Narrative Final Report to
National Center for Preservation Technology & Training
(Attachment C)

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Project Title
Assessment of Handheld Multibeam Sonar Imagery for the Study of Submerged Cultural Resources

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EXECUTIVE SUMMARY

The Lake Champlain Maritime Museum (LCMM) has undertaken innovative research in the non-invasive documentation of submerged archaeological sites. In recent years, handheld imaging sonars have been developed that provide near-visual quality information regardless of underwater conditions. The adaptation of existing imaging sonars for use on underwater sites will have widespread applicability to the nation's thousands of submerged archaeological sites located in turbid waters that make detailed archaeological documentation impractical. LCMM has prototyped the feasibility and methodologies for this technology using a Blue View DF900-2250 Dual Frequency Miniature Multibeam Imaging System on sites in Lake Champlain. This research was undertaken with funding from the National Center for Preservation Technology and Training, grant number MT-2210-09-NC-02.

LCMM archaeologists tested the Blue View DF900-2250 on one test subject in shallow water. The system was then brought to a medium-depth shipwreck of known historic context and construction technique, Wreck GGG. Finally, the Blue View DF900-2250 was tested on the shallow-water wreck of the *Champlain II*, a nineteenth century steamboat. Each of these sites was in Lake Champlain. Safe diving techniques were practiced throughout all activities.

After multiple dives on one test subject and two shipwrecks, LCMM archaeologists have determined that the Blue View DF900-2250 Dual Frequency Miniature Multibeam Imaging System is not an effective tool to document the details of a shipwreck. However, it is an extremely useful system to provide a "big picture" image that could not be created by any other method at our disposal. Especially in low visibility environments, it also provided a safety mechanism by which we could immediately locate a separated diver.

PROJECT DELIVERABLES

- **Technical Report** *Assessment of Handheld High-Frequency Multibeam Sonar Imaging for the Study of Submerged Cultural Resources.*
- **Webpage** created for the project and results, including a PDF of the Technical Report at http://lcmm.org/mri/projects/multibeam-sonar.htm.
- **Article** in the Fall/Winter 2009 edition of the LCMM bi-annual newsletter (distribution 8,000). See Appendix A: Newsletter Article. All LCMM newsletters are archived at http://www.lcmm.org/museum_info/newsletters.htm.
- **Final Press Release** See Appendix B: Final Press Release
- **Article** summarizing the work funded by grant for general audience to be published in NCPTT Notes (see Executive Summary, above.)

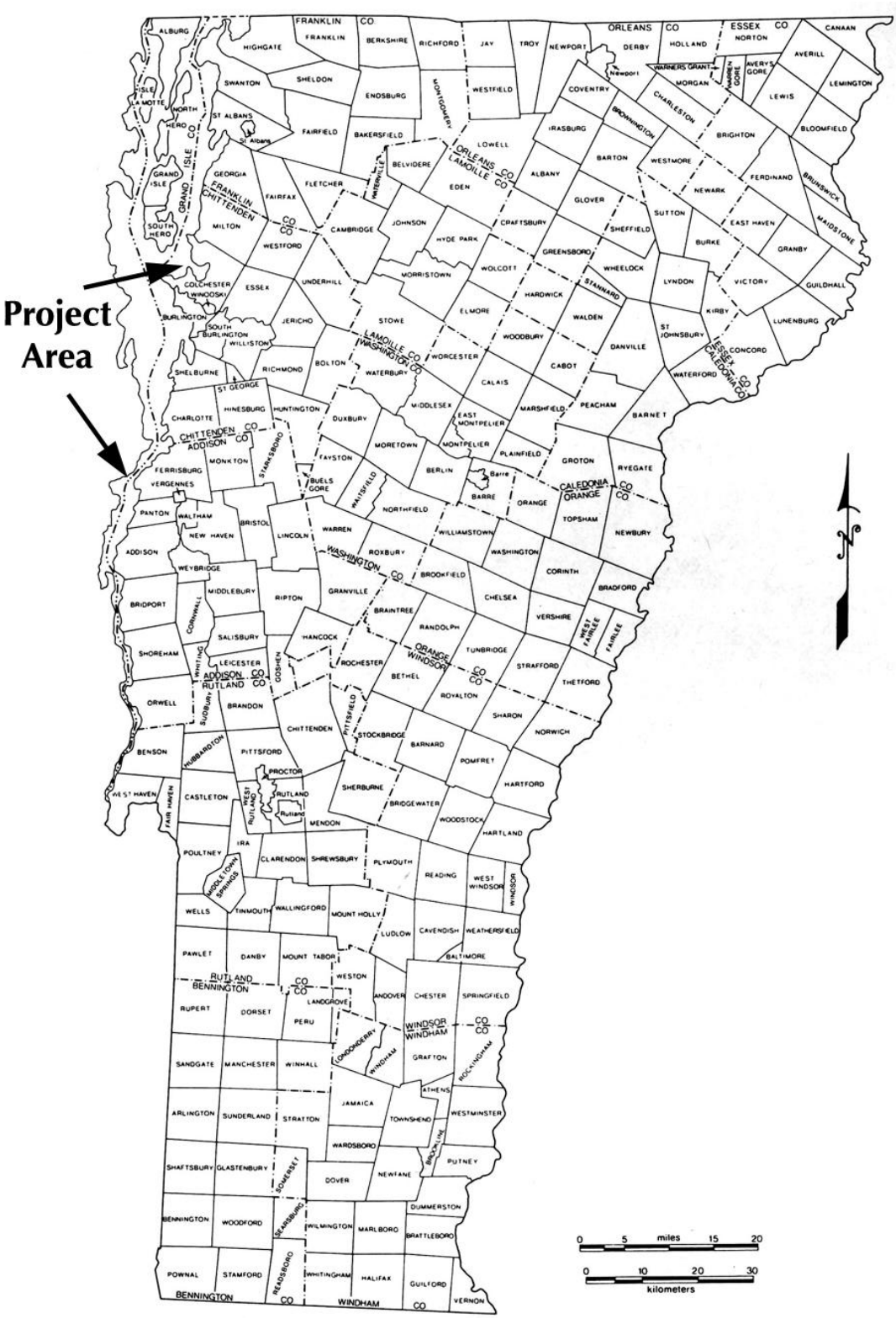


Figure 1: Map of the State of Vermont showing the location of the project.

METHODS AND/OR MATERIALS

EQUIPMENT & MATERIALS

The equipment used in this project is a Shark Marine Navigator equipped with a BlueView DF900-2250 Dual Frequency Miniature Multibeam Imaging System.

The Navigator is a handheld unit with an LCD screen and Windows-based computer system and hard drive. The Navigator displays and records acoustic data from the Multibeam Imaging System. The Multibeam Imaging System has two different frequencies (900 and 2250 kHz). The 900kHz head is a medium range imaging system providing resolution of objects one inch or larger from a maximum distance of 180 feet. The higher frequency 2250kHz head is a short range imaging system providing resolution of .4 in (1.0cm) from a maximum distance of 40 ft (12.2m).

This equipment was designed for low-visibility conditions primarily to aid commercial divers in the inspection and repair of underwater infrastructure and in search and recovery operations. Its small size, only slightly larger than a shoebox, allows the diver to easily transport it underwater. The LCD screen gives the diver an immediately visible high resolution sonar image which is also recorded onto the Navigator's hard drive. Although the manufacturer presumes it will be useful for the archaeological study of underwater sites, it has not yet been field tested for such a purpose.

The methodological approach to this project was to seek to objectively determine the practicality, utility and accuracy of imaging sonar in documenting submerged archaeological sites. Three objectives were identified in the initial plan: compare photograph and multibeam imagery of a site, compile a photomosaic of this test site, and record the site using the sonar imagery.

Photograph/Multibeam Image comparison: The original plan included ten locations of the wreck to be chosen for comparison between photographic images and sonar images. The comparative analysis of the same subject/area is essential to understand what archaeological features are or are not shown in the sonar image. Specifically, the presence/absence of fasteners (nails and bolts used to hold the wreck structure together) and seams between wooden structural components (typically plank seams) in the sonar images will be thoroughly described.

Photomosaic compilation: Underwater archaeologists now commonly create photomosaics of shipwreck sites. These overall site images are composed of numerous individual photographs digitally stitched together. They are used to illustrate the overall condition of the site. Multiple photomosaics taken over a period of time can aid

in understanding the deterioration of a site. Photomosaics can only be composed for sites with good underwater visibility since they rely on clear visual images. The equipment proposed for this project allows the viewer to capture individual acoustic images which can then be turned into a photomosaic.

Overall site sonar image recording: Underwater video is a commonly employed tool for underwater archaeologists, which is simply not available in low visibility environments. Sonar imagery will be recorded for the overall site to evaluate its efficacy in recording an archaeologically useful video of a shipwreck site.

Figure 2: LCMM divers Pierre LaRocque and Adam Kane prepare the BlueView DF900-2250 Dual Frequency Miniature Multibeam Imaging System for deployment. (LCMM Collection.)

RESULTS AND DISCUSSION

FIRST TRIAL

In order to evaluate the efficacy of the Blue View DF900-2250 Dual Frequency Miniature Multibeam Imaging System, LCMM divers did a test dive with the equipment in the waters near Stave Island in Lake Champlain in October 2009. LCMM archaeologists constructed a sample board with lettering raised one inch off the board. This was submerged in shallow water and the Multibeam Imaging System was deployed with an LCMM diver. After collecting and analyzing several passes of sonar video, it was determined that the sonar was not picking up the detail of the lettering.

This site was nearby to an underwater cribbing structure. This was also investigated with the sonar unit. While this large structure and its primary construction elements were readily visible, the sonar did not provide significant detail. Further testing was planned to evaluate this on a shipwreck.

SECOND TRIAL

LCMM divers Pierre LaRocque and Adam Kane deployed the Blue View DF900-2250 Dual Frequency Miniature Multibeam Imaging System again in the deeper waters of Malletts Bay on a known wreck (Wreck GGG - VT-GI-925) to test the system again.

Wreck GGG was located in Malletts Bay by LCMM in the 2001 Lake Champlain Lake Survey and verified by archaeological divers in October 2002.[1] It is 25ft 2in (7.7m) in length with a beam of 8ft 2in (2.5m). Its rectangular hull and raking scow ends are typical of a barge. It lies in approximately 58 ft (17.7m) of water in Malletts Bay, an area well known for its brick manufacturing history.[2] The barge was fully loaded with a cargo of bricks, indicating that its sinking was not intentional. It was likely that the barge was being towed from a local brickyard to a building site when it was lost. There were no definitive features of the wreck indicating its age; however, its general build was suggestive of mid-nineteenth to early twentieth century construction.[3]

LCMM divers returned to Wreck GGG in 2010 to test the Blue View DF900-2250 Dual Frequency Miniature Multibeam Imaging System in the hopes of using it to document this known wreck. After multiple passes and time on the site, it was not providing enough data to be an exacting enough tool for shipwreck documentation. It did, however, provide an excellent "big picture" image of the wreck. This type of overall image is rarely achievable with standard video and photography in good conditions, and impossible in low visibility environments.

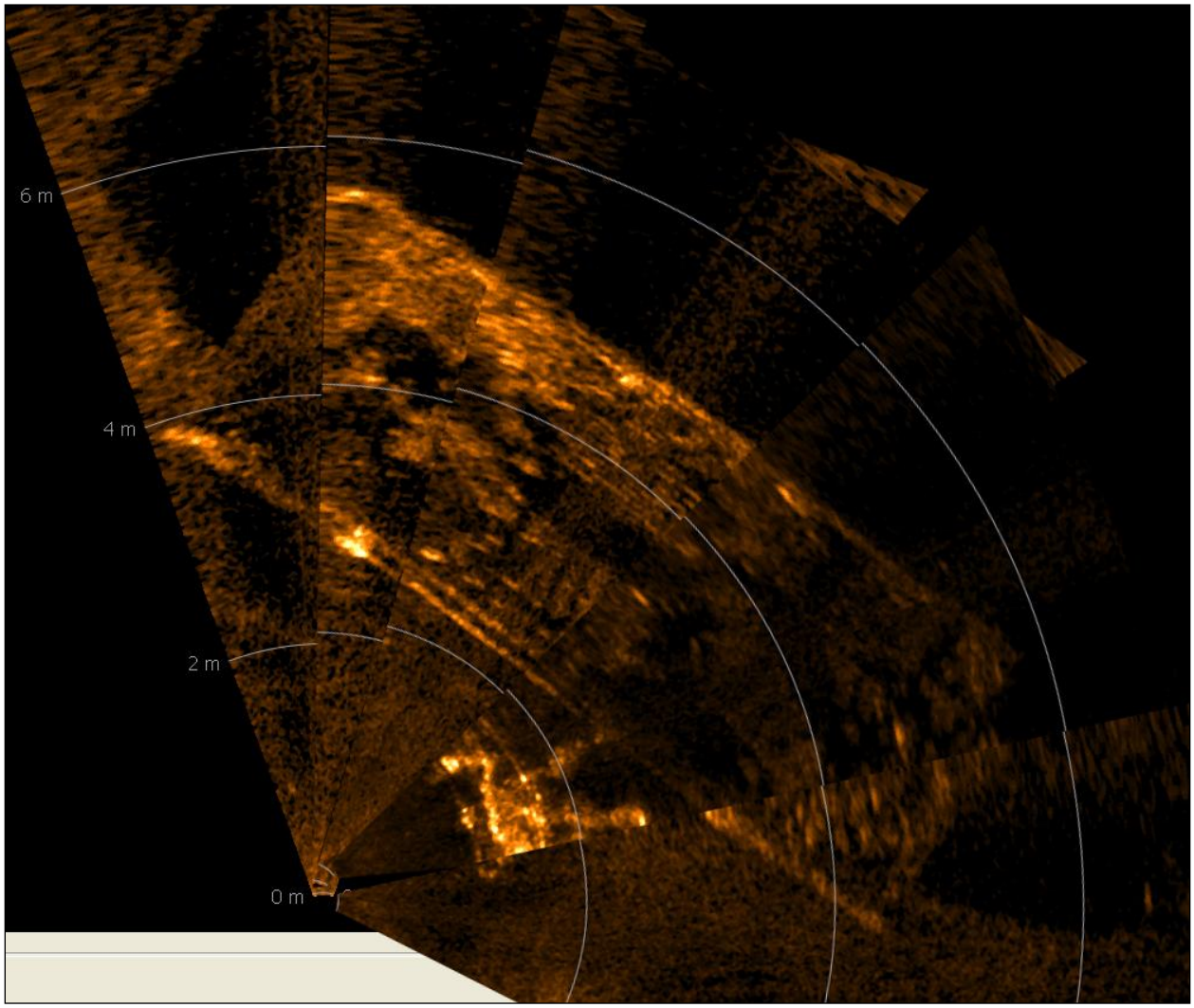


Figure 3: Mosaic of Wreck GGG from five sonar images. (LCMM Collection.)

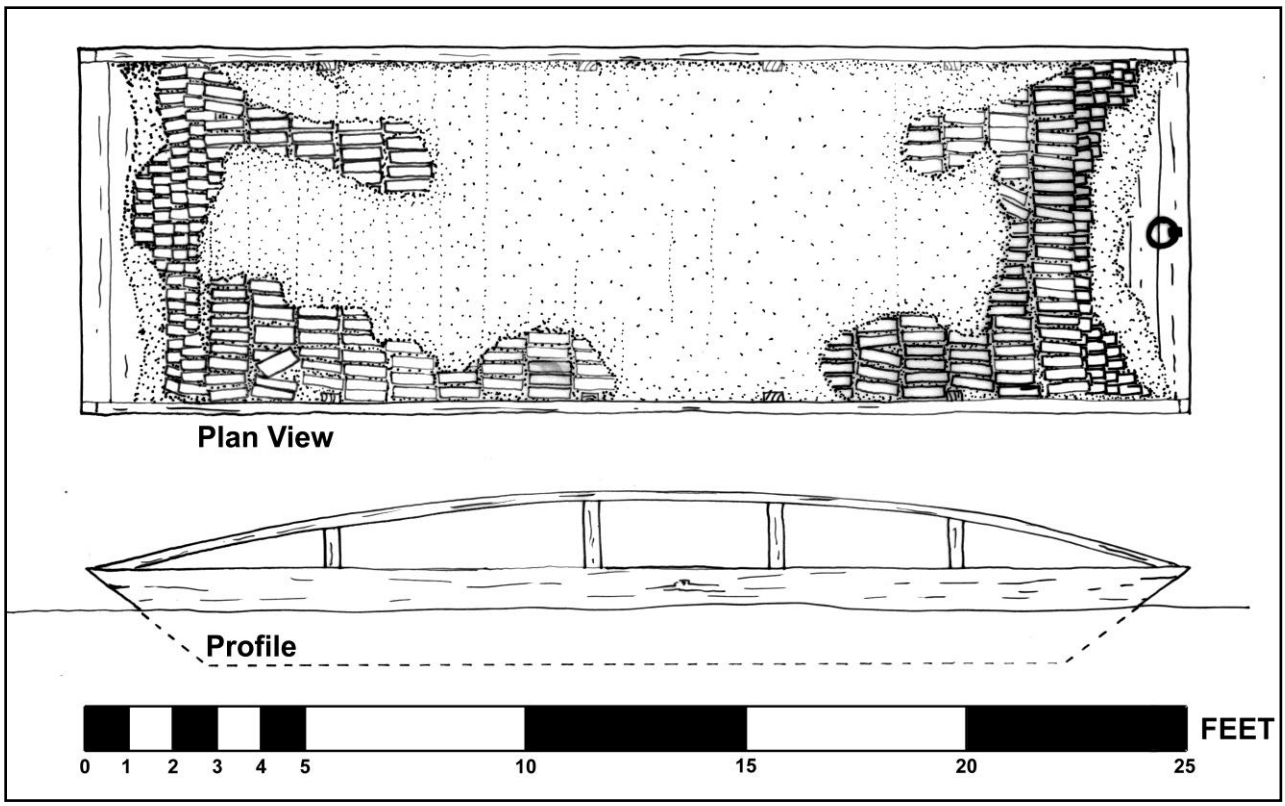


Figure 4: Preliminary plan view and profile of Wreck GGG (LCMM Collection, drawn by Adam Kane).

THIRD TRIAL

Before ruling out this equipment for shipwreck documentation, LCMM divers George Schwartz and Adam Kane took the Blue View DF900-2250 Dual Frequency Miniature Multibeam Imaging System to a third site, the wreck of the steamboat *Champlain II*. This shipwreck *Champlain II* is in shallow waters – maximum depth is 35ft (10.7m), very near to the New York shoreline. *Champlain II* holds an important place in the development of steamships on Lake Champlain, holding two distinct careers during her eight years of service (1868-1875).

The vessel *Oakes Ames* was built in 1868 by her captain for the specific purpose of ferrying railroad cars across Lake Champlain for transfer between the Rutland Railroad in Burlington on the Vermont side of the lake, and the Montreal and Plattsburgh Railroad in Plattsburgh, New York. *Oakes Ames* had a successful career as a railroad car ferry until 1873, when a consolidation of property by the Delaware and Hudson Railroad rendered her obsolete. She was sold in the same year to the Champlain Transportation Company for conversion into a passenger steamship, and was renamed *Champlain II*.[4]

Oakes Ames's large central tunnel for rail cars was transformed into *Champlain II*'s ornately decorated main hall, which stretched 162ft (49.4m) along the main deck. In addition to the main hall, the converted steamer had 46 roomy new berths, along with a post-office and barber shop. The steamer operated as a passenger line vessel throughout the 1874 summer season until she ran aground on July 16, 1875 on the New York shoreline.[5] The pilot was determined to have been under the influence of morphine at the time of the accident. After significant salvaging, the shipwreck was stripped bare, partially dismantled, and dragged into deeper water to sink fully.

LCMM divers attempted to document details of the wreck using the Blue View DF900-2250 Dual Frequency Miniature Multibeam Imaging System in October 2009. The Blue View DF900-2250 once again did not provide enough detailed information for this task.

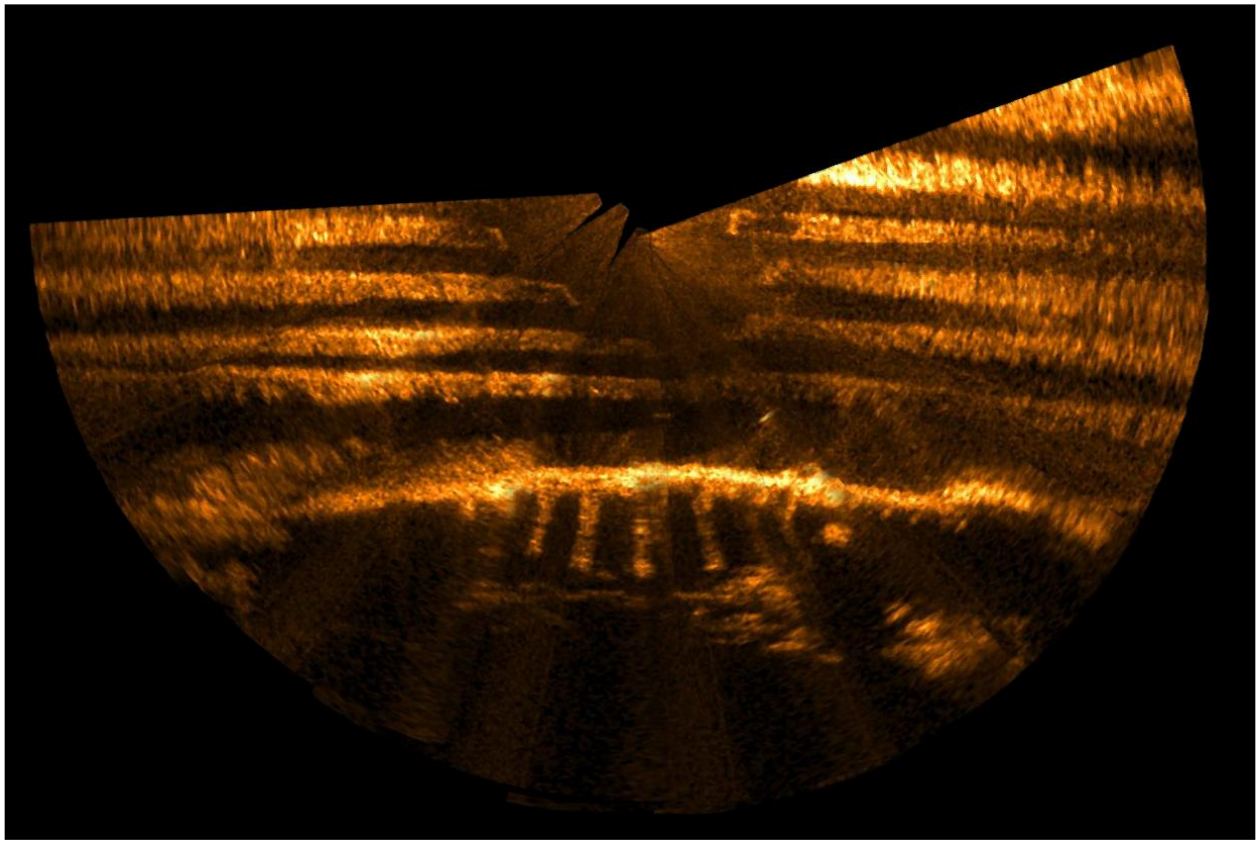


Figure 5: Mosaic of the shipwreck *Champlain II* from eight sonar images. (LCMM Collection.)

As a result of these three trials, it was determined that the Blue View DF900-2250 Dual Frequency Miniature Multibeam Imaging System would not be useful in documenting the deeper wreck of the steamboat *Phoenix* located in 70 ft (21.3m) of water. It was not

deployed on this shipwreck.

UNEXPECTED RESULTS

When LCMM divers visited Wreck GGG and *Champlain II*, the site was not immediately visible, so archaeologists utilized the multibeam imaging system to locate the wreck. This worked surprisingly well; the sonar unit located the wreck immediately.

In low visibility sites such as Wreck GGG, this tool would be extremely useful in locating separated divers. One diver could scan the region with the sonar unit and locate the second diver right away; this would provide an appreciable increase in safety. For example, the sonar image in Figure 6 was taken in very low visibility conditions, but the diver is clearly visible.

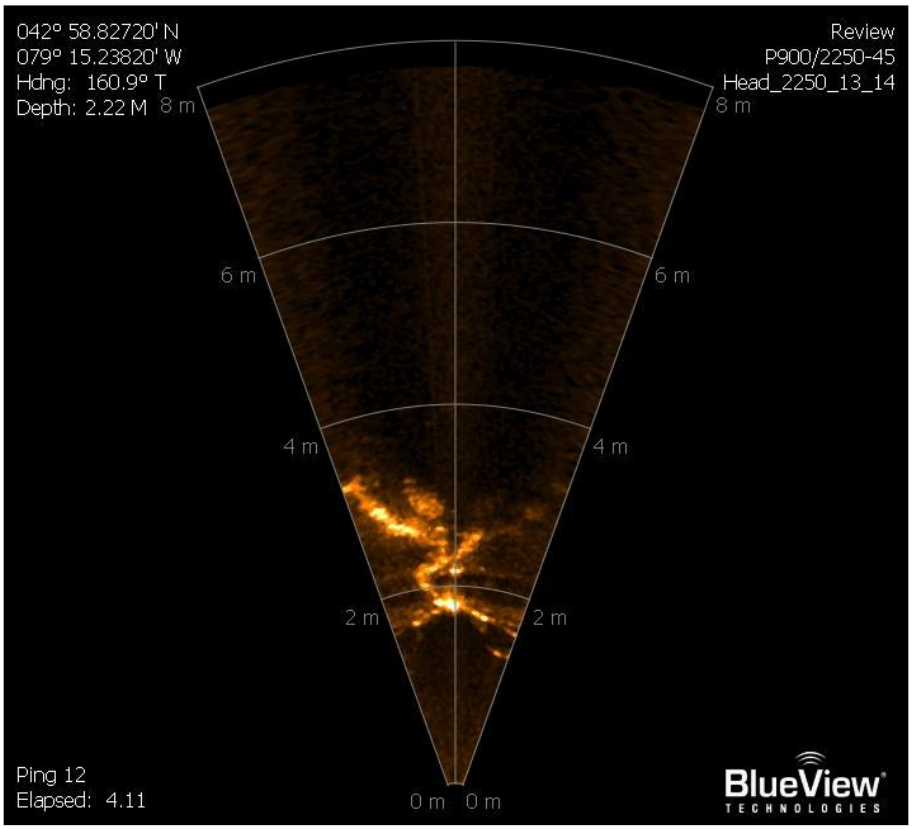


Figure 6: Sonar image on Wreck GGG with scuba diver clearly visible. (LCMM Collection.)

CONCLUSIONS

After multiple dives on one test subject and two shipwrecks, LCMM archaeologists have determined that the Blue View DF900-2250 Dual Frequency Miniature Multibeam Imaging System is not an effective tool to document the details of a shipwreck.

However, it is an extremely useful system to provide a "big picture" image that could not be created by any other method at our disposal. Especially in low visibility environments, it also provided a safety mechanism by which we could immediately locate a separated diver.

These results were presented at the Society for Historical Archaeology in Jacksonville, Florida in January, 2010. The session was entitled "Technology Across the Divide: State of the Art Tools for Terrestrial and Marine Archaeologists." The presentation was entitled "Shipwreck Documentation Using Handheld Multibeam Sonar" and was presented by LCMM Archaeological Director Adam Kane.

ACKNOWLEDGMENTS

Lake Champlain Maritime Museum wishes to acknowledge the following individuals and institutions for their support of this project:

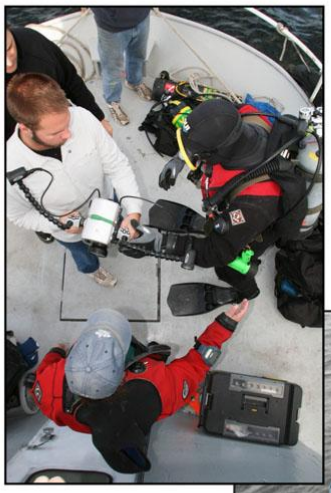
National Center for Preservation Technology & Training
George Schwartz
The Hazelett Family
Texas A&M University

APPENDIX A: NEWSLETTER ARTICLE

MARITIME RESEARCH INSTITUTE

***Phoenix* Revisited**

In October 2009, the MRI dive team staged a two week archaeological study of the steamboat *Phoenix* in Colchester, Vermont. *Phoenix* was built in 1815 in Vergennes, and her career came to a tragic end in 1819 when she caught fire enroute from Burlington to Plattsburgh. Six people perished in the lake as the boat burned. Today, *Phoenix* is the world's oldest known steamboat wreck. The project was undertaken in partnership with doctoral candidate George Schwarz, who is writing his dissertation for Texas A&M University on the shipwreck. Funding was provided by the National Park Service's National Center for Preservation Technology and Innovation, the Society for Industrial Archaeology, and the National Geographic Society. The diving focused on recording the curvature of the boat's frames, so that its shape can be accurately reconstructed, and shooting video for a photomosaic. We intend to return for another round of diving this summer. Many thanks to Bill and Dawn Hazelett and their caretakers for graciously providing housing on Stave Island. Their generosity was critical to the project's success.



(Left) Texas A&M Graduate Student Brad Krueger hands an underwater video camera to LCMM archaeologist Pierre LaRocque.

(Below) LCMM Archaeologist Chris Sabick gives LCMM Archaeological Director Adam Kane a hand prior to a dive.

Photos: Tiago Miguel Fraga.

Figure 7: LCMM Newsletter article, Spring/Summer 2010. All LCMM newsletters are archived at http://www.lcmm.org/museum_info/newsletters.htm. (LCMM Collection.)

APPENDIX B: FINAL PRESS RELEASE

FOR IMMEDIATE RELEASE:
February 10, 2011

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More information about this project as well as a detailed Technical Report are located at LCMM's website, www.lcmm.org.

ENDNOTES

[1] Adam I. Kane, Christopher R. Sabick, and Sara R. Brigadier, *Lake Champlain Underwater Cultural Resources Survey, Volume VI: 2001 Results and Volume VII: 2002 Results* (Vergennes, VT: Lake Champlain Maritime Museum, 2002).

[2] Ibid.

[3] Ibid.

[4] Elizabeth R. Baldwin, Arthur B. Cohn, Kevin J. Crisman, and Scott A. McLaughlin, *Underwater Historic Preserve Feasibility Study of the Lake Champlain Steamboat* Champlain II *Westport, Essex County, New York.* (Ferrisburg, VT: Lake Champlain Maritime Museum, 1996).

[5] Ibid.