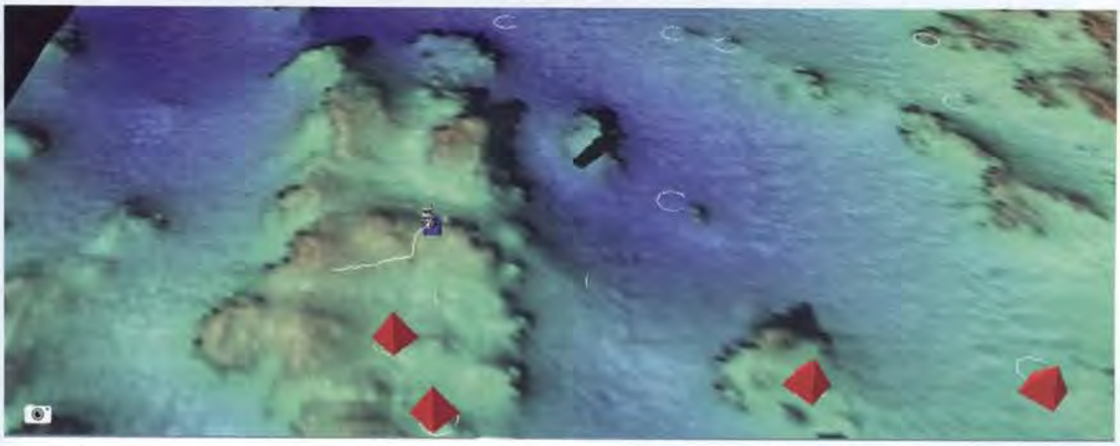
ARCHAEOLOGY AND TECHNOLOGY



Exploring History in the Mediterranean

by Jeffrey G. Royal

RPM Nautical Foundation was founded in 2001 by Texas A&M University's Institute for Naval Architecture (INA) Director George Robb as a non-profit research organization that sought to apply developing technologies in other oceanographic fields to Nautical Archaeology. With the appropriate equipment and methods, the aim was to move beyond the limits of typical archaeological diver depths while maintaining the standards that had been developed after decades of previous fieldwork. The challenge of applying a variety of existing technologies to marine archaeology that has a solid foundation in methodological theory and practice is a continual process of experimentation, learning, and adaptation. However, this process has led to sound methodological approaches and practices that have yielded significant archaeological results. Flagged and based in the central Mediterranean location of Malta, the foundation's research vessel *Hercules* can be deployed throughout the Mediterranean on a project-by-project basis (Figure 1). RPM Nautical Foundation (RPMNF) has directly conducted numerous archaeological projects in nine Mediterranean countries from Spain and Morocco to Turkey and Israel. In all cases, projects are carried out in conjunction with the host country's cultural authority and assists in the management of submerged cultural resources, scholarly research, and educational programs.

Much of the equipment utilized by RPMNF has long been featured in the efforts of ocean-based industries, such as multibeam echo sounders, ROVs, beacon positioning systems, and vessels with dynamic positioning. It is the combination of these technologies that has proved successful. By the end of 2003, after years of planning, construction, and alterations, the research vessel

Figure 1: RPM Nautical Foundation's research vessel *Hercules*.

Hercules was ready for project deployment. The 37-m long *Hercules* was specifically designed for archaeological survey and excavation in water depths greater than 30 metres. This archaeological research vessel is designed as a self-sufficient base for a wide range of project functions in moderate to relatively deep waters, with the majority of the work taking place in a coastal setting. Project functions include the deployment of ROVs, manned submersibles, and remote sensing equipment (multibeam and side scan sonar systems), as well as dive operations. The R/V *Hercules* is equipped with a dynamic positioning system that, in conjunction with differential global positioning system (DGPS) and a high precision acoustic imaging (HIPAP) positioning system, allow precise vessel and vehicle tracking. Data is collected and processed through a bank of computers within a dedicated hub from where the command of survey and ROV operations also occurs. The R/V *Hercules* is also equipped with adequate deck space and lifting systems to transport and deploy submersibles and auxiliary vessels, as well as RPMNF's hyperbaric chamber and integrated Nitrox system for multi-diver operations.

One of the design functions for the R/V *Hercules* is to conduct archaeological surveys. Since deployment in 2004, a series of projects during each field season has assisted in refining survey methodology and operating parameters. The *Hercules* is outfitted with a hull-mounted, dual-headed multibeam echo sounder system (Kongsberg EM3002D) for shallow-water investigation, as well as a single-head system (Kongsberg EM1002S) for deep-water mapping. Operating at an average range of 300 kHz, the EM3002D has an effective operating depth for suitably discerning anomalies in archaeological investigation to a depth of circa 100 m. Although the EM1002S (95 kHz) will produce surface maps down to 600 m, the beam footprints do not allow for the effective resolution required. Hence, multibeam survey operations are limited to the coastal waters out to the 100 m contour. When applicable, the EM1002S is relegated to mapping a survey area in preparation for side scan coverage. Multibeam imagery has proved far superior to that of side scan for these near-shore waters in large part due to the ability to accurately discern geologic formations such as large rock outcrops, ridges, and sediment flows. A superior visual understanding of the seafloor allows better anomaly assessment, which generally results in fewer overall anomalies than with side scan imagery. When dealing with large areas, the ability to narrow the anomaly totals is crucial for efficiency. It is critical to produce highly-detailed, three-dimensional maps for such effective analysis; therefore, technicians use the vanguard of software developed for other ocean-based industries; specifically, the multibeam data is first processed with CARIS HIPS-SIPS – a comprehensive bathymetric data cleaning and validation tool integrated

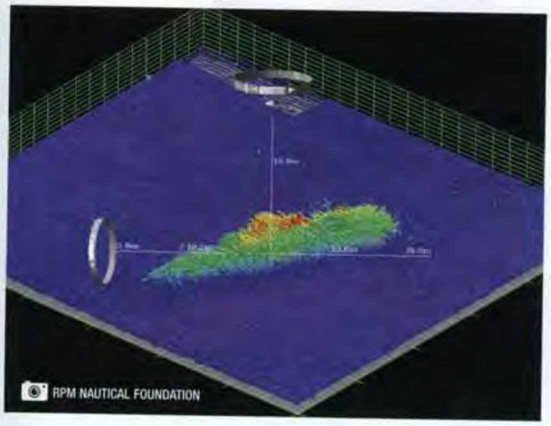


Figure 2: A multibeam data image of a modern shipwreck from IVS 3D Fledermaus software.

with powerful vector product creation – and imaged in Interactive Visualization Systems (IVS) 3D Fledermaus software (Figure 2).

Some examples of large-scale multibeam projects include projects in Spain, Turkey, Sicily, and Albania. The offshore waters of Cadiz, Spain, were the inaugural project for the *Hercules* in 2004 where the project's multibeam survey area covered approximately 160 km². In Turkey, survey was conducted along 37 km of coastline on the southeast portion of the Bozburun peninsula; the multibeam portion was completed in approximately two months over the 2005 and 2006 seasons and resulted in a total coverage area of over 120 km². A multi-season project in the Egadi Islands of Sicily began in 2005 and achieved 154 km² of multibeam surveyed area as of 2008. An ambitious undertaking commenced in 2007 with the onset of the Albanian Coastal Survey project. As one of the components of this project, RPMNF will survey the entire length of the Albanian coast. Upon completion of the 2008 field season, 198 km² were completed that stretched approximately 40 km from the border with Greece to the north of Saranda (Figure 3). Such projects are typical of the survey strategy employed, whereby all possible areas receive survey coverage without presupposition of where cultural material may be deposited. Furthermore, such extensive coverage provides contextual geologic information that assists in assessing areas where cultural material is likely buried, or received scouring, or may be deposited in rock formations. Based on the numerous projects throughout the Mediterranean, this method has proved itself to be preeminent for locating submerged cultural remains.

The majority of potential sites identified from remote sensing data are verified and documented with a ROV, a Seaeye Panther XT (Figure 4), while those few in shallower waters are investigated by divers. In order to effectively and accurately place the ROV on targets, the multibeam data is coordinated with the *Hercules'* positioning systems. Both the ROV and deployment cage are fitted with beacons as part of the Kongsberg HIPAP 350 tracking system employed onboard. To accomplish the coordinated interface of positioning and bathymetric data, a module of Fledermaus software was modified by the maker IVS 3D specifically for testing aboard the *Hercules*. This module takes the various DGPS strings of

Figure 3: Extent of multibeam survey coverage through 2008 as part of the Albanian Coastal Survey Project.

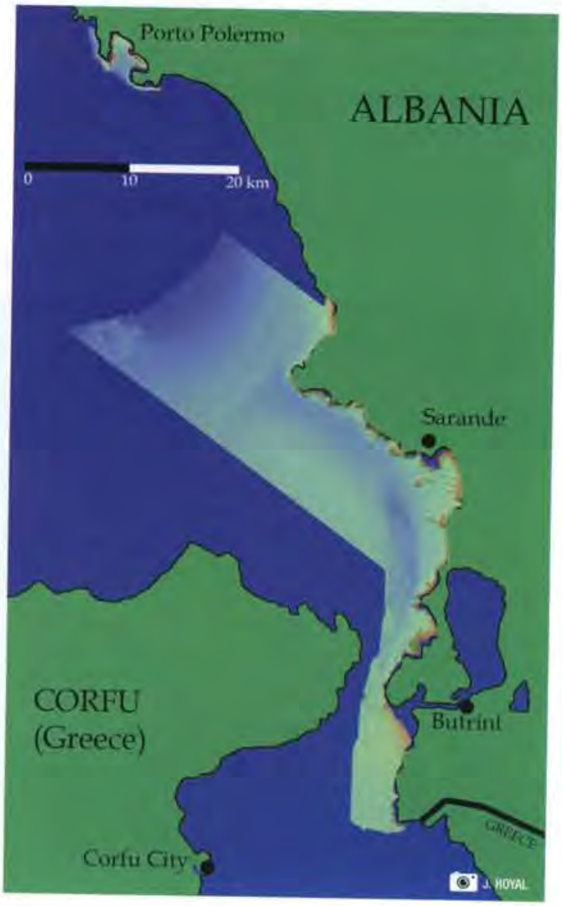


Figure 4: RPM Nautical Foundation's Seaeye Panther XT ROV used for site discovery, recording, and excavation.

positioning data that are collated in HI-PACK and interactively renders icons within a three-dimensional seafloor model at a rate approximating real time (Figure 5). For ROV operations, the icons include the *Hercules*, ROV, and the ROV's deployment cage.

Armed with the visually accurate and interactive model of the seafloor and vessels, the *Hercules* is situated above pre-assigned target coordinates. As all targets are marked with icons on the three-dimensional seafloor model, it is possible to manoeuvre from one target to another when distances are not prohibitive. By interpreting the sonar image from the unit affixed to the ROV with the seafloor model, it is then possible to investigate potentially productive geologic formations for trapped artifacts as well as identify smaller objects that do not appear to be geologic in nature (Figure 6). Video cameras naturally contribute to manoeuvring during verification as well; their effectiveness being constrained by visibility. It was using this methodology that an ancient warship ram, probably dating to the 3rd century BCE (Before Common Era), was discovered off the coast of Sicily. This bronze ram is under a metre in length and rose less than one-half metre off the seafloor. After attaching a harness and lifting gear with the ROV, the ram was raised to the deck with a crane (Figure 7). A rare find, it now resides with the Superintendant's Office of Maritime Archaeology for Sicily to undergo conservation and dating. Each field season, these methods and procedures evolve as new technologies and challenges arise.

Another area of ongoing methodological development is applying the current technology to retrieving artifacts. When new sites are discovered, a thorough video documentation is conducted; a laser affixed to the ROV

Figure 5: The positions of the R/V *Hercules*, ROV, and deployment cage are monitored in real time through IVS 3D Fledermaus software.

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Figure 6: Data from the multibeam positioning model (left) along with video (centre) and sonar (far right) feeds from the ROV are coordinated in the operations room.

provides a 10-cm scale in video and photographic images (Figure 8). Subsequent to this recording, diagnostic artifacts are sought in some cases over the periphery of the site that will aid in understanding the date and provenance of the site (Figure 9). All artifacts are under the jurisdiction of the host government for conservation, study, and museum display. The ROV is outfitted with two multifunction manipulators (one six-function and one five-function) with modified padded grips. Additionally, a water jet is affixed to one manipulator and a small venture dredge to the other. Sediment from the dredge passes through a mesh bag in order to capture any small artifacts. On sites, sediment removal is limited to the accumulated overburden and restricted to that sediment directly adjacent to peripheral artifacts selected for retrieval. As it is difficult to determine the structural integrity of artifacts prior to lifting, care is taken to minimize stress by removing any sediment holding the artifact to the seafloor. The nature of the seafloor sediments requires varied methods for securing artifacts. For example, the loose sand in Sicily requires only light suction for removal of sediment to remove surface artifacts, while the denser silt in Albania requires a combination of some blowing with the suction to ensure safe lifting.

Preparations began in 2008 for excavation of a Roman-era wreck site in Sicily discovered during the 2006 field season. A major part of the preparation was photographing the entire site from a plan-view in order to construct a photomosaic of the site. For this process, a Tritech Typhoon camera was experimented with that incorporated a 5-laser auto-scale function. The camera

Figure 7: Retrieval operations of the 3rd century BCE bronze ram off the Egadi Islands, Sicily.

Figure 8: The laser scale in the ROV's images (to left) here on a 6th century CE amphora wreck site in Turkey.

is designed for pipeline work and had mixed results with archaeological site recording. The loose, coarse sand plus excellent visibility and low mound at this site make it an ideal candidate for developing excavation methodology and technological application. Excavation is planned for 2009 and will be limited to a few square metres in select areas of the site. Metal grid squares of one-square metre in dimension will be placed on the site and measured into place before the ROV removes sediment (Figure 10). Several methods will be utilized for positioning of the squares on the site. Before a grid square is placed in position, a series of datum will be placed around the site. The distances between datum will be measured by the ROV's sonar that features sub-centimetric precision at the close ranges involved. Grid squares will be measured in position by the sonar as well as its relational measurements to the datum. Processing of the distance measurements and the spatial recording

Figure 9: Retrieval of an amphora for analysis from a late 6th / early 5th century BCE Greek wreck site in Albania.

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Figure 10: Grid square and laser scale from the Tritech Typhoon camera during photo runs of a Roman wreck site dated to between 300-400 CE off the Egadi Islands, Sicily.

of discovered objects in relation to the datum will be processed in Site Recorder 4, an archaeological mapping program specifically developed by 3H Consulting Ltd. for underwater archaeological site recording. Additionally, plan-view video and photography with the laser scale will be taken at intervals to provide another check on the datum, grid square, and artifact positions.

RPMNF's remote sensing, verification, and excavation methodology has proved successful in the study of shipwreck sites and harbour works, particularly at depths below typical archaeological diving, in Cadiz and Cartagena, Spain; Malta; Morocco; Cyprus; Sicily; Amalfi and Calabria, Italy; and Turkey. The location and assessment data of sites has proved beneficial to the governments of these countries where projects were undertaken as it provides their cultural authorities pertinent information for protecting their submerged archaeological resources. The bathymetric data resulting from these expeditions is also made available to each host country's hydrographic and geologic departments in order to supplement oceanographic mapping programs.

Through this application of inventive technologies to nautical archaeology, the maritime heritage of the Mediterranean can be better protected and understood each year.

Dr. Jeffrey Royal serves as the Archaeological Director of RPM Nautical Foundation and is an Adjunct Professor with the Institute of Nautical Archaeology.

His research interests cover the Mediterranean Sea and the Roman era. Specially, Dr. Royal looks at the development and changes in amphora morphology and the implications on overseas Mediterranean trade; the distribution of Roman annona and associated trade; the assessment of warships, strategies and tactics used in the Mediterranean during the Roman era; and Corinthian trade in the Adriatic Sea between the 6th to 2nd centuries BCE.

Dr. Royal has directed projects in Sicily, Italy, Spain, Morocco, Turkey, Albania, and Israel. His research appears in archaeology-related publications and is often presented during international conferences. He can be reached at jroyal@rpmnautical.org.