Remote Sensing of Deepwater Shipwrecks

Underwater archaeology is still a relatively new field in terms of age and technological advances. With the advent of SCUBA technology in the 1950’s and 1960’s, the ocean environment became more accessible to scientists, archaeologists, and recreational divers alike. While SCUBA allowed researchers to reach shipwreck sites in shallow waters above 50 meters, any wrecks below this depth were inaccessible to study. A common misconception is that most shipwrecks are found along shallow coastlines that mariners favored over the vast open seas, meaning most wrecks can be found at depths of 50 meters or less. Despite the risks of crossing open oceans and seas, many vessels chose this course.

From more recent deepwater wrecks like the Titanic to ancient Roman vessels lost in Skerki Bank, many sunken vessels can be found at great depths. For the purpose of this project, many archaeologists and scientists agree that deep water is water greater than 50 meters, although 70 meters is also accepted. Although depths greater than 50 meters can be reached with special technical diving certifications and equipment, it is often too risky and inefficient to work at these depths for an extended period of time. Despite these physical constraints, deep submergence technology has advanced the study of underwater archaeology and allowed archeologists to literally reach new depths.

With the development of remotely operated vehicles (ROV) and autonomous underwater vehicles (AUV), almost 98% of the world’s ocean floor has become accessible to researchers (Foley and Mindell, 2002). All archaeologists studying deepwater wrecks rely on this technology to study archaeological sites as they would be studied on land or in shallower depths. Without remote sensing, it would be impossible to find or study any deepwater wrecks. Although human operated vehicles and submersibles allow archaeologists to visit the site, there is no way to take accurate measurements in this fashion. ROVs and AUVs serve as the two main platforms for remote sensing equipment that allow archaeologists to gather critical data. One of the most complicated aspects of deepwater archaeology is reconciling normal archaeological standards in such a harsh environment. Many archaeologists and scientists involved in this work agree that this is the main goal of deepwater projects.

To gather the data that is necessary to understanding spatial relationships in an archaeological context, remote sensing equipment is mounted to ROVs or AUVs, or towed on what is commonly called a towfish. Deepwater archaeologists tend to use the same three types of active remote sensors, side scan sonars, multibeam sonars, and sub-bottom profilers. All rely on acoustic sonar systems to collect important geophysical and site data. Because wrecks are small in terms of oceanographic measurements, precision and resolution are critical to successfully mapping deepwater wrecks up to proper archaeological standards. Used in conjunction with remotely sensed data, ROVs and AUVs also collect high-resolution photographs and videos. Photomosaics are almost always used to create a reliable site map. With video, photography, and remotely sensed data, archaeologists can analyze spatial relationships in order to determine site formation, site degradation, how the vessel sank, and other important pieces of archaeological
information. In addition to these capabilities, ROVs and AUVs are often equipped with tools to retrieve artifacts and take samples as well as high-powered lights to illuminate the sea floor.

The underwater world poses a unique set of problems to archaeologists, engineers, and other scientists working at great depths. As an uncontrolled environment, with factors including currents, pressure, loss of visible light, it is often difficult and expensive to study wrecks. Yet under these conditions, many deepwater wrecks are left incredibly preserved. One of the most common problems among archaeologists working in deep water is the reliance of expensive equipment and the steep costs associated with research vessels. Although ROVs are the most common platforms for remote sensing equipment, AUVs are becoming a more accessible and affordable option for archaeological projects. Because these operations can be so expensive, many archaeological projects often coincide with biological and oceanographic studies. Many wreck sites are discovered in deepwater when other projects are studying the area. This is the case for the Deep Gulf Wrecks Project in which many wrecks were found by gas and oil companies looking to drill in deep water.

The field of deepwater archaeology is rapidly developing as the need to study deep wreck sites increases. There are many ongoing deepwater archaeological projects throughout the world, including the Deep Gulf Wrecks Project led by the Bureau of Ocean Management and projects in the Black Sea. Scientists and engineers at the University of Rhode Island and the Woods Hole Oceanographic Institute have been frontrunners in the development of new technologies. It is vital that archaeologists trained in social sciences continue to work with other scientists in order to properly study and understand deepwater wrecks. Although still expensive to run deepwater archaeological operations, it is becoming more accessible, which is both advantageous and detrimental to shipwreck sites. For-profit companies like Odyssey Marine Exploration are taking part in deepwater searches for profitable wrecks, and reaping the benefits of artifact retrieval without careful mapping or remote sensing of the sites.

Despite non-scientific communities joining part in the search for deepwater wrecks, technological advancements are allowing archaeologists to perform more careful excavation operations. While no excavation has been fully completed at the depths being considered, it is likely to become a reality in the near future. These excavation methods would follow the same procedures used in shallow water and on land, rather than the simple artifact retrieval that has been most common on projects. It is also likely that wrecks may be found in waters even deeper than currently being studied. Deepwater archaeology is truly a frontier for current archeologists as it is still a relatively young field.

**Annotated Bibliography**


Ballard’s article introduces readers to the field of archaeological oceanography, which developed concurrently with the advancement of deep-submergence technology. He discusses some of the early history of deepwater archaeology, noting the need for the technology developed out of the search for the *RMS Titanic*. The first use of remotely operated vehicles for archaeological purposes, however, was used in the Skerki Bank Project, which the author was also part of. While Ballard does mention a few other early projects using remote sensing techniques and
applications, his main focus is on his projects. Using side scan sonar, sub-bottom profilers, and ROVs, Ballard summarizes the functionality of the sensors and platforms used on his projects. This chapter fails to take into account the developments of other archaeological oceanographers. While Ballard is certainly a pioneer in the field, almost all of his references are his own works. Nevertheless, it is still an important article for understanding remote sensing in deepwater archaeology despite the fact that the term “archaeological oceanography” is rarely used.


Bingham et al. detail the operations and limitations of using an autonomous underwater vehicle during the 2005 Chios ancient shipwreck survey field season. The article seeks to acknowledge the limitations of AUVs while discussing opportunities for improvement for remote sensing, AUVs, navigation, and imaging techniques. Instead of the commonly followed multistep process of an underwater archaeological investigation that includes surveying, target identification, site investigation, and possible excavation, the authors focus on the SeaBED AUV as a platform to accomplish multiple archaeological methodologies. The authors highlight the advantages of an AUV, noting its ability to operate off a moderately sized, less expensive research vessel and can have a significant bottom time. While many deepwater archaeological investigations use ROVs, it is interesting to see these scientists utilizing an AUV. They argue that new technological advancements usually coincide with new research questions and problems for deepwater archaeological sites. For the research at hand, the authors used an AUV with navigation sensors for positioning and guidance, optical/sonar sensors for mapping features and the seafloor, and in situ chemical sensors to analyze the wreck’s environment. This allowed them a very successful field season in a very short amount of time. While intended to be broad, the article still provides enough detail to fully educate readers about AUVs in deepwater archaeology.


Church and Warren’s article seeks to reconcile the methodologies and approaches of all archaeological projects with deepwater archaeology, emphasizing that the goals for each are inherently the same. Through collection of information, material recovery and analysis, in situ documentation, and site mapping, the same standards are applicable for deepwater sites as any other archaeological site. The primary difference, the authors argue, is the use of sound investigation methodologies to produce high-resolution data necessary for finding small features in a vast ocean. High-resolution geophysical data can provide deepwater archaeologists with vital information that can aid ground-truth, site mapping, and site excavation investigations. The authors focus on three types of sensor systems, side scan sonar, sub-bottom profiler, and multibeam sonars, all of which were used to plan investigations and ground truth surveys for the Deep Gulf Wrecks Project (see Irion et al.). By analyzing this data it becomes much easier to properly investigate the deepwater archaeology sites under acceptable archaeological standards. For Church and Warren, is important to learn as much as possible about what will be excavated
before excavations even begin. While the available geophysical data may not be enough to fully assess the site's three-dimensionally, it is necessary to acquire the appropriate data prior to creating a field plan. Although Church and Warren use the term excavate as it applies to deepwater archaeology, a more appropriate term would be retrieval. Most artifacts are not systematically excavated from the ocean floor as easily as artifacts on land or in shallow water, but rather they are systemically retrieved.


Foley and Mindell focus on the fundamentals behind deepwater archaeology. Importantly, they note the processes that keep deepwater wrecks preserved including anoxic environments, lack of wave action, and inaccessibility to treasure hunters, just to name a few. Unlike other studies that usually mention artifact retrieval, they choose to focus on methods and technologies that can remotely collect archaeological data with little concern for site disturbance. This article seems to be an ideal introduction to anyone unfamiliar with remote sensing in underwater archaeological applications, breaking remote system down into two broad categories, optical and acoustic systems. Precision navigation is the key to completing accurate deepwater archaeology surveys that conform to recognized archaeological standards. While underwater technologies, precision navigation, and remote sensing are critical to deepwater investigations, investigation becomes archaeology with proper research designs, interpretation of the collected data, and relevance to larger historical questions. It is important that this article unites underwater technology with archaeological theory to get at the true meaning of deepwater archaeology.


In this article, Irion *et al.* explore the government’s responsibility to manage and protect submerged cultural heritage with the aid of remote sensing as gas and oil companies expand development into deep water in the Gulf of Mexico. For this article’s purpose, deep water is water deeper than 1,000 feet, which is the depth most new wells are being drilled. Despite previous surveys of shallow water areas and modeling predictions of shipwreck sites for the Gulf, deepwater wrecks were not taken into consideration until over a dozen wrecks were located in deep water. A new project, the Deep Gulf Wrecks Project, was initiated to document and map the wrecks while studying environmental conditions on and around the sites. All of these wrecks were discovered with the use of remote sensing surveys and remotely operated vehicles (ROV). Many of the wrecks are associated with World War II, including the German submarine *U-166*. The authors note the importance, but costly efforts, of deepwater archaeological investigations, arguing that these studies would not be funded without additional study of the environmental and biological impacts of the wreck sites. While deepwater archaeology can be extremely costly, the authors seem to undermine the historical and archaeological value the discovered wrecks sites can have by reminding readers of the costs and arguing that the study was only funded because of additional biological and environmental studies. In doing this, the authors also challenge the advancements such projects can have in the field of underwater remote sensing.

Mindell discusses the advancements of precision and accuracy in remote sensing for deepwater sites in underwater archaeology in his chapter. He notes the importance of using ROVs and AUVs and the precision and reliability of their acoustic navigation to map archaeological sites at a fine scale before the retrieval of any artifacts. Because spatial relationships are fundamental to archaeology, it is critical that any mapping or photographing of sites record location and orientation of artifacts and site features. This allows archaeologists to create dimensional maps and predict site formation. Mindell reviews the history of utilizing closed-loop control of ROVs to create precise photomosaics and microbathymetry, beginning first at Skerki Bank. Emphasizing the major problem of deepwater remote sensing, navigation, Windell notes that underwater positional accuracy systems are the backbone of deepwater archaeology. This includes long baseline acoustic navigation and an acoustic trilateration system called EXACT. With EXACT, absolute referencing allows precision surveys to be repeatable, making site formation, site degradation, biological activity, and human disturbances measurable. Mindell successfully reviews some of the advantages and disadvantages to archaeological studies of deepwater shipwrecks and sites.