

**UNESCO SCIENTIFIC COLLOQUIUM ON FACTORS IMPACTING THE  
UNDERWATER CULTURAL HERITAGE**  
**10<sup>th</sup> Anniversary of the Convention on the Protection of the Underwater Cultural  
Heritage**



Royal Library of Belgium, Brussels, Belgium.  
13<sup>th</sup> & 14<sup>th</sup> December, 2011.

**Innovative, non-destructive techniques and methodologies for the survey and the exploration of submerged cultural remains on the shallow and deep seafloor**

*Dimitris Sakellariou, Hellenic Centre of Marine Research, Greece, [sakell@hcmr.gr](mailto:sakell@hcmr.gr)*

**Deep vs. shallow water survey techniques**

Marine technology and marine geological – geophysical techniques and methodologies for the survey of the seafloor and its substrate have already been available for over 4 decades. Recent developments have increased their efficiency and the resolution of the geophysical recordings. Remote sensing techniques like deep towed side scan sonar, multi beam systems, subbottom profilers and magnetometers have found wide application in underwater archaeological surveys, particularly in deep waters and self areas. With their use large areas of the seafloor can be (and have been) surveyed with high resolution at almost any depth and in relatively very short time.

Spectacular discoveries of archaeological remains, particularly shipwrecks dated to various historic periods from the first millennium BC till more recent times (post-Medieval, post-Byzantine and even recent post 2<sup>nd</sup> World War wrecks) in deep waters have been possible with the use of advanced marine geophysical, remote sensing techniques and sophisticated underwater vehicles, manned submersibles (HOV), remotely operated (ROVs) and autonomous underwater vehicles (AUVs) operating from open-sea oceanographic vessels (Hobbs et al. 1994; Søreide and Jasinski, 1998; Barto Arnold III et al. 1999; Ballard et al., 2000; 2001; Quinn et al., 2000; 2002; Blondel and Pouliquen, 2004; Papatheodorou et al., 2005, Sakellariou, 2007; Sakellariou et al 2007, Foley et al, 2009).

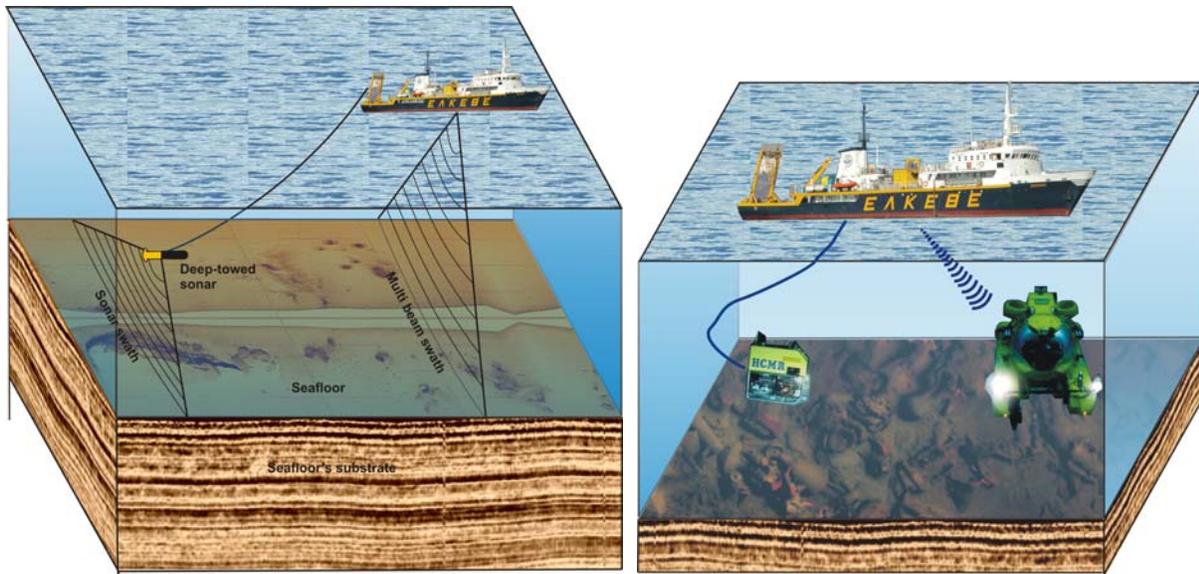


Fig. 1 (left): Simplified, synthetic illustration of the use of remote sensing techniques (deep towed sonar, subbottom profiler, multi beam) from marine research vessels for deep-water archaeological surveys. A side scan sonar image has been used for the seafloor and a section of a seismic subbottom profile for the substrate. The vessel shown is R/V AEGAEO of the Hellenic Centre for Marine Research.

Fig. 2 (right): Synthetic illustration of the operation of remotely operated vehicle (ROV Super Achilles) and submersible (Thetis) on an ancient shipwreck. A section from the photomosaic of a 4<sup>th</sup> century BC wreck off Chios Island, Greece (Foley et al, 2009) has been used for the illustration of the seafloor.

The imperative to investigate shipwrecks at full ocean depths derives from the new views of ancient cultures they present. Beyond scuba diving depth and wave-induced disruptions, deep waters hold vast numbers of shipwrecks containing well-preserved artifacts (Ballard et al., 2001; Ballard et al., 2000; Ballard et al., 2002; McCann & Freed, 1994). Significant advancements has been made in the last twenty years in the design, engineering and capabilities of underwater vehicles and sensors and have enabled very detailed imaging of the deep seafloor, detection and characterization of anthropogenic objects, visual investigation and sampling. Deep towed or autonomous underwater vehicles, equipped with high resolution side scan sonars, combined or not with chirp profilers and multi beam systems enable detailed exploration and imaging of the seafloor. Powerful underwater vehicles (submersibles, ROVs, AUVs) equipped with high definition cameras, sampling tools and various sensors are capable in producing high definition photomosaics of the wrecks and collecting artifacts.

Opposite to the deep water archaeological research, very few archaeological surveys in the shallow environment of the coastal zone or shallow lakes have incorporated remote sensing techniques for the detection, exploration or mapping of archaeological remains. Conventional archaeological survey, mapping and detailed drawing of remains on the seafloor are carried out by diving archaeologists with limited or no access to state of the art seafloor mapping facilities and equipment, commonly available in oceanographic and marine geological institutions. The lack in communication between the underwater archaeology community and the marine geosciences and engineering communities may be one of the reasons for the limited use of remote sensing techniques in shallow underwater archaeological research.

The second reason is that the majority of the available marine survey techniques are designed for use in the stable environment of deep waters while their operational capabilities in the very dynamic shallow waters are very limited. Therefore, most of the times these techniques have been used in very shallow waters they failed to collect data of similar quality to the data collected in deep waters. In addition to the operational limitations, the use of the remote sensing techniques in shallow waters has been proved logistically too complicated: the requirements for sufficient power supply for the operation and for relatively large space on the survey vessel for the installation of the various devices make their use inconsistent to the concept of low-budget, shallow-water, archaeological or prehistoric landscape surveys from small vessels. These difficulties have been encountered by many scholars, marine geoscientists and archaeologists, who attempted to explore very shallow sea- or lake-floors by using remote sensing techniques.

### **Shallow water submerged cultural heritage**

What is the significance of the shallow coastal zone for the submerged cultural heritage? Why it is important to survey the shallow seafloor for submerged cultural remains?

Most archaeologists worldwide have ignored, till recently, submerged environments in the belief that it is logistically and technically too difficult to deal with them and that any submerged cultural remains would have not survived the inundation. In contradiction to these arguments, several thousand submerged prehistoric and historic archaeological sites have been found on the European continental shelf and in water depth shallower than 10-12m and many times shallower than 5m from the Baltic to the eastern Mediterranean and the Black Sea during the last 25 years (Bailey, 2004; Bailey & Flemming, 2008; Fischer, 2004; ).

The eustatically driven global sea level rise after the last Ice Age has led to the drowning of numerous prehistoric and historic sites and their preservation in the shallow coastal zone. Regional and local processes like the isostatic rebound (uplift) effect in Northern Europe and the active, vertical tectonic movements (subsidence / uplift) in the Central and Eastern Mediterranean modified the global picture by moving large or small land masses vertically (Flemming, 1998; Harff et al, 2007). Over 2000 Mesolithic and Neolithic settlements 6000-8000 years old have been found on the Baltic seabed, off Denmark, Sweden, Germany and Poland. Neolithic villages, 9000 years old, are located at 10m depth off the coast of Israel while Neolithic and Bronze Age villages have been found in the Black Sea off the Bulgarian coasts. Many younger sites in the date range 5000-10,000 years old have been identified off the Mediterranean coasts. Numerous Classical, Hellenistic, Roman and younger archaeological sites, predominantly harbor installations and constructions are scattered all along the European shoreline at depths shallower than 5m with the greater density in the Eastern Mediterranean and Black Sea.

Most of the known submerged shallow sites in all sea areas have been discovered by chance. Some of them are exposed on the shallow seafloor, others are seasonally covered by coastal sediments or have been recently exposed due to progressing coastal erosion while many others, not yet discovered, may rest for centuries and millennia below the seafloor, permanently buried by recent and Holocene coastal deposits. In addition to the drowned archaeological remains, submerged physical prehistoric landscapes and paleo-sealevel indicators are preserved on or beneath the shallow seafloor.

## Science-driven technological advances for shallow water surveys

The underwater archaeological community, the marine geoscientific and the marine engineering communities are facing a major challenge: to work together with the aim to develop science driven, innovative, non-destructive technologies designed to work in shallow and very shallow waters and able to support high resolution survey, early detection and mapping of archaeological sites and prehistoric landscapes.

In the last years, some attempts have been made to incorporate shallow water parametric multi beam systems, subbottom profilers, side scan sonar, electric resistivity methods operating from small boats or even mounted on small autonomous surface or underwater vehicles. First results are promising but there is still a long way to go till these methods and techniques become operational and standardized.

The necessary first step is to improve mutual understanding between geoscientists, engineers and archaeologists about appropriate methods of investigation and a wider recognition of the need for interdisciplinary research on shallow submerged cultural remains.

The aim will be to establish an innovative methodology for the survey, early detection and mapping of submerged archaeological sites and prehistoric landscapes exposed on or buried beneath the shallow seafloor of the coastal zone or lakebed by developing user friendly, light, portable, “plug-and-play” combined devices designed to operate from small boats and collect ultra high resolution data.

The major goal is to improve knowledge on the investigation methods and the interpretation of underwater geological, palaeoenvironmental and archaeological evidence for the location and preservation conditions of submerged prehistoric and historic human occupation sites and activities, create best practices for the new, interdisciplinary field of marine geoarchaeological research and provide guidance for earth scientists, archaeologists, heritage professionals, government agencies, commercial organizations, policy makers and a wider public.

## References

- Bailey, G.N. 2004. The wider significance of submerged archaeological sites and their relevance to world prehistory. In N.C. Flemming (ed.) *Submarine prehistoric archaeology of the North Sea: Research Priorities and Collaboration with Industry*. London: CBA Research Report 141, pp. 3-10. (ISBN 1-902771-46-X).
- Bailey, G.N. & Flemming, N. 2008. Archaeology of the continental shelf: marine resources, submerged landscapes and underwater archaeology. *Quaternary Science Reviews* 27 (23–24), 2153–65.
- Ballard, R. D., McCann, A. M., Yoerger, D., Whitcomb, L., Mindell, D., Oleson, J., Singh, H., Foley, B., Adams, J., Piechota, D., and Giagrande, C., 2000, The discovery of ancient history in the deep sea using advanced deep submergence technology, *Deep-Sea Research I* 47: 1591-1620
- Ballard, R. D., Hiebert, F. T., Coleman, D. F., Ward, C., Smith, J. S., Willis, K., Foley, B., Croff, K., Major, C., & Torre, F. (2001). Deepwater archaeology of the Black Sea: The 2000 season at Sinop, Turkey. *American Journal of Archaeology*, 105(4), 607–623.
- Ballard, R. D., Stager, L. E., Master, D., Yoerger, D., Mindell, D., Whitcomb, L. L., Singh, H., & Piechota, D. (2002). Iron age shipwrecks in deep water off Ashkelon, Israel. *American Journal of Archaeology*, 106(2), 151–168.

- Barto Arnold III, J., Oertling, T. J., and Hall A. W., 1999, The *Denbigh* project: initial observations on a Civil War blockade-runner and its wreck-site, *IJNA* 28: 126-144.
- Blondel, P. and Pouliquen, E., 2004, Acoustic textures and detection of shipwreck cargo – example of a Roman ship near Elba, Italy, in T. Akal, R.D. Ballard, and G.F. Bass (eds), *Proceedings of the Conference on: The application of recent advances in underwater detection and survey techniques to underwater archaeology*, 135-142. Bodrum, Turkey.
- Fischer, A. (2004) Submerged Stone Age—Danish examples and North Sea potential. In N. C. Flemming (ed.) *Submarine prehistoric archaeology of the North Sea: research priorities and collaboration with industry*, 23–36. CBA Research Report 141. York, English Heritage and Council for British Archaeology.
- Flemming, N. C. (1998) Archaeological evidence for vertical movement on the continental shelf during the Palaeolithic, Neolithic and Bronze Age periods. In I. S. Stewart, C. Vita-Finzi (eds.) *Coastal tectonics*, 129–46. London, Geological Society Special Publications 146.
- Foley, B.P., K. DellaPorta, D. Sakellariou, B. Bingham, R. Camilli, R. Eustice, D. Evagelistis, V. Ferrini, M. Hansson, K. Katsaros, D. Kourkoumelis, A. Mallios, P. Micha, D. Mindell, C. Roman, H. Singh, D. Switzer, T. Theodoulou, 2009. New Methods for Underwater Archaeology: The 2005 Chios Ancient Shipwreck Survey. *HESPERIA* 78 (2009), pp. 269–305 (publ. by the American Archaeological School at Athens).
- Harff, J, Lemke, W, Lampe, R, Lüth, F, Lübke, H, Meyer, M, Tauber, F, Schmölcke, U. (2007) The Baltic Sea coast – a model of interrelations among geosphere, climate, and anthroposphere. *Geological Society of America*, 133–42. Special Paper 426.
- McCann, A. M., & Freed, J. (1994). Deep water archaeology: A late Roman ship from Carthage and an ancient trade route near Skerki Bank off northwest Sicily. *Journal of Roman Archaeology*, Supplementary Series, 13.
- Quinn, R., Cooper, A. J. A. G., and Williams, B., 2000, Marine geophysical investigation of the inshore coastal waters of Northern Ireland, *IJNA* 29: 294-298.
- Quinn, R., Breen, C., Forsythe, W., Barton, K., Rooney, S., and O'Hara, D., 2002. Integrated geophysical surveys of the French Frigate *La Surveillante* (1797), Bantry Bay, Co. Cork, Ireland, *Journal of Anthropological Science* 29: 413-422.
- Papathodorou, G., Geraga, M. and Ferentinos, G., 2005, The Navarino Naval Battle Site, Greece – an integrated remote-sensing survey and a rational management approach, *IJNA* 34: 95-109
- Søreide, F., and Jasinski, M. E., 1998, The *Unicorn* wreck, central Norway – underwater archaeological investigations of an 18<sup>th</sup>-century Russian pink, using remotely-controlled equipment, *IJNA* 27/2: 95-112.
- Sakellariou, D. (2007) Remote sensing techniques in the search for ancient shipwrecks: how to distinguish a wreck from a rock in geophysical recordings. *Bulletin of the Geological Society of Greece* vol. XXXVII/4, p. 1845-1856.
- Sakellariou, D., Kourkoumelis, D., Georgiou, P., Micha, P., Mallios, A., Theodoulou, T., Kapsimalis, V., and Dellaporta, K., 2007. Searching for ancient shipwrecks in the Aegean Sea: The discovery of *Chios* and *Kythnos* Hellenistic wrecks with the use of marine geological-geophysical methods. *Int. J. Nautical Archaeol.*, 36/2, p. 365-381.