Growing specialization in the field of nautical archaeology is expanding the boundaries of underwater research. Remote sensing and deep water capability make more wrecks accessible to archaeologists each year. But there is one basic obstacle facing the underwater researcher that "high tech" tools have not completely solved. Individuals who work underwater eventually encounter low or zero visibility conditions where they must not only function but be productive. To work in low visibility proper training, technique, experience, and equipment are essential. The scientific dive training program at East Carolina University tailors its training to research scientists who work in the dark, muddy sounds and rivers of the Southeast. As a result, the University's Program in Maritime History and Nautical Archaeology has successfully excavated and documented a number of historically significant shipwreck sites in difficult diving conditions. This paper will discuss zero visibility training, tools and equipment used to investigate the side wheel paddle steamer Maple Leaf.

INTRODUCTION

As the more easily investigated wreck sites in the world are documented archaeologically, the growing proportion of remaining submerged sites lie in increasingly "unfriendly" environments to the underwater archaeologist. Rivers, for example, offer a variety of well-preserved submerged cultural resources due to their inherent fresh water nature and fluvial sedimentation processes. However, obstacles such as strong currents, heavy silt suspension, thick mud, and zero visibility, limit accessibility to a host of these important archaeological resources. Ironically, the same factors that impair access to sites located in riverine environments also frequently offer conditions of enhanced preservation. The challenge to underwater archaeology is to overcome these riverine conditions in the conduct of accurate and meaningful archaeological site documentation.

Archaeological site recording is a visually intensive process. Whether on land or underwater, archaeologists commonly draw, map, photograph and video as part of their work. Field procedures take many forms, from aerial surveys (to locate cultural resources), to predisturbance site documentation, and finally to various phases of site excavation. It is very important to understand that site excavation is permanently destructive and can never be undone. As a result, archaeology requires a high standard of recording in order to "recreate" the site on paper. Site documentation and excavation proceed along a very controlled framework utilizing two- and three-dimensional recording. Traditional tools for doing this include using dredges, datum points, baselines, plumb bobs, levels, and measuring tapes. In the last ten years the speed and accuracy of data collection have increased with technological advances in photogrammetry, video mosaic imaging, SHARPS (Sonic High Accuracy Ranging and Positioning System), and other techniques.

Working underwater in limited or zero visibility poses obvious problems and the best rule is to keep it simple. We will outline some of the techniques developed over the years that allow detailed archaeological work in zero visibility and high energy environments as practiced on the wreck of the side wheel steamer Maple Leaf in northern Florida.

The Maple Leaf and its cargo represent a unique archaeological site, important to both historians of the American Civil War and of the ship building tradition of the Great Lakes region. The largely intact
hull is a product of mid-nineteenth century Canadian steamship technology. It offers archaeologists the opportunity to study ship design techniques uniquely suited to the Great Lakes region.

Contained within the hull is a repository of American Civil War material culture that undoubtedly represents the largest collection of its kind in the nation. Fresh water anaerobic riverine conditions have lead to the remarkable preservation of a vast assortment of organic artifacts such as rubber, paper, textiles, and wood, in the form of musical instruments, written material, rain gear, and personal effects which are usually lost in a marine environment. Further, the artifacts come from a discrete archaeological horizon and can often be specifically identified according to regiment, company, and individual owner (Cantelas and Rodgers 1994).

**HISTORICAL BACKGROUND**

In the early morning hours of April 1, 1864, the Union transport Maple Leaf struck a submerged Confederate torpedo (mine), while traversing the waters of the St Johns River in north Florida. The force of the explosion blew a large hole in the hull and toppled the foremast. The vessel settled quickly to the muddy bottom taking four crew members with her, while the upper deck remained awash. The ship had become the first torpedo casualty in a long and escalating river war (Martin 1993:21-30).

The Maple Leaf began its career fourteen years earlier on Lake Ontario as a package freight and passenger vessel. When launched from the Marine Railway Yard in Kingston, Ontario in 1851, the side wheel steamer measured 173.2 feet between the stem and stern posts (181 feet overall), 24.7 feet beam and 10.6 feet depth of hold (Certificate of Ownership 1851). The vessel had the characteristic walking beam engine, overhanging paddle guards (sponsons) and bishop arches typical of east coast and Great Lakes steam ships.

Maritime trade on the Great Lakes prospered during the nineteenth century due to the country's westward expansion. However, economic set backs did occur, especially during the 1850s. Steamboat lines suffered from increasing railroad competition as rail lines spread westward along the lake shore and pressure intensified after the national economic collapse of 1857. For most of its career the Maple Leaf operated out of Rochester, New York and traded across the lake with Canadian towns on the north shore. As hard economic times continued through the end of the decade, the Maple Leaf's owners offered lower fares and excursion trips, successfully keeping the vessel in service until after the outbreak of the American Civil War.

At the War's outset the Federal government declared a coastal blockade of Confederate ports. Union naval forces were embarrassingly inadequate to carry this out and Britain threatened to ignore the "paper blockade" and support the Confederate cause of independence. This situation created a financial boon for many private ship owners. To enforce the blockade and quickly build a wartime fleet, the Federal government chartered and bought many civilian vessels for military service. With this in mind, a group of Boston investors purchased the Maple Leaf in 1862 for charter to the federal government at $550 per day. In late August 1862, the ship steamed down the St. Lawrence River for service as an Army transport on the southeast Atlantic coast (Maple Leaf Charter 1862; Union and Advertiser, August 14, 1862). Nineteen months later the vessel met its end while transporting the personal belongings and camp equipment of three Union regiments, the brigade headquarters of Brigadier General Foster, and regimental sutler's stores (Proceedings of a Board of Survey 1864).

In the years following the Maple Leaf's loss, the wreckage posed a threat to river navigation. To mitigate the problem, the U.S. Army Corps of Engineers contracted with a marine salvor to clear the ship from the channel. As a result, all structural components above the ship's main deck were removed, while the lower hull remained intact (United States Army Engineers 1882, 1888). By the early 20th century, the wreck site had disappeared from river navigation charts.
PROJECT HISTORY AND SITE ENVIRONMENT

The wreckage of the Maple Leaf remained obscure until rediscovered in 1984 by St. Johns Archaeological Expeditions, Inc. (SJAEI). The first organized activity on the site began in 1988 and continued in 1989. During this two year period, SJAEI volunteers entered the aft cargo hold to recover diagnostic artifacts, thus establishing the ship's identity (Cantelas 1992:29-30). All three Union regiments, documented as having been assigned stowage, are represented in the material record of recovered artifacts; the 112th New York Infantry, the 169th New York Infantry, and the 13th Indiana Infantry (Proceedings of a Board of Survey 1864; New York Times April 13, 1864; Hyde 1866). In the summer of 1992, ECU began a three year research project in conjunction with SJAEI. The project's scope of work included documenting the vessel's remains and conducting excavations in the cargo spaces. Site assessment identified important features of the ship and provided information critical to planning future research (Cantelas 1992:3-12).

Figure 1. Site plan of the Maple Leaf excavated between 1992 and 1994. The paddle wheel shaft and engineering spaces are located amidships.

The Maple Leaf (8DU8032) is located in the St. Johns River approximately twelve miles upstream from downtown Jacksonville, Florida. The vessel sank in a 1.5 mile wide bend in the river near Mandarin Point and rests perpendicular to the stream flow with the bow pointing east. Water depth at the site is 21 feet at high tide.

The wreck site is located in some of the most demanding environmental conditions offered by the St. Johns River. Swift tidal currents ebb and flow across the site and carry a low level suspended silt layer across the bottom to quickly fill any attempted excavation. On the river bottom, powerful diving lights offer only the comfort of a dull brown glow when held to the diving mask and pressure and depth gauges cannot, under most circumstances, be read at all.

Up to three meters of sediment covers the main deck and only a few structural features protrude to indicate the wreck site. The largest component is the paddle wheel shaft that identifies the midships area. The tops of the stem post and rudder stock identify the bow and stern.
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The St. Johns is a blackwater river with a high tannin content (supplied by peat marshes) giving the water a dark reddish-brown hue. Semidiurnal tides affect Florida's Atlantic coast with two highs and two lows per tidal day. The average tidal currents measure .83 knots for both ebb and flood tide (Bodge 1987:6-7). The highest tides, and subsequently the strongest currents, occur during full and new moon phases. Rain and wind are two other factors that affect current strength and though maximum current velocities have not been empirically measured, they have been observed to be two, to as much as four times the average current flow.

The river bottom surrounding the site area is a flat featureless plain of gelatinous, highly organic sediment. The sediments consist of sand, colloidal silt, clay, and organic matter. The top stratum is a soft mud described as fluff. Flocculation (falling out of suspension) is the main cause of sediment deposition at the Maple Leaf site and increases during the summer (Duncan 1994:126-128).

Prior to deposition, the river carries the organic matter and colloidal clay and silt as a suspended load along the river bottom in a noticeable suspended layer half a meter thick (Duncan 1994:127). The suspended material settles out when the water is trapped in a depression causing constant and immediate refilling of excavation units. In addition, man-made debris (beer cans, trash bags, and fish nets) carried in this layer also settle out, often placing modern artifacts deep inside excavation units.

Visibility in the water column is dependent on dissolved tannin and suspended load. Natural light penetration is not a factor on the site. Artificial light penetration is dependent on diver activity and suspended silt. It can range from nil to 2 meters in the water column. In the suspended layer near the bottom, visibility is totally obscured. As a result, all excavation work on the site is hampered by zero visibility unless the suspended silt layer is diverted from the area (Cantelas 1993:12).

TOOLS

The project research design called for two very different excavation strategies; clearing the open main deck and excavating inside the overhead environment of the cargo holds. The type of diving and data recovery performed by the two groups participating in the project (SJAEI and ECU) were strongly segregated along the two strategies primarily to accomplish overall project goals. It cannot be emphasized too strongly that training and experience is the key to zero visibility archaeological site operations. Both groups received extensive training in separate types of diving.

SJAEI, a volunteer organization, worked inside the cargo holds under the main deck, using a surface supply diving system. The system supported two divers using Kirby Morgan band masks with the umbilical/tether acting as a guideline to the surface. Hardwire communication provided excellent sound quality, important for monitoring diver safety and topside recording of data transmitted by divers. Volunteers were trained in all aspects of operating the system in an "apprentice" program over several years before making a dive on the site. The diving system's pneumatic depth gauge, accurate to one tenth of one foot, proved very important for taking accurate vertical measurements while documenting the site.

During three successive field schools, ECU's Program in Maritime History and Nautical Archaeology excavated the Maple Leaf's main deck on the starboard side. The first two weeks of each field project was devoted specifically to black and brown water diving safety, archaeological excavation, and documentation techniques. ECU's Diving Safety Office configured a full face mask redundant scuba system with wireless communications. An assortment of masks were used: the Divator MKII (AGA), AGA sport model, EXO-26, and TEC-1 masks. A pony bottle linked to the primary system provided a redundant air source to the full face mask. Wireless communications made communicating between divers easier and allowed a surface dive master to monitor air and activity (Sibthorp 1995:99-100; Van Tilburg 1994:315-316). Both groups found that time spent training was more than made up for in the confidence, organization, efficiency, and work accomplished by an experienced crew (Sellers 1993:131).

A variety of underwater lights were used but head mounted halogen lights proved the most useful. Lights were generally turned off to save batteries unless they were needed to read a tape or view gauges.
In extremely low visibility, divers could read a tape or see a detail through a visibility bag. A zip-lock bag filled with clear water and pressed against a tape with a light shining in from the side, or a Cyalume® light stick placed in the bag, worked very well. Pressing the mask against the bag allows the diver to see through the bag (Van Tilburg 1994:316-317)

**THE SILT BARRIER**

Successful documentation of the *Maple Leaf* depended on the use of a structure to efficiently divert the current and silt flow. This was accomplished by the development of an economical silt barrier structure. The silt barrier was simply a low-profile portable coffer dam constructed from light metal and fabric panels. The sections measured four by eight feet and were assembled of rigid, heavy gauge wire mesh covered over with geotextile silt barrier fabric. Each panel was guided (literally "flown") into place by two divers following mooring and orientation lines. "Flying", or the horizontal maneuvering of a panel in heavy current, is an acquired skill. Each panel was placed upright on its long axis and driven into the mud far enough to remain stable for a short time. Heavy duty Tivek wire ties were used to secure it to long metal fence poles and its neighboring panel. In this fashion, an entire excavation unit (approximately 60 by 60 feet) can be enclosed in a day or two, even under zero visibility conditions.

Once the barrier was in place, it and the baseline served as navigation references, while the mooring lines served as "elevators" to and from the diving platform. The site layout was easily memorized by divers using these references and the work of excavation inside the silt barrier began.

The silt barrier immediately proved useful in ways not foreseen in its development. Not only did it block the current and silt flow on the site but it served as a useful structure to secure equipment such as hoses and suction dredges. It also served as a sort of highway for divers to find their way to all areas of the site. Divers soon became adept at listening for each other on the perimeter, thus passing each other on opposite sides and eliminating the nasty collisions that frequented initial operations. Despite the formidable physical and psychological challenges involved in zero visibility, perhaps the most common threat to health on this site came from divers colliding or inadvertently thrashing each other at the unexpected brush of a hand or flipper from another diver.

**SITE DOCUMENTATION TECHNIQUES**

Once the silt barrier was in place the process of excavation began in earnest. Five to eight feet of silt covered the main deck. After removing mud and silt inside the silt barrier visibility increased to as much as half a meter using the illumination supplied by 50 to 75 watt diving lights. This allowed archaeologists to place labeled cross lines perpendicular to the base line at measured intervals in order to divide the site into small workable areas for individual measured sketches.

Divers were then assigned areas to sketch that were bordered by the base line and cross lines. Diver-to-diver and diver-to-surface wireless communication aided in the trilateration of large features from the base line. On completion, the measured sketches were transferred to the large site map and studied for

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Rubicon Foundation Archive (http://rubicon-foundation.org)
inconsistencies. Measurements were retaken if adjoining sketches did not consistently match. Despite the obstacles, the overall site maps were extremely accurate and have proven invaluable in the interpretation of deck plans, hold plans, and cargo loading profiles on similar ships.

For excavations inside the ship, entry to the aft cargo hold was through a hole cut in the aft deck and through the forward cargo hatch. Small silt barriers were built on the Maple Leaf's deck to isolate the excavation inside the cargo holds from the silt and debris carried by the river. A three dimensional mapping technique incorporating a computer program called the Direct Survey Method (DSM) was used to map artifacts inside the cargo holds (Rule 1989). Instead of locating a point with a two dimensional grid and plumb bob (cumbersome even on land), DSM measurements are taken directly from datums to the point being measured. The current incarnation of DSM, Web for Windows, runs on the Microsoft Windows operating system.

In operation, datums were established on the underside of the deck beams bordering the deck opening. Distance measurements and relative depths between datums and artifacts were taken with tape measures and a pneumatic depth gauge (Cantelas 1993:50-55). These raw field measurements are processed using a multidimensional scaling algorithm to produce a mathematical best-fit Cartesian coordinate. The program also quantifies errors in the measurements, giving an objective measure of accuracy. The data and plans generated by Web can be exported to other Window applications or interfaced with AutoCad (Rule 1992).

The problem of taking consistent measurements inside the hold with no visibility was solved by designing and building a measuring device. It incorporated a tape measure sandwiched between two clear lexan sheets. A clear, semicircular lexan viewing tube filled with water was cemented to the lexan sheet covering the top of the tape. The tube kept the diver's eyes far enough from the tape to focus on the numbers. An underwater light mounted next to the tube transmitted light via the lexan to illuminate the tape. Light did not have to penetrate directly through silty water. In operation, the diver stretches the tape from a datum to the point being measured, holding the point against a mark on the lexan base under the viewing tube. He reads the measurement by holding the lexan tube against his face plate to see the mark against the tape. The measurement is then relayed to the surface and recorded (Cantelas 1993:55). Although cumbersome, the system proved very reliable in documenting the packing arrangement of cargo found in the aft hold.

**FINDINGS**

The Maple Leaf was built as a wooden hulled, upper cabin steamer, having two decks above the main deck, to carry passengers and package freight. Classed as a side wheel steamer, or steamboat in Great Lakes parlance. Sponsons, or guards, extended deck space beyond the edge of the hull to the end of the paddle wheels, overhanging the hull by 9.6 feet. Today, only the hull and main deck survive. Over three successive field seasons, the entire starboard main deck, extending 180 feet, was excavated and mapped. Controlled test excavations were completed in the forward and aft cargo holds. Documentation was limited primarily to the starboard side due to difficult working conditions and the expense of field operations.

The wooden hull is deeply buried making examination of lower structural members like the keel impossible. Except for a few areas in the interior, only the upper edge of the hull was examined. The vessel is generally double framed with carvel planking on the exterior and ceiling planking on the interior which completely covers the frames. The ceiling butts against the lower edge of the deck clamp, a large timber just below the main deck, that runs the length of the vessel to help stiffen the hull. The clamp also functions as a support for deck beams that lie across the hull and extend from the side of the vessel to the edge of the sponsons. This extension forms the overhanging deck, or guard, characteristic to the sponson hull of side wheel paddle steamers. Deck planking, fastened to the deck beams, forms the main deck and is the base on which the upper cabins were built. Hanging knees and lodging knees provide additional support for deck beams. The starboard guard extends 9.6 feet from the side of the hull, the Maple Leaf's beam, therefore, was extended by the sponsons nearly 20 feet. Deck beams that support the sponson have all broken where they pass through the hull causing the sponson to sag. The opening for
the paddle wheel is centered on the guard 102 feet aft of the stem and measures 32 feet in length and 8.5 feet in width. The remains of the wooden spoke paddle wheel are located in the opening.

On early nineteenth century side wheel steamers, the paddle wheels extended from the side of the hull with short guards. However, shortly afterward, shipbuilders fully developed the large sponson hull to utilize the existing ship architecture to create more deck space. The main deck was carried out to the edge of the paddle box and tapered in to meet the stem and stern. Angled braces fastened to the hull supported the overhanging guard from below. This structure often added twenty feet or more to the vessel's beam on the main deck depending on the width of the paddle wheels (Cuthbertson 1931:243-244; Russell 1861:108,113; Gardiner 1993:168).

In wooden ships the elastic nature of the hull allowed it to bend and flex. Toward each end the hull narrows, reducing the surface area available for buoyancy support. As a result, the bow and stern tend to droop, or hog. These hogging and sagging forces become an increasing problem as wooden ship length increases. For longitudinal reinforcement the Maple Leaf's hull incorporated bishop arches, or hogging trusses, to combat hogging forces. Portions of the Maple Leaf's starboard hogging truss were found near the bow and stern where the ends terminated at the deck. The arch timber measures approximately 12 inches square and is composed of multiple timbers scarphed together and iron fastened. The hogging truss actually worked with the massive deck clamp to stiffen the hull longitudinal against hogging forces.

The main deck is largely intact except for areas damaged by the sinking and later salvage efforts. The blast of the torpedo explosion probably caused the destruction seen near the starboard bow. In later efforts to clear the river channel of navigation hazards, contractors were hired to demolish the ship's machinery which caused damage to the amidships deck. Another damaged area is located between the forecastle and forward cargo hatches and may have been caused by a salvage attempt. Union forces intended to recover some material from the vessel, including the anchors, but whether these efforts were successful has not been confirmed (ORA, I, XXXV, II: 47, 123).

Ten feet aft of the stem is the manually operated windlass. It primarily functioned to raise the anchors carried at the bow. As anchor chain was brought aboard it passed over the windlass barrel and through the deck into the chain locker below. The Maple Leaf's anchors and chain are missing and have probably been salvaged.

Four hatches provided passage to the lower hull. The hatch to the forecastle crew's quarters is located 23.6 feet aft of the stem post. A short distance aft is the forward cargo hatch, likely damaged by salvage activity. A large hatch located 64.5 feet aft of the stem measured 5 feet by 6 feet. Wood was loaded through this opening into fuel bunkers. A cast iron coal scuttle is located near the hatch to facilitate loading coal into the same bunkers. The aft cargo hatch, located at the aft end of the engine room, was nearly obliterated when the vessel's machinery was demolished.

The Maple Leaf's engineering spaces are located amidships and measure 71.7 feet long (Certificate of Ownership 1851). Much of this space was decked over with an opening left for the gallows frame to rise above the ship. Demolition work to clear the Maple Leaf as a navigation obstruction removed the gallows frame and other superstructure from the engineering spaces and destroyed much of the deck covering the central area.

The Maple Leaf was equipped with two cylindrical boilers placed on either side of the gallows frame (Certificate of Ownership 1851). The starboard boiler is approximately 7 feet in diameter, 27.5 feet long and passes under the paddle shaft. It is a return fire tube boiler with the firebox facing forward. The stack on the forward end is encircled by the steam dome that rests on top of the boiler.

The engine is no longer on board but a few historical descriptions provide limited information. The cylinder diameter measured 52 inches with an 11 foot stroke (Heyl 1967:171). The stroke length is verified by the crank which measures 5.5 feet between the centers of the crank pin and paddle shaft. A fragment of the air pump cylinder, including a flange and brass compression ring, are the only engine
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parts found. Original diameter of the air pump cylinder was approximately 24.25 inches and wall thickness 1 inch. Deep vertical striations, that occurred during use, mark the interior of the cylinder wall.

The gallows or A-frame functioned to support the walking beam and linked the engine to the paddle shaft. It also incorporated supports to hold the paddle shaft. On the *Maple Leaf* this massive structure was constructed of large timbers held together with iron tie rods. As stated, the A-frame was lost during the 1880's to channel clearing work. Only the stubs of timbers remain on the wreck along with many twisted and broken tie rods.

A fragment of the walking beam remains articulated with the paddle shaft connecting rod and paddle cranks. Apparently, demolition caused the beam to break and fall aft, pivoting on the crank pin, carrying the connecting rod with it and smashing through the aft cargo hatch. The connecting rod now rests horizontally and the walking beam fragment hangs vertically below it. The fragment is 8.7 feet long and has broken near a connecting rod pin used to power a boiler feed water pump.

The walking beam is solid cast iron. A large pin passes through the end of the walking beam to provide an attachment point for the paddle shaft connecting rod. The rod is fastened to the pin with a keyed strap assembly which is disassembled on the port side of the walking beam. Apparently, this was an unsuccessful attempt to disconnect the rod previous to demolition.

The connecting rod is wrought iron and measures 18.4 feet between the crank pin and the walking beam pin. The rod is still partially connected to the crank on the paddle shaft. In 1883, channel clearing displaced the massive iron paddle wheel shaft pulling it apart at the center crank pin and breaking the port end. Workers unshipped the 12 inch diameter paddle shaft from its mounts by removing the bearing caps, or pillow blocks (Russell 1883). Two paddle wheel flanges on each end of the shaft were used to mount the radial arms of the paddle wheel.

The starboard shaft is actually a two piece construction held together with a bolted flange. Historical records document that the *Maple Leaf* broke its paddle shaft shortly after leaving the port of Charlotte, New York, on July 16, 1859 (*Union and Advertiser* July 16, August 1, 1859). The *Maple Leaf* had a career punctuated with breakdowns, repairs and rebuilding (Girvin 1993:111). This is not unusual for any commercial vessel today or in the nineteenth century.

The aft cargo hold excavation revealed a remarkably intact cargo space with packages and materials still maintaining some semblance of the original packing arrangement. Cargo was largely packed in small containers such as wooden crates and barrels. Other items included field desks and numerous tent poles used as dunnage to fill open spaces. Some displacement of cargo was caused when the vessel sank and filled with water. Heavy material sank while buoyant items floated. Over time some of the containers deteriorated spilling their contents. These included carpet bags and boxes fastened with iron nails. Eventually, sediment filled the interior locking all the artifact material in place.
Figure 4. A detailed plan and profile of the broken walking beam and connecting rod. The walking beam and connecting rod fell aft during demolition. The lower end of the rod is fastened to a crank on the paddle shaft.

Figure 5. This profile shows the distribution of boxes and a barrel packed inside the aft cargo hold. Data on artifact locations, especially packing containers, were collected using Web for Windows then incorporated into a CAD program to prepare final drawings.
Following the Federal loss at the Battle of Olustee in North Florida on February 20, 1864, the three federal infantry units near Charleston, South Carolina, were given short notification they were being transferred to Jacksonville, Florida. The men were ordered to take only essential equipment including weapons, ammunition, five days rations and shelter tents. Camp and garrison equipment, tents and baggage were left in charge of the Quarter Master Sergeant for later shipment to Jacksonville (Hyde 1866:66-67; Foster 1864). These "soldier's traps" were eventually loaded into the aft cargo hold of the Maple Leaf (PBS).

The material recovered from the aft hold consisted of camp and garrison equipment within good archaeological context. All the material was personal property, not new, unused equipment. Careful analysis of the artifacts revealed information on how garrison soldiers lived, what they did for recreation, and what sorts of things could be found in camps. These included government issue equipment like uniforms, buttons, shoes, leather accouterments, muskets, mess kits and rubber blankets. Soldiers also owned elaborate smoking pipes, finely made leather boots, good ceramic china, ambrotypes of loved ones, and played checkers. The complex organization of the cargo hold along with expensive, labor intensive conservation processes, made excavation slow and demanding work. Approximately five percent of the Maple Leaf's interior spaces have been excavated.

CONCLUSION

Diving and recording techniques evolved rapidly over the three year period ECU investigated the Maple Leaf. Although most photography and video documentation proved impossible due to visibility and back scatter problems, the measured sketches of well trained diving technicians proved faster, while retaining nearly the same accuracy as some high tech solutions to the problem of zero visibility. Systems such as SHARPS (Sonic High Accuracy Ranging and Positioning System) may give highly accurate recording parameters, but require lengthy set up and calibration periods (Waddell 1990: 57-62).

The Maple Leaf is a unique and extremely significant shipwreck site, yet the environmental conditions that have preserved the site also make it very difficult to investigate. This environmental challenge necessitates innovative and economical solutions for the successful completion of a field project on a limited budget. Experience has shown on sites such as the Maple Leaf that planning, training, and inventiveness, far outweigh the costs and problems of high-cost technical fixes. High resolution sonar and permanent coffer dams are inherently expensive and have shown sporadic results. For the $600 cost of an underwater silt barrier, the Maple Leaf project has gathered a tremendous amount of data concerning Great Lake ship construction techniques and Civil War era material culture.

The portable silt barrier is simple to use and may be erected by regular personnel. In addition to its low cost, the barrier is non-invasive (will not harm nearby sites), extremely flexible, and expandable to any size or easily moved to new areas. It also does not obstruct navigation channels as it lies near the river bottom.

Significantly, the Maple Leaf investigations have documented, for perhaps the first time, the main deck and inner hold layout of a Great Lakes steamer of the mid-nineteenth century. Engineering space research also revealed machinery and gauge examples as well as repair and utilization functions of some remaining machinery. The Web for Windows computer mapping program revealed the intricate packing arrangement of the aft cargo hold and the amazing depth and scope of Civil War era material culture. This research will inevitably add a great deal to our understanding of this important era (Cantelas and Rodgers 1994).

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