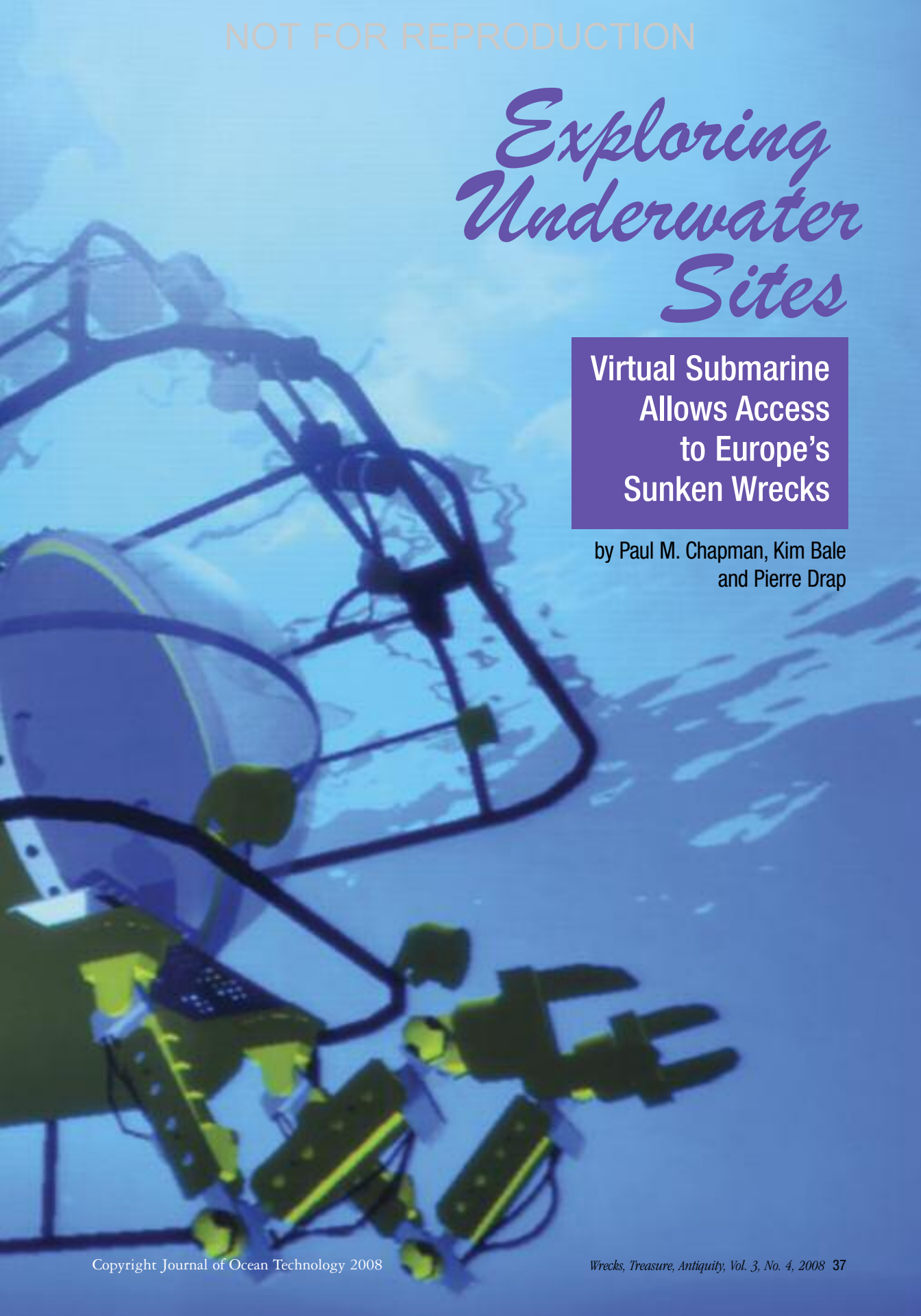
UNIVERSITY OF HULL

Exploring Underwater Sites

Virtual Submarine Allows Access to Europe's Sunken Wrecks

by Paul M. Chapman, Kim Bale and Pierre Drap



Computer graphics have been used successfully for a number of years to help improve our understanding of both offshore activities and land based archaeological sites. 'Marine visualization' has traditionally been dominated by the oil and gas industries, focusing on activities such as pipeline and debris clear-up operations, with limited work on shipwreck visualization. Previous work by the authors relating to shipwreck visualization has focused on relatively modern vessels such as the SS Richard Montgomery*, which sank in Sheerness, UK, August 1944. This article introduces the reader to the VENUS project (Virtual ExploratioN of Underwater Sites), a multidisciplinary project funded by the European Commission that focuses on procedures for surveying and visualizing maritime archaeological sites.*

The VENUS project aims to provide accurate three-dimensional immersive reconstructions of underwater archaeological sites providing virtual access to all. Valuable submerged archaeological sites such as shipwrecks are continually jeopardized by activities such as trawling that destroy the crucial surface layer of the site. The preservation of these wrecks, through the generation of thorough and exhaustive 3D records, is therefore of the utmost importance. At present, these sites are out of reach to all but a few specially trained archaeologists. By recreating the sites as interactive computer generated virtual environments, we permit both experts and the general public to study these important pieces of cultural heritage in a safe, cost-effective and pedagogical (learning) environment.

VENUS is composed of five objectives:

- Defining a series of best practices and procedures for collecting and storing data from the underwater archaeological site in an efficient, economic and safe manner;
- The survey of wrecks (at various depths) using autonomous underwater vehicles (AUVs), remotely operated vehicles (ROVs) and various techniques of data acquisition (sonar + photogrammetry);
- The provision of software tools (to archaeologists) for signal, data and information processing and management. These tools will allow the extraction of digital models and management of confidence levels of the collected data;
- The generation of software tools for the immersive interaction and visualization of the collected data. These tools will provide archaeologists with an improved insight into the data and the general public with simulated dives to the site;
- Disseminating the results to archaeologists and the general public via the project website (www.venus-project.eu).

Before the advent of the first civilizations in the eastern Mediterranean, the seas laid empty for millennia before becoming the main stage for the conflicts and discoveries of the ancient world. From Marathon to Lépante, from the Punic Wars to the Crusades, the Mediterranean Sea is full of historical artifacts from the dead world. Beyond its current political divisions, the Mediterranean Sea is divided into three cultural groups: the Christians, Muslims and Greek Orthodox, each of which are linked to Rome, Carthage and Constantinople. Before the advent of the first civilizations in the eastern Mediterranean, the Romans, despite imposing their will and political unification on the Mediterranean world, did not erase these cultural differences, choosing instead to use its internal seas as a gigantic trading crossroad: oils from Spain, corn from Egypt, wines from Algeria and Rhodes, slaves from Nubia, ceramics from Gallia, marble from Greece and bronze from Italy.

Amongst the varied selection of goods that travelled the Mediterranean Sea during the reign of the Roman Empire was a great quantity of Portuguese amphorae. These amphorae, used to carry the famed Lusitanian fish sauce, were shipped far and wide from the Pillars of Hercules to the Rhine frontiers.

Today, underwater archaeology provides access to Christian, Muslim and Greek Orthodox shipwrecks, complex works that testify to the wealth and diversity of past civilizations. By combining new methods of excavation, data capture and visualization, VENUS hopes to provide the opportunity for archaeologists and the

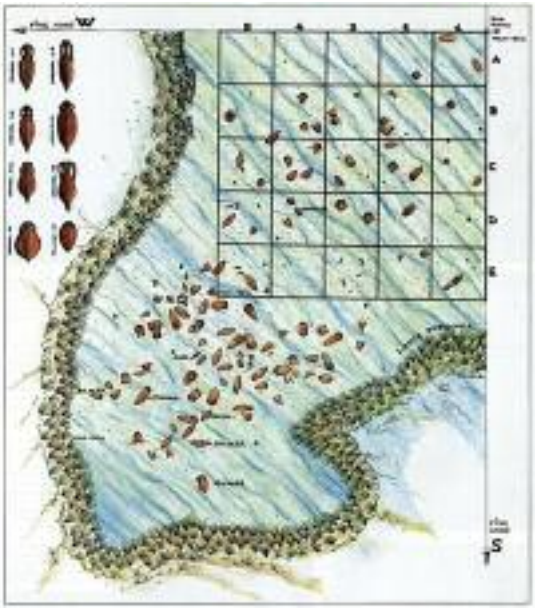


Figure 1: 1989-1991 Claudio Ruffilli's original drawing of the Pianosa site (a hand drawn survey and record of the 'Scoglio della Scola' site in Pianosa).

general public to study these sites and improve our understanding of these important trade routes for many years to come.

Case Study: Pianosa, Italy

The underwater archaeological site of Pianosa, discovered in 1989 by divers (Giuseppe Adriani and Paolo Vaccari), is located close to the Scoglio della Scola, off the east coast of the island at a depth of 35 m. The site is characterized by the presence of about one hundred amphorae of different origin and epoch. The various amphorae range from Dressel 1A (100 BC) to Beltran 2B (late middle of the second century) and Dressel 20 (late first to the early third century AD) and include some African amphorae. The site was surveyed in 2001 by the Nucleo Operativo Subacqueo (MIBAC-SBAT) divers. This survey concluded that the site had remained completely intact and undamaged and was the first archaeological site to be surveyed by the VENUS consortium.

As the depth of the site (35 m) did not allow for divers to be submerged for long periods of time, robotic equipment such as ROVs with sonar transducers and optical cameras were used to survey the majority of the site.

Figure 1 shows the pre-existing site documentation that was available to the VENUS research team. This excellent drawing by Claudio Ruffilli is typical of archaeological documentation for both marine and land based archaeological sites.

The Pianosa survey involved a significant interdisciplinary collaboration and focused on the collection of geo-referenced optical data for photogrammetric reconstruction. The data collection was carried out by divers from the VENUS partner CNRS (French National Centre for Scientific Research) and by Integrated Systems for Marine Environment (ISME) which provided a ROV (Phantom S2) equipped with a high resolution underwater camera developed by another VENUS partner, COMEX (Figure 2). After a detailed sonar and photogrammetric

Figure 2: Surveying Pianosa with ROV.

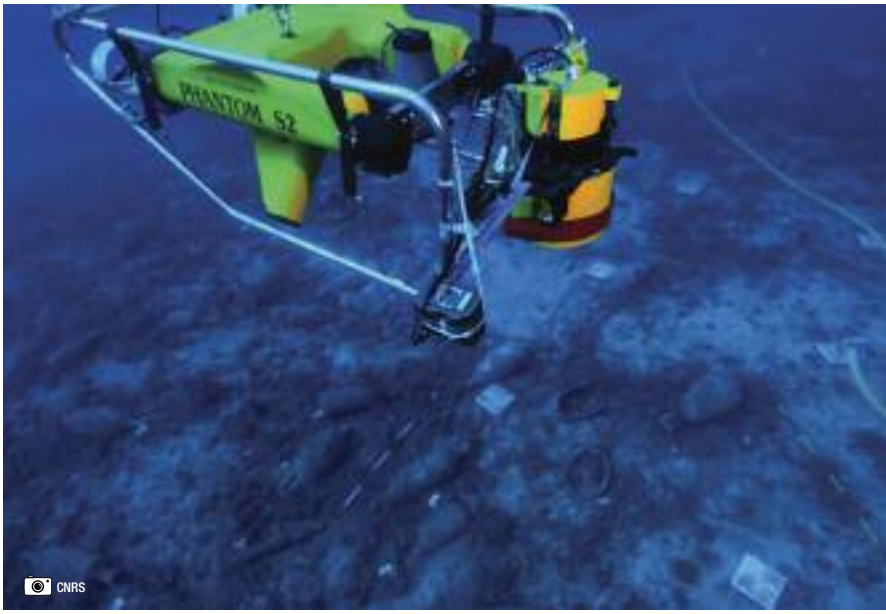


Figure 3: VENUS-PD permits the user to take control of an underwater submersible and pilot the vessel down to accurate 3D reconstructions of archaeological sites.

survey, the processed data was then passed to the SimVis research group for visualizing in their immersive public demonstrator. Figure 2 shows a photograph of the archaeological site during the survey. Fifteen concrete markers were used as a visual guide for the ROV pilot. For a more detailed explanation of the sonar and photogrammetric process, see www.venus-project.eu.

The VENUS Public Demonstrator

Due to significant experience in the development of marine visualization, SimVis was tasked with managing the virtual reality public demonstrator (VENUS-PD). The goal of this simulator was to take data collected from the Pianosa survey (bathymetric terrain data, artifact type, position, etc.) and generate an accurate first person perspective of the entire dive process, from the survey vessel down to the archaeological site of Pianosa at a depth of 35 m. Throughout the entire dive experience, the user maintains full control over the submarine and is able to manipulate the vessel with full six degrees of freedom using a commercially available game controller such as the XBox 360 wireless gamepad. Figure 3 shows Kim Bale from SimVis launching the submersible prior to the dive down to the Pianosa archaeological site. At the touch of a button he is able to switch to first person perspective to experience and control the dive from the cockpit.

VENUS-PD includes a storyboard feature which is triggered by certain events in the dive process. For example, when the user finally arrives at the archaeological site, a storyboard explaining the history of Pianosa is displayed including a photograph of a replica of the original trading vessel (Figure 4). This storyboard feature has turned out to be a useful technique for explaining to the general public important elements of the site and the importance of the VENUS project.

VENUS-PD was developed using OpenSceneGraph, an open source, high

Figure 4: Recreated wreck similar to the Pianosa wreck (200AD). Model of Grand Ribaud F Etruscan wreck, 2000.

Figure 5: VENUS-PD approaching the Pianosa site.

performance 3D graphics toolkit (www.openscenegraph.org). Significant advances in graphics card technology (driven by the games industry) have permitted real-time per-pixel rendering of the underwater site including realistic ocean surface rendering, fogging (used for increased depth perception), silt effects, lighting effects (replicating light rays as they travel through the water column onto the seabed) and underwater biological life including fish and plants. These special effects all improve the pilot's sense of immersion and improve the authenticity of the virtual Pianosa site. Consequently, when the user locates the 200AD Pianosa amphorae (Figure 5 and Figure 6), they are confronted with an extremely accurate representation of the archaeological site as surveyed by the VENUS team in December 2006. If the real site is destroyed in the future, through trawling or other activities, it is comforting to know that the 3D digital copy will remain and continue to educate and captivate members of the general public.

Although the actual vessel itself would have disintegrated hundreds of years ago, the VENUS-PD software allows the user to visualize what the wreck would have looked like shortly after sinking (Figure 1). Currently the only artifacts remaining at the Pianosa site are the amphorae cargo. Visualizing an accurate model of the original vessel provides the general public with an improved understanding of the size and shape of the original trading vessel.

The UK SimVis research team has focused on the public demonstrator and realistic rendering of the site. VENUS researchers at the University of Evry, Paris, are developing visualization tools that import the same data but have targeted archaeologists as the end users. In this instance, the user requirements for the software are very different and the focus is on gaining insight into the data from a more scientific and archaeological perspective and not generating realistic visualizations of the site.

Future Developments

The VENUS consortium has recently completed two more archaeological marine surveys. The first site, Barco da Telha, is in Sesimbra, Portugal, and lies at a depth of 55 m. The second survey is a Roman wreck, Port-Miou C, and lies at a depth of 105 m in front of the limestone coast of the Calanques, between Marseilles and Cassis. The new data collected from the Portuguese and French sites will soon be imported into VENUS-PD and permit users to explore all three of the digital copies of these fascinating underwater sites.

For more information on the VENUS project, see www.venus-project.eu.

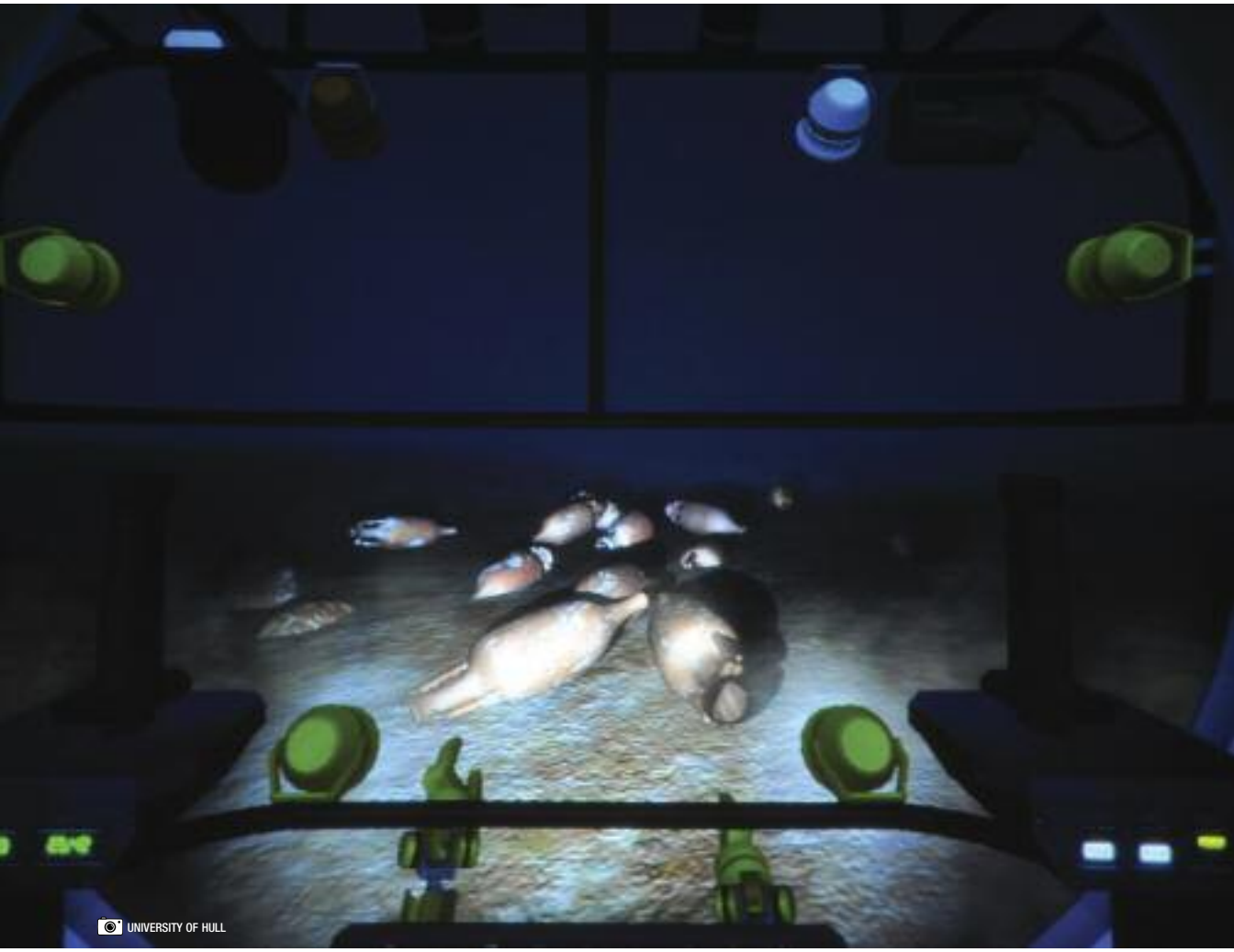


Figure 6: VENUS-PD permits the user to pilot a virtual submarine down to an accurate model of the archaeological site.

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Kim Bale is a Research Assistant based within the SimVis Research Group at The University of Hull. He holds BSc and MSc degrees in software engineering and computer graphics and is currently in the final year of his PhD investigating techniques for the visualization of multivariate time-series datasets. His recent research is focused on seabed visualization, realistic real-time rendering techniques and information visualization for medical applications.

Pierre Drap is currently Researcher in CNRS (French National Council for Scientific Research). His scientific interests are mainly concerned with close range photogrammetry and knowledge representation with a particular focus on underwater archaeology and more generally in cultural heritage.