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The editorial staff can be contacted at oceanbiz@sea-technology.com.

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COVER—The 6-meter NOMAD ODAS buoy, belonging to Environment Canada's Marine Monitoring Network, is shown during a service trip off Canada's west coast near Haida Gwaii. The buoy is part of a national network that has provided operational meteorological and oceanographic data since 1986. AXYS Technologies Inc. (Sidney, Canada) manufactures and services the WatchMan control systems, sensors and telemetry integrated onto these buoys. (Photo credit: Randy Kashino, AXYS Technologies Inc. field service specialist)

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Use of AUV for Deepwater Shipwreck Search

AUV with Side Scan Sonar and High-Resolution Camera Maps Shipwrecks at 1,000 to 1,500 Meters Depth

By Garry Kozak

Owner

GK Consulting

Derry, New Hampshire

Deepwater searches have traditionally involved deep-towed side scan sonar systems requiring very long tow cables and large winches. This requires large survey support vessels to handle the equipment, resulting in the vessel charter becoming the major cost in a deep-search project. Towing in deepwater was challenging and frustrating because of the lack of positioning control of the towfish when on a tow cable lagging 3 to 4 miles behind a ship.

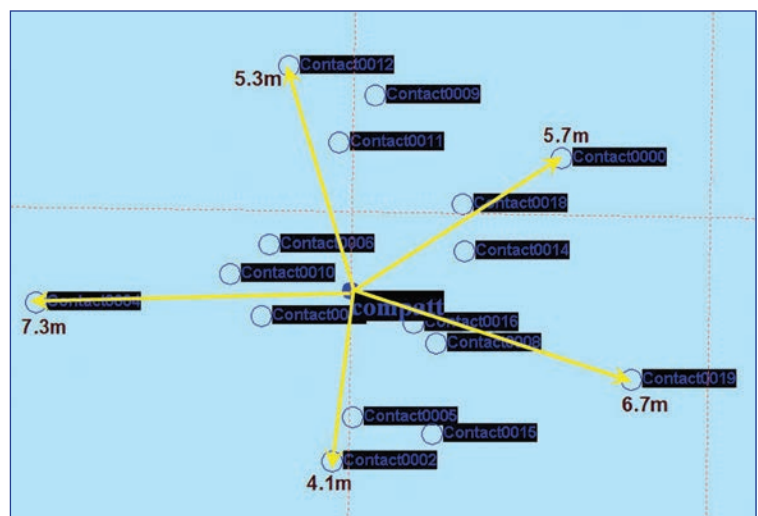
When a target of interest was located, the time-consuming process of making high-frequency, short-range classification passes with the side scan sonar was more luck than skill. Deep-towed sonars experienced other drawbacks, like susceptibility to heave that causes towfish motion and distorts the sonar images, tow cable failure and poor terrain following. Turnaround times to the next survey line could take hours, lowering search productivity and raising project costs.

Today, AUVs are a mature technology that routinely completes search missions with none of these drawbacks. A deep-water project for shipwreck search and classification at 1,000 to 1,500 meters depth with a large search area presented economic and mission strategy challenges. Looking at the trade-offs between a deep-tow side scan sonar and an AUV solution, it became clear that an AUV offered many advantages over a towed system. Though the initial cost outlay for an AUV is high, the savings made by not requiring a large support vessel and crew made an AUV an economical solution, with better data quality and payload flexibility.



Survey Payloads

A Bluefin Robotics Corp. (Quincy, Massachusetts) 12-inch 1,500-meter-depth-rated AUV, the Bluefin-12D, equipped with two swappable payload packages was selected for the project. The first payload was an EdgeTech (West Wareham, Massachusetts) 2200-M



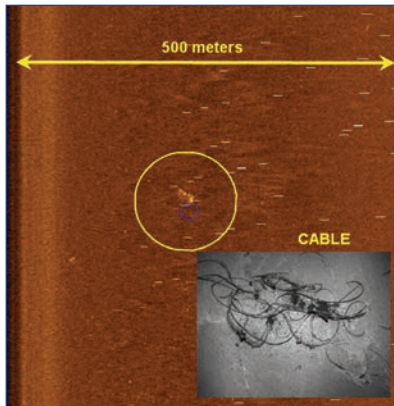
(Top) Preparing to launch the Bluefin AUV.

(Middle) The test target, placed at 1,400 meters depth for AUV position accuracy trials.

(Bottom) Absolute target position error averaged less than 6 meters.

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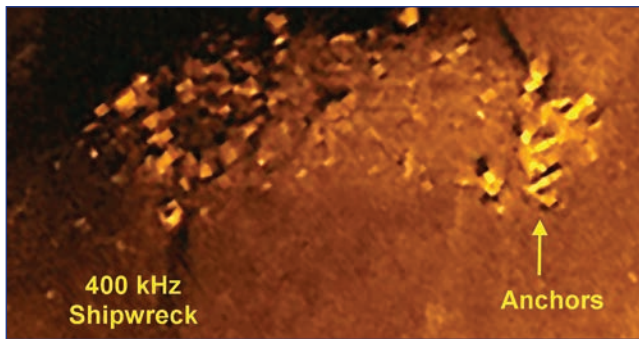
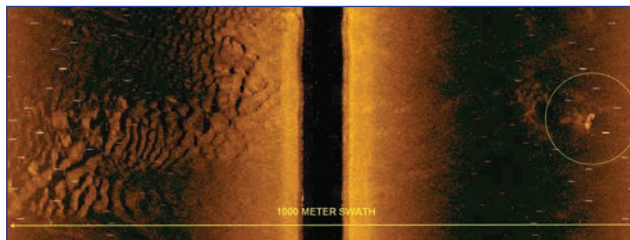
side scan sonar operating at 100 and 400 kilohertz. The system was selected because its high frequency did not degrade with depth. The search phase used the 100-kilohertz frequency on a 500-meter range (1,000-meter swath) to acquire targets, then the 400-kilohertz frequency classified the target using a 75-meter range (150-meter swath). The second payload was a high-resolution digital camera with LED strobe built by the Woods Hole Oceanographic Institution (WHOI), which was used to photograph mosaic targets that had been classified by the high-frequency side scan to be of interest.

AUV Positioning Accuracy

Vehicle positioning accuracy was a major mission concern since the high-frequency sonar runs required short ranges to classify targets of interest. The positioning control to run a photomosaic mission required a line spacing of 3 meters.

The AUV's positioning capability was tested using a target designed to test both the sonar target position accuracy and the photomosaic line control. The target was placed on the seafloor at 1,500 meters depth. An acoustic beacon was attached to the target so that a precise position could be calculated as a benchmark to evaluate the target position error generated from the sonar and photomosaic.

The test results exceeded expectations by confirming that the AUV positioning of the target from the sonar had an error of less than 6 meters, with the average about 5 meters, and that the AUV could maintain a 3-meter line spacing to photograph the target to produce a quality photomosaic.



Side Scan Sonar Performance

The 2200-M's low frequency was tested for range capability to verify that the 100 kilohertz would cover a 1,000-meter swath with no range fall off. The range performance met all mission requirements. Detection of small targets in the long range, such as rope and cable, was accomplished. The long search range showed shipwrecks very well and allowed large areas to be searched with high coverage rates per dive.

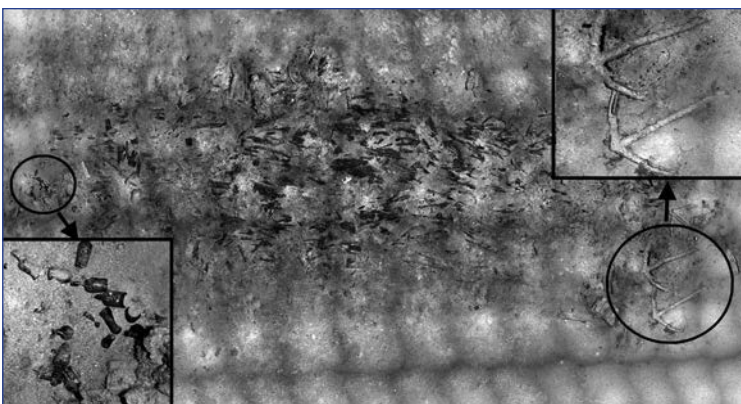
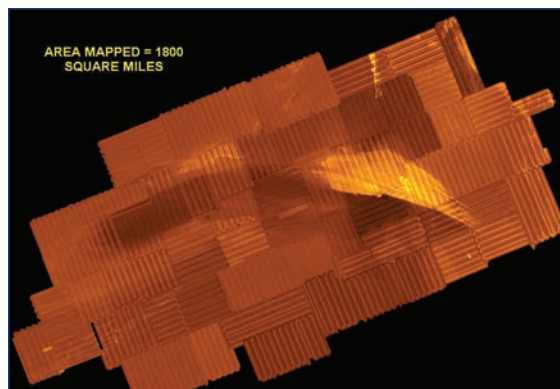
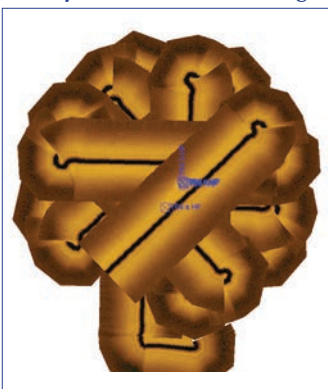
The 400-kilohertz sonar produced detailed high-resolution images that aided in classifying whether a feature located during the long-range reconnaissance mode was the remains of a shipwreck.

The classification mission used a clover-leaf pattern that provided multiple aspects of the target for analysis, which is not possible to achieve with a deep-tow system. When a feature was classified as a wreck site, the sonar payload was removed from the AUV and replaced with the camera payload. The payload switch took a couple of hours, resulting in minimal down time.

Sonar Data Processing

A typical dive averaged 24 hours and generated about 15 gigabytes of sonar data. After each dive, the vehicle was recovered, data downloaded and the batteries swapped for the next mis-

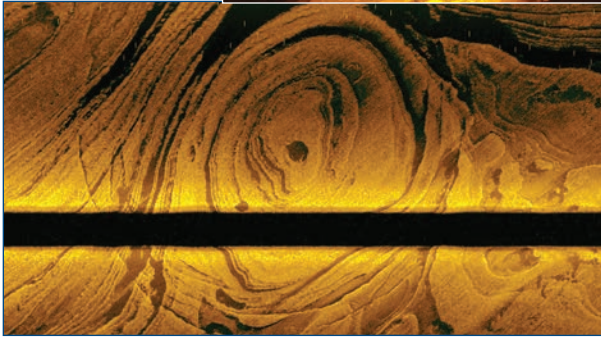
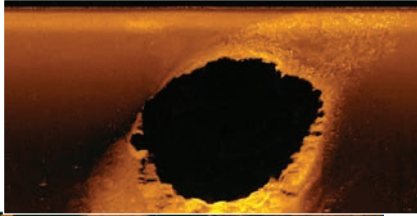
(Top) A cable detected on 1,000-meter swath. (Middle) A 200-plus-year-old British shipwreck detected on 1,000-meter swath. (Bottom) The 500-kilohertz classification of a 200-plus-year-old British shipwreck at 75-meter-range scale.



(Top left) The AUV's clover-leaf survey pattern for classification.

(Top right) The 1,800-square-mile mosaic of AUV-collected sonar data.

(Left) Photomosaic of a 200-plus-year-old British shipwreck.



(Top) A 250-meter-diameter crater discovered at 1,100 meters depth.

(Bottom) "The eye of Saturn" geologic structure discovery.

sion segment. The ability to swap batteries allowed surface turnaround times of three to four hours between segments.

SonarWiz 5 software, made by Chesapeake Technology Inc. (Mountain View, California), was used to review the data, process it into a mosaic, run quality control on the AUV navigation tracks, conduct target analysis and reports, and import the digital camera images to get a first blush of photo quality from a dive. SonarWiz enabled the import of 24 hours of sonar data in approximately 30 minutes, speeding up data review and analysis. The software was able to handle all the data collected over the span of the search (more than a terabyte) and to mosaic 1,800 square miles of seafloor in a single project.

Digital Camera Photomosaics

The WHOI's black-and-white camera had a resolution of 1,360 by 1,024 pixels, with illumination supplied by an LED array strobe. A typical photo mission generated 20 gigabytes of data, containing more than 8,000 georeferenced digital images.

The process of producing a final photomosaic involved several steps. It became apparent that trying to import more than 8,000 images into any mapping program was problematic, with most programs crashing.

A manual method was used to distill the images containing target features. Once this process was completed, the selected images were imported into SonarWiz 5 to get an idea of the quality and navigation precision for the mosaic.

Creating a photomosaic by straight mapping of the georeferenced picture tiles resulted in a visually distorted product. However, this step was useful as a guide for using a feature-matching method with consumer panoramic software, such as Photoshop.

The end product was a large-scale, high-resolution composite photomosaic that allowed detailed analysis to determine the type and age of the shipwreck located. The shipwrecks that were found dated back as early as the 1600s.

Conclusions

This project showed the economic, strategic and data-

quality advantages of using an AUV instead of a traditional towed system for deepwater search. The Bluefin AUV performed reliably, the EdgeTech sonar produced consistently high-quality data and the WHOI camera system proved reliable, with only one incident of software failure.

The mission's objective was to locate shipwrecks, but in the process of mapping a large seafloor area, several unusual geological features were discovered. The first was a massive hole in the seafloor measuring 250 meters in diameter and showing evidence of some type of flow (gas or fluid), as shown by the sediment trail that led down current. The second feature measured 600 meters in diameter and was nicknamed "the eye of Saturn" because of its unusual shape. Further study of these features could be of interest to geologists.

References

For a list of references, contact Garry Kozak at 2kozak@comcast.net. ■

Garry Kozak of GK Consulting specializes in shipwreck location and has been involved in undersea search for the past 40 years. He is a recognized expert in undersea search operations, providing global consulting and training expertise to navies and companies with a critical underwater search need. He now works with EdgeTech.



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