

Investigation and Imaging of Archeological Sites by Manned Submersible

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Abstract— Manned submersibles can provide a low-impact and collaborative platform for initial investigations of sensitive archeological sites. Direct visual inspection in combination with acoustic imaging equipment from the manned submersible *Antipodes* has resulted in the discovery and documentation of historically valuable sites while providing mission critical navigational feedback. This paper describes the process of discovery and image optimization of wreck sites from a submersible.

Keywords— submersible; HOV; nautical archaeology; sonar

I. INTRODUCTION

Nautical archeology presents many challenges, from the first detection of a new site, to the survey, study, excavation and/or restoration of the wreckage. Sidescan sonar has become an essential tool in locating wreck sites and can help not only pinpoint the site-of-interest's provenience and depth, but also give a general understanding of type and layout of the wreckage. Even with recent advances in topside sonar capabilities, these systems are limited in terms of access and fine-scale detail necessary for more advanced studies. In shallow environments, divers may be put into the water to execute the delicate job of digitally and acoustically imaging an unidentified archaeological site [1]. However, in deeper locations, vehicles must be used to conduct high-resolution metrology efforts. Using a manned submersible to dive archeological sites offers both performance and operational advantages. Not only are submersibles an essential alternative to human divers but also improvements in submersible technology have led to tools with which to gather a wide range of data, as well as the ability to transport multiple investigators to a site where they can work collaboratively [2].

II. METHODS

Seattle-based OceanGate Inc. owns and operates several manned submersibles that have been used to conduct numerous studies on deep-sea wreck sites with the use of sonar and video imagery (fig. 1). *Antipodes*, the flagship manned submersible of OceanGate, accommodates a crew of four, plus a pilot, and boasts twin 147-cm hemispherical acrylic domes, which provide exceptional views for direct observation and filming to depths of 305 meters. Teledyne BlueView Technologies's 2D sonar head, the P900-130, and 3D micro bathymetry sonar systems, the BV5000- 1350 on a scanning pan and tilt, were fitted to *Antipodes* forward frame. The combination of the 2D

sonar system used for navigation and the 3D head for metrology data allowed investigation of wreck sites in a wide range of conditions, primarily in regions of low water clarity. Digital stills and video were also a critical component for onsite investigation through *Antipodes* acrylic domes.



Fig. 1. Some of the wreck sites investigated by OceanGate submersibles.

Initial test dives, for which *Antipodes* was fitted with BlueView sonar, resulted in an operational plan for best practices while scanning wrecks of significant size. Testing demonstrated the importance of positioning for accurate data, including optimal overlap and correct distance from target. *Antipodes* fine-scale maneuvering ability allowed for accurate positioning of the sonar head, however, long 3D scans required keeping the submersible still while scanning. The submersible was placed on the seafloor and pre-determined locations and distances from the target to achieve appropriate overlap and reduced movement (fig. 2). Since many wrecks also serve as artificial reefs to a myriad of fish species, multiple scans were conducted at sites with high congregations of fish and other unexpected anomalies. Post processing of data involved a two-step process. First unwanted artifacts, such as fish in most cases, were removed from the raw data. Secondly, common

reference targets were used to merge point clouds into a 3D image.

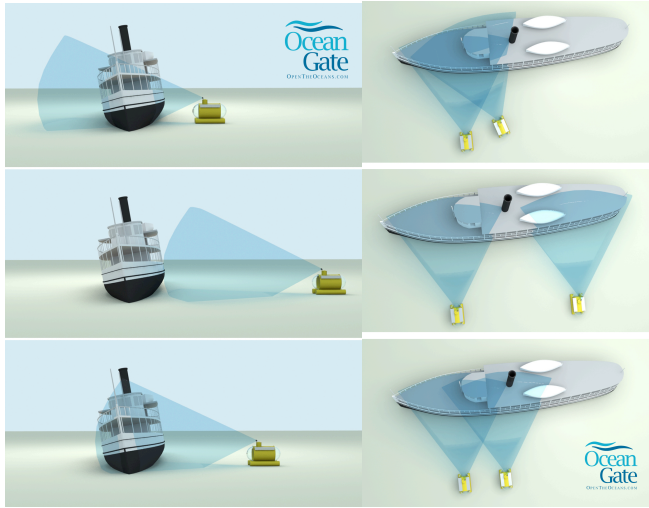


Fig. 2. The spread of sonars used affects area coverage.

III. USE CASE EXAMPLES

OceanGate participated in several nautical archaeological expeditions in the Pacific Northwest from Seattle down to Monterey Bay and Southern Florida. Shipwreck scans in Washington sound, the SS *Al-Ind-Esk-A-Sea*, a 110-meter fish-processing vessel near Everett, Washington in, and the SS *Governor*, a 140-meter cruise liner near Port Townsend, Washington were done from *Antipodes*. Many of these sites were characterized with high current and low visibility. Sonar was used as the primary form of navigation around the wrecks and provided a majority of the imagery, as high levels of backscatter made standard optical imaging methods suboptimal. The P900-130 head, used for obstacle avoidance, also imaged fine-scale detail of the ship's rigging and other entanglement hazards such as monofilament line. Several scans lasting approximately 20 minutes were taken with the 3D BV5000 head at each site resulting in a XYZ point cloud.

During 2012, OceanGate lead a year-long expedition to Miami, Florida to conduct research in conjunction with the Miami-Dade Artificial Reefs Program to investigate undefined targets identified by the county's Department of Regulatory and Economic Resources (RER). *Antipodes*, configured with 2D and 3D sonar heads, was towed out to predetermined sites of interest. On 19 separate dives between depths of 10-280 m lasting between 1-8 hours, *Antipodes* imaged several new archeological sites, including a WWII Hellcat airplane and sunken steel pier from the 1800s. First 2D scans were performed while flying over new wreck sites to determine scale and locate potential hazardous obstacles, followed by closer investigation where video and digital still imagery were recorded to further define a site. Once the 2D scans and videos were reviewed topside, a plan for 3D scan locations was determined. Over a nine-month period *Antipodes* dove on the Hellcat site, KB04, located 4.12 nautical miles from shore in 70 m of water, a total of ten times, including a long-duration dive of eight hours (fig. 3.).

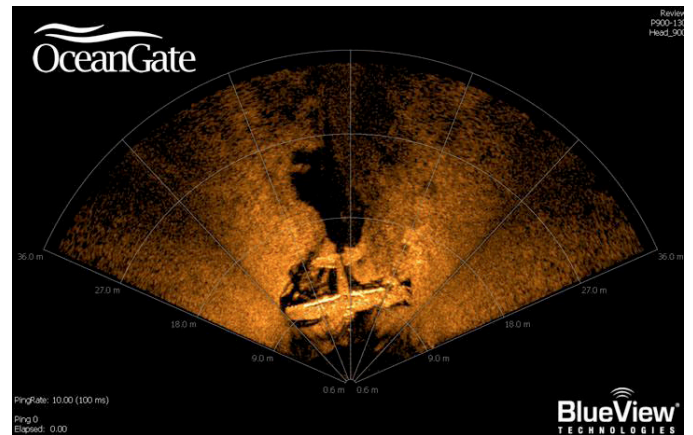


Fig. 3. WWII-era fighter plane, the Grumman F6F Hellcat.

Scans over this period of time revealed changes in sediment deposition around the wreck and fluctuations in biota, specifically lionfish, *Pterois volitans*, an increasingly invasive species in South Florida waters [3]. OceanGate donated its collection of photographs, videos, and technical scans of the Hellcat to the Naval History & Heritage Command in Washington, D.C. The files will be used in the preservation of this federally protected site and in possible future research on the plane.

IV. CONCLUSIONS

Nautical archaeologists in academia and the public-private sector increasingly require support services to keep pace of their rapidly changing field. Further, because new marine archaeology sites are continually being discovered as human activity in the marine environment grows, there is an urgent need to explore these and existing sites before they deteriorate.

The combination of high-tech acoustic imaging equipment and three dimensional viewing capabilities on a highly maneuverable platform has produced valuable data for government and private industry. Sonar imaging from manned submersibles delivers a low-impact solution in naval archeological investigations at historically valuable sites while providing mission critical navigational feedback.

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