Applying Modern Technology to Save a Historic Warship: The *Monitor* National Marine Sanctuary

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Abstract—On March 9, 1862 the ironclad warships USS *Monitor* and CSS *Virginia* (ex-USS *Merrimack*) fought to a draw at Hampton Roads, Virginia, in one of the most recognized sea battles in history. Now, 135 years later, the *Monitor* is fighting a losing battle against both natural and human threats. The *Monitor's* hull, lying in 230 ft. (71 m) of water off Cape Hatteras, North Carolina, is deteriorating at an alarming rate. The National Oceanic and Atmospheric Administration (NOAA) is responsible for the *Monitor* which, in 1975, was designated America's first National Marine Sanctuary. As a result, NOAA is aggressively applying comprehensive planning strategy and ocean technology to the problem of protecting the *Monitor*.

I. INTRODUCTION

At the time of its launching in 1862, the USS *Monitor* represented state-of-the-art technology. The design was unlike anything the world had ever seen; the *Monitor* would change the way major sea powers would build warships in the future. A radical departure from conventional wooden broadside warships, the *Monitor's* hull was almost completely submerged, presenting enemy ships a target with only a 13-inch (33 cm) freeboard. The only structures above the deck were a revolving gun turret amidships and a small pilot house near the bow.

The *Monitor's* hull was composed of two distinct sections: the lower hull, constructed entirely of iron and the upper hull, built of iron and wood [1]. The side armor belt consisted of an iron shelf filled with wood timbers and covered with five layers of 1-inch-thick (2.5 cm-thick) iron plate [2]. The deck was built of oak beams covered with pine planks and two layers of 1-inch (2.5 cm) iron plate [3]. The revolving turret, constructed with eight layers of 1-inch iron plate, stood 9 feet (2.7 m) tall with an interior diameter of 20 feet (6.1 m). This "shot proof tower" housed two 11-inch Dahlgren smoothbore cannon [4].

The *Monitor's* keel was laid on October 25, 1861, and the completed vessel was launched on January 30, 1862 [5]. The ship arrived in Hampton Roads on the evening of March 8, 1862. Earlier that day, the CSS *Virginia* (ex-USS *Merrimack*) had made her maiden voyage into Hampton Roads and wreaked havoc on the Union fleet. Two warships were sunk and a third was run aground and heavily damaged. A receding tide was all that intervened between the remaining Union ships and the Confederate ironclad [6].

Arrival of the *Monitor* brought new Union hope to a battle that was certain to resume the next day [7]. Early on March 9, the *Virginia* steamed back into Hampton Roads, prepared to finish off the wooden ships. The *Monitor* advanced to engage her iron counterpart, thus commencing one of the most celebrated sea battles in history (Fig. 1) [8].

These two revolutionary ships, though quite different in appearance, shared several innovative traits. Both were clad in thick iron armor; both had partially submerged hulls; both were totally without masts or sails, operating by steam power alone; and both were designed to be effective with few cannon. The Battle of Hampton Roads was the first time in history that these features were tested against each other. In battle, the *Monitor's* design proved to be an advantage. Its low profile was an almost impossible target for Confederate fire. The revolving turret allowed the *Monitor* to fire from almost any angle without having to maneuver the ship for position. The four-hour battle ended in a draw with neither ship being able to significantly damage the other [9].

The repercussions of this battle were felt worldwide. Although there were other ironclad warships in existence, they were untried in battle against similar foes. The battle of Hampton Roads brought about the rapid abandonment of conventional wooden broadside warships. In the United States, the *Monitor*

Fig. 1. The first battle of ironclad warships took place March 9, 1862, in Hampton Roads, Virginia between the USS *Monitor* and the CSS *Virginia* (Century Illustrated Monthly Magazine).

gave her name to an entirely new classification of low-freeboard, turreted vessels. By the end of the American Civil War 60 monitors of various classes had been completed or were under construction. Even though these monitors had all the characteristics of the first, each successive class incorporated design modifications [10]. The USS *Monitor*, the prototype, was wholly unique.

Although impervious to cannon fire, the *Monitor* succumbed to the seas. While being towed south along the Atlantic coast, the *Monitor* foundered in a gale off Cape Hatters, North Carolina on New Years Eve, 1862, with the loss of 16 lives [11].

II. MANAGEMENT AND PROTECTION

Located in 1973, the wreck of the USS *Monitor* was designated the nation's first marine sanctuary on January 30, 1975. The *Monitor* National Marine Sanctuary is one of twelve marine protected areas managed by the Sanctuaries and Reserves Division of the National Oceanic and Atmospheric Administration (NOAA). The wreck of the USS *Monitor* is listed on the National Register of Historic Places and has also been designated a National Historic Landmark.

The *Monitor*'s inaccessibility is a major factor influencing both management and research. It lies on a flat, featureless, sandy bottom in 230 ft. (71 m) of water, 16 nautical miles SSE of Cape Hatteras Lighthouse [12]. Water depth places it out of the reach of most scuba divers. The *Monitor* rolled over as it sank, causing its turret to pull free and fall to the bottom, upside down. The hull then settled onto the turret. The inverted hull now rests partially buried in sediment with the stern port quarter supported above the bottom by the displaced turret. The lower hull has collapsed forward of the midships bulkhead, and the stern armor belt and associated structure is badly deteriorated. The position of the turret under the port quarter elevates

Fig. 2. A diver measures the *Monitor*'s inverted turret, which lies beneath the armor belt (Farb *Monitor* Expeditions).

the stern and port side, producing a list to starboard and creating severe stresses on the hull (Fig. 2). The wreck of the *Monitor* presents NOAA with unique archaeological and engineering challenges that have been met, to some extent, through a comprehensive program of archival and on-site research.

III. SCIENTIFIC INVESTIGATIONS OF THE *MONITOR*

During the past two decades, NOAA has conducted several major expeditions to the *Monitor* site to generate data necessary to make sound management decisions about the wreck. Assessment of the *Monitor* in the late 1970s revealed that the wreck had suffered damage and deterioration from three factors: damage that occurred at the time of sinking, deterioration caused by more than a century of exposure to a dynamic seawater environment, and damage resulting from human activities. Several researchers have hypothesized that the *Monitor* was depth-charged during World War II, resulting in part of the visible damage to the lower hull, and possibly, to the stern armor belt. More recently, there is evidence that the wreck has been damaged by illegal anchoring and fishing activities.

A report issued in 1991 on a major expedition conducted by NOAA in 1987 cited a number of major changes in the condition of the wreck since 1983. Analysis of data generated by the 1987 expedition and two NOAA reconnaissance missions in 1990 identified evidence of damage to the stern, particularly in the area of the propeller and skeg. Much of this evidence was interpreted as indications of unauthorized human activity in the Sanctuary. Subsequent NOAA reconnaissance missions in 1991 and 1992 confirmed the increased deterioration of the wreck. A private fishing vessel, anchored illegally on the *Monitor* in 1991, apparently initiated a chain reaction of deterioration and collapse that is still underway [13].

During July and August, 1993 NOAA conducted the *Monitor* Archaeological Research and Structural Survey (MARSS) Expedition. The principal goals were to: (1) map and videotape the *Monitor*'s hull to quantify and document site changes; (2) deploy a permanent mooring; (3) locate, map and recover exposed, threatened artifacts; and (4) conduct test excavations and mapping of the *Monitor*'s turret in order to assess the feasibility of recovery. Despite adverse weather conditions, the permanent mooring was deployed and limited test excavations were carried out both inside and outside the turret [14].

The 1995 *Monitor* Archaeological Research, Recovery and Stabilization Mission (MARRS'95) was conducted August 12 to September 2, 1995. The primary goal of the mission was to stabilize the *Monitor*'s deteriorating hull by moving its displaced skeg and recovering its propeller. Among the participants were NOAA, the U.S. Navy, The Mariners' Museum, the National Undersea Research Center/University of North Carolina at Wilmington, and Key West Diver, Inc. Although the expedition was interrupted by Hurricane Felix and two lesser storms, a NOAA team conducted a series of self-contained, mixed-gas dives—the first such dives ever approved by NOAA. Navy

divers employed the Mk 21 mixed-gas, surface-supplied dive system staged from the USS *Edenton* (ATS-1) in a series of dives designed to recover the *Monitor*'s propeller. Adverse weather conditions prevented recovery of the propeller despite several attempts [15].

A. 1996 Laser Line Scanner Survey

During October 9-16, 1996, an imaging survey was conducted at the *Monitor* National Marine Sanctuary using a new type of laser line scanner system. The primary objective of the survey was to utilize the state-of-the-art synchronous laser line scanner to generate high-resolution color images of the *Monitor* and its surrounding debris field. The mission was made possible by the cooperation and participation of NOAA, the U.S. Navy, Raytheon Electronic Systems and the Harbor Branch Oceanographic Institution. The survey utilized the Harbor Branch Research Vessel *Edwin Link* and the Research Submersible *Clelia*, on which the laser system was mounted.

The major goals of the expedition were to thoroughly image the *Monitor*'s hull from various altitudes and angles; image the debris field for approximately 30 meters around the hull; image the seabed in a larger perimeter around the hull; and conduct daylight surveys, recording the site on videotape.

Poor visibility and strong currents on the bottom created difficulty for the submersible and imaging system. Because of the extremely poor visibility, the submersible pilot was forced to remain close to the bottom until visual contact was made with the wreck. He then used thrusters to rise above the wreck to a suitable altitude for operation of the laser (13 to 15 ft., 4.0 to 4.6 m). The problem of maintaining a correct height above the wreck was made more difficult by the fact that the wreck rises as much as 18 ft. (5.5 m) above the bottom, but in 'steps' rather than a steady increase. During each pass over the wreck, the pilot and laser operator were forced to make frequent real-time corrections. The pilot had to adjust the height above the wreck and the laser operator had to adjust the signal gain in all channels to compensate for the changing distance between the laser and the wreck. Complicating matters further, the strong current forced the submersible off course on almost every pass, causing most of the resulting images to show the shape of the wreck as a steeply curved arc.

The expedition was hampered throughout by heavy seas, strong winds, swift currents, and poor visibility. Despite these difficulties, more than two gigabytes of laser imaging data were obtained on two submersible dives. A review of all data files verified that the laser line scanner system worked well and that a significant portion of the *Monitor*'s hull is represented in one or more of the image files (approximately 70 percent of the hull was captured). The images are being corrected, optimized, and assembled into a composite view of the *Monitor*'s hull (Fig. 3). Had bottom conditions been more favorable, there is little doubt that excellent color images of the *Monitor* would have been obtained [16].

B. 1997 Laser Line Scanner Survey

During June 11-15, 1997, NOAA conducted a second laser line scanner imaging survey at the *Monitor* National Marine Sanctuary. The survey was a cooperative effort involving NOAA's Sanctuaries and Reserves Division, NOAA Corps Operations, NOAA Ship *Ferrel*, Northrop Grumman Oceanic Systems, and Science Applications International Corporation. The Northrop Grumman laser system was mounted in a tow vehicle and deployed from NOAA ship *Ferrel*, for a series of transects over the wreck site. Survey operations commenced on June 12, but had to be terminated shortly after 1:00 a.m. on June 14 due to deteriorating weather conditions. The survey was hampered by strong ocean currents, but video and digital still images of the *Monitor* were obtained and are being analyzed. It is hoped that this and the 1996 laser imaging survey will provide sufficient data for a complete mosaic of the *Monitor*'s hull.

IV. COMPREHENSIVE PLAN DEVELOPMENT

Following a NOAA briefing in 1996 on the *Monitor*'s deteriorating condition, Congress placed a mandate in the 1997 National Marine Sanctuary Program reauthorization bill requiring NOAA to produce a "long-range, comprehensive plan for the management, stabilization, preservation, and recovery of artifacts and materials" from the *Monitor*. NOAA was also instructed to seek the assistance of other governmental organizations in this effort. The plan is to be completed by September 30, 1997.

Fig. 3. The 1996 laser line scanner survey produced new and very detailed images of the *Monitor*, including this image of the inverted turret and a portion of the port armor belt (U. S. Navy).

This comprehensive plan will document NOAA's response to the challenging problem of the *Monitor's* deterioration. It will describe each major planning element in detail and address all aspects of management, protection and possible recovery. Development of the plan involves resources for planning, budgeting, and coordination with governmental and non-governmental agencies with expertise in salvage and marine engineering, conservation, exhibition and other specialties, many of which must be obtained outside of NOAA's Sanctuaries and Reserves Division.

A variety of technological tools are being applied to the *Monitor's* plight. One of the most useful and important management tools recently developed for the computer is the Geographic Information System (GIS), which can be used to store, sort, recover, and analyze a wide range of geographically related data. A GIS database is being developed for the *Monitor* site to provide immediate access to spatially related historical, engineering, archaeological, photographic and video records. By selecting areas or features of the wreck, the end user will be able to query corresponding database records and access photographic and/or artistic images. The program will be expanded to identify priorities for future research and provide control for on-site data collection. In addition, the program provides a variety of tools and data for use by the *Monitor* National Marine Sanctuary in developing the comprehensive, long range plan. Development of the *Monitor* GIS database is a cooperative effort by NOAA, Environmental Systems Research Institute, Inc., and the Institute for International Maritime Research, Inc.

The *Monitor* GIS system consists of an interactive matrix of photographic and computer aided design (CAD) images, GIS coverage and data files. The most important images are a digitized 1974 photomosaic plan view of the wreck and a CAD drawing generated from the original *Monitor* builders plan. These images serve as the basis for GIS coverage containing information about the wreck's structure, architectural features and contents. The end user can select various components of the vessel, such as the armor belt, turret or propeller, and display pertinent information and images. In addition, the system contains a GIS-based survey "web" consisting of key control points for future mapping and data recovery. Once established in both the GIS database and on the site itself, these reference stations can be used to provide spatial control for future monitoring and research activities at the site. The system also contains an updatable artifact catalog allowing access to tabular, textual and photographic images of finds; a photographic inventory allowing access to image and spatial data; and select video sequences. The location of each recovered artifact is entered into GIS and represented by a symbol. By selecting the symbol the end user will access database information including provenience, drawings, photographs and interpretive material pertinent to the artifact. Ultimately the system can be developed into a three-dimensional computer reconstruction and comprehensive GIS of the USS *Monitor* [17].

The *Monitor* National Marine Sanctuary GIS provides NOAA with an important tool for managing the remains of the USS *Monitor* as well as a comprehensive means for data storage and retrieval that can be expanded to serve the sanctuary indefinitely. It also serves as a tool for monitoring and assessing the condition of the wreck, identifying historical and archaeological research objectives and making data available to NOAA and, ultimately, the public.

Monitor Sanctuary staff are working with several agencies and individuals to develop the comprehensive plan, which will address a range of management and research options for the immediate future. The plan will include the following major sections:

A. Historical/Archaeological Research

NOAA staff have compiled a detailed survey of available historical sources in the *Monitor* Collection and other repositories. The survey includes records, reports, and correspondence of the *Monitor's* designer, the builders, and engineers. Detailed specifications for the *Monitor's* turret and engine have been prepared to facilitate assessments of the feasibility of recovery and requirements for detailed conservation plans. From this information, significant historical/archaeological questions that might be answered through additional on-site investigations have been identified.

B. Engineering Recovery Plan

Engineering plans developed during the 1970s are no longer current. The plan will address the rapidly deteriorating condition of the wreck and assess options for stabilization or recovery in light of the condition of the wreck and current salvage technology. All options for complete or partial recovery of the *Monitor* will be identified and assessed. A recommended option will be presented, along with a methodology and budget for carrying out that option.

C. Engineering Site Stabilization Plan

While proposals for site stabilization have been developed in the past, the premises upon which they were based are no longer valid. The appropriateness of site stabilization will be assessed based on the best available data, current technology and the rapid deterioration of the *Monitor*. All options for mechanical and/or electrochemical stabilization of the *Monitor's* hull will be identified and assessed. A preferred option will be recommended, if feasible, along with an applicable methodology and budget.

D. Archaeological Recovery Plan

A study of the contents of the *Monitor* is being developed in order to assess the potential for artifacts in each area of the vessel. In as much detail as possible, this plan addresses

size, type, and material of artifacts or groups of artifacts expected to exist in each area of the ship. The contents study builds upon work begun by Capt. Ernest W. Peterkin in the mid-1980s. The information will provide data necessary for the recovery plan and will also facilitate development of a detailed conservation plan to address the required conservation processes and associated costs for large numbers of artifacts.

E. Conservation Plan

Since the availability of adequate technology to conserve all or portions of the *Monitor* is critical to determining future recovery efforts, this study must address available conservation options for processing large iron objects from the marine environment. Several previous conservation studies are being used as the basis for this plan, but this will be the most complete and comprehensive plan yet developed.

F. Exhibition Plan

This study will assess the exhibit potential for major hull components and contents. It will also address requirements for specialized environments and maintenance for recovered objects. A cursory exhibit concept prepared in 1988 served as a starting point for this study.

The comprehensive plan will reflect new data from the Sanctuary as well as recent deep-water technological advances. The resulting plan will be critical to determining the fate of the *Monitor*. In addition, it will aid NOAA in managing, protecting and assessing shipwrecks in other active and proposed sanctuaries. From a broader perspective, the plan will also benefit submerged cultural resource managers throughout the world. The plan's management strategy and content will be relevant to other deep-water sites, such as the *Titanic*, the War of 1812 brigs in Lake Ontario, shipwrecks in the Mediterranean and many others. The entire preservation community could benefit from NOAA's approach to preserving the *Monitor*.

V. LONG-RANGE PLANS

NOAA believes that the *Monitor*, a designated National Historic Landmark, deserves to be protected and, to the fullest extent possible, preserved for the future. Ocean technology appears to be the only means of achieving that goal. The comprehensive plan now under development must determine which options can be carried out, given realistic constraints on funding and other resources.

REFERENCES

1. John Ericsson, *MONITOR 1861: Specifications of an Impregnable floating battery composed of iron and wood, original proposal to the Navy Department*, National Archives, Record group 45, Naval Records Collection, Office of Naval Records and Library, Subject File A - D.
2. Ernest Peterkin, *Drawings of the USS Monitor*, 1985, ERICSSON BATTERY/TRANSVERSE SECTION OF BULWARK AND ARMOR, pg. 196 -197.
3. *Ibid.*, Bulwark Bracket Riveting Diagram, pg. 69; Side Armor of the Ericsson Battery, pg. 190; Ericsson Battery Bulwark, pg. 192.
4. Ericsson, *Specifications*; Monitor 1861.
5. William Connant Church, *Life of John Ericsson*, Vol. 1 pg. 259, 1906; Chief Engineer Alban Stimers to Commander Joseph Smith, January 30, 1862, National Archives, Record Group 71, Misc. letters.
6. *Official Record of the Union and Confederate Navies in the war of the Rebellion*, Series I, Vol. 7, ppg. 41-54, GPO, 1898.
7. *Ibid.*, pg. 5.
8. *Ibid.*, ppg. 14-40.
9. There are many sources for descriptions and specifications of the USS *Monitor* and the CSS *Virginia* (ex-USS *Merrimack*). Following are a few:
USS *Monitor*: Peterkin, *Drawings of the USS Monitor*; Church, *Life of John Ericsson*, 1906; Lt. Edward Miller, *USS MONITOR- The Ship That Launched A Modern Navy*, 1978; Frank M. Bennett, *The Monitor and the Navy Under Steam*, 1900; *Official Records of the Union and Confederate Navies in the War of the Rebellion*, Series I, Vol.'s 7 - 8 GPO 1898 - 1899. CSS *Virginia*: John W. Porter, *History of Norfolk County Virginia 1861-1865*; 1892; William C. Davis, *Duel Between the First Ironclads*, 1975; William N. Still, *IRON AFLOAT, The Story of Confederate Armorclads*, 1971; *Official Records of the Union and Confederate Navies in the War of the Rebellion*, Series I, Vol. 6 - 7, 1898.
10. *Dictionary of American Naval Fighting Ships*, GPO 1975.
11. O.R.N., Series I, Vol. 8, ppg. 339 -354, 1899.
12. Miller, Edward M., *U.S.S. Monitor: The Ship that Launched a Modern Navy*. Annapolis, Maryland: Leeward Press, 1978, pp. 57-84, 91-93; Watts, Gordon P., Jr., "The Location and Identification of the Ironclad USS *Monitor*," *International Journal of Nautical Archaeology and Underwater Exploration*, 4.3, pp. 310-329, 1975.
13. Arnold, J. Barto III, et. al., *The 1987 Expedition to the MONITOR National Marine Sanctuary: Data Analysis and Final Report*, Washington: National Oceanic and Atmospheric Administration, 1991.

14. Broadwater, John D., "*Monitor* Archaeological and Structural Survey, Quick Look Report," unpublished report, September 1993.

15. Broadwater, John D., "*Monitor* Archaeological Research, Recovery and Stabilization Mission Quick Look Report," unpublished report, November 1995.

16. Broadwater, John D., "*Monitor* National Marine Sanctuary Laser Line Scanner Survey Quick Look Report," unpublished report, October 1996.

17. Watts, Gordon P., Jr., Development of a Geographic Information System to Facilitate Resource Management in the *Monitor* National Marine Sanctuary. Unpublished document, July 1996.