located in the database at the exact coordinates of the current project site is referred to as the "*Fort Victoria*", and is the only iron- or steel-hulled passenger steamer in within a 5-mile radius.

Vessel Significance

As stated in National Register Bulletin 15, *How to Apply the National Register Criteria for Evaluation* (National Park Service n.d.), and Bulletin 20, *Nominating Historic Vessels and Shipwrecks to the National Register of Historic Places* (National Park Service 1985), "the quality of significance in American history, architecture, archaeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association." To be considered significant and therefore eligible for nomination to the NRHP, the property must meet one or more of the four National Register criteria:

> A. Be associated with events that have made a significant contribution to the broad patterns of our history; or
>
> B. Be associated with the lives of persons significant in our past; or
>
> C. Embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
>
> D. Yield, or likely to yield, information important in prehistory or history [National Park Service 1985:5-6].

A vessel's significance, as stated in Bulletin 20, is based on a "representation of vessel type and (its) association with significant themes in American history and comparison with similar vessels" (National Park Service 1985:4). Of the five basic types of historic vessels that may be eligible for NRHP nomination as stated in National Register Bulletin 20, *Nominating Historic*

Vessels and Shipwrecks to the NRHP, the *Fort Victoria* site falls into the defined category of "shipwrecks." Bulletin 20 defines a shipwreck as "a submerged or buried vessel that has foundered, stranded, or wrecked. This includes vessels that exist as intact or scattered components on or in the sea bed, lakebed, river bed, mud flats, beaches, or other shorelines, excepting hulks" (National Park Service 1985:3). The significance of shipwrecks, as opposed to intact vessels (i.e., hulks), "requires that the wreck display sufficient integrity to address architectural, technological, and other research concerns" (Pearson and Simmons 1995:129).

The RMS *Fort Victoria* is representative of the apex of riveted steel-hulled steamships. The wreck of the *Fort Victoria* is also likely to yield historical information regarding shipboard life in the early "Golden Age" of ocean-going passenger liners through study of the portable artifacts. However, several factors diminish its value with respect to American history. First, the value of the vessel as a historic resource is diminished significantly due the factors surrounding the development of its current state, including having been blasted and wire-dragged as a hazard to navigation. As well, the RMS *Fort Victoria* is a British vessel of Scottish construction, and not significantly linked with events in American history. These, combined with its location in an active navigation channel, do not justify the expense of additional investigations. The site is therefore not considered eligible for listing on the National Register of Historic Places.

RECOMMENDATIONS

ASSESSMENT OF PROJECT EFFECTS

Normally, properties found potentially eligible, eligible, or listed on the NRHP must be considered within the framework of the proposed action. Relative to the assessment of project effect, it is quite clear that the *Fort Victoria* wreck site will be adversely affected by the current dredging activities. Usually, avoidance by project impacts on any historic property is the best preservative measure for that property, and avoidance should be the first option discussed by the managing agencies. However, if no alternatives to the proposed project are possible and the site cannot be avoided by dredging plans, a determination of adverse impact to the property should be made by the managing agencies. Subsequently, additional investigations of the property should be warranted in order to mitigate those adverse effects. However, since the RMS *Fort Victoria* is not considered historically significant due to its highly eroded nature and its primary association with British history, no further investigation is warranted or recommended.

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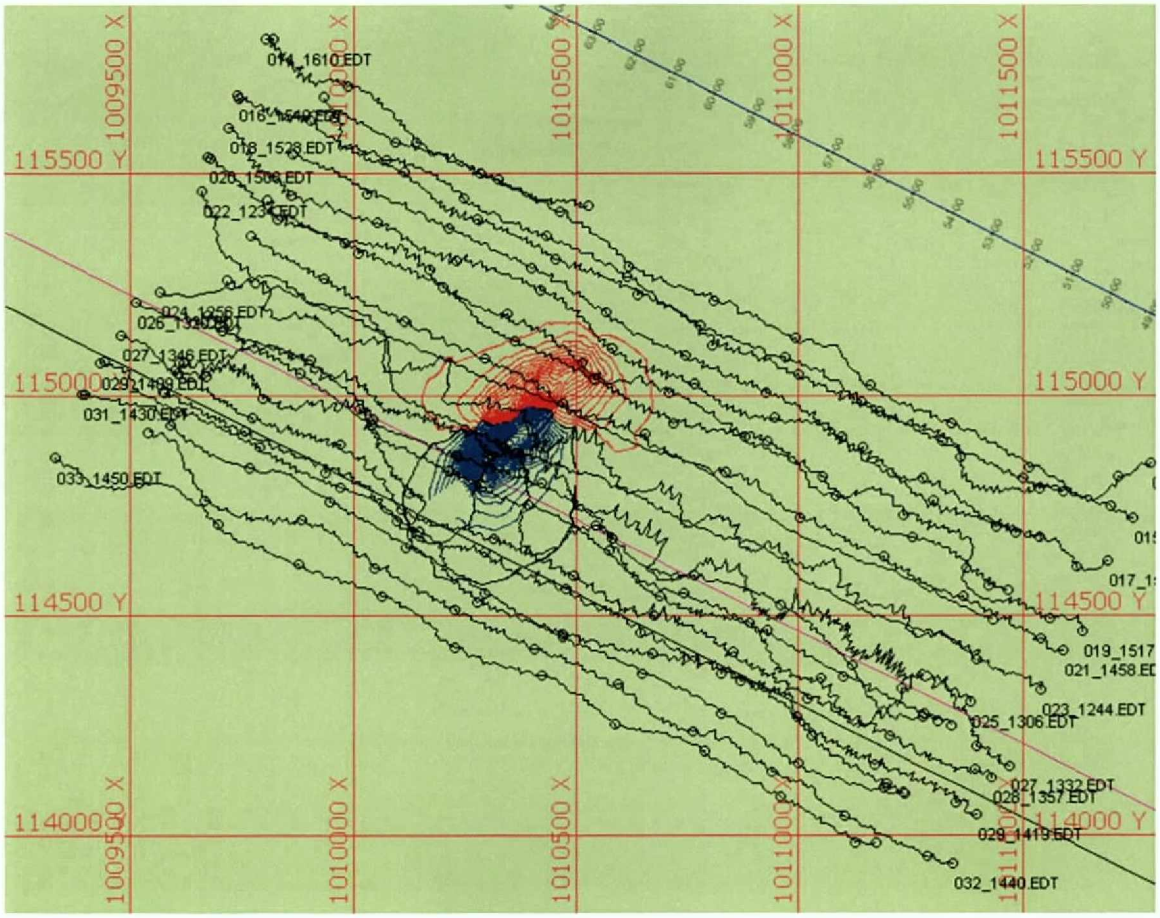
Appendix A: Magnetic Profiles



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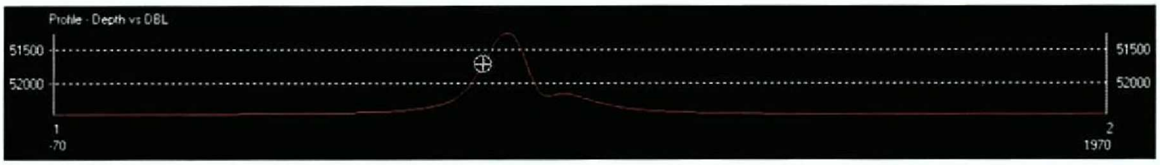

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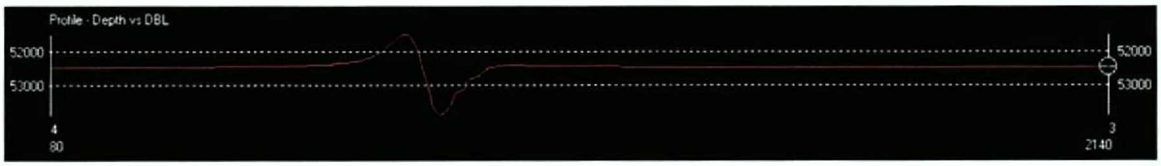

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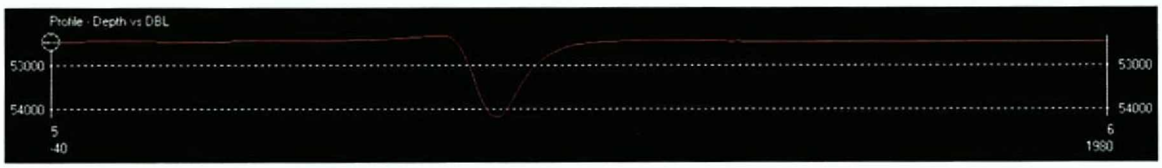

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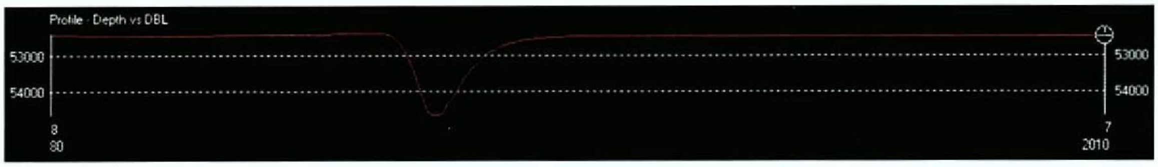

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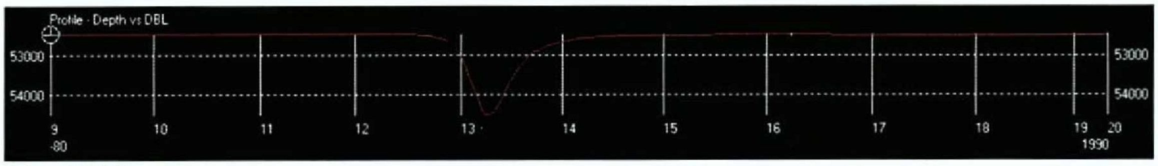

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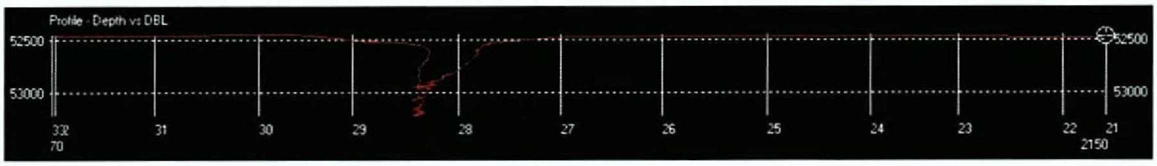

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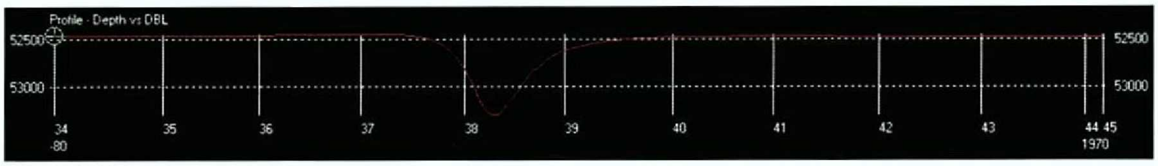

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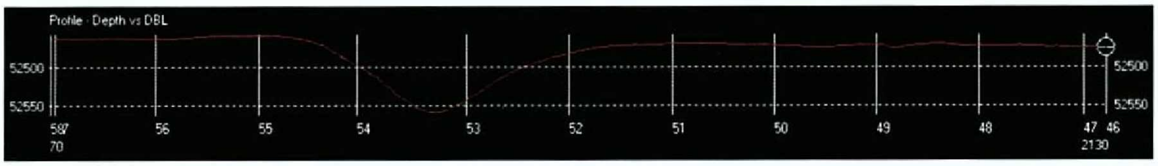

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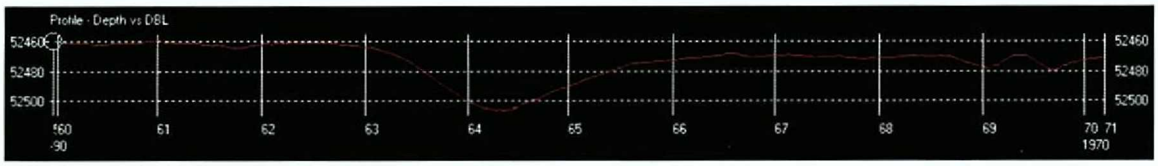

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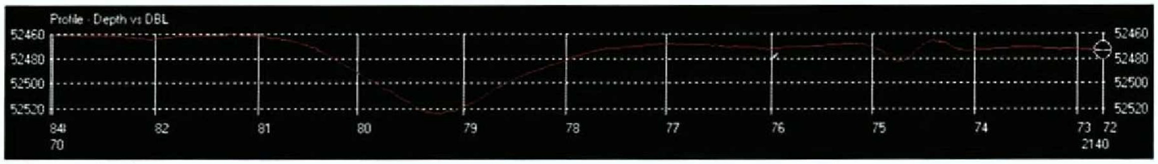

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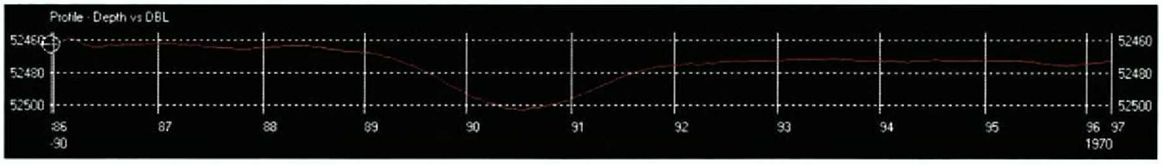

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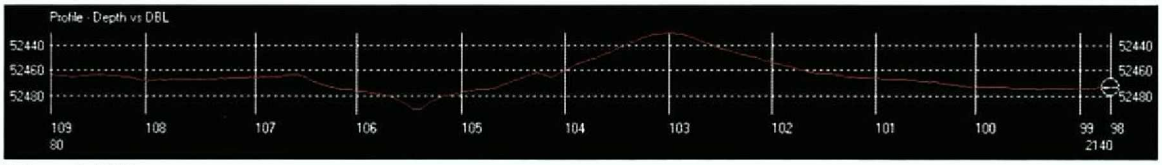

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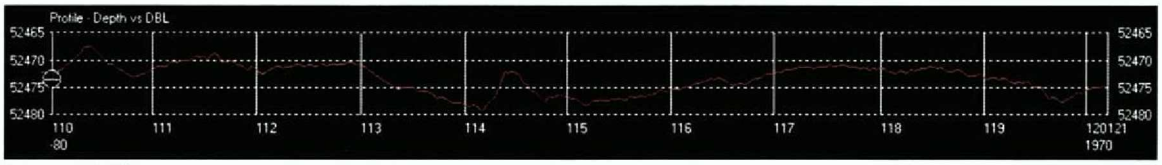

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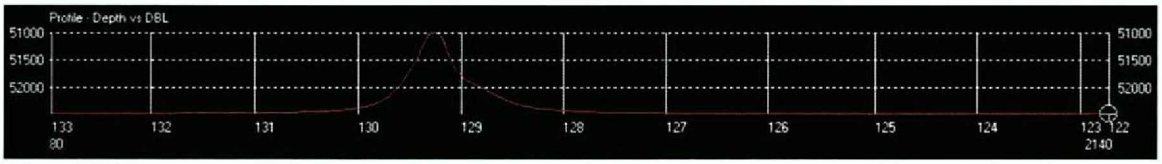

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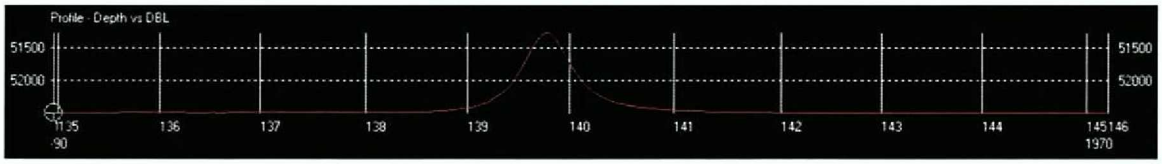

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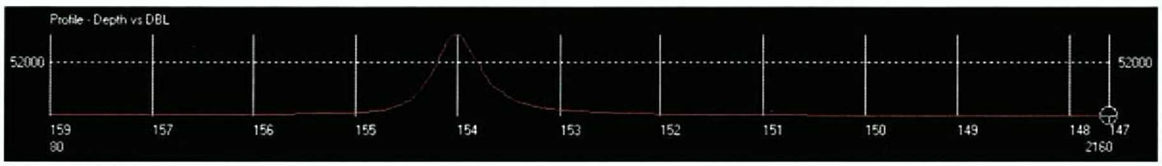

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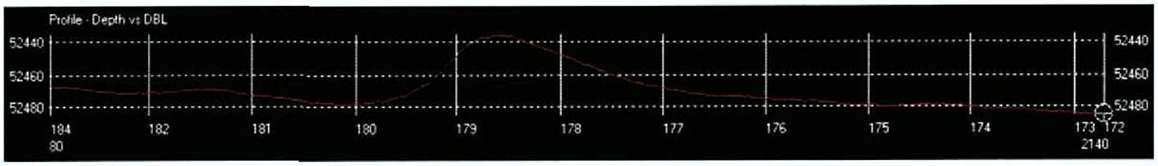

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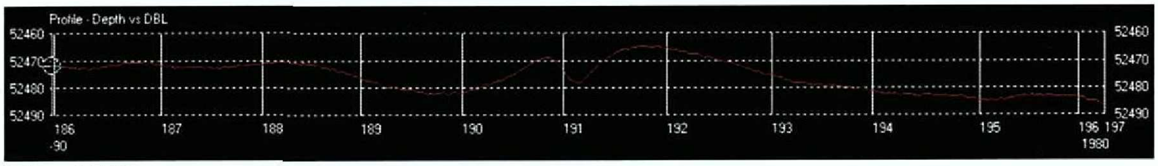

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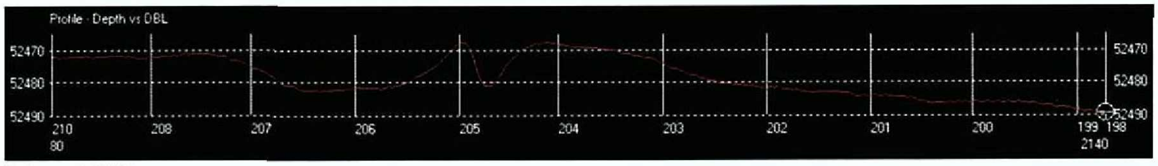

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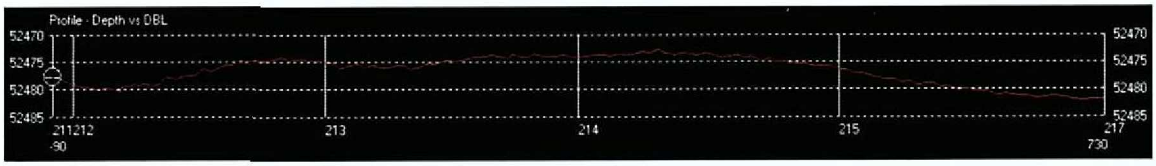

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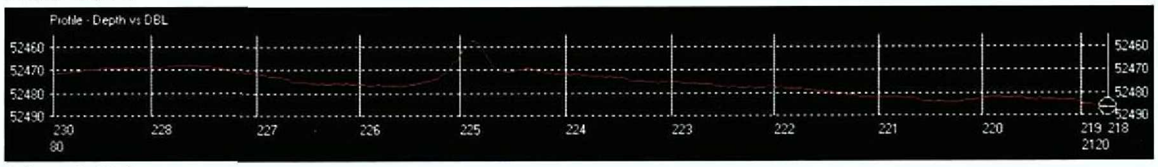

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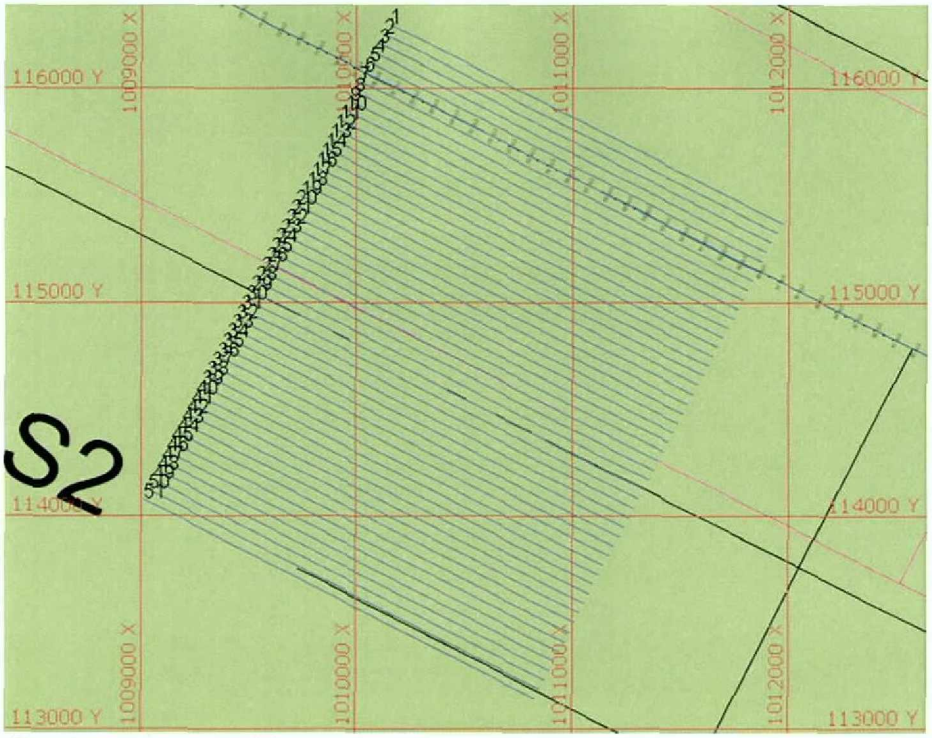
Appendix B: Seismic Profiles



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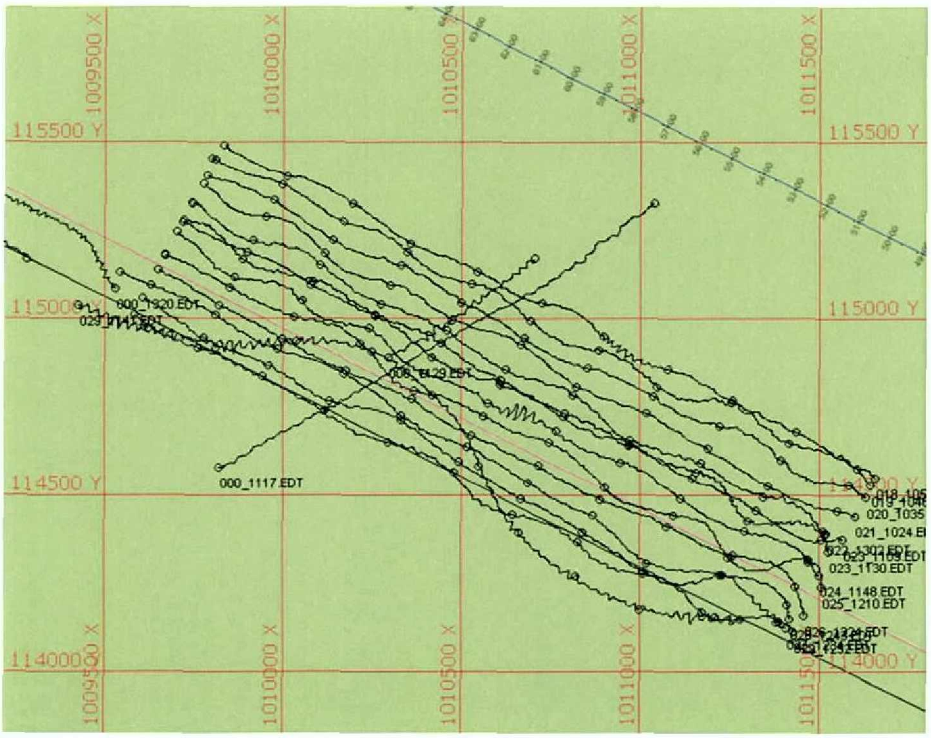

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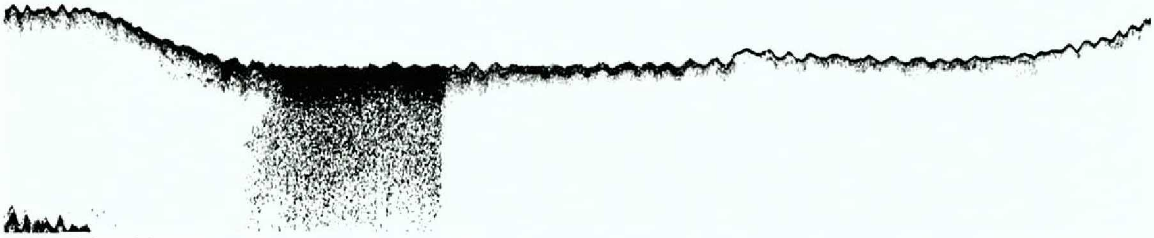
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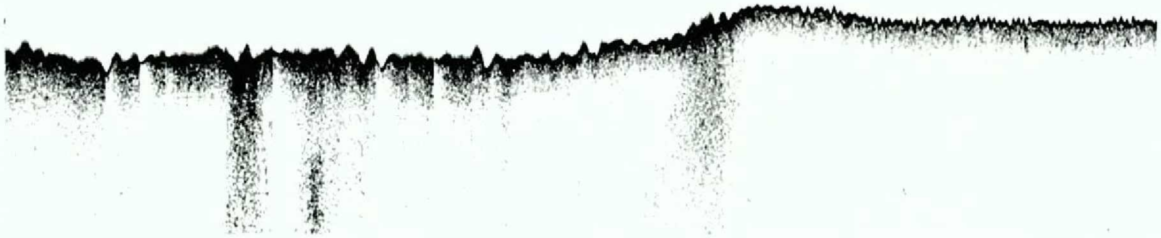
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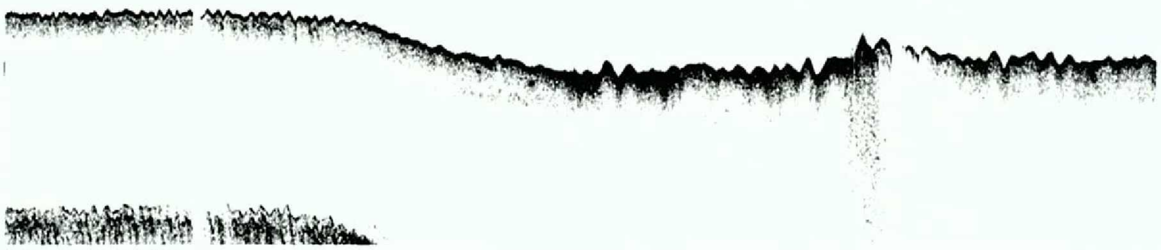
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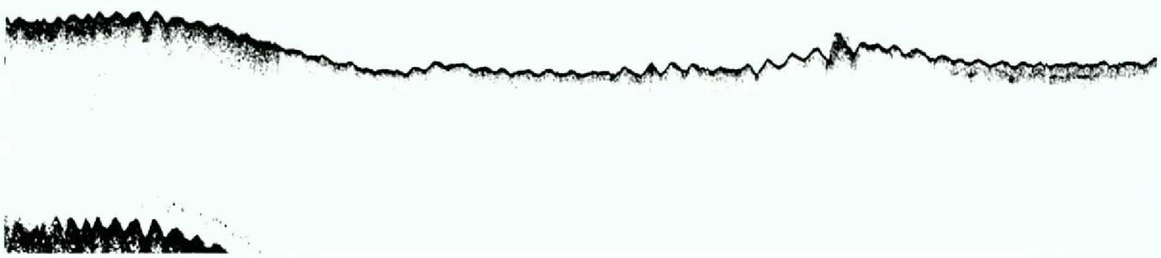
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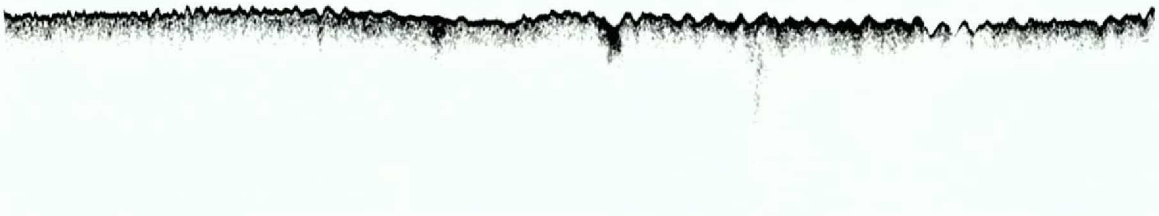

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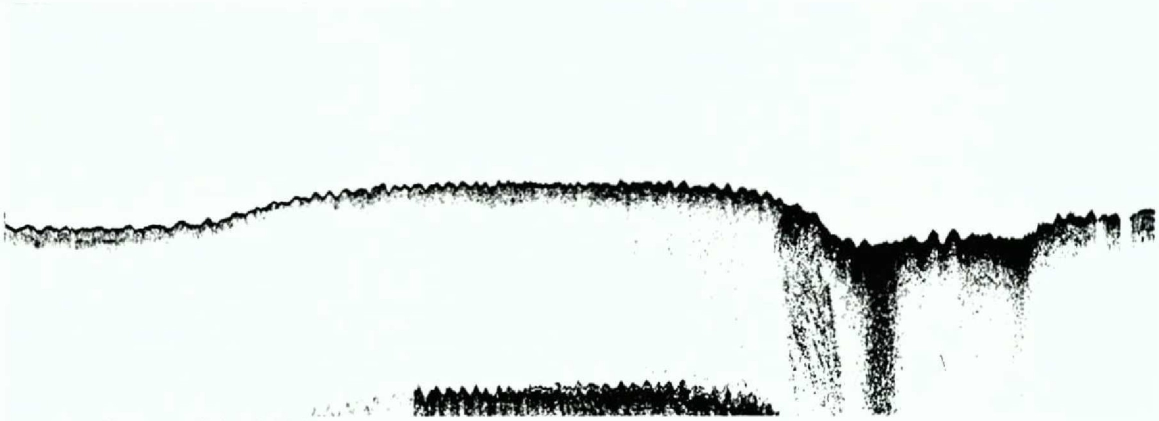
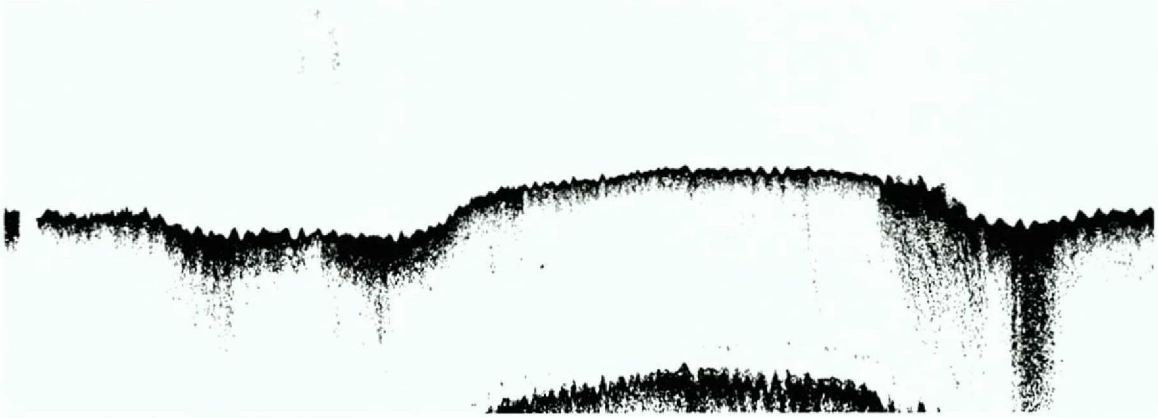


Perpendicular S-N-1117



Perpendicular S-N #2-1129

Appendix C: Scope of Work

Scope of Work to Dive at Potential Wreck in Ambrose Channel to Determine Historic Significance and Undertake Selected Recordation of Remains Encountered In Connection with the New York and New Jersey Harbor Navigation Project Lower Bay Port of New York and New Jersey

I. Introduction

A possible wreck was identified through dredging activities in Ambrose Channel. The nature of this find requires that this feature be evaluated by a qualified maritime archeologist as to its eligibility for listing on the National Register of Historic Places (NRHP). This work can be accomplished through a dive on the feature in question. This will be accomplished through relocating the target using remote sensing and diving by an experienced maritime archaeologist to evaluate any remains encountered. Recommendations for further work, if required, will be developed. This potential wreck was not identified through previous cultural resource studies undertaken for the Harbor Navigation Project as no studies were undertaken in channel due to the assumption by all parties that anything in channel would have been dredged away.

II. Contractor Services and Required Investigations

Task 1. Conduct Historic Research

The possible wreck may be that of the *Fort Victoria*, a cruise ship built in 1913 that collided with another vessel on December 18, 1929 and sank in Ambrose Channel. The wreck was a hazard to navigation and was apparently blasted and dragged. This background work will help in determining if indeed the possible wreck is the *Fort Victoria*.

Task 2. - Develop a Dive Plan

a. The Dive Plan shall serve as a safety plan and research strategy for the underwater inspections. The Dive Plan and all diving will comply with Regulation No. 385-1-93 of the Safety Contract Diving Operations Requirements (Corps 1991; Appendix A), Occupations Safety and Health Standards 29 CFR 1910, EM 385-1-1, "Safety and Health Requirements Manual" dated November 2003 (Section 30 and Appendix O) and the U.S. Diving Manuals, Volume I and II, and all other applicable regulations and guidelines.

b. The Dive Plan will be reviewed by the District's Agency Diving Coordinator (ADC). **ADC acceptance of the Dive Plan must be obtained before any diving is undertaken**.

c. The Dive Plan will also indicate the location of the targets to be inspected and provide an overall research strategy for conducting the dives.

Task 3. - Conduct underwater inspection

This task includes the mobilization and demobilization for the survey.

a. Relocate and inspect the potential wreck to determine if it is a cultural resource and evaluate if it is potentially eligible for the NRHP.

b. The inspection is primarily intended to relocate the potential wreck and to determine if it is potentially significant, obtain measurements as feasible and determine if additional work is warranted. No artifacts will be recovered during the inspection.

c. To the extent practical given prevailing water conditions, black and white or color photographs should be taken of all of the visible features. The location and nature of any observed artifacts or key aspects of the targets should be photographed whenever possible.

d. The Contractor will provide a safe working environment for all persons in his/her employ as prescribed by 29 CFR 1910 EM 385-1-1, "Safety and Health Requirements Manual" dated November 2003; the U.S. Navy Diving Manuals, Volumes I and II; and applicable U.S. Army Corps of Engineers regulations. The Contractor will be responsible for all damages to persons and property that occur in connection with the work and services under this Contract, without recourse against the Government. The Contractor is responsible for having adequate insurance coverage for all activities required under this Contract. The dates for the dives must be coordinated with the New York District. A New York District Dive Coordinator may be required to be on site during the investigations.

e. The Contractor will provide the Corps with an interim report upon conclusion of the underwater investigations. This update will summarize the results of the investigations based upon field observations and brief the District on the data gathered by this fieldwork.

Task 4. – Data Analysis and Report Preparation

a. Conduct data analyses in order to synthesize the results of the underwater inspections. The analyses should be aimed at identifying the potential wreck, if possible, and determining the need for and the nature of further study. The

Contractor will prepare a detailed draft and final report to the professional standards specified.

Qualification requirements:

A. Agencies, institutions, corporations, associations, or individuals will be considered qualified when they meet the minimum criteria given below. In addition to the cost proposal, vitae for the Principal Investigator and main supervisory personnel must be submitted in support of their academic and experiential qualifications for their intended positions, if they have not been included in the original contract proposal.

1. **Archaeological Project Director or Principal Investigator (PI).** For investigations required by this Scope, the Principal Investigator position must be filled by an archaeologist who specializes in underwater/nautical archaeology as defined below. Persons in charge of an archaeological project or research investigation contract, in addition to meeting the appropriate standards for archaeologist, must have a doctorate or an equivalent level of professional experience as evidenced by a publication record that demonstrates experience in project formulation, execution, and technical monograph reporting. Suitable professional references may also be made available to obtain estimates regarding the adequacy of prior work. If prior projects were of a sort not ordinarily resulting in a publishable report, a narrative should be included detailing the proposed project director's previous experience along with references suitable to obtain opinions regarding the adequacy of this earlier work. The Principal Investigator must
have at least one (1) year supervisory experience in underwater archaeology.

2. **Underwater/Nautical Archaeologists.** In addition to meeting the formal qualifications for an underwater or nautical archaeologist specified here, individuals filling this position must also meet the qualifications for divers as defined below. The underwater/nautical archaeologist will have at least one (1) year of supervised experience in marine archaeology, including extensive underwater training. The individual must have a demonstrated knowledge and at least six (6) months experience in the methods, techniques, and use of equipment required for archaeological survey and data recovery at submerged shipwreck sites. The minimum formal qualifications for individuals practicing archaeology as a profession are a B.A. or B.S. degree from an accredited college or university, followed by 2 years of graduate study with a concentration in anthropology and specialization in archaeology during one of these programs, and at least two summer field schools or their equivalent under the supervision of an archaeologist of recognized competence; a Master's thesis or its equivalent in research and publications is highly recommended, as is the Ph.D. degree. Individuals lacking such formal qualifications may present evidence of a publication records and references from archaeologists who do meet these qualifications.

Appendix D: Health and Safety Plan

HEALTH, SAFETY AND ACCIDENT PREVENTION PLAN

SCOPE OF WORK AT POTENTIAL WRECK IN AMBROSE CHANNEL TO DETERMINE HISTORIC SIGNIFICANCE AND UNDERTAKE SELECTED RECORDATION OF REMAINS ENCOUNTERED IN CONNECTION WITH THE NEW YORK AND NEW JERSEY HARBOR NAVIGATION PROJECT, LOWER BAY, PORT OF NEW YORK AND NEW JERSEY

Contract No. W912DS-05-C-0018

Delivery Order No. 0002

1.0 INTRODUCTION

1.1 Purpose

This document is the Remote Sensing Safety Plan (RSSP) to be employed by Panamerican Consultants, Inc., (Panamerican) of Memphis, Tennessee during diving operations for the New York District, U.S. Army Corps of Engineers (COE), to examine a possible historic wreck site in Ambrose Channel. Survey operations will include location, identification, and assessment of the potential significance of the wreck site. This investigation will be conducted for the COE in response to their Scope of Work (SOW) entitled *Scope of Work at Potential Wreck in Ambrose Channel to Determine Historic Significance and Undertake Selected Recordation of Remains Encountered in Connection with the New York and New Jersey Harbor Navigation Study, Florida*, under Contract No. W912EQ-05-C-0018, Delivery Order No. 0000.

The following site-specific HSAP was prepared to provide safe procedures and practices for PCI personnel engaged in conducting cultural resources and archaeological investigations at the wreck site. The plan has been developed using as guidance the Occupational Safety and Health Administration (OSHA)1910.120 regulations and the US Army Corps of Engineers Safety and Health Requirements Manual (EM 385-1-1; 2003). The purpose of this HSAP is to establish personnel protection standards and mandatory safety practices and procedures for this task specific effort. This plan assigns responsibilities, establishes standard operating procedures, and provides for contingencies that may arise during the field archaeological and cultural resources efforts.

If for any reason the HSAP is altered in objective, personnel, or equipment, the New York District's Health and Safety Officer shall be contacted and shall review any revision prior to actual operation.

1.2 Applicability

The provisions of the plan are mandatory for all personnel engaged in archaeological and cultural resources investigations. All personnel who engage in these activities must be familiar with this plan and comply with its requirements.

All personnel will be responsible for operating in accordance with the OSHA regulations 29 CFR Part 1910.120 - 'Hazardous Waste Operations and Emergency Response' and U.S. Army Corps of Engineers EM.385-1-1. It should be noted however, that although this plan was produced in accordance with these requirements this work is not being conducted in areas designated as hazardous waste or material areas.

This plan is applicable to all aspects of the tasks detailed below associated with an archaeological and cultural resources investigations to be performed in project areas.

The plan is based on available information concerning possible industrial contaminants and physical hazards that exist, or may exist, at the project site and during planned tasks. If more data concerning the nature and/or concentrations of contaminants become available, the plan will be modified accordingly. Modifications will be made by the Site Safety Officer. All modifications will be documented in the plan and field book and provided to the Project Manager and the Health and Safety Manager for approval.

A copy of this plan will be available for review by all on-site personnel. In addition, a copy of the plan will be provided to all subcontractors prior to their initial entry onto the site.

Before field activities begin, personnel will be required to read the HSAP. All personnel must agree to comply with the minimum requirements of the site-specific plan, be responsible for health and safety, and sign the Statement of Compliance for all on-site employees before site work begins.

IT should be noted the Panamerican personnel will NOT be diving during this investigation.

1.3 Field Activities

The tasks associated with the performance of the archaeological and cultural resources investigations include:

- Mobilization and Demobilization
- Documentary Research
- Remote Sensing using magnetometer, side scan sonar, and subbottom profiler
- Data Analysis

1.4 Personnel Requirements

Remote sensing will require a two person team. One person will run the navigation system, magnetometer, and side scan sonar, while the second team member will run the subbottom profiler. Key personnel vitae are included in Appendix A.

Key personnel are as follows:

Project Manager- Mr. Stephen R. James, Jr.
Field Director/Principal Investigator - Mr. Andrew D. W. Lydecker
Remote Sensing Specialist – Dr. Michael K. Faught

Site personnel and their duties are outlined below:

1) Field Director/Principal Investigator

The Field Director and/or Principal Investigator will be responsible for all personnel and subcontractors on-site and designates duties to the on-site personnel. The Field Director has the primary responsibility for:

- Assuring that personnel are aware of the provisions of this plan and are instructed in the work practices necessary to ensure safety in planned procedures and for dealing with emergencies.
- Verifying that the provisions of this plan are implemented.
- Assuring that all field personnel have the required training.
- Assuring that appropriate personnel protective equipment (PPE), if necessary, is available for and properly utilized by all personnel.
- Assuring that personnel are aware of the potential hazards associated with site operations.
- Supervising the monitoring of safety performances by all personnel to ensure that required work practices are employed.
- Maintain sign-off forms and safety briefing forms.

2) Remote Sensing Specialist

It shall remain the responsibility of each field crew member to follow the safe work practices listed in this HSAP and in general to:

- Be aware of the procedures outlined in this plan.
- Take reasonable precautions to prevent injury to himself and to his coworkers.
- Perform only those tasks that he believes can be done safely, and immediately report any accidents or unsafe conditions to the Safety Officer and Field Director.
- Notify the SSO and Field Director of any special medical problems (i.e., allergies or medical restrictions) and make certain that on-site personnel are aware of any such

problems.

- Think "safety first" prior to and while conducting fieldwork.

The PCI crew can request assistance from the site safety officer or emergency personnel at any time during the course of fieldwork. Each crew member has the authority to halt work should he deem conditions to be unsafe. Visitors will be required to report to the Field Director and Site Safety Officer and follow the requirements of this plan.

2.0 COMPREHENSIVE WORK PLAN

This section comprises the organizational structure and work plan for the relocation and inspection of the Ambrose Channel wreck.

2.1 Project Phases

Located in the Ambrose Channel, the vessel lies within New York State. The SOW lists the Tasks, with the field portion as follows:

1. Perform magnetometer, side scan sonar and subbottom profiler survey of the wreck and immediate surrounding area to determine the size and extent of the possible wreck. Accompany the dive team while on site collecting the high resolution video. Observe and direct the diver while collecting video and extracting a sample of the possible wreck, Prepare and submit an interim report based on the conclusion. This report will summarize the results of the investigations based upon field investigations and the data gathered by the fieldwork.

2.2 Vessel Access

The locations of the vessel to be examined mandate the employment of a large crew-type dive vessel for survey and diving. The vessel is completely submerged and lies at least partially in the navigation channel.

2.3 Photography

Photodocumentation tools will play an integral role in the investigation process. High resolution video documentation will be used, as it allows a much more comprehensive view, and will aid in the mapping and analysis. In addition, the video record can be archived, and it can be employed as a teaching or reference tool of our maritime history.

2.4 Artifact Recovery

As stipulated in the SOW, apart from documentation, not artifacts will be recovered and conserved during this investigation

2.5 Required Equipment Types

Major Equip. Type	Specific Requirement
Survey Vessel	A diving platform large enough to accommodate the entire survey team plus survey equipment and peripherals such as compressors and/or generators is required.
Camera Equipment	High resolution underwater video cameras will be used to document selected portions of the wreck site.

2.6 Schedule and Duration of Recordation

The project is tentatively scheduled for May 2nd – May 3rd, 2007. Work will take place on each day that weather and safe water levels permit safe diving. Work will not commence until the Health and Safety Plan is approved by the USACE Health and Safety Officer.

3.0 HAZARD EVALUATION

Based on the nature of these archaeological activities, which include recordation of deteriorating structures, the hazard potential is deemed moderate. Activities will also be conducted in areas of historic industrial activity. The potential of encountering low levels of industrial contamination exists. The following summarizes the potential hazards associated with deteriorating structures as well as potential chemical, physical and biological hazards.

3.1 Activity Hazard Analysis

3.1.1 Vessel Activity

HAZARD CASE	MEANS OF PREVENTION	ACTION IN
Weather	Monitor weather prior to leaving port. Constantly observe weather while conducting investigations. Indications of imminent foul weather are antithetical to safe investigations.	Do not have vessel leave port. Vessel return to port.
Fire aboard Vessel	All survey crew will become familiar with placement of fuel shutoff and fire suppression equipment.	Contact nearest Coast Guard facility. Engage fire suppression equipment.
Falling objects	All overhead objects will be secured.	Apply first aid or other appropriate treatment.
Falling, Tripping, and Slipping	Crew will be aware of the local environment and wear proper foot gear for environment. One hand for the boat one hand for self rule.	Apply first aid or other appropriate treatment. Seek medical help if necessary.
Man Overboard	Crew will wear Personal Flotation Device (PFD) when applicable.	Discontinue investigation. Recover man overboard.
Hypothermia	Crew will wear appropriate clothing for environmental conditions. Avoid exposure to extreme cold and unnecessary discomfort.	Supply with warm liquids and cover until body temperature returns to normal.
Drowning	Crew will wear Personal Flotation Device (PFD) when applicable. Crew will be familiar with the dive vessel and emergency equipment placement for immediate use if necessary.	Administer CPR as appropriate & seek medical attention immediately.
Vessel Sinking	Evaluate seaworthiness of vessel prior to any survey or work activity. Know location of all floatation devices and life rafts on project vessel. Know radio signal for emergencies "May Day".	Contact nearest Coast Guard facility. Abandon vessel.

3.2.2. General Hazard Analysis

ACTIVITY	POTENTIAL PROBLEMS	MEANS OF PREVENTION
Work Site	General public, pleasure and commercial vessels	Limit or Prevent Access as necessary Maintain communication via marine band radio.
Accident Prevention	Public and personal *injury*	Wear proper clothing and safety equipment. Signage and other applicable warning devices. .
Emergencies, Injuries and Accident Reporting	Public and personal injury.	Maintain survey crew certification in both CPR and First Aid. Maintain first aid kits. Post local emergency numbers. Promptly report and investigate all accidents.
Machinery And Equipment Operation	Equipment or property damage .Potential for personnel injury.	All machinery and equipment will be operated only by knowledgeable operators
Vehicle Operation.	Equipment or property damage Potential for personnel injury.	All survey crew members will obey local traffic laws Project vehicles will be properly maintained.
Loading and Offloading Equipment	Equipment or property damage Potential for personnel injury.	Each crew member will know abilities and not exceed them. Assign proper number of personnel to each task.
Water Access	Drowning, falling, or slipping	All floating plant marine

And Equipment Operation	work will be performed in accordance with the requirements of EM385-1-1 Section 26

The above is a list of potential hazards that may be encountered during the current project. This list will be presented to each survey crew member for their review and input prior to any survey activity.

While on site other, not readily definable hazards may occur. A continuous evaluation of hazards will be conducted while engaging in project activities. Each new hazard that presents itself will be listed as they occur and preventive measures will be developed and implemented. Upon the completion of the investigation a review of the effectiveness of the present hazard analysis will be conducted to evaluate the overall effectiveness and determine if any changes or additional input is needed. Any hazards encountered during the investigation not previously listed will be included in a post survey hazard evaluation for better pre-project hazard analysis during future projects.

4.0 SAFE WORKING PRACTICES

4.1 General Practices

The following general safe work practices apply:

- Contact with potentially contaminated substances should be avoided. Puddles, pools, mud, etc. should not be walked through if possible. Kneeling, leaning, or sitting on equipment or on the ground should be avoided whenever possible.
- Unusual site conditions shall be promptly conveyed to the SSO and project management for resolution.
- A first-aid kit shall be available at the site.
- Field personnel should use all their senses to alert themselves to potentially dangerous situations (i.e., presence of strong, irritating, or nauseating odors, deteriorated surfaces, unstable debris, etc.).
- Field personnel must attend safety briefings and should be familiar with the physical characteristics of the investigation, including:
  - Accessibility to associates, equipment, and vehicles.
  - Site access.
  - Routes and procedures to be used during emergencies.
- Personnel will perform all investigation activities with a buddy who is able to:
  - Provide his or her partner with assistance.
  - Notify the SSO or Field Director if emergency help is needed.
- Work activities shall be terminated immediately in event of thunder and/or electrical storm.
- The use of alcohol or drugs at the site is strictly prohibited.

5.0 PERSONAL PROTECTIVE EQUIPMENT

As required by OSHA in 29 CFR 1920.132, this plan constitutes a workplace hazard assessment to select personal protective equipment (PPE) to perform the archaeological and the cultural resources investigation.

Protective clothing and equipment to initiate the project will include:

- Work clothes including long pants
- Steel-toed safety boots
- Safety glasses
- Hard hat
- Personal floatation device (work vest)

6.0 EMERGENCY INFORMATION

In the event of an emergency, the field team members or the SSO will employ emergency procedures. A copy of emergency information will be kept in the field vehicle and will be reviewed during the initial site briefing. Copies of emergency telephone numbers and directions to the nearest hospital will be prominently posted in the field vehicle.

6.1 Emergency Medical Treatment And First Aid

A first aid kit large enough to accommodate anticipated emergencies will be kept in the boat. If any injury should require advanced medical assistance, emergency personnel will be notified and the victim will be transported to the hospital. Keys for the field vehicle will be left in or near the ignition.

In the event of an injury or illness, work will cease until the SSO and Field Director have examined the cause of the incident and have taken appropriate corrective action.

6.2 Emergency Telephone Numbers

Emergency telephone numbers for medical and chemical emergencies will be posted in the field vehicle are listed below:

EMERGENCY	911	EMERGENCY
HOSPITAL	201-858-5000	Bayonne Hospital 29th St. and Ave., E. Bayonne, NJ 07002
HOSPITAL	718-226-9000	Staten Island University Hospital 475 Seaview Ave.,

Staten Island, NY 10305

HOSPITAL	718-226-2000	Staten Island University Hospital 375 Seguine Ave., Staten Island, NY 10309

UNITED STATES COAST GUARD, 1ST DISTRICT

GROUP NEW YORK	212-668-7913	
SEARCH AND RESCUE	212-668-7913/7937	24-HOUR HOTLINE
Operations Office	212-668-7913	USCG, 1st District, Governor's Island
Air Station	718-765-2409	USCG Air Station Brooklyn
Waterways Office	212-668-7906	Waterways,Governor's Island

NEW JERSEY STATE MARINE POLICE, PORT NEWARK

State Marine Police	201-578-8173	Port Newark Office

6.3 Emergency Standard Operating Procedures

The following standard operating procedures are to be implemented by on-site personnel in the event of an emergency. The SSO shall manage response actions.

- Upon notification of injury to personnel, the designated **emergency signal shall be sounded**, if necessary. All personnel are to terminate their work activities and assemble with the SSO. The emergency medical service and hospital emergency room shall be notified of the situation. If the injury is minor, but requires medical attention, the SSO shall accompany the victim to the hospital and provide assistance in describing the circumstances of the accident to the attending physician.
- Upon notification of an equipment failure or accident, the SSO shall determine the effect of the failure or accident on site operations. If the failure or accident affects the safety of personnel or prevents completion of the scheduled operations, all personnel are to leave the area until the situation is evaluated and appropriate actions taken.
- Upon notification of a natural disaster, such as tornado, high winds, flood, thunderstorm or earthquake, on-site work activities are to be terminated by the SSO and all personnel are to evacuate the area.

6.4 Emergency Response Follow-Up Actions

Following activation of the Emergency Response Plan, the SSO shall notify the project manager and other PCI managers. The SSO shall submit a written report documenting the incident within two working days (see Attachments).

6.5 Medical Treatment For Site Accidents/Incidents

The SSO shall be informed of any site-related injury, exposure or medical condition resulting from work activities. All personnel are entitled to medical evaluation and treatment in the event of a site accident or incident.

SITE MEDICAL SUPPLIES AND SERVICES

The SSO or a trained first aid crew member shall evaluate all injuries at the site and render emergency first-aid treatment as appropriate. If an injury is minor but requires professional medical evaluation, the SSO shall escort the employee to the appropriate emergency room. For major injuries occurring at the site, emergency services shall be requested.

First-Aid Kits

A first-aid kit shall be available, readily accessible and fully stocked. The first-aid kit shall be located within specified vehicles used for on-site operations.

7.0 PERSONNEL TRAINING REQUIREMENTS

7.1 Initial Site Entry Briefing

Prior to initial site entry, the SSO shall provide all personnel (including site visitors) with site-specific health and safety training. A record of this training shall be maintained. This training shall consist of the following:

- Discussion of the elements contained within this plan
- Discussion of responsibilities and duties of key site personnel
- Discussion of physical, biological and chemical hazards present at the site
- Discussion of work assignments and responsibilities
- Discussion of the correct use and limitations of the required PPE
- Discussion of the emergency procedures to be followed at the site
- Safe work practices to minimize risk
- Communication procedures and equipment
- Emergency notification and procedures

7.2 Additional Training

The following additional training is required for all full-time site workers.

- Red Cross Standard First Aid
- Red Cross CPR

7.3 Daily Safety Briefings

The SSO will determine if a daily safety briefing with all site personnel is needed. The SSO shall document the daily briefings in the field log book. This documentation shall include health and safety topics covered and attendees at the briefing. The briefing shall discuss the specific tasks scheduled for that day and the following topics:

- Specific work plans
- Physical, chemical or biological hazards anticipated
- Fire or explosion hazards
- PPE required
- Emergency procedures, including emergency escape routes, emergency medical treatment, and medical evacuation from the site
- Weather forecast for the day
- Buddy system
- Communication requirements
- Site control requirements