Project co-financed by the European Regional Development Fund

UNDER THE AUSPICES OF H.E. THE PRESIDENT OF THE HELLENIC REPUBLIC MR. PROKOPIOS PAVLOPOULOS

International Conference in Management of Accessible Underwater Cultural and Natural Heritage SItes:

"DIVE IN BLUE GROWTH"

16-18 October 2019
Athens, Acropolis Museum, Auditorium

CONFERENCE PROCEEDINGS

ISBN 978-618-84442-2-5

Introduction

The International Conference in Management of Accessible Underwater Cultural and Natural Heritage Sites, *"Dive in Blue Growth"*, was organized by the University of Patras in collaboration with Region of Thessaly, Ephorate of Underwater Antiquities, ATLANTIS Consulting and the active participation of BLUEMED partners, under the auspices of H.E. the President of the Hellenic Republic Mr. Prokopios Pavlopoulos, in Acropolis Museum, in Athens, from 16 to 18 October 2019.

Coastal areas and islands of the Mediterranean are tourism-based economies with key underwater assets that are vulnerable to extreme climatic conditions. They face common challenges: a) lack of coordinated policies, methods and tools to support sustainable economic development, b) ineffective protection of underwater heritage and inability to use it for sustainable tourism development, c) insufficient measures to tackle impacts of extreme climatic conditions.

BLUEMED aims to protect and preserve in a unified manner the underwater natural and cultural heritage of the Mediterranean, to help coastal and island economies prosper through a sustainable blue model for tourism development, and to protect our marine ecosystem. BLUEMED is part of Interreg MED 2014-20 Programme, co-financed by the European Regional Development Fund.

The overall success of the Conference is based on the warm welcome that conference subjects received and the high level of participation, as more than 300 people from 11 countries, from Europe, Asia and the America participated in the conference.

The three productive days of the Conference, in which 55 speakers from all over the world participated, was a great opportunity for underwater archaeologists, public organizations, local governments, universities, marine researchers, NGOs, tourist organizations, diving park/dry dive managers, and underwater industry players to exchange views on problems and solutions for underwater natural and cultural heritage.

Roberto Petriaggi, Istituto Superiore per la Conservazione ed il Restauro (ISCR) consultant for Restoring Underwater Project, Dimitris A. Pados, Charles E. Schmidt Eminent Chair Professor of Engineering and Computer Science in the Florida Atlantic University and Christos Economou, Head of the Unit Sea basin strategies in DG MARE, specialist Maritime Regional Cooperation and Maritime Security participated as Keynote Speakers in the International Conference.

During the conference different perspectives were discussed in the 3 very interesting conference topics:

- Management and protection of accessible Underwater Cultural Heritage sites and diving parks

- Initiatives for sustainable Blue tourism through accessible UCH sites and diving parks
- Technologies for offering dry dive experiences to non-drivers.

Conference participants had the opportunity to live a dry dive experience in BLUEMED pilot sites with the Virtual Reality glasses and equipment that University of Calabria provided.

In the following, you can find the submitted full papers that were presented during the Conference.

For more information about *"Dive in Blue Growth"* Conference visit the official website of BLUEMED (bluemed.interreg-med.eu).

Acknowledgement

We express our sincere gratitude to all who have actively contributed towards the success of this International Conference and particularly the authors for their contributions. We are indebted to all who assisted in the organizing effort.

Conference Chair

Dr. Kalamara Pari
Director of the Ephorate of Underwater Antiquities
Hellenic Ministry of Culture and Sports

Dr. Davidde Barbara
Director of the Underwater Archaeology Operation Unit (NIAS - Nucleo per gli Interventi di Archaeologia Subacquea) at the Istituto Superiore per la Conservazione ed il Restauro -Superior Institute for Conservation and Restoration (ISCR)
Italian Ministry of Cultural Heritage and Activities (MiBAC

Committees

Scientific Program Committee

Dr. Pari Kalamara

Dr. Barbara Davidde

Dr. Yorgos Stephanedes

† Sebastiano Tusa

Dr. Fabio Bruno

Dr. Irena Radic Rossi

Organizing Committee

Aggela Veneti

Angelos Manglis

Dimitra Chondrogianni

Irini Kafousia

Anastasia Mitsopoulou

Michela Ricca

Valentina Puglisi

Salvatore Medaglia

Public Relations Committee

Stjepan Rezo

Consuelo Garcia

Yianna Samuel – Rhoads

Nikola Miskovic

Welcoming Committee

Panagiota Saranti

Anastasia Mitsopoulou

Michela Ricca

Zoi Pataki

In memory of Sebastiano Tusa who tragically passed away in the Ethiopian Airlines plane crash (Sunday March 10th, 2019).

Project co-financed by the European Regional Development Fund

UNDER THE AUSPICES OF H.E. THE PRESIDENT OF THE HELLENIC REPUBLIC MR. PROKOPIOS PAVLOPOULOS

INTERNATIONAL CONFERENCE IN MANAGEMENT OF ACCESSIBLE UNDERWATER CULTURAL AND NATURAL HERITAGE SITES:

"DIVE IN BLUE GROWTH"

ATHENS, GREECE
16-18 October 2019
ACROPOLIS MUSEUM, AUDITORIUM

CONFERENCE AGENDA

DAY 1- 16 October 2019

09.00 -09.30 REGISTRATION OF PARTICIPANTS

09:30 -10.00 OPENING AND WELCOME REMARKS
Yorgos J. Stephanedes, *Professor, Civil Engineering, BLUEMED Scientific Coordinator at University of Patras*
Kostas Agorastos, *Regional Governor of Thessaly*

Lina G. Mendoni, *Minister of Culture and Sports*

Prof. John Chrysoulakis, *Secretary General for Greeks Abroad, Ministry of Foreign Affairs*

Angela Gerekou, *President of Board of the Greek National Tourism Organization (GNTO)*

Luigi Ficacci, *Director of the Istituto Superiore per la Conservazione ed il Restauro, Ministry of Cultural Heritage and Activities (MiBAC)*

10.00 -10.30 KEYNOTE SPEECH

The "Restoring Underwater Project": how everything started
Dr. Roberto Petriaggi, Underwater Archaeologist, Consultant of the Istituto Superiore per la Conservazione ed il Restauro for the Restoring Underwater Project

10.30 -12.00 **Management and protection of accessible Underwater Cultural Heritage (UCH) sites and UCH diving parks**
Session Chair: Yorgos J. Stephanedes

Reflections on the prospects and the institutional framework of the organization of the Accessible Underwater Archaeological Site: starting with BLUEMED
Pari Kalamara

Touristic potential of the Supetar, Cavtat, underwater archaeological zone
Irena Radić Rossi, Katarina Batur

Sustainable management and protection of accessible Underwater Cultural Heritage sites; global practices and bottom-up initiatives
Angelos Manglis, Anastasia Fourkiotou, Dimitra Papadopoulou

Protecting marine biodiversity at accessible Underwater Cultural Heritage (UCH) sites and UCH diving parks
Yianna Samuel, Yiannos Mylonas, Stavros Stylianou, Gregory Konnaris, Pavlos Diplaros, Georgios Fyttis

12.00 -12.30 ***Coffee break***

12.30 -14.00 **Technologies for offering dry dive experiences to non-divers**
Session Chair: Fabio Bruno

Diving into a sea of history. Communicating the Underwater Experience in a Museum: An Analysis of ARQVA's Interactive Media
Antonio Cosseddu

Raising the awareness about underwater archaeological heritage through Edutainment and Virtual/Augmented Reality
Fabio Bruno, Marco Cozza , Maurizio Mangeruga , Dimitrios Skarlatos , Panagiotis Agrafiotis , Barbara Davidde Petriaggi , Roberto Petriaggi , Selma Rizvic , Fotis Liarokapis

Results of the "SOMMERGIAMOCI" project in the MPA Gaiola underwater park
Maurizio Simeone, Paola Masucci, Caterina De Vivo

An innovative platform for virtual underwater experiences targeting the cultural and tourism industries
Paraskevi Nomikou, Konstantinos Karantzalos, Andreas El Saer, George Pehlivanides, Panagiotis Tsoris, Christos Stentoumis, Anna Dura, Giotis Ioannidis, Michalis Sarantinos, Varvara Antoniou, Othonas Vlassopoulos, George Katopodis, Katerina Plessa, Ilias Kalisperakis, Konstantina Bejelou, Konstantinos Monastiridis

Deep-Sea archaeology in the Exclusive Economic Zone (EEZ) of Cyprus
Achilleas Iasonos

14.00 -15.00 ***Light lunch and networking***

15.00 -15.30 KEYNOTE SPEECH

Financing Opportunities for Blue Growth

Christos Economou, Unit Sea basin strategies, DG MARE, Maritime Regional Cooperation and Maritime Security

15.30 -17.00 **Initiatives for sustainable Blue tourism through accessible UCH sites and diving parks**

Session Chair: Barbara Davidde Petriaggi

Technological protection of an underwater archeological site; a newly discovered Roman shipwreck from the 1st century BC, on the island of Pag
Vedran Dorušić, Matko Čvrljak

Theraic Sea: A bottom-up initiative for marine conservation and sustainable living
Maria Salomidi, Sylvaine Giakoumi, Vangelis Paravas, Pierre-Yves Cousteau

Towards the Creation of Accessible Underwater Archaeological and Historical Sites in Fournoi and Leros (Eastern Aegean): an Interreg VA, Hellas - Cyprus 2014 -2020 program under Development
George Koutsouflakis

Project: blue HOMER
Marko Mišić, Toni Mandušić

17.00 -18.30 **Management and protection of accessible UCH sites and diving parks – Case studies**

Session Chair: Angelos Manglis

The studies on the underwater cultural heritage of Istanbul from the Anatolian side to the Princes' islands
Ahmet Bilir, Mustafa Şahin

Accessing Underwater Cultural Heritage on dry feet: some Sicilian case studies
Francesca Oliveri

Preservation, management and protection of Tangible Underwater Cultural Heritage of Anfeh (North Lebanon)
Nadine Panayot Haroun

Community cultural infrastructure: sustainability of the underwtaer cultural heritage of Bocachica, Cartagena
Liliana Patricia Rozo Pinzón

The in situ preservation as a priority option. Experiments in the upper Adriatic Sea
Massimo Capulli

18.30 -20.00 ***Networking hour***

10.00 -18.00 PARALLEL ACTIVITY

Dive in Virtual Reality!
Live a Virtual Diving experience in BLUEMED pilot sites #VR #drydive
Supported by 3D Research s.r.l.

DAY 2- 17 October 2019

09.00 -09.30 REGISTRATION OF PARTICIPANTS

09.30 -11.30 **Management and protection of accessible Underwater Cultural Heritage (UCH) sites and UCH diving parks**
Session Chair: Pari Kalamara

How the Greek pilot sites were selected and the creation of the Knowledge Awernsess Centers (KACs) in Greece
Angeliki G. Simosi

EGNAZIA: Enhancement and use of submerged Structures along the coast guided diving and snorkeling tours
Gianpaolo Colucci

Change behavior and raise awareness about the Adriatic's underwater treasures as common goods: the UnderwaterMuse Project
Rita Auriemma, Carlo Beltrame, Ivanka Kamenjarin, Danilo Leone, Ivan Šuta, Maria Turchiano

MUSAS: an innovative project for the enhancement of the Underwater Cultural Heritage
Barbara Davidde Petriaggi, Michele Stefanile, Marco D'Agostino, Sandra Ricci, Carlotta Sacco Perasso

Linking WWI and II Underwater Cultural Heritage to Sustainable Development in the Mediterranean: An Integrated Participatory Strategic Planning Approach
Vasilike Argyropoulos, Anastasia Stratigea

Tourism experience in the Underwater Archaeological heritage site: managing emotional state to increase archaeological diving tourism in the Sunken City of Baiae
Cristina Canoro, Francesco Izzo, Barbara Masiello

11.30 -12.00 KEYNOTE SPEECH

Autonomous underwater localization, communication, and networking
Dr. Dimitris A. Pados, Charles E. Schmidt Eminent Chair Professor of Engineering and Computer Science, Florida Atlantic University

12.00 -12.30 ***Coffee break***

12.30 -14.30 **Initiatives for sustainable Blue tourism through accessible UCH sites and diving parks**
Session Chair: Angelos Manglis

Diving and Underwater Cultural Heritage: a reasonable or a forced marriage? The Greek case
Dimitris Kourkoumelis, Alexandros Tourtas

Protection and development of the Lake Bolsena underwater heritage
Antonia Sciancalepore, Edigio Severi, Maria Letizia Arancio, Barbara Barbaro

Cartographic Documentation and Proposed Criteria towards the Protection and Preservation of Wrecks from the Great War in the Greek Seas
Elpida Katopodi, Kimon Papadimitriou

The National Marine Park of Alonnisos Northern Sporades: an area of rich natural and cultural heritage facing human and climatic pressures
Dimitris Poursanidis, Vasiliki Vasilopoulou

A fresh (water) case study: the time travel under water project in Lake Attersee
Cyril Dworsky

A framework for underwater cultural heritage and environmental services evaluation
Lydia Stergiopoulou

S/S Burdigala, former Schnelldampfer Kaiser Friedrich (1897-1916)
Dimitris Galon

14.30 -15.30 ***Light lunch and networking***

15.30 -18.30 **Management and protection of accessible Underwater Cultural Heritage (UCH) sites and UCH diving parks**
Session Chair: Elpida Hadjidaki, Yianna Samuel

Performance management in Underwater Cultural Heritage (UCH) site, UCH diving parks and Knowledge Awareness Centers (KACs)
Dimitra Chondrogianni, Yorgos J. Stephanedes, Panagiota-Georgia Saranti, Irini Kafousia

SUB: THE WRECKS in THE GREEK SEAS, 1830-1951. The Underwater Heritage of Navy's Shareholding Fund And Mariners' Retirement Fund
Panagiotis Tripontikas

Management and protection of a little known underwater archaeological site: the case of the "Roman Villa of the Dolia" in Ancient Epidaurus; past experience and future prospects
Barbara Davidde Petriaggi, Panagiota Galiatsatou, Angelos Tsompanidis

L'Anfora ASD, the sustainable tourism and use of submerged archaeological sites in Apulia
Gianpaolo Colucci, Paola Palumbo

Japanese Shipwreck and Diving Tourism in Sangihe Islands Indonesia
Sultan Kurnia Alam Bagagarsyah

The Faro Convention and the sustainable valorization of the underwater heritage. Case studies and projects in the Adriatic and Ionian Sea
Rita Auriemma

Perspectives and obstacles for accessible underwater archaeological sites. The case of Crete
Theotokis Theodoulou

Public Access to Underwater Archaeological Sites. Enjoying and Protecting our Maritime Heritage
Carles Aguilar

"Hippocampus" the Microscopic Mythical Dragon of the Sea
Vasilis Mentogiannis

10.00 -18.00 PARALLEL ACTIVITY

Dive in Virtual Reality!
Live a Virtual Diving experience in BLUEMED pilot sites **#VR #drydive**
Supported by 3D Research s.r.l.

DAY 3- 18 October 2019

09.00 -09.30 REGISTRATION OF PARTICIPANTS

09.30 -11.30 **Technologies for offering dry dive experiences to non-divers**
Session Chair: Fabio Bruno

A low cost equipment and SFM software photogrammetric survey of two shipwrecks in the sea area of Methoni, Southwestern Greece
George Michailidis

Operating contemporary recreational submersibles in Kea's Underwater Historic Park
Ioannis Tzavelakos

Reconstructing a submerged villa maritima: the case of the villa dei Pisoni in Baia
Barbara Davidde Petriaggi, Michele Stefanile, Roberto Petriaggi, Fabio Bruno, Raffaele Peluso, Marco Cozza

Opto-acoustic 3D Reconstruction for Virtual Diving on the Peristera Classical Shipwreck
Fabio Bruno, Antonio Lagudi, Matteo Collina, Salvatore Medaglia, Pari Kalamara, Dimitris Kourkoumelis, Nikola Miskovic, Dula Nad, Nadir Kapetanovic, Mato Markovic

Remotely operated group of vehicles for underwater scientific exploration and intervention
Lorenz E. Baumer, Yanis Bitsakis, Mathias Buttet, Eftstratios Charchalakis, Alessia Mistretta, Alexandros Sotiriou

Monitoring and protection of accessible underwater cultural heritage
Siarita Kouka, Paraskevi Nomikou, Konstantinos Karantzalos, Aikaterini Tagonidou

11.30 -13.30 **Initiatives for sustainable Blue tourism through accessible UCH sites and diving parks**
Session Chair: Yianna Samuel

In situ conservation of cannons in marine environment: cathodic protection, cleaning treatment and coverage with geotextiles
Flavia Puoti, Barbara DaviddePetriaggi, Marco Ciabattoni, Claudio Di Franco

Underwater Archaeological Sites as a touristic and educational resource. The Isla Grosa Project
Carlota Pérez-Reverte Mañas, Felipe Cerezo-Andreo

Western Black Sea underwater cultural tourist routes
Preslav Peev

New institutions for diving tourism: Diving Parks, Archaeological Diving Parks, Modern Shipwrecks & Implementation opportunities and problems in Greece
Thanassis Stathis, Dimitris Markatos, Kostas Koutsis

Creation of a virtual museum and a diving park east of the island of Lemnos on the site of the wreck of the Svyatoslav ship
Sergey Fazlullin, Ivan Gorlov, Yury Tkachenko, Sergey Khokhlov, Michael Bardashov, Rolan Sadekov

Integrated management plan for the preservation and promotion of cultural and natural environment at Pavlopetri (Elafonissos, Greece)
Despina Koutsoumba, Stamatis Zogaris, Ioannis Kapakos, Maria Salomidi, Stergiopoulou Lydia

13.30 -14.00 CONCLUSIONS
Moderator: Dimitra Chondrogianni

Fabio Bruno, Barbara Davidde Petriaggi, Pari Kalamara, Angelos Manglis, Yianna Samuel, Yorgos J. Stephanedes

Table of Contents

Reflections on the perspectives and the institutional framework of the organization of the Accessible Underwater Archaeological Site: starting with BLUEMED

Dr. Pari Kalamara[1]

[1] Director of the Ephorate of Underwater Antiquities, Archaeologist with Grade A', Greek Ministry of Culture

Abstract: BLUEMED has given to our Service the opportunity to identify gaps and needs for the proper operation of the Underwater Archaeological Sites -and I refer here to sites that can be accessible to visitors using SCUBA- and to mature its choices towards this direction. So, this urged the planning to address issues related with monitoring of the sites, the creation of a framework of principles concerning their operation, the identification of the potentialities and weaknesses of such an operational planning, which will shape future impact on a plethora of sectors (protection of cultural heritage, issues of accessibility, socio-economic area development, development of alternative forms of tourism, etc.).

At the same time, it helped to advance the strategic planning for the coastal, already accessible, underwater archaeological sites, although the latter do not fall under the scope of the program.

More specifically, the related options, the procedures developed for their implementation in practice, any changes required in the existing legal framework and the expected results will be described.

Keywords: Accessible Underwater Archaeological Sites, Institutional framework, strategic planning

In 2016 the Ephorate of Underwater Antiquities (EUA) undertook the European project with the acronym BLUEMED as one of the fourteen partners from five countries, Greece, Italy, Spain, Croatia and Cyprus, and lead partner the Region of Thessaly. The project will be completed by January 2020. BLUEMED aimed to protect and exploit the underwater natural wealth and biodiversity of the Mediterranean, and study, for the first time on a global level, the best practices for the protection and promotion of the underwater cultural heritage and particularly regarding the operation of Accessible Underwater Archaeological Sites (AUAS, or "underwater museums") at ancient shipwrecks. For the Ephorate, its participation in the project has been a unique opportunity to focus on a desired issue for many years, the opening of the underwater cultural heritage to the general public and especially to the diving community, to identify and document the challenges and needs associated with the endeavor, to face the difficulties that arise from it, to seek feasible solutions, to make synergies. Today, that we are standing towards the end of the course, I am allowed to say that the overall experience has been particularly positive, thanks to the excellent cooperation developed between the partners, beneficial also for the Ephorate in various ways. More specifically, the project provided to the Ephorate a interdisciplinary framework of continuous exchange of experiences with the other partners, giving a the boost to focus on the issue «organization and operation of the Accessible Underwater Archaeological Sites», to understand the individual issues involved, to know the practices already

implemented and to design in detail the actions that should complement the opening of the sites for the public. At the same time, it gave rise to the involvement and activation of a large part of the Ephorate's human resources towards this direction, the awareness of the role of different specialties in this endeavor and the cultivation of a sense of teamwork within the service. The common objective was the preparation for the successful operation of the declared from the Hellenic Ministry of Culture and Sports in 2015 as Accessible Underwater Archaeological Sites in the area of Northern Sporades – West Pagasetic (1), as well as the organization of the Knowledge Awareness Centers related to them. The opening of the Accessible Underwater Archaeological Sites to a wide audience falls into the field of recreational diving.

Of course, according to the Law 3028/2002 "On the Protection of Antiquities and Cultural Heritage in general" (Law 3028/2002, article 15) (2) and for the better protection of underwater cultural goods, diving activity with breathing apparatus is explicitly prohibited «unless a permit has been granted by the Minister of Culture which is issued after the Council's opinion» within the declared, demarcated archaeological sites, but also within the protection zones of declared underwater monuments or sites (3). It should be noted that in 2003 (4) all shipwrecks, both ships and aircraft, which sank before the last fifty years, have been characterized as monuments within a protection zone of 300m. around them and are now protected under the provisions of Law 3028.

The Law 3409/2005 on "Recreational diving and other regulations" (Law 3409/2005, article 11, par. 1) (5) however, provided for the first time in Greece the possibility of establishing "underwater museums", at which the visit is carried out under conditions: «... declared archaeological sites can be characterized as underwater museums, where guided diving is permitted, always accompanied by diving guards of antiquities or archaeologists.». It is the same law that changes the general view of the Hellenic state in dealing with «recreational diving» (6), which altogether until then was prohibited throughout our territorial waters and has since been allowed everywhere off the limits of archaeological sites and protected ecological areas.

To make it clearer, in 2005 the possibility is given to organize diving parks within archaeological sites and at the same time to operate «underwater museums», under the conditions that were mentioned above, two provisions that create the proper conditions for the development of diving tourism in the country.

During the period 2012 - 2015, with the Joint Ministerial Decisions of the Ministers of Culture and Merchant Shipping some areas of already declared archaeological sites are characterized as Accessible Underwater Archaeological Sites, for which there is the intention on behalf of the state to open them for the diving public.

Fig.1: Shipwreck in Sapientza, Methoni. Shipwreck of columns, ©MCS-EUA, photo by Panagiotis Gkionis

Fig.2: Shipwreck in Sapientza, Methoni. Shipwreck of sarcophaghi, ©MCS-EUA, photo by Panagiotis Gkionis

Fig. 3: Amphorae from the area Lavrio – Makronissos (2015), © MCS-EUA, photo by Vassilis Mentogiannis

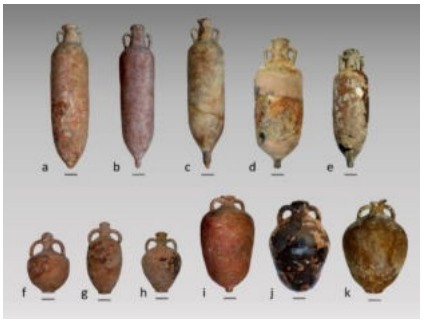


Fig. 4: Amphorae from the area Lavrio – Makronissos (2015), © MCS-EUA, photo by Petros Vezyrtzis

Fig. 5: Shipwreck of Peristera, Alonissos, ©MCS-EUA, photo by Matteo Collina, Univerità della Calabria –DIMEG

They are actually sites of ancient shipwrecks, located in three regions of the country, constituting groups per region that subsequently require a united management, at the areas of Methoni-Pylos Messinia (7), Lavrio-Kea Attica and Cyclades (8) and West Pagasetic – Northern Sporades.(9) Moreover, the total of the accessible cores of the area of West Pagasetic – Northern Sporades has recently been strengthened by the Joint Ministerial Decision of 2019 (10), with four new shipwrecks at the area of Alonissos, rendering the tourist-developmental perspective of the Accessible Underwater Archaeological Sites at the area more dynamic.

Fig. 6: Shipwreck of Peristera, Alonissos, ©MCS-EUA, photo by Matteo Collina, Univerità della Calabria –DIMEG

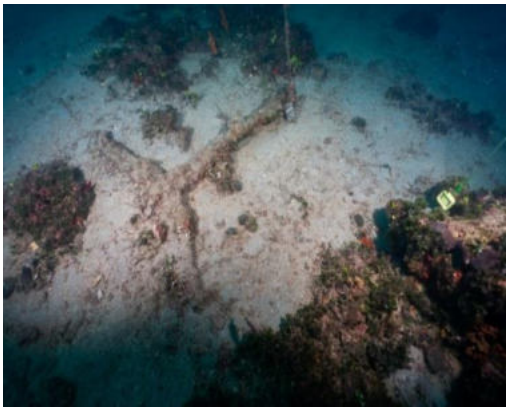


Fig. 7: Shipwreck of Glaros, West Pagasetic, ©MCS-EUA, photo by Matteo Collina, Univerità della Calabria – DIMEG

Fig. 8: Shipwreck of Kikinthos, West Pagasetic, ©MCS-EUA, photo by Matteo Collina, Univerità della Calabria–DIMEG

Fig. 9: Shipwreck of Telegrafos, West Pagasetic, ©MCS-EUA, photo by Matteo Collina, Univerità della Calabria–DIMEG

However, until today, despite the aforementioned legislative and administrative arrangements, the pressing demands of the diving community and the in principle positive disposition of the involved public authorities on this endeavor, no Accessible Underwater Archaeological Site has been operational nor has opened for the public (11).

The Sites of West Pagasetic – Northern Sporades have been at the centre of our interest in the framework of BLUEMED (12), as pilot sites.

Each of these sites has its own characteristics, which are not simply limited to the different history of each shipwreck *–the shipwreck of Peristera Alonissos goes back to the last quarter of the 5th century B.C. and is linked with one of the largest known until today ships of the period; the rest are shipwrecks of the Late Roman period (at Telegrafos) and the Byzantine period (at Kikinthos and Glaros)–***but also at the level of their preservation and the image that they present today at the seabed** *–for example at Glaros many dispersed traces of more shipwrecks are preserved, at Kikinthos the jars and amphorae are shattered, while at Telegrafos, little authentic archaeological material remains at the seabed)–* **regarding the kind of the archaeological research (excavation or survey) which has been conducted on each site** *–Peristera* **(13)** *and Telegrafos* **(14)** *have been systematically excavated by EUA and the Hellenic Institution of Marine Archaeology (HIMA) under the direction of the archaeologists Elpida Chatzidaki and Elias Spondylis respectively, while an underwater survey has been conducted at the positions of the Pagasetic* **(15)** *also by HIMA and again under the direction of Elias Spondylis–* **at the environmental characteristics of the site etc**. *– Peristera is located within the National Marine Park of Alonissos and Northern Sporades while the vegetation at Glaros is hypertrophic during some periods of the year, thus sometimes it covers the antiquities.*

These particular characteristics of the four sites, which inevitably lead to different choices in terms of both the narration that will be formed for the visitor and the management of the sites, were partly known thanks to the archaeological researches of the Ephorate and the Hellenic Institute of Marine Archaeology which had been realized, and to the related publications, but were fully understood by the personnel the EUA involved in the project (16) during the on-site, underwater missions organized in the framework of the Project (October 2018, March-April 2019, July 2019, October 2019, November 2019 and December 2019). In the context of these missions, the active manpower of the Ephorate,

which undertook the responsibility for the implementation of the Project, had the opportunity to get an immediate view of the sites that had to organize as accessible, to protect and promote in various ways, answering to a number of questions.

One first question that was raised was what kind of infrastructure is required; and if they are required. The design up until today, based on the experience of BLUEMED and the preparation of a relevant Application Form of the project for the funding of the project «Organization of the Accessible Underwater Archaeological Sites in Alonnissos - Western Pagasitic» by the current National Strategic Reference Framework – Thessaly Regional Operational Program, submitted by the EUA in October 2018, that was recently approved, has helped to identify the minimum necessary infrastructures.

Apart from the marine area, the infrastructures of an Accessible Underwater Archaeological Site may also concern the dock from which the vessels travelling to and from the Accessible Underwater Archaeological Sites will start and return, i.e. the points of departure and arrival. Besides, BLUEMED plans to deploy the Knowledge Awareness Centres (KACs) to a close location at the point of departure and arrival (17), in order to provide information to diving visitors but also to render the underwater cultural heritage accessible and understandable even to non-divers (18). But in the context of this presentation we will focus on the infrastructures at the marines area where diving will be carried out, infrastructures which concern both the safety of the monument and the functionality and quality of the visit.

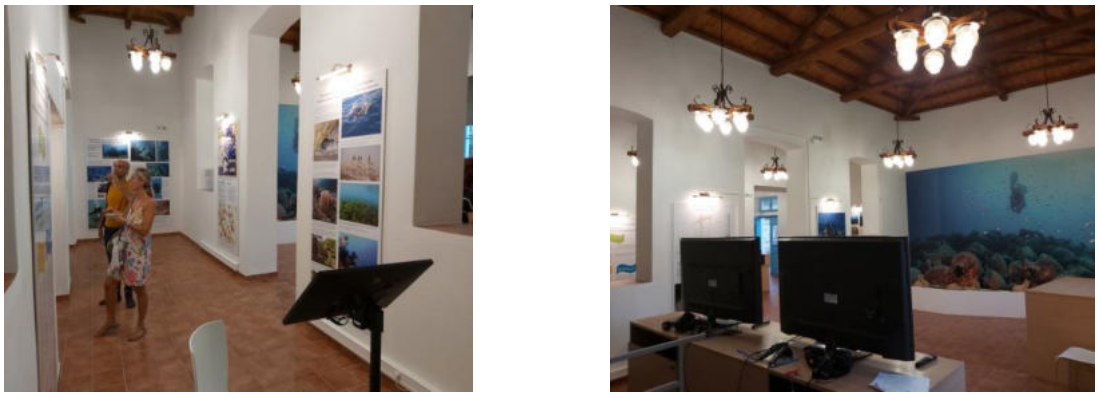


Fig. 10: Knowledge Awareness Centre in Alonissos, photo by Angelos Manglis

Its safe operation requires, in principle, the placement of mooring buoys for the approach of vessels at the site, for both visitors and audit authorities, and in particular two mooring buoys per site are favored. The necessary beacons for the marking of the boundaries of the site can also be placed on the mooring buoys.

Concerning the visitors, whose course at the seabed or the «movement path» will have been determined from the beginning, and for the quality of the visit, the marking of the points of archaeological or environmental interest at the seabed is considered necessary with the placement of a limited number of informative signs, that could also serve as compasses for divers –the information will be elementary and possibly confined to the object's identity. For similar purposes –safety and quality of visit– the placement of other elements may be favored, such as a rope to ascend – descend, a rope to mark the route, etc., which will per site become object of a specific study for the conversion of the sites to accessible ones, that is being prepared by the EUA and will be officially approved by the Ministry of Culture and Sports.

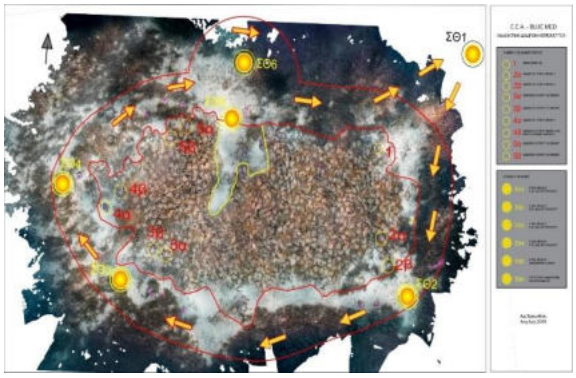


Fig. 11: Peristera shipwreck, ©MCS-EUA, orthophotomosaic by Univerità della Calabria–DIMEG, design of the visiting route by Aikaterini Tagonidou

Fig. 12: Public visiting of Peristera shipwreck, 6 & 7 April 2019, ©MCS-EUA, photo by Yiannis Issaris

Underwater infrastructures are also required for the safety of the monument. A placement of cameras is already being tested for the "Development of a System of an Underwater Visual Surveillance of Accessible Underwater Archaeological Sites – Underwater Museums", which will enable remote monitoring of sites with a view of the seabed, both during visits and when the sites will be closed. The system is intended to be connected to and give an alarm signal to the Centre of Reception and Processing Alarm Signals of the Ministry and local port authorities.

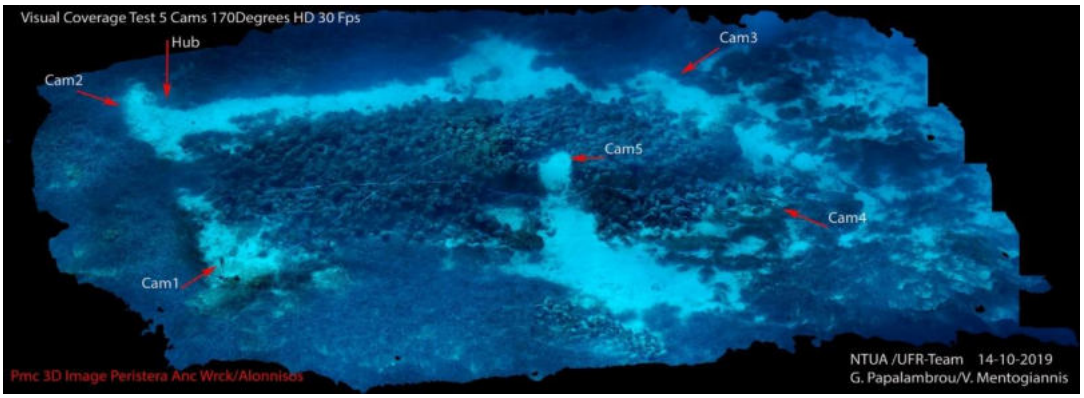


Fig. 13: Peristera shipwreck, ©MCS-EUA, orthophotomosaic with the points of cameras' placement by NTUA/UFR Team, photo by George Papalambrou – Vassilis Mentogiannis

At the seabed of Kikinthos and Peristera monitoring sensors for environmental parameters, temperature and visibility of the marine environment of the monuments, are also placed in the framework of BLUEMED by the Oceanography Centre - University of Cyprus. The data, that will be collected by the EUA, will provide the basis for long-term monitoring of the sites and for the diagnosis of any environmental changes that the opening to the public may bring.

The intention is for the infrastructure facilities to be kept to the minimum and to be placed in such a way that any damage of the monument or any obstacle for the movement of visitors or the navigation to be avoided. The aforementioned infrastructures are greatly affected by the evolution of technology.

Nevertheless, the safety of these sites is also based on their systematic monitoring of both the state of the monuments and their natural environment, which of course requires the establishment of relevant

monitoring indicators and the provision of comparative baseline material - the latter must reflect the situation before their opening to the public and was collected in the framework of BLUEMED, during which monitoring indicators were also discussed.

In particular, one of the first actions in the context of the project, in October 2018, was the three-dimensional modelling of the four pilot sites, by our Italian and Croatian partners from the Universities of Calabria and Zagreb respectively, with the aim to operate in two directions. Immediately, for the creation of an interactive digital immersion application, already installed at the Knowledge Awareness Centres at Chora, in Alonissos and in Amaliapolis as well as the other pilot sites in Italy and Croatia, providing access to shipwrecks and to non-divers. In the long term, to provide a reliable basis for monitoring any changes of the site, so that timely intervention for their protection and documented decision-making can be achieved.

Fig. 14: Member of the University of Calabria–DIMEG's team photographs Peristera shipwreck in order to create the 3D photomosaic of the shipwreck, ©MCS-EUA, photo by Matteo Collina, Università della Calabria–DIMEG

In addition, based on the three-dimensional modelling of the Peristera shipwreck, the conservators of the EUA realized a mapping design of the amphorae Peristera shipwreck and marked them in three categories based on their state of preservation, using colour: those that are concreted and therefore immovable, those that are semi-concreted and those that are free, introducing a new methodology that

Fig. 15: The separation of the amphorae of Peristera shipwreck into six sections, ©MCS-EUA, orthotophotomosaic by Università della Calabria–DIMEG, drawing by Helen Margaret Bardas, Angelos Tsompanidis

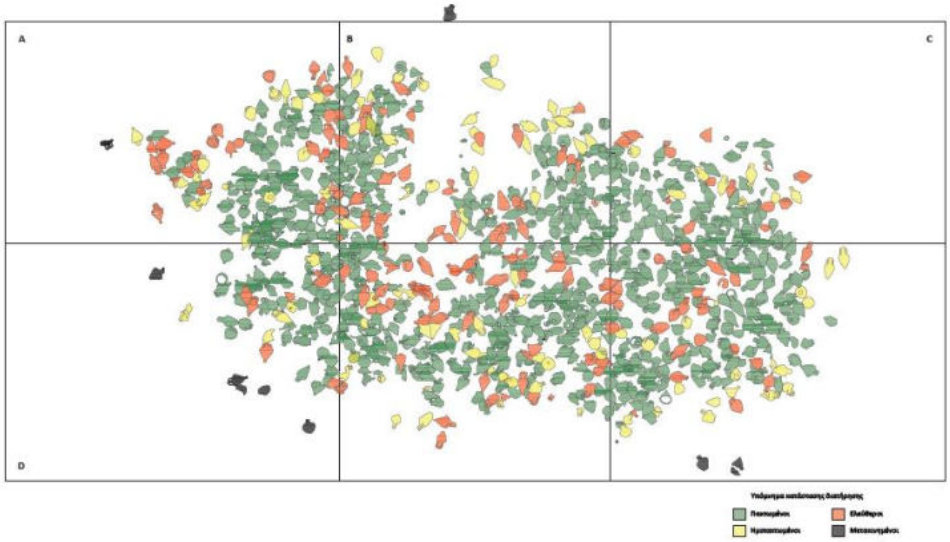


Fig. 16: Mapping design of the amphorae of Peristera shipwreck and their state of preservation, ©MCS- EUA, drawing by Helen Margaret Bardas, Angelos Tsompanidis

will allow the location of the weakest points against natural phenomena or illegal actions but also the creation of a reliable mapping which will further facilitate the monitoring of the site –of course this method is not applicable to all environments and it depends on the intrinsic characteristics of each site.

At the same time, the use of underwater tablets, with 3D photography and geo-referencing capabilities, purchased in the framework of the project, allows the easy direct comparison of the data obtained each time with the original 3D digital background, and will also contribute to the proper supervision of the site.

The Oceanography Centre - University of Cyprus, carried out at the beginning of the project, prior to any diving activities, the collection of biological data for the creation of a database to ensure also the possibility of monitoring changes, in the natural environment of monuments,.

Besides the above, the functioning of the Greek Accessible Underwater Archaeological Sites presupposes the decision-making and its reflection on legislative improvements and / or administrative acts that will shape the institutional framework for the operation of the Accessible Underwater Archaeological Sites as far as general principles and specific aspects of the operation of each site are concerned (i.e. duration and opening hours of each site, permitted number of visitors and escorts per visit, method of training and licensing of the involved diving centers and their personnel etc.).

First of all, it is necessary to amend the Law 3409/2005 as to who accompanies the diver-visitors. It is now clear, that this point has been disfunctional and that the Ministry of Culture and Sports shall and can take over the safety of the accessible underwater sites, but the escort and safety of the visitor goes beyond its jurisdictions and capabilities, and can be undertaken by the Diving Centres, under the supervision of the Ephorate of Underwater Antiquities.». The initial concept of the abovementioned Law of «accompanied diving» always remains, of course.

The specific settings, such as opening hours, number of visitors per visit, etc., can be specified by an operation mode for each site or group of sites depending from the same point of departure – arrival.

The basic general operating principles of the Accessible Underwater Archaeological Sites, however, which refer to issues such as the placement of mooring buoys, beacons, underwater safety systems and other elements that may affect navigation require the issuing of a Joint Ministerial Decision. The setting of a visit fee in favor of the Archaeological Resources Fund or of a system of issuing group e-tickets, the way of training and licensing professional divers, who could be engaged in the Accessible Underwater Archaeological Sites, as well as the process of withdrawing their license demand also arrangements.

In any case, for the proper functioning of the Accessible Underwater Archaeological Sites, it is though necessary to have on-site, at each point of departure – arrival, from which more that one site is controlled, a group of diving personnel of the EUA, which will have the responsibility for monitoring, protecting and generally taking care of the underwater sites. The conduct of systematic or emergency underwater surveys at the sites will be at the jurisdiction of this team and the EUA in general, based on an operation mode for each site. Also, cleanliness, maintenance and care for the proper operation of the sites.

In addition, the experience from BLUEMED has made it clear that supporting functions of the endeavor, such as knowledge Awareness Centers or the promotion of the Accessible Underwater Archaeological Sites as tourist destinations, can be undertaken by local authorities through the Municipalities and / or the Region. Summing up, diving centers, local and regional institutions and central government are invited to work together for the exploitation of the challenge posed by the development of cultural diving tourism, an environmentally friendly, sustainable form of tourism with expected positive consequences on local economies.

Even more, we believe that the opening of the sites will contribute to raising awareness and to the better protection of the underwater monuments in the end.

So, in closing, it is worth mentioning that until today the concept of the accessible underwater cultural heritage has been almost exclusively associated with the visit of shipwrecks by divers. There is, however, also a huge cultural stock of coastal underwater antiquities, which is already freely accessible to swimmers or snorkellers and whose conceptual accessibility we must primarily improve as Ministry, for the benefit of their protection. Furthermore, individual monuments linked with modern and recent Greek and European history could also become interesting visiting points.

In any case it must be said that the Accessible Underwater Archaeological Sites of Alonissos and West Pagasetic will become the guide for other corresponding projects in the future (19).

REFERENCES

(1) ΥΠΠΟΑ/ΓΔΑΠΚ/ΔΙΠΚΑ/ΤΠΚΑΧΜΑΕ/Φ53/12387/6960/772/240/2015, Official Government Gazette 119/B/21-1-2015.

(2) Law 3028/2002 "On the Protection of Antiquities and Cultural Heritage", article 15, Official Government Gazette 153/A/28-6-2002.

Official Government Gazette 153/A/28-6-2002.

(3) In general, the allowed diving activities with breathing apparatus –except recreational diving– within the archaeological sites were determined in 2004 with the Joint Ministerial Decision ΥΠΠΟ/ΓΔΑΠΚ/ΑΡΧ/Α1/Φ41/11228/1865, "Determination of the conditions of anchoring and fishing and underwater activities with breathing apparatus", Official Government Gazette B-336/11-2-2004 signed by the

Ministers of Agriculture, Culture and Merchant Shipping. (4) Ministerial Decision ΥΠΠΟ/ΓΔΑΠΚ/ΑΡΧ/Α1/Φ43/48604/3385/5-9-2003, "For the declaration of shipwrecks as protected monuments", Official Government Gazette 1701/B/ 19-11-2003.

(5) Law 3409/2005 on "Recreational diving and other regulations", article 11, par. 1, Official Government Gazette 273/A/4-11-2005.

(6) Law 3409/2005 on "Recreational diving and other regulations", article 11, par. 1: "Underwater activity at sea using breathing devices or other underwater means, for leisure, is allowed all over the country while it is prohibited: (a) to specified marine areas of archaeological sites by the competent services of the Ministry of Culture in accordance with Articles 12 and 15 of Law 3028/2002 (Official Government Gazette 153 A) and b) in specific ecologically sensitive marine ecosystems according to the laws 1650/1986, 3044/2002 and the joint ministerial decision 33318/3028/1998".

(7) Ministerial Decision ΥΠΠΟΑ/ΓΔΑΠΚ/ΔΙΠΚΑ/ΤΑΧ/Φ41/176862/94489/11963/5535/2013, Official Government Gazette 2489/B/3-10-2013.

(8) Ministerial Decision ΥΠΠΟΑ/ΓΔΑΠΚ/ΔΙΠΚΑ/ΤΠΚΑΧΜΑΕ/Φ17/344762/203211/16908/4712/2015, Official Government Gazette 2655/B/9-12-2015.

(9) Ministerial Decision ΥΠΠΟΑ/ΓΔΑΠΚ/ΔΙΠΚΑ/ΤΠΚΑΧΜΑΕ/Φ53/12387/6960/772/240/2015Official Government Gazette 119/B/21-1-2015.

(10) Ministerial Decision ΥΠΠΟΑ/ΓΔΑΠΚ/ΔΙΠΚΑ/ΤΠΚΑΧΜΑΕ/197458/127075/5380/1806/2019, Official Government Gazette 2714/B/2-7-2019.

(11) The first dive was realized by scuba diving at Peristera shipwreck in Alonissos in the framework of EUA's events for the dissemination of the goals and results of BLUEMED project, on 6th and 7th of April 2019 in Alonissos.

(12) The present study was presented as speech at the International Conference in Management of Accessible Underwater Cultural and Natural Heritage Sites "Dive in Blue Growth", which was organized in the framework of publicity actions for the results of the European program BLUEMED [Athens, 16-18 October 2019, the Acropolis Museum].

(13) Χατζηδάκη, Ε. (1992). Αρχαιολογικόν Δελτίον 47, Χρονικά Β΄2, 697-699. Χατζηδάκη, Ε. (1992). "Η ανασκαφή του Κλασικού Ναυαγίου της Αλοννήσου», Ενάλια IV, τεύχος 1/2, 16-25. Χατζηδάκη, Ε. (1993). Αρχαιολογικόν Δελτίον 48, Χρονικά Β΄2, 586-587. Hadjidaki, E. (1996). "Underwater excavations of a late fifth century merchant ship at Alonnesos, Greece: the 1991-1993 seasons", Bulletin de Correspondence Hellénique 120, 561-591. Hadjidaki, E. (1997). "The Classical Shipwreck at Alonnesos", in Res Maritimae: Cyprus and the Eastern Mediterranean from Prehistory to Late Antiquity, American School of Oriental Research, Archaeological Reports no 4, Atlanta, 1997, 125-134. Χατζηδάκη, Ε. (1999). Αρχαιολογικόν Δελτίον 54, Χρονικά Β΄2, 1019-1020.

(14) Σπονδύλης, Η. (2002). "Αναγνωριστική έρευνα ΙΕΝΑΕ δυτικών ακτών Παγασητικού, έτους 2000", *Ενάλια VI*, 24-31, Αθήνα: ΙΕΝΑΕ. Σπονδύλης, Η. – Δεμέστιχα, Σ. (2004). "Αναγνωριστική έρευνα ΙΕΝΑΕ δυτικών ακτών Παγασητικού, έτους 2003", *Ενάλια VIII*, 21-27, Αθήνα: ΙΕΝΑΕ. Σπονδύλης, Η. (2008). "Υποβρύχια έρευνα στον Παγασητικό κόλπο. Ερευνητική περίοδος 2004", *Ενάλια IX*, 6-21, Αθήνα: ΙΕΝΑΕ. Σπονδύλης, Η. (2008). "Έρευνα ΙΕΝΑΕ δυτικών ακτών νότιου Παγασητικού, έτους 2005. Σύντομη έκθεση", Ενάλια IX, 39-42, Αθήνα: ΙΕΝΑΕ. Βλαχάκη, Φ. (2008). "Εργασίες και αποτελέσματα τεκμηρίωσης κατά την υποβρύχια αρχαιολογική έρευνα του 2004 στο Ναυάγιο 7 του Παγασητικού κόλπου", Ενάλια IX, 22-31, Αθήνα: ΙΕΝΑΕ. Ανδρουτσάκη, Μ.-Κ. (2008). "Υποβρύχια αρχαιολογική έρευνα του ΙΕΝΑΕ στον Παγασητικό κόλπο κατά το 2004: Συντήρηση κεραμεικών ευρημάτων", Ενάλια IX, 32-38, Αθήνα: ΙΕΝΑΕ. Δεμέστιχα, Σ. (2010). "Το φορτίο του Ναυαγίου 7 στον Παγασητικό κόλπο. Πρώτη ερμηνευτική προσέγγιση", in Δ. Παπανικόλα-Μπακιρτζή, Ν. Κουσουλάκου (eds.), Κεραμική της ύστερης αρχαιότητας από τον ελλαδικό χώρο (3ος -7ος αι. μ.Χ.), Επιστημονική Συνάντηση, Θεσσαλονίκη, 12-16 Νοεμβρίου 2006, Θεσσαλονίκη: ΥΠΠΟΤ-ΑΠΘ. Demesticha, S. – Spondylis, E. (2011). "Late Roman and Byzantine trade in the Aegean. Evidence from HIMA

Survey Project at Pagasitikos Gulf, Greece", Skyllis 1, 34-40. Σπονδύλης, Η. (2012). "Υποβρύχια έρευνα ΙΕΝΑΕ στον Παγασητικό κόλπο. Ερευνητική περίοδος 2005", Ενάλια XI, 16-39, Αθήνα: ΙΕΝΑΕ. Σπονδύλης, Η. (2017). "Παγασητικός: Ανασκόπηση υποβρυχίων ερευνών (2000-2013) ", Ενάλια XII, 18-3, Αθήνα: ΙΕΝΑΕ.

(15) Σπονδύλης, Η. (2002). "Αναγνωριστική έρευνα ΙΕΝΑΕ δυτικών ακτών Παγασητικού, έτους 2000", Ενάλια VI, 24-31, Αθήνα: ΙΕΝΑΕ. Σπονδύλης, Η. (2008). " Έρευνα ΙΕΝΑΕ δυτικών ακτών νότιου Παγασητικού, έτους 2005. Σύντομη έκθεση", Ενάλια IX, 6-21, Αθήνα: ΙΕΝΑΕ. Σπονδύλης, Η. (2008). " Έρευνα ΙΕΝΑΕ δυτικών ακτών νότιου Παγασητικού, έτους 2005. Σύντομη έκθεση", Ενάλια IX, 6-21, Αθήνα: ΙΕΝΑΕ. Σπονδύλης, Η. (2012). "Υποβρύχια έρευνα ΙΕΝΑΕ στον Παγασητικό κόλπο. Ερευνητική περίοδος 2005", Ενάλια XI, 16-39, Αθήνα: ΙΕΝΑΕ. Σπονδύλης, Η. (2012). "Υποβρύχια έρευνα ΙΕΝΑΕ στον Παγασητικό κόλπο. Ερευνητική περίοδος 2005", Ενάλια XI, 16-39, Αθήνα: ΙΕΝΑΕ. Σπονδύλης, Η. (2017). " Παγασητικός: Ανασκόπηση υποβρυχίων ερευνών (2000-2013) ", Ενάλια XII, 18-31, Αθήνα: ΙΕΝΑΕ.

Demesticha, S. – Spondylis, E. (2011). Late Roman and Byzantine trade in the Aegean. Evidence from HIMA Survey Project at Pagasitikos Gulf, Greece", Skyllis 1, 34-40. Σπονδύλης, Η. (2017). "Παγασητικός: Ανασκόπηση υποβρυχίων ερευνών (2000-2013) ", Ενάλια XII, 18-31, Αθήνα: ΙΕΝΑΕ. Diamanti, E., Spondylis, E., Vlachaki, F. & Kolyva, E. (2017). "Surveying the Underwater Archaeological Site of Cape Glaros at Pagasetikos Gulf", in D. Aguilera, A. Georgopoulos, T. Kersten, F. Remondino and E. Stathopoulou (eds), 3D Virtual Reconstruction and Visualization of Com-plex Architectures, 1-3 March 2017, Vol. XLII-2/W3, Nafplio, Greece. Σπονδύλης, Η. (2017). "Παγασητικός: Ανασκόπηση υποβρυχίων ερευνών (2000 – 2013) ", Ενάλια XII, 18-31, Αθήνα: ΙΕΝΑΕ. Σπονδύλης, Η. & Μιχάλη, Μ. (2018). "Πεδίο Εφαρμογής του Ερευνητικού Σχεδίου ITACA στην Ελλάδα: Η Υποβρύχια Αρχαιολογική Έρευνα στις θέσεις Μετόχι και Γλάρος του Παγασητικού Κόλπου", Ενάλια XIII, 78-109, Αθήνα: ΙΕΝΑΕ.

(16) General co-ordinator: Dr Pari Kalamara, archaeologist, Director of the EUA; scientific field co-ordinators: the diver archaeologists Dr Dimitris Kourkoumelis (Head of the EUA's office in Northern Greece) and Dr Theotokis Theodoulou (Head of the EUA's office in Crete); diver archaeologists: Despoina Koutsoumpa, Eugenia Loizou; diver architects: Ekaterini Tagonidou, Elianna Kolyva; diver conservators: Chryssa Fouseki (Head of the EUA's Conservation Department), Angelos Tsompanidis, Irini Malliou, Aggeliki Bei, Helen Margaret Bardas; diver technicians: Spiros Moureas, Themis Troupakis, Kostas Kipriotis; archaeologist – museologist: Elia Vlachou; administrative support: Aris Michail, Sotiria Sideri, Chryssoula Pleura, Anastasia Mitsopoulou, Paraskevi Margariti.

(17) For the points of departure-arrival the concession of a space is required from the port authorities, which will generally control the anchorage points of vessels at the area. Building facilities are required for the KACs where the EUA can also place a control room.

(18) This increases the number of the public that will become more aware and engaged in the long-term with the protection of the underwater cultural heritage, while in the framework of the development of diving tourism in the area, KACs can also serve as poles of interest for the escorts of diving visitors.

(19) From this position I would like to thank particularly the Region of Thessaly, the project's coordinator, and namely the Regional Governor, Mr. Agorastos. Besides special thanks go to the Minister of Culture and Sports, Mrs. Mendoni, who honoured the entire effort with her presence at the International Conference "Dive in Blue Growth" as well as to the political leadership of the Ministry in general for their overtime support on this endeavor.

Touristic potential of the Supetar (Cavtat) underwater archaeological zone

Irena Radić Rossi [1], Katarina Batur[1]
[1] University of Zadar, Zadar, Croatia

Two decades ago, information about some well-preserved ancient shipwrecks near the islet of Supetar in front of Cavtat reached the responsible institutions. The first site consisted of a group of large ceramic dolia (containers for storing liquid or solid provisions) from the 1st cent. BC or the 1st cent. AD, while the second contained several hundred cylindrical North African amphorae from the 3rd/4th cent. AD, exposed on the seabed.

The extraordinary state of preservation of both sites impressed the scientists. The finds were left in situ, with physical protection (iron cage) placed over the amphorae. The initial idea of the establishment of the underwater archeological park up to recently had no success. It was refreshed in the framework of the BlueMed Project, resulting in some attractive initiatives toward public presentation.

Protective cage placed over the amphorae does not allow the direct contact with finds, and the penetration into the cage should not be practiced due to the safety reasons. In such case, virtual presentation of the site is a valuable solution to the problem, as the visitors can capture details which are otherwise not available.

The site with the dolia cargo is of special interest due to their large dimensions, leaving every visitor amazed. Historical information about dolia includes curiosities, mythological stories and anecdotes, which can be used for the presentation purposes. The site is easy to reach, and the finds on the seabed offer unique experience during visits. Considering the main features of the site, where the remains of the wooden ship hull were recently discovered, the future turistic promotion could rely on the active participation of divers in the whole process of the archaeological fieldwork research.

Keywords: *in situ* protection, amphorae, dolia, underwater presentation, citizen science

Sustainable management and protection of Accessible Underwater Cultural Heritage sites; global practices and bottom-up initiatives

Angelos Manglis[1], Anastasia Fourkiotou[2] and Dimitra Papadopoulou[3]

[1] Civil Engineer MSc, Founder & Vice President of Atlantis Consulting SA
amanglis@atlantisresearch.gr

[2] Archaeologist, MA fourkiotou@atlantisresearch.gr

[3] Dipl. Environmental Engineer, MSc papadopoulou@atlantisresearch.gr

***Abstract*:** This paper aims to present the better practices for the protection and sustainable management of Underwater Cultural Heritage (UCH) worldwide as well as relevant bottom-up initiatives. The development of accessible UCH sites and diving tourism further indicate the sustainable character and the positive effects of such models for local economies, including both economic benefits and social opportunities. It also supports that the responsible physical access to sites through dive trails or virtual visits fosters public awareness and consequently the protection of underwater cultural heritage. Knowledge Awareness Centers and innovative technologies enhance the participation of locals and tourists and promote their engagement in the protection of sites. The Med area is an ideal environment encouraging some pioneering initiatives in this direction.

Keywords: Underwater Cultural Heritage, value, protection, accessibility, local benefits, sustainability, Dry Dive, inclusion

1. VALUE AND PROTECTION OF UNDERWATER CULTURAL HERITAGE

For most people Underwater Cultural Heritage is synonymous to ancient shipwrecks, however, the concept includes also a variety of submerged sites and prehistoric landscapes. According to the UNESCO 2001 Convention on the Protection of the Underwater Cultural Heritage (UNESCO 2001, *Article 1, §1*), "Underwater Cultural Heritage encompasses all traces of human existence of a cultural or historical character that lie under water or have now been recovered for at least 100 years". This cultural wealth is estimated around three million ancient shipwrecks worldwide (UNESCO 2013) and it grows radically when modern wrecks of ships or aircrafts are also included. In Greek seas only, the estimations on the number of wrecks of vessels and aircrafts of the World War II report around one thousand in number (Papadimitriou 2018). In fact, on the centennial of WWI awareness is being raised on their historic and cultural value as memorial sites as well (UNESCO 2014) and the need for their protection. Aside the impressive numbers, what is primarily important is the multidimensional value of UCH for humanity. In particular, when accessible and communicated to the public, UCH can foster peoples' interaction with their historic background and marine environment. Several cases of accessible underwater cultural sites and maritime museums highlight such a benefit from a cultural, educational and sustainable socioeconomic development standpoint (Tikkanen 2011).

Recognizing the value of UCH, we need to assess all possible threats with a view to its safeguarding for the next generations. Apart from the apparent risks due to the marine environment, several human activities such as trawling, anchorage or looting also cause serious damage to the UCH (UNESCO "Threats to Underwater Cultural Heritage"). In order to protect the sites effectively, strict legislation and delimitation has proven ineffective in practice, considering the recent technological developments in marine research even in deep waters. Instead, what calls is for public awareness and active

engagement of stakeholders, supported by systematic mapping, research and study of sites, as well as the implementation of integrated actions for the protection and promotion of underwater cultural and natural heritage.

Granted that there is no such thing as a best solution, the different environmental and cultural context of each site should be taken into consideration. Under this understanding, UNESCO has suggested that the preservation of UCH *in situ* should be considered as the first option, while it encourages the responsible non-intrusive access to sites to observe or document in situ, in order to create public awareness, appreciation, and protection of cultural heritage (UNESCO 2001, *Article 2, §10*). Furthermore, it has encouraged the adoption of "practicable measures to raise public awareness regarding the value and significance of underwater cultural heritage and the importance of protecting it" (UNESCO 2001, *Article 10*). In this direction, different models have been developed around the world over the past years.

2. ACCESSIBILITY & MANAGEMENT

There are different approaches of management of UCH with both advantages and challenges in terms of protection and accessibility. A method mostly adopted over the past decades due to difficulty of accessibility or for preservation reasons has been the exhibition of shipwreck finds in land-based maritime museums. There are several examples in Europe and worldwide, where artifacts or whole wrecks have been recovered (UNESCO "Underwater Archaeology Museums"). There is even the model of museums in the form of restored ships that allow visitors to get to know to the structure of different types of ships in various time eras. Among the most known examples of land-based museums are the ARQUA National Museum of Underwater Archaeology in Spain, the Mary Rose Museum in the UK, the Bodrum Museum of Underwater Archaeology in Turkey, and the Roskilde Viking Ship Museum in Denmark[1]. The most popular Vasa Museum in Sweden with one million visitors per year ("About the Vasa Museum" 2019) has become a point of reference in this paradigm. The advantage of on-land museums is that since they are easily accessible they raise broad public awareness on cultural heritage. Equally impressive are the so-called underwater museums in aquarium settings, with most characteristic examples being the Baiheliang Underwater Museum and the Guangdong Maritime Silk Road Museum in China (UNESCO "Underwater Archaeology Museums"). Despite their costly construction - the Baiheliang museum cost 28 million US Dollars -, both models have maintained the original marine and cultural context in a spectacular aquarium setting and provided in situ access to the non-diving visitors.

Easier access to submerged sites due to technological development has led to accessible Underwater Archaeological Sites, a model that best meets the UNESCO Convention 2001 suggestion for preservation in situ and raising of public awareness. Their optimum advantage is that they offer an in situ experience for both divers and non-divers. More specifically, there is the possibility for dive trails for SCUBA divers as well as snorkeling or tours with submersibles for the non-diving visitors in cases of low depth sites, like the ROV trips for tourists in Orkney, UK, Dalarö Sweden or in Vermont USA. There are several names used for this model: underwater parks, underwater archaeological trails, preserves, sanctuaries or underwater museums as well as plentiful examples (UNESCO "In situ

[1] For more information visit the museums websites: www.culturaydeporte.gob.es/mnarqua/en/museo/visitan, https://maryrose.org/, https://www.vasamuseet.se/en, http://www.bodrum-museum.com/, https://www.vikingeskibsmuseet.dk/en/

access"); the Underwater Archaeological Park of Caesarea in Israel, the Croatian Underwater Museums, the Victorian Underwater Shipwreck Discovery Trail in Australia.

In situ accessibility should primarily safeguard the underwater natural and cultural heritage. In this purpose, the use of a protective covering in the Bou Ferrer wreck (UNESCO "Diver access") or of a metal cage in the case of Croatia (Zmaić 2009) is under dispute in terms of cultural and environmental sustainability of the sites. What is usually applied is the establishment of official dive trails to secure the divers safely approaching at the wrecks. There is usually an underwater rope path combined with information labels or waterproof booklets that guide the divers around the site. This is the case for example at the Park Kronprins Gustav Adolf in Helsinki, Finland and the Norman's Bay wreck diver trail in East Sussex, UK, while at the Lossen Trail in Norway there are signs on stone slabs laying on the seafloor in order not to affect the surroundings. It is worth noting that at Park Kronprins Gustav Adolf, the first established in the Baltic Sea, entry is free for individual divers who do not require permission to dive or take photos. In the USA, the Florida Underwater Archaeological Preserves and the Thunder Bay National Marine Sanctuary are also examples of open access sites, where the local community is engaged in the monitoring of the sites (Delgado et al. 2015). At the Underwater Archaeological Park of Baiae in Italy, the local diving clubs are authorized to guide visitors along the marked itinerary. Among the UNESCO best practices of fostering accessibility to UCH are the examples of Andalusia, where site visit is encouraged to include both diving clubs and private individuals, the guided tours under the supervision of underwater archaeologists at the Bou Ferrer, which is the only accessible ancient shipwreck in Spain, as well as the public visits during the conduction of an underwater archaeological excavation to the well-preserved shipwreck of Deltebre I in Catalonia, Spain (UNESCO "Best Practices").

3. PUBLIC AWARENESS & INNOVATION TECHNOLOGY

There is currently a great interest and a broad public appeal on issues concerning the underwater natural and cultural environment. In an effort to stimulate awareness among stakeholders on the sustainable development of the Ocean, the United Nations have declared the upcoming decade (2021-2030) as the Decade of Ocean Science for Sustainable Development ("Ocean Decade"). This is the perfect timing to include the underwater cultural heritage in the broader discussion of the protection and sustainable management of the underwater environment, in terms of its social aspects. The great response of the public towards UCH issues is obvious by the increase in numbers of visitors in underwater museums (e.g. the Vasa Museum) and accessible underwater cultural sites (e.g. the Underwater Archaeological Park of Baia). Moreover, it reflects on the positive reaction to initiatives such as the Big Anchor Project ("Big Anchor Project") or the several citizen science projects. In the context of this dynamic, the engagement of the public in the protection strategies of UCH is not a step very far away.

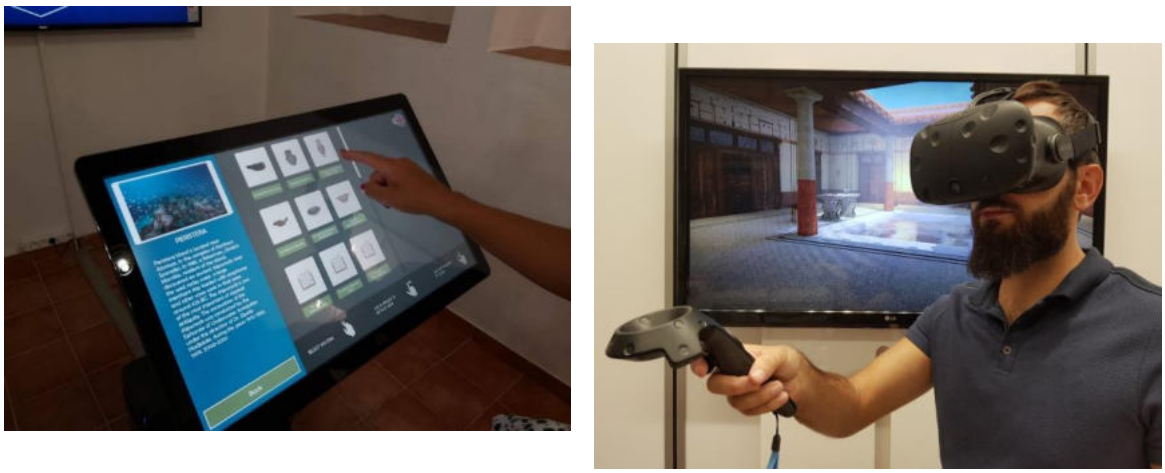


Fig.1 Innovative technologies applied for the promotion of UCH in the BLUEMED project.

Regardless of whether access is open or controlled, public accessibility to UCH is a crucial parameter in terms of protection and sustainability of the sites, given that it enhances broad awareness on the value of UCH (UNESCO 2013). According to the Cultural Heritage Diagram, when people understand the value of their cultural heritage they are more likely to participate actively in safeguarding it and as a result develop an ongoing interest for its protection (Thurley 2005). What calls is for the integration of responsible accessibility practices**,** in order to attract both the diving community and non-divers. For this purpose, innovative technologies are being more and more integrated into promoting UCH to the general public, including wet and dry dive techniques. As a result, 3D reconstructions of submerged cultural remains and the surrounding marine environment can advance the diving experience and offer a virtual reality experience of real time diving from a distance. This is now possible due to recent technological developments that have allowed high-resolution research and mapping even in deep waters (Sakellariou 2011). Such examples are the Blake Ridge Shipwreck off the North Carolina coast or the 2.400 year old shipwreck recently found in the Black Sea, both in more than 2.000 meters depth.

Virtual museums have been the focus of interest lately as an effective way to stimulate interest on UCH (UNESCO "Virtual Museums"). In the North and Baltic Sea, the Nordic Blue Parks project has designed underwater trails combining natural and cultural heritage sites, while the Vrouw Maria Underwater Project created an interactive, real-time virtual reality simulation of a shipwreck (Tikkanen 2011). The Virtual Archaeology Museum launched by BOEM is featuring 3-D models, video footage and mosaic maps of wrecks in the Gulf of Mexico "Virtual Archaeology Museum". The Pearl Harbor Virtual Reality Center provides virtual reality tours of the USS Arizona Memorial in Hawaii and has contributed to the Memorial becoming a destination for 1.7 million international tourists in 2018 ("Pearl Harbor National Memorial Park"). In the UK, Historic England has supported virtual tour visits of several wrecks, such as the Coronation wreck in Plymouth and the HMS Colossus Dive Trail ("Visit a protected wreck site"). This initiative has actually increased the number of visitors to the sites indicating the growing interest on the display of modern wrecks and the contribution of technology in this direction. Virtual dive trails not only facilitate accessibility but also stimulate awareness on the protection of UCH as they serve teaching purposes for schools or universities, thus offer immediate access to disabled visitors in case they cannot dive (Cant 2018), which is an aspect of great social validity. Most importantly, advanced applications contribute to the underwater cultural heritage becoming a part of people's lives so that sites are more effectively protected and maintained.

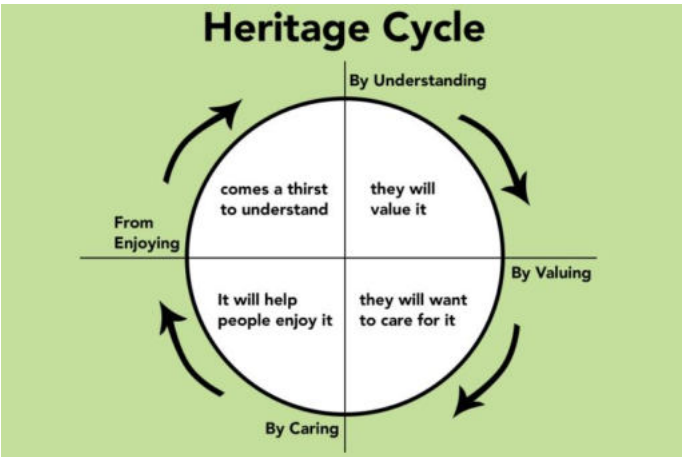


Fig 2. The Heritage Cycle Diagram. A graphic originally developed by designed by cultureindevelopment.nl

4. SUSTAINABILITY & GROWTH

Actually, the participation of the public, including divers and non-divers, locals and visitors, as well as the various type of stakeholders involved, comprise strong allies not only in long-term sustainability of UCH sites but also in the economic prosperity of a region. Indeed, according to the 2013 United Nations Resolution on Culture and Sustainable Development (United Nations 2014), culture is a key factor of sustainable socioeconomic development on a national, regional and local level. It is a current growing belief that cultural heritage can contribute significantly to the overall socioeconomic development of society and along with environmental sustainability and social and economic development, these are considered as indicators of sustainable growth. Growth refers to economic benefits as well, granted that the integration of cultural heritage to society offers an added economic value. The investment on the promotion of underwater cultural heritage can increase the number of people visiting the sites and as a result generate financial flows for the local community. The first thing that comes to mind is that tickets generate revenue for the maintenance and operation of the sites. However, the greatest added value of a UCH site is the economic activity that is developing throughout the whole region and eventually offers a high beneficial return directly to the local community.

Taking advantage of the emerging trend of alternate forms of tourism (Dwyer et al. 2008) and the development of diving tourism globally (PADI statistics), the attraction of divers to UCH sites can increase the economic activity in coastal or island areas, that normally depend on short touristic periods. It is worth noting that divers visiting submerged sites spend longer time in a region than tourists visiting land museums (UNESCO 2018). In addition, when they travel from distant countries visiting two or three countries for at least a week each, significant indirect revenues usually are generated, such as on food or accommodation. Consequently, the divers' profile of a high spender at off-season weekly destinations fits the parameters of sustainable growth for areas with underwater cultural wealth. Therefore, the UCH exploitation can contribute significantly to local economic growth, including profits for businesses and increase of income for local coastal and island economies, such as new employment opportunities in the tourism sector. This is the case for example at the Vasa Museum in Sweden or the Thunder Bay National Marine Sanctuary in the USA (Delgado et al. 2015). Most importantly, it is expected to create a competitive advantage for local communities on a Glocal scale, since they will highlight their unique cultural and natural wealth internationally.

From a different perspective, an investment on the promotion of the UCH will not have any negative effect on the touristic profile of a region, since it has a low environmental impact. On the contrary, the opportunity for a coastal or island region is to combine different regional assets, more particularly, the

natural and cultural underwater wealth and organize actions to educate the public on their protection. Such examples are the Florida Keys National Marine Sanctuary, which protects North America's only coral barrier reef and offers home to a unique marine life or the SS Yongala Shipwreck in Australia located in the Great Barrier Reef Marine Park. In Greece, the National Marine Park of Alonissos North Sporades is the largest marine protected area in Europe and the nature reserve for a series of rare species and remarkable archaeological underwater heritage. Such combination of assets can support operation sustainability for both parties and thus foster protection, considering that the seabed attracts the interest of divers in general and possibly will raise awareness and attract on the protection of underwater cultural heritage.

Granted that the sustainability of an intervention plan depends on the socioeconomic environment, the support of local stakeholders and a strong cooperation network among local institutions are key factors towards this goal. The model in the Thunder Bay National Marine Sanctuary in the USA is based on the participation of the local community in the decision-making process, and has actually generated a sense of responsibility and pride of the local community on their heritage (Delgado et al. 2015). In fact, the community engagement and active management are considered among the elements of

Fig.3 The classical wreck of Peristera in Alonissos, Greece. © MCG, EUA

success of such a bottom-up approach (Scott-Ireton 2006).

5. A BOTTOM-UP INITIATIVE

An example of a bottom-up initiative and active cooperation among stakeholders with the purpose to protect and promote the underwater cultural heritage has been developed over the past years in Greece. It is about a long-term effort that initiated in 2006 and has led recently to the first accessible UCH site of the Peristera classical wreck of around 425 B.C. in Alonissos Island, in North Sporades Archipelagos of Magnisia, open to the public from the summer 2020 onwards. It all started with the Prototype Innovative Development Plan 'Ano Magniton Nisoi', an awarded integrated intervention plan that structured on a multi-stakeholder partnership that involved state authorities as well as local-civil society's bodies and private associations. Indicatively, such are the Hellenic Ephorate of Underwater Antiquities, the Hellenic Organization for Tourism, the Hellenic Center for Marine Research, the Hellenic Institute of Marine Archaeological Research, the local municipalities of Alonissos and Skopelos islands. It aimed to highlight different features of this island region, such as the National Marine Park of Alonissos Northern Sporades and the submerged wrecks in the area,

therefore it is an example of a good practice aiming at sustainable local economic development and environmental upgrading of a region. The plan proposed the creation for the first time in Greece of pilot accessible underwater archaeological sites combined with diving parks where qualified diving centers would support their operation. The main idea was to highlight the underwater cultural and natural heritage in situ, promoting public accessibility and thus supporting archaeological survey with the operation of a Research Center for Marine Archeology. Equally innovative was the idea of the integration of innovative technologies for the non-diving audience, a goal that was not to be realized until recently.

What followed was the "Operational Plan for the Construction of Underwater Museums & Diving Parks in the Sporades Islands & Western Pagasitikos", a flagship project under the National Strategic Reference Network 2007-2013. It actually proposes the creation of a network of accessible underwater archaeological sites in an extended area of intervention at the Magnisia region. The planning was based on the promotion of at least five sites as a total, in order to create a weekly diving tourism destination with a prosperous competitive advantage of a Glocal character. Currently, the plan is to be developed under the framework of the Partnership Agreement 2014-2020 with the implementation period starting in October 2019, while it incorporates 4 different projects that are addressed to the Ministry of Culture (960.000€ budget), the Municipality of Alonissos (1.350.000€ budget), the Municipality of Almyros (1.200.000€ budget) and the Region of Thessaly (600.000€ budget).

In order for the original idea to become a reality, the Euro-Mediterranean project BLUEMED, developed under the European Interreg 2014-2020 Programme, had a decisive role (https://bluemed.interreg-med.eu/), as it is implementing the design of accessible Underwater Archaeological Sites in three different Mediterranean countries, including Greece. More specifically, the sites of the project are the Baia Underwater Archaeological Park and the Capo Rizzuto Marine Protected Area in Italy, the Cavtat Underwater Archaeological Site in Croatia and 4 underwater archaeological sites in Magnesia, Greece: Peristera in Alonissos and Kikinthos, Akra Glaros and Telegraphos wrecks on the west coast of the Pagasitikos Gulf. The project proposes physical dive or virtual trails with enriched information provided on both archaeological and the marine ecosystem features. An Augmented Diving System improves the diving experience while interactive applications are also available at the Knowledge Awareness Centers (KACs), where the visitors can enjoy a virtual diving experience at the sites and the digital exhibition of selected finds. The advantage of KACs is that since they are established in situ where the sites are also located, they enhance public awareness to locals and tourists on the value of the protection and preservation of underwater cultural and natural heritage. In addition, granted that KACs provide all information in a digital form, they can be easily installed at various points such as airports, museums or international exhibitions. As a result, they can attract visitors thus disseminate information about other sites too, through an international dynamic network. At the same time, the project has developed an online platform (http://meddiveinthepast.eu/) that not only offers the opportunity for virtual diving but also provides archaeological information about the project sites, the nearby diving centers and other related information about other Mediterranean UCH sites. In this context, the platform is creating a network across the Mediterranean of underwater cultural heritage tourism destinations.

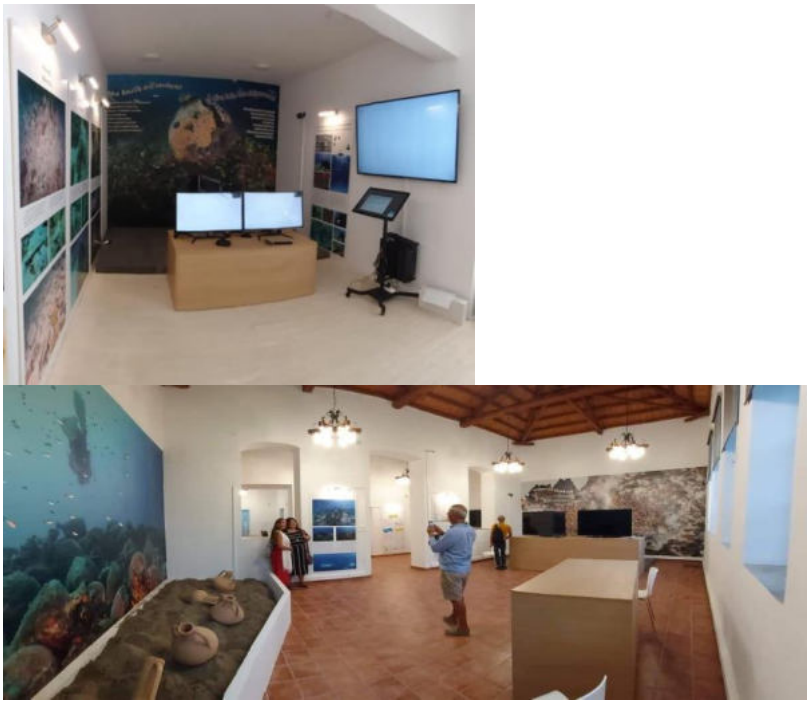


Fig 4. Knowledge Awareness Centers in Amaliapolis and Alonissos respectively, Greece.

The management model proposed in the case of Alonissos in Greece aims at the sustainable operation of the accessible underwater archaeological site and the two Knowledge Awareness Centers established in Alonissos and Amaliapolis. Except for the tickets, sustainability is based on the fact that the operation management lies not on a newly founded organization but on already existing bodies, in particular the local municipalities of Alonissos and Almyros, the Region of Thessaly and the Ministry of Culture and Sports. It is in fact a triple helix cooperation based on a trilateral programmatic agreement that sets clear the responsibilities of each body. More particularly, the Ministry of Culture is responsible for the protection of the sites and the visits to the sites, while the Municipalities are responsible for on-land operation issues such as the operation of KACs. The Regional Authority is responsible for the financing, monitoring and therefore viability of the operation of KACs and sites. A crucial element for the sustainability of the proposed model is the role of diving clubs. The Ministry of Culture will train and authorize local diving centers to accompany scuba divers to the sites in a way that will follow the operational framework of the sites towards their protection and yet satisfy and inform the visitor.

6. CONCLUSION

The long-term effort in Greece indicates how local initiatives could be effective when they develop on the fruitful collaboration among local, regional and national stakeholders of a public, civil and private character– in this case in the form of a quadruple helix partnership. It is also an example of a better practice for blue growth in the Mediterranean region, being a model compatible with the sustainable touristic model of the Med that can offer multiple cultural and socio-economic benefits to the local communities, especially at island and coastal areas. Responsible in situ accessibility and public awareness are strong preconditions in the protection and promotion of UCH; as a result, Knowledge Awareness Centers and innovative technology contribute to the participation of the public and most importantly foster the inclusion of the diving community and non-divers as well. The establishment of at least five underwater cultural sites is a parameter of operation sustainability of the sites as well as

the increase of the economic activity in the region, in terms of diving and tourism in general. As a result, all benefits of this relatively low investment are directly attributable to the local communities. Future planning should incorporate the promotion of both ancient and modern underwater cultural heritage while impressive finds urge for the enhancement of further research, study and mapping of the sites at a regional level. What is more, UCH should be taken into account in terms of maritime spatial planning. With the support of Municipalities, Regions and Ministries of Culture and Tourism, the Underwater Cultural Heritage should be also included in the RIS+ in the next Programmatic Period and take advantage of funding opportunities (ERDF, Interreg or Fisheries Funds).

7. REFERENCES

Cant S. (2018). Review of 2017-18 Virtual Dive Trails - Accessibility: summary of key best practice features, internal report for Historic England.

Delgado J. and Varmer O. (2015). "The Public Importance of World War I Shipwrecks: Why a State Should Care and the Challenges of Protection". In: Ulrike Guérin, Arturo Rey da Silva and Lucas Simonds (eds.)The Underwater Cultural Heritage From World War I, Proceedings of the Scientific Conference on the Occasion of the Centenary of World War I Bruges, Belgium, 26 & 27 June 2014. UNESCO, Paris, 2015.

Dwyer L. & Edwards D. & Mistilis N. & Adler C. & Scott N. & Cooper C. (2008). Megatrends underpinning tourism to 2020: Analysis of key drivers for change.

Papadimitriou K. (2018). "Ναυάγια πλοίων κατά τη διάρκεια του Β' Παγκοσμίου Πολέμου. Θεματική Χαρτογράφηση στην περιοχή Παγασητικού – Πηλίου". Πρακτικά 15ου Εθνικού Συνεδρίου Χαρτογραφίας "Η Χαρτογραφία των Κρίσεων", Θεσσαλονίκη 31/10-2/11/2018.

Sakellariou D. (2011). Innovative, Non-destructive Techniques and Methodologies for the Survey and the Exploration of Submerged Cultural Remains on the Shallow and Deep Seafloor. In: UNESCO Scientific Colloquium on Factors Impacting the UCH. Royal Library of Belgium, Brussels, 13&14 December 2011. pp. 78-83.

Scott-Ireton D. A. (2006). "Florida's Underwater Archaeological Preserves: Preservation through Education", in Grenier R., Nutley D. and Cohran I. (eds), Underwater Cultural Heritage at Risk: Managing Natural and Human Impacts, ICOMOS, 2006, ref. http://www.international.icomos.org/risk/2006/fulldocan.pdf

Tikkanen S. (2011). "The Nordic Experience – Access Through Maritime Dive Trails and Virtual Simulation". In: UNESCO Scientific Colloquium on Factors Impacting the UCH (Royal Library of Belgium, Brussels, 13&14 December 2011), pp.62-65.

Thurley, S. (2005). Into the future. Our strategy for 2005-2010. In: Conservation Bulletin [English Heritage] (49).

United Nations (2014). Culture and sustainable development. Resolution adopted by the General Assembly on 20 December 2013 [on the report of the Second Committee (A/68/440/Add.4)], 68/223. 71st plenary meeting. United Nations, 12 February 2014.

UNESCO (2001). "The UNESCO Convention on the Protection of the Underwater Cultural Heritage, UNESCO, Paris, 2 November 2001". Available at: http://www.unesco.org/new/en/culture/themes/underwater-cultural-heritage/2001-convention/official-text [Accessed June 2019]

UNESCO (2013). "The Benefit of the Protection of Underwater Cultural Heritage for Sustainable Growth, Tourism and Urban Development". Elaborated by the UNESCO Secretariat and the Scientific and Technical Advisory Body of the Convention on the Protection of the Underwater Cultural Heritage, 2001. Available at: http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/CLT/pdf/UCH_development_study_2013.pdf [Accessed June 2019]

UNESCO (2014). The Underwater Cultural Heritage From World War I, Proceedings of the Scientific Conference on the Occasion of the Centenary of World War I Bruges, Belgium, 26 & 27 June 2014.Ulrike Guérin, Arturo Rey da Silva and Lucas Simonds (eds.).

UNESCO (2018). Culture for the 2030 Agenda, Underwater Cultural Heritage, p. 20. UNESCO, Paris 2018.

United Nations (2014). Culture and sustainable development. Resolution adopted by the General Assembly on 20 December 2013 [on the report of the Second Committee (A/68/440/Add.4)], 68/223. 71st plenary meeting. United Nations, 12 February 2014.

Zmaić V. (2009). The Protection of Roman Period Shipwrecks "In Situ" - Underwater Museums. In: Exploring Underwater Heritage in Croatia. A Handbook. L. Bekić, I. Miholjek (eds.) Zadar, 1-4/10/2009.

Web References (all retrieved June 2019)

"Threats to Underwater Cultural Heritage". Available at UNESCO website http://www.unesco.org/new/en/culture/themes/underwater-cultural-heritage/protection/threats/

"Underwater Archaeology Museums". Available at UNESCO website: http://www.unesco.org/new/en/culture/themes/underwater-cultural-heritage/access/museums/

"About the Vasa Museum". Available at the Vasa Museum website: https://www.vasamuseet.se/en/about

"In situ access". Available at UNESCO website: http://www.unesco.org/new/en/culture/themes/underwater-cultural-heritage/access/in-situ-access/

"Diver access". Available at UNESCO website: http://www.unesco.org/new/en/culture/themes/underwater-cultural-heritage/partners/diving-community/diver-access/

"Best Practices". Available at UNESCO website: http://www.unesco.org/new/en/culture/themes/underwater-cultural-heritage/underwater-cultural-heritage/best-practices-of-underwater-cultural-heritage/

"United Nations Decade of Ocean Science for Sustainable Development (2021-2030)". Available at UNESCO website: https://en.unesco.org/ocean-decade and https://www.oceandecade.org/

"Big Anchor Project Makes a Splash, 31.01.2019". Available at the Nautical Archaeology Society website: https://www.nauticalarchaeologysociety.org/big-anchor-project-makes-a-splash

"Virtual Museums". Available at UNESCO website: http://www.unesco.org/new/en/culture/themes/underwater-cultural-heritage/access/virtual-museums/

"Virtual Archaeology Museum". Available at Bureau of Ocean Energy Management website: https://www.boem.gov/Virtual-Archaeology-Museum/

"Pearl Harbor Memorial". Available at the Pearl Harbor National Memorial Park website https://www.nps.gov/valr/learn/index.htm

"Visit a protected wreck site". Available at: https://historicengland.org.uk/get-involved/visit/protected-wrecks/

Protecting marine biodiversity at accessible Underwater Cultural Heritage (UCH) sites and UCH diving parks

Y. Samuel[1], Y. Mylonas[2], S. Stylianou[1], G. Konnaris[1], P. Diplaros[1], G. Fyttis[1]

[1]University of Cyprus, Oceanography Centre, 1 University Avenue, 2109 Aglantzia, Cyprus

[2]University of Cyprus, Department of Computer Science, 1 University Avenue, 2109 Aglantzia, Cyprus

Underwater Cultural Heritage (UCH) sites and UCH diving parks are typically found in coastal areas, which also happen to be some of the most biologically diverse areas on Earth, harbouring many of the world's plant and animal species and providing important ecological services. The high biodiversity and abundance of marine species found in these areas is often one of the factors that constitutes them very attractive to tourists, as well as snorkellers and divers. However, the increased attractiveness and visitability of these sites, inadvertently increases the pressure on the marine ecosystem leading to possible negative impacts and possible damage. Managers of UCH sites and diving parks should record marine biodiversity and abundance prior to opening the UCH sites to visitors as to create a baseline dataset for their ecosystem and continue monitoring on an annual or bi-annual basis if possible, in order to observe and changes and deviations. Further, managers should promote responsible snorkelling and diving and adopt good practices in order to protect and preserve the integrity of the ecosystems and species and attract visitors, thus sustaining the high-quality visitor experiences that will ensure the ongoing financial viability and economic health of local communities.

Keywords: marine biodiversity, diving surveys, photoquadrats, protection of marine diving sites, diving best practices

Diving into a sea of history. Communicating the Underwater Experience in a Museum: an Analysis of ARQVA's Interactive Media.

Antonio Cosseddu[1]

[1]Soprintendenza archeologia, belle arti e paesaggio per le province di Sassari e Nuoro
Italian Ministry of Culture

Abstract: Museums are among the places that can offer dry dive experiences to non-divers. The mission of the Museo Nacional de Arqueología Subacuática.ARQVA (Cartagena, Spain) is to increase public awareness, appreciation and protection of underwater cultural heritage and to make public the activities of professionals who work for it, placing the focus on the concept of "archaeological site".

Some interactive stations are placed along the halls of the museum, with the aim of involving different types of visitors and bring them closer to the experiences of underwater archaeology; a summative evaluation that we've carried out at the museum in 2017 explore the relationship between visitors and these mediums and the different levels of engagement on the road to knowledge.

Keyword: Underwater archaeology; Public archaeology; Museum design; Interactive exhibits

1. IMMERSE YOURSELF IN OUR UNDERWATER CULTURAL HERITAGE

The Museo Nacional de Arqueología Subacuática, or ARQVA, in Cartagena (Murcia, Spain), is one of few museums in the world entirely dedicated to underwater archaeology. Unlike other similar institutions, however, it does not merely guarantee the conservation, use and promotion of a series of underwater finds.

As clarified in its founding statement2, ARQVA has set itself the goal of communicating the value of our entire underwater cultural heritage, promoting a greater awareness of its riches and the professional activities that work to foster its protection and conservation.

To do so, as the first panel in the exhibition space states, the museum "invites visitors to immerse themselves in our underwater cultural heritage."

The museum's architectural choices (VÁZQUEZ CONSUEGRA 2008) evoke in visitors the idea of a dive before their visit even begins; one of the museum's outer walls is made entirely of glass, allowing the public to view the finds from above.3 The entrance plaza is thus transformed into the surface of the sea, and visitors are conducted down a long ramp on their suggestive descent toward the artifacts.

The exhibition space is divided into three sections: "Patrimonio Cultural Subacuático" on the right, and "Mare Hibericum" and "Del Mar a los Oceanos" on the left. At visit's end, the walk back up the same ramp communicates the return to the surface after a dive.

The museographic project develops in a direction that is strongly connoted by this suggestion. In the sections "Mare Hibericum" and "Del Mar a los Oceanos," models of an ancient Greek kyrenia and a medieval coca float beneath the vaulted ceiling next to the large wall of glass. This reinforces the idea

2 Real Decreto 1508/2008, http://www.boe.es/boe/dias/2008/10/14/pdfs/A41176-41178.pdf

3 The exhibition level is built underground in an area which, until the mid-19th century, was under the sea.

that visitors are strolling along the seafloor and, by looking up, are seeing the water's surface on which the two ships are sailing.

Center stage in the "Patrimonio Cultural Subacuático" section is occupied by the to-scale reconstruction of the Phoenician ship "Mazarrón 2"; the entire right-hand side of the space presents an enormous LED wall that recreates themes and atmospheres from the marine world. This wreck, immersed in a virtual sea, is surrounded by reconstructions of a group of large buoys, whose red color is extremely eye-catching (Fig. 1). The buoys are actually interactive devices, both mechanical and digital, whose goal is to bring visitors closer to the experiences of underwater archaeology. They constitute a response to today's public's growing demand for spaces designed for practical, experimental learning, capable of creating an interaction that brings out the scientific and historical content the exhibition wants to communicate.

To analyze the functioning of these expository elements and assess their degree of attractiveness and usability, in 2017 a summative evaluation[4] was carried out via direct observation and questionnaires which has made it possible to define their strengths and weaknesses (COSSEDDU 2018). The evaluation's results allow ARQVA, as well as other museums and operators in the sector, to gain more in-depth knowledge of the variables present in the complex relational system between the public and a museum's interactive media.

Fig. 1. The to-scale reconstruction of *Mazarrón 2* surrounded by the buoys

4 The aim of this evaluation, conducted thanks to the collaboration and availability of the director and the entire museum staff, was to verify the effectiveness of the expository choices adopted.

2. THE UNDERWATER EXPERIENCE THROUGH INTERACTIVE MEDIA

The five buoys of the Patrimonio Cultural Subacuático[5] are dedicated to the topics of diving and the techniques of excavation, recovery and analysis in the undersea world. The goal is not only to take visitors down into the marine depths and show them how underwater archaeologists work, but also to explain the scientific principles that regulate the latter's activities.

All the buoys have the same structure: above a reddish-orange hemispherical base stands a cylindrical glass column full of water, inside of which the phenomenon in question takes place. Beside the columns are the command buttons and the screens that explain the phenomenon represented.

Buoy 1. Diving is easy (Fig. 2).

-Typology: digital and mechanical interactive device.

-Theme: the dive.

-Description: the column contains a small diver and a seafloor with a wreck.

-Functioning: the visitor begins the interaction by pressing a button that activates the diver's descent toward the wreck. When surfacing begins, the screen (Fig. 3) shows a comparison between the time spent in the marine depths and the relative decompression phases, inviting the visitor to wait the necessary number of seconds – the time displayed passes more quickly than normal, of course – to carry out the various phases correctly, and then to press the button again to continue the ascent to the surface.

-Data on usage: "attraction power"[6] was 0.79, the average stop time was roughly 1 minute and 30 seconds, while "holding power"[7] was 0.44.

Of the 89 people who stopped in front of the device, only 72 used it. 8 visitors used it more than once (the second-ranked element in this category), while on 6 occasions a discussion occurred between visitors in the same group with regard to its functioning.

It was also one of the 8 elements in the museum (out of a total of 65) toward which the 113 visitors surveyed showed clear and evident signs of annoyance.

5 Another buoy, separated from the other five, is dedicated to the theme of the side-scan sonar surveys.

6 The ratio of visitors that stopped in front of the interactive element to the total number of visitors (SHETTEL 1992).

7 The ratio of the time spent by visitors with the interactive element to the time necessary to use it in a correct and complete manner (SHETTEL 1992)

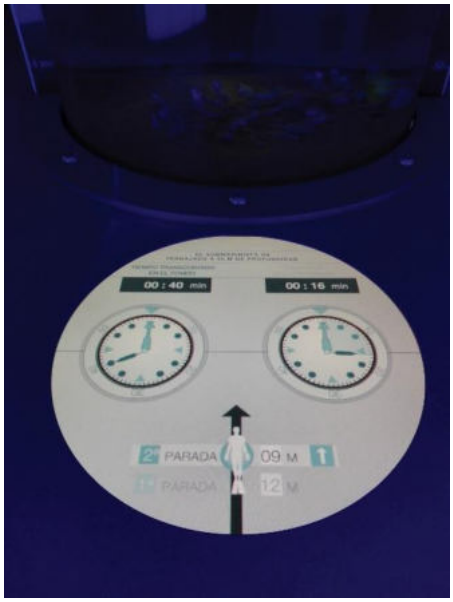


Fig. 2, 3. Buoy 1. Diving is easy. The screen shows a comparison between the time spent in the marine depths and the relative decompression phases

Buoy 2. Objects change color under water.

-Typology: mechanical interactive device.

-Theme: the progressive absorption of color under water.

-Description: a luminous ball is present inside the column.

-Functioning: the ball descends toward the base, gradually changing color.

-Data on usage: "attraction power" was 0.69, the average stop time was roughly 55 seconds, while "holding power" was 0.66. Of the 78 people that stopped in front of the buoy, 67 actually used it (4 of them as viewers of others who were using it).

Buoy 3. The underwater vacuum.

-Typology: mechanical interactive device.

-Theme: principles regulating the functioning of the underwater vacuum

-Description: the water column is divided into two parts, one of which contains, on the bottom, the reproduction of marine sediment where the mouth of the underwater vacuum is present.

-Functioning: the vacuum removes the sediment and unloads it into the other part of the column.

-Data on usage: "attraction power" was 0.56, the average stop time was roughly 38 seconds, while "holding power" was 0.77.

Buoy 4. When objects speak (Fig. 4).

-Typology: digital interactive device.

-Theme: investigating the different types of objects that can be discovered under water.

-Description: the water column contains a bottle of Coca Cola and a fragment of a Roman amphora. At the base of the column is an interactive digital screen.

-Functioning: when visitors click on the button, they have two minutes to take a quiz about the two objects.

-Data on usage: "attraction power" was 0.63, the average stop time was roughly 71 seconds, while "holding power" was 0.71.

Buoy 5. The lifting balloon (Fig. 5).

-Typology: mechanical interactive device.

-Theme: recovery of objects from the seafloor.

-Description: in the water column is present a lifting bag attached to a basket with a small amphora.

-Functioning: when the bag fills up with air, it floats upward and brings the basket with the amphora inside with it.

-Data on usage: "attraction power" was 0,48, the average stop time was roughly 52 seconds, while "holding power" was 0.62.

Fig.4. The buoy 4. When objects speak

Fig. 5. Buoy 5. The lifting balloon

3. CONSIDERATIONS

Analysis of the visit itineraries in this section (COSSEDDU 2018, pp. 284-285) has shown that the buoys significantly influence the choices of visitors, who prefer them to the panels and videos.

The evolution of the interactive media's "attraction power" however, reveals a gradual diminishing of their usage, which goes from 0.79 for the first (nearly four out of every five visitors) to 0.48 for the last (less than one out of every two visitors). This datum indicates that the public was not entirely convinced by the experiences proposed.

The questionnaires given to visitors to evaluate elements of the museum also appear to confirm this finding: the buoys achieved a score of 5.98/7, which in theory is a good result, but actually positions them only in fourth place (out of a total of eight typologies of exhibition elements investigated) in this special visitor approval classification.

What's more, the interactive elements were the second most-criticized category; some felt they were too simple, indeed more suitable for a public of children, while others complained that the phenomena were not represented with sufficient clarity.

This contrasting picture is the sum of particularly positive aspects and others that, in order to reach their goal, would benefit from various modifications.

Among the factors that have a positive impact on the use and comprehension of the buoys are their closeness to one another and the recognizability of their design; in fact these stations are positioned around the wreck of the "Mazarrón 2", almost as if to mark it out on the surface of the museum-sea, and are also distinguished by their identical color and design.

Physical accessibility is guaranteed by a height appropriate for both adults and children, while the lack of archaeological finds in this section8 makes it possible to avoid one of the most frequent problems for museums equipped with interactive elements: the competition between these types of media and the finds on display, which often end up being obscured.

By choosing to tackle the scientific principles at the foundation of underwater archaeological fieldwork, the museum has also diversified its target audience, speaking not only to those interested in history, but also to visitors fascinated by the technical and scientific aspects as well. Also interesting in this sense is the museum staff's attempt to respond to hypothetical questions visitors might ask themselves, putting themselves in the public's shoes and making sure the visitors are at the center of the museum experience, even at a preliminary, organizational phase.

Moving on to the negative aspects, the most important of them is certainly the scant level of interaction generated. Visitors do not have the chance to choose between various options, they are not challenged, but are merely asked to activate a demonstration by pressing a button and then be passive spectators, which risks creating possible feelings of frustration or boredom. The only genuine exception is interactive digital element n. 4, which registered an elevated "holding power" despite requiring a stop of at least two minutes.

Another factor that limits the use of the buoys, despite the presence of the digital screens that explain the phenomena investigated, is the lack of simple and direct communication. Museum visitors are notorious for their impatience with reading instructions, preferring to proceed by trial and error (HEIN 1998). This phenomenon manifested itself particularly with interactive element n. 1, where the public is invited to wait the necessary time for the decompression stops before proceeding with the surfacing maneuver, yet almost no one did so.

It is also possible that uniformity in design alone is insufficient to clarify the relationship between these media. A different communicative choice could have made visitors aware that they were beginning a journey through the scientific phenomena at the foundation of an underwater dig, and thus increased their comprehension and engagement.

A final aspect that should be strengthened is the relational context. Many visitors choose to go to museums in a group, using the visit first and foremost as a social experience (FALK, DIERKING pp. 146-172). ARQVA's buoys, however, can only be used by one person at a time; thus one person is the

8 The few artifacts present in the section, rather than communicating their own particular historical/archaeological contexts of provenance, have the function of recounting the phases of excavation, recovery and conservation.

protagonist, and all the others have to settle for being spectators. This problem could be remedied by recreating, inside the museum, the relationship formed between dive companions; the many procedures the latter undertake together (dressing, checking equipment, using communication signals in the water, the ways of conducting diving activities and, more generally, the constant mutual surveillance) lend themselves perfectly to the creation of interactive group activities.

After all, since for reasons of security and enjoyment it's better to go on a dive with a companion you can trust, it's equally preferable to share a museum visit, taking advantage of that cognitive accelerator provided by the participation in new group experiences.

4. FINAL REFLECTIONS

To communicate the experience and emotions of underwater archaeology to the public without leaving the rooms of a museum, ARQVA relies on precise architectural choices and a wide range of communicative techniques in which interactive media play a central role. These tools, which have now been present in museums for many years, continue to evolve and multiply, because they allow the public to participate actively in the learning process that develops during the visit.

By choosing not to use every space in the hall to exhibit objects from its collections – a painful choice for many curators – ARQVA shows that it has overcome the old conception of the "object-centered" museum, whose principal end is to catalogue objects in order to conserve them. The Spanish museum, on the other hand, was created with the aim of being "discourse-centered" and putting narration at the center of its museological project (PUJOL TOST). This type of approach makes it possible to overcome the barrier erected due to the intellectual effort necessary to understand and codify the artifacts exhibited. The interactive elements dedicated to the dive experience also enable it to overcome another taboo common to many art, history and archaeology museums: the possibility of tapping into visitors' interests by transmitting ideas that can have practical applications.

The investigation conducted at ARQVA shows, however, that in the case of interactive elements it is necessary to make further progress to effectively transmit the museum's cultural authoritativeness and riches to visitors, allowing them, via interactive activities and the possibility of making autonomous choices and a more extensive social usage, to determine the outcome of their experience and share it with the rest of their group.

5. REFERENCES

Azuar Ruiz R. et al. (2007). "El Plan Museológico del Museo Nacional de Arqueología Subacuática (Cartagena, Murcia)", Museos.es, Revista de la Subdirección General de Museos Estatales, Vol. 3, pp. 48-63

Azuar Ruiz R. (2009). "Museografía del Patrimonio Cultural Subacuático. El Museo Nacional de Arqueología Subacuática. ARQVA", Museo, Mar y Arqueología. Revista de la Asociación Profesional de Museólogos de España, Vol.14, pp. 73-88

Azuar Ruiz R. et al. (2009). "El Museo Nacional de Arqueología Subacuática. ARQVA", VERDOLAY. Revista del Museo Arqueológico de Murcia, Vol. 12, pp. 159-181

Azuar R., Perez Bonet M.Á. (2009). "El Patrimonio Arqueológico Subacuático y su musealización: El Museo Nacional de Arqueología Subacuática. ARQVA", Monografies del CASC, Vol. 8, pp. 671- 679

Cohen-Stratyner B. (2013). "Authority and Meaning-Making in the Digital Era", Exhibitionist, pp. 22-26

Cosseddu A. (2018). Un'eredità da proteggere e comunicare. Summative evaluation del Museo Nacional de Arqueología Subacuática.ARQVA di Cartagena (Spagna), PCS European Journal of pstclassical archaeologies, Vol. 8 pp. 271-301

Doering Z.D. (1999). Strangers, guest or clients? Visitors experiences in museums, International Studies, Smithsonian Institution

Falk J.H, Dierking L.D. (2013). The museum experience Revisited, Routledge

Hein, G. (1998). Learning in the Museum, Routledge

Hernández Cardona F.X., Martinez Gil T., Rojo Ariza M.C., (2010). Los límites de la interactividad. Manual de museografía interactiva, Trea, pp. 575-612

Hillman T. (2006). The Physical Context of Hands-on Interactive Museum Exhibits: Identification and Categorization of Pedagogically Relevant Concepts

Mcmanus P. (1987), "It's the company you keep...The social determination of learning-related behaviour in a science museum", The international journalof museum management and curatorship, Vol. 6, pp. 263- 270

Pujol-Tost L. (2011)."Digital Heritage. Integrating ICT in exhibitions", Museum Management and Curatorship, Vol. 26 (1), pp. 63-79.

Santacana I Mestre J., Martín Piñol C., (2010). Introduccion al analisis de modelos de museografia interactiva, Manual de museografía interactiva, Trea, pp. 25-86

Shettel H. (1992). "Front-end Evaluation: Another Useful Tool", ILVS Review Vol. 2(2), pp. 275-280

Vázquez Consuegra G. (2008). "El Museo Nacional de Arqueología Subacuática. ARQVA (Cartagena, Murcia)", Museos.es, Revista de la Subdirección General de Museos Estatales, Vol. 4, pp. 42-55

Raising the awareness about underwater archaeological heritage through Edutainment and Virtual/Augmented Reality

F. Bruno[1], M. Cozza[1], M. Mangeruga[1], D. Skarlatos[2], P. Agrafiotis [2],
B. Davidde Petriaggi[3], R. Petriaggi [3], S. Rizvic[4], F. Liarokapis[5]

[1] 3DResearch s.r.l. – University of Calabria, Rende (CS), Italy
[2] Department of Civil Engineering and Geomatics, Cyprus University of Technology, Limassol, Cyprus
[3] Istituto Superiore per la Conservazione ed il Restauro, Roma, Italy
[4] Department of Computer Science University of Sarajevo, 71000 Sarajevo, Bosnia and Herzegovina
[5] HCI Lab, Faculty of Informatics, Masaryk University, Brno, Czech Republic

***Abstract*:** The recent developments of underwater photogrammetry have brought to a wide diffusion of the practice to digitally record the 3D models of submerged cultural assets. These 3D models can be used to implement software applications devoted to improve the digital accessibility to both scholars and the general public, interested in having a better grasp of underwater sites and maritime archaeology. This kind of applications can benefit from the edutainment approach in order to educate, entertain and inspire the wider public through creative storytelling and self-motivating learning.

In this context the Horizon 2020 i-MARECulture project (Advanced VR, iMmersive serious games and Augmented REality as tools to raise awareness and access to European underwater CULTURal heritagE), funded under the call 'Virtual museums and social platform on European digital heritage, memory, identity and cultural interaction' (CULT-COOP-08-2016), aims to develop and integrate serious games, interactive storytelling, immersive technologies and underwater augmented reality for supporting the wide public in acquiring knowledge about the European maritime cultural heritage.

This paper will focus on two of the various applications developed in the i-MARECulture project and in particular to the ones focused on the case-study of the underwater archaeological Park in Baiae near Naples. The first application is a Virtual Reality dry visit experience that enables every user to explore the "Villa con ingresso a protiro" without the need to conduct a proper dive. Furthermore, the same hypothetical reconstruction of the Villa can be enjoyed by divers directly underwater by means of an Augmented Reality system based on a specially designed underwater tablet that will serve as a virtual guide for divers that visit the underwater archaeological sites.

Keywords: i-MARECulture, Virtual Diving, Underwater Augmented Reality.

1. INTRODUCTION

1.1. Scope

The main goal of the i-MARECulture [1][2] project is to raise public awareness of European identity by focusing on maritime cultural heritage, which by default brings together different civilizations. In particular, the project aims in bringing inherently unreachable underwater cultural heritage, within digital reach of the wide public, by implementing virtual visits, serious games with immersive technologies and underwater Augmented Reality (AR). Scope of the project is to design, analyze,

develop and validate pioneer applications and systems in the context of Virtual Museums through collaborative and innovative research from a diverse group of scientists, researchers, archaeologists, experts and museums. The project merges the advancements in Virtual and Augmented Reality (VR and AR) with the underwater environment. By using existing technology, it is already delivering through its new website (www.imareculture.eu) breakthrough applications and digital experiences in the area of Virtual Museums, empowering different types of users to engage with European underwater cultural heritage digital resources.

1.2. Approach

Submitted in the call 'Virtual museums and social platform on European digital heritage, memory, identity and cultural interaction' (CULT-COOP-08-2016), the i-MARECulture project investigates and delivers new ways to personalize the museum visit for a digital or physical visitor, while supporting social cohesion and European identity. Virtual museums are particularly strong in visualizing CH that is either intangible, does not exist anymore, is partially destroyed or is remotely located. Ancient maritime commerce represents a perfect example of civilizations' interaction and cultural exchange, but unfortunately not easily exhibited to the wider public. Ships, shipwreck sites and underwater sites in general are far from public's reach and understanding. Enabling immersive technologies to allow for content enhanced dry visits of visitors on such sites, i-MARECulture project is raising public's awareness and stirs further interest about maritime culture.

One of the main goals of the project is to bring shipwreck sites to the reach of the wider public, so that they can have a personalized and interactive dry visit using VR headsets from the comfort of their house. Museum visits could be further enhanced by using immersive technologies, such as VR caves and holographic screens. The latter allows for all visitors to witness an interactive 3D experience of another visitor, since they carry no special glasses or any other equipment while freely walking around the objects under investigation. Regarding these dry VR visits, the focus is given to the quality of immersion into the virtual world, using as much detail as possible and high-end equipment.

Moreover, within the project, AR applications are developed in order to enhance the underwater experience of diver visitors, as there are submerged archaeological sites. Specially designed underwater tablets and smartphones provide assisted navigation to the diver/visitor and, using AR and custom applications, give additional information about specific exhibits based on proximity and diver's preferences. After the end of the project, these AR applications will be used to explore a sunken city, where the AR tablet will provide the diver with conceptual designs of the original status of villas and related constructions, which are now laying in ruins.

Following the need to extend any visit, serious games and storytelling encourage and surround the physical visit both before and after it. As a pre-visit experience, users will be able to participate in a seafaring game, sailing between ancient ports for commerce, using the limited resources and limitations of that specific time period. Similarly, as a training tool for archaeologists, experts will be able to partner up for a virtual excavation dive on an ancient shipwreck, with all limitations and problems that such dives have, and learn the use of the airlift.

Three sites have been carefully selected for project's implementation, based on their potential to support the context of each action, as well as their data availability, so that no assets were to be allocated on data acquisition: the Mazotos shipwreck site, the Xlendi shipwreck site and the Baiae underwater archaeological park.

Lately, i-MARECulture project delivered two libraries of 3D ship models and amphorae of the studied period. The 3D objects of these libraries are used in serious games. The libraries are designed with ontology, so that they can be useful for further archaeological archiving and are released to the public through the webpage of the project: www.imareculture.eu. All actions are being evaluated in order to attain measurable results and are enhanced by appropriate storytelling. It should be also mentioned that the experienced maritime archaeologists involved in the i-MARECulture project ensure the historic accuracy of every aspect, both through storytelling as well as realistic representations and game scenarios.

2. STATE OF THE ART

VR and augmented reality have been used in a number of occasions for allowing users/tourists to explore cultural heritage as well as educating them [9][21]. For underwater cultural heritage there have been fewer applications, due to the difficulties of the environment.

For exploring underwater cultural heritage in VR, geolocated and multi-resolution textured 3D models of underwater archaeological sites have been used [11]. In another study, more specific methods for realistic modelling and VR presentation of underwater archaeological assets were presented based on the Mazotos shipwreck site [17].

The virtual diving exploration of Cala Minnola shipwreck site [24] allowed users to perform an entertaining and interdisciplinary learning experience by receiving archaeological, historical, and biological information by means of a number of points of interest (POIs) and a virtual dive buddy that guides the users during the exploration of the digital replica of the submerged site.

Moreover, educational applications were proposed such as a training system for real-time underwater excavation in VR [16] and another one to teach the basics of photogrammetry to maritime archaeologists [14].

Conceptual gamification framework is proposed in [3] as framework for VR applications based upon the use of game elements in a 360-degrees video environment to enhance user interaction with a case study of the cultural heritage site, in Rethymno city, Greece. This application uses 360-degrees video to convey information about this historic place.

Russian Hermitage Museum [4], has produced the application called The Hermitage VR Experience. This novel VR experience for visitors is a 19-minute movie in 360-degrees format, where the actors and the narrator are performing selected scenes from Hermitage palace's history.

In Livia's Villa Reloaded [5] actors are telling the story in the 3D reconstruction of the Livia's Villa.

A Night in the Forum is an Educational Environmental Narrative Game that uses PlayStation®VR to take the users back in time to The Roman Forum during Augustan rule [6]. The game is happening in the virtual reconstruction of the Roman forum, where the user has a role of a guard and carries out assigned tasks through which he/she learns stories of Augustus and about Roman citizens during a time.

VR storytelling is also used in [3][7][8] demonstrating how this way of communicating information is efficient, engaging and attractive to the users. To our knowledge, this storytelling methodology has not been used by now in UW applications.

Concerning underwater AR applications, the first one described in literature was developed in 1999 [15] where an HMD for Navy divers was presented. A more sophisticated system was presented in 2009 by Morales et al. [18]. It consists in an Underwater Augmented Reality (UWAR) system that provides visual aids to increase commercial divers' capability to detect, perceive, and understand elements in underwater environments. The AREEF system which allows people to discover underwater word of corals, fishes or fairy-tale wrecks in a swimming pool in a comfortable and safe way [10]. Successively, in 2013, the AREEF system was improved in order to be used by more than one person [19] and also by children [20].

3. DRY VISIT IN VIRTUAL REALITY

The dry visits application consists in a Virtual Reality experience that enables the users to simulate a real diving session from the scuba diving viewpoint and explore the 3D digital replica of the three pilot sites selected for the i-MARECulture project. Since this paper focuses on the case-study of the Baiae underwater archaeological park, this section describes the dry visit applied to the scenario of "Villa con ingresso a protiro". Nonetheless, it is worth to point out that the dry visit application has been designed and developed to enable the users to explore all the three underwater archaeological sites' scenarios, which will be dynamically loaded in runtime from a single application. Starting from a virtual environment menu, the user can select the site to explore, view the related video-interviews, play the tutorial and start the virtual diving experience. The user wears a Head Mounted Display (HMD) to navigate the virtual environment and interact with some 3D objects to receive historical and archaeological information about the submerged artefacts. The light-weight helmet isolates the user from the distractions of the actual physical environment and encompasses the entire field of view. It contains a high-resolution stereoscopic display; adjustable optics; an optical tracking system capable of tracking both the position and the orientation of the user's head; and a stereo audio output. Moreover, the HMD is usually coupled with one or two wireless handheld controllers equipped with several buttons, joystick and a touchpad as a means of human-computer interaction.

Fig. 1: A user interacting with the VR system to explore the underwater area of "Villa con ingress a protiro".

The interactive virtual scenario of the "Villa con ingresso a protiro" has been created starting from the 3D reconstruction of the underwater archaeological area. This digital replica of the submerged site has been enriched, by means of the Unity editor, with the surrounding seafloor, flora and fauna, the terrestrial environment (coastline, etc.), and additional 3D models (boat, buoy, etc.). Furthermore, graphical effects have been added to the scene to simulate the underwater environment, thus enhancing the realism of the experience. In particular, these effects include physical accurate simulation, such as light rays, refractions, fog, caustics, particles and bubbles. Moreover, the 3D models of the flora and fauna replicate the plants and fishes who populate that specific marine ecosystem, i.e. the

Mediterranean Sea. In order to maximize enjoyment and engagement by capturing the interests of the users, the virtual scenario has been then populated with 3D models that represent the points of interest with associated multimedia data. In particular, they can contain: audio files that provide archaeological, historical and biological information; the activation of a 3D hypothetical reconstruction of the "Villa con ingresso a protiro"; 360-degrees videos settled in the hypothetical reconstruction scenario. In order to simplify the management of the multimedia contents, they are stored into a remote database and they can be accessed from the dry visit application by means of a web service and a RESTful API.

The hypothetical reconstruction is a 3D virtual environment that shows the complex of "Villa con ingresso a protiro" as it appeared in the past [23]. It has been achieved by means of a theoretical and multidisciplinary scientific approach [23] that exploits the 3D data together with drawings and other historical and archaeological information in an iterative feedback reconstruction process. This process involved several professional figures and consisted in several phases. It started with the gathering of data (historical documentation, 3D models, scientific literature) and its analysis that led to the formulation and the investigation of different interpretation hypotheses. Then, the architectural remains have been modelled and validated by means of an iterative critical revision. In particular, this process is based on interleaving a phase of technical reconstruction with a strong critical revision to generate a feedback process, iterating the construction/correction loop as much as needed. The result is the final 3D reconstruction, as it appeared in the past, of the "Villa con ingresso a protiro" (Fig. 2). It's worth to point out that, thanks to the abovementioned iterative feedback process, the hypothetical virtual reconstruction has been examined and approved by the scientific experts [23].

Fig. 2: Different portions of the 3D hypothetical reconstruction of the Villa: the impluvium (a), the room with the pelte mosaic (b), garden (c), columns (d).

The game logic of the dry visit application presents three distinct elements: exploration, storytelling, and interaction. In order to simulate a real diving session, the exploration starts above the water surface, where the user can see the coastline that overlooks the archaeological site, as well as additional 3D models representing the boat and the buoy. Once the user dives in the submerged virtual environment, he/she can explore the underwater area and interact with the POIs that provide historical and archaeological information. A virtual dive buddy guides him/her among the six 360-degrees short videos that have to be played in a very specific order, since they compose a story settled in the ancient Baiae. Moreover, as already specified above, a special POI enables the user to switch from the 3D representation of the Villa to the reconstruction of its ancient status. Once activated the virtual hypothesis environment, the user can "walk" into the Villa and explore its original magnificence. The user interaction occurs by means of an HMD technology to look around and one or two wireless controllers that enable the user to explore the virtual environment and interact with the POIs. Moreover, a directional arrow and the virtual dive buddy show the direction to reach the underwater archaeological area and related multimedia content.

The results of the preliminary tests have shown that this virtual experience represents an effective tool to enable the citizens to access to the Underwater Cultural Heritage, in particular to the "Villa con ingresso a protiro" in the underwater archaeological Park of Baiae.

3.1. 360 Storytelling

In order to introduce the users with the life during the Roman Empire, we created a set of 360-degrees videos according to the scenario proposed by the archaeologists. The story is about a rich aristocrat who is buying a statue from a sculptor to decorate the garden of his luxurious villa. As parts of the story are activated during the VR exploration in different locations in the underwater Villa remains, we divided the plot in the following segments:

- the intro story consists of a 360-degrees video sequence of Baiae remains on land with a voice over introducing the viewer to the city and its historical significance, as well as the place where the plot is set;
- the sculptor's workshop scene where all characters introduce themselves (the sculptor, his apprentice, the aristocrat, and the slave);
- the street with shops scene where the sculptor tells his apprentice how beautiful is Baiae and prepares him for the meeting with the aristocrat;
- the villa entrance scene where the sculptor and his apprentice are greeted by the doorman and let inside the villa;
- the room with mosaics scene where the slave announces the visitors to the aristocrat;
- the atrium scene where the sculptor is introducing his apprentice to the villa;
- the discussion of the sculptor and the aristocrat about the statue design and price.

The stories (except the intro) are combinations of actors recorded against the green screen with computer generated backgrounds. Background images are renders from 3D villa reconstruction model, as well as 3D models of a generic street with shops and sculptor's workshop. The video is accompanied by 3D sound in order to obtain the full user immersion.

The main challenge of VR storytelling was to direct the story in a way that important replicas or parts of the plot do not remain unnoticed by the viewer, as he/she can now turn around and his/her field of view is not limited anymore, as in the case of classic video. However, this possibility increases user immersion in the scene and provides an opportunity for exploring the details of the environment, which is particularly useful in virtual cultural heritage reconstructions. The stories have, apart from

giving the users a hint on the life in ancient Baia, also enabled them to perceive the decorations and various details of "Villa con ingresso a Protiro", creating impressions that they are really there.

Fig. 3 shows the work of various professionals involved in stories production (director, producer, cameraman, actors, make-up artists, graphic designers), while in Fig. 4 are presented screenshots from some of the stories.

Fig. 3: The stories production team.

Fig. 4: Screenshots from Baiae VR storytelling.

3.2. PRELIMINARY TESTING

Informal testing has been performed for the VR Baiae dry visit application. In particular, the application was shown to 6 VR experts as well as 6 VR students. Initial results indicate that the application is immersive and interesting. Some minor issues were spotted including scaling of the interactive storytelling actors/agents. Overall, the experience was rated as positive and a formal evaluation with questionnaires is currently on its way.

Specific study was conducted to evaluate if the use of actors contributes to the immersion and edutainment of the VR cultural heritage application [22]. First, we have performed a heuristic evaluation (HE) by 5 experts in the field of VR/AR development and UX experience. The results of the HE facilitated design of the questionnaire for user experience study. The study involved 23 participants, and evaluation included both quantitative and qualitative part. Perceived user experience

was measured with web-based structured questionnaire, and the evaluators were observing the study participants while they were engaged in the VR digital stories.

Our study showed that the use of actors in VR storytelling contributed to the quality of user experience and evoked positive level of immersion and indicated beneficial effect for edutainment, since users learn through the empathy with actors. The results brought to our attention significance of eye-contact with the actors for immersion and of proper use of cues for directing the user attention in 360-degree videos.

4. UNDERWATER AUGMENTED REALITY

As evidenced in section 2, the experimentation of Augmented Reality (AR) in underwater environment is a challenging research field and, however, it has been never done in submerged cultural sites mainly because several technical challenges need to be resolved for implementing a sufficiently accurate method for absolute localization and tracking in the marine environment.

In the i-MARECulture project two different systems have been developed to perform an augmented visualization representing the hypothetical 3D reconstruction of the archaeological remains as appeared in the past by means of a commercial tablet housed in a waterproof case. The first system integrates a marker-based tracking with inertial sensors, while the second one adopts a marker-less approach that integrates acoustic localization and visual-inertial odometry.

4.1. MARKED-BASED AR

Estimation of the user/diver position in AR is one of the most challenges issues. Even if nowadays there are a number of good approaches for terrestrial applications, in underwater environments the situation is very different. Sensor based approaches are typically limited to acoustic tracking but one the main disadvantages, amongst others, is the cost of the sensors. On the other hand, computer vision approaches can be also used with a promising result. The focus of this research is to develop AR interfaces for underwater environments for different weather/turbidity conditions. This was a big challenge due to the variability of the underwater visibility conditions.

We introduced a new method [12][13] based on white balancing that enhances underwater images to improve the results of detection of markers. To assess the effectiveness of our results, a pilot underwater testing was performed in underwater archaeological park of Baiae. The focus of the testing was limited to one building that lies on the sea bottom: "Villa con ingresso a Protiro", with a characteristic mosaic in one of the rooms. Divers were able to perceive the abovementioned 3D hypothetical reconstruction of the villa in AR. Fig. 5, illustrates screenshots of preliminary user testing at Baiae.

Four current methods of underwater image dehazing that restore the visibility decreased by underwater environments were implemented and evaluated for their capability to improve marker detection for augmented reality. The evaluation of dehazing techniques was carried out by comparing the number of successful marker detections in several test videos. Results show that the marker tracking performance may differ greatly according to depth, location, and the actual light and turbidity conditions. Our method (underwater white balancing) combined with a fast marker detector gives better results than more sophisticated marker detector that runs much slower [12][13].

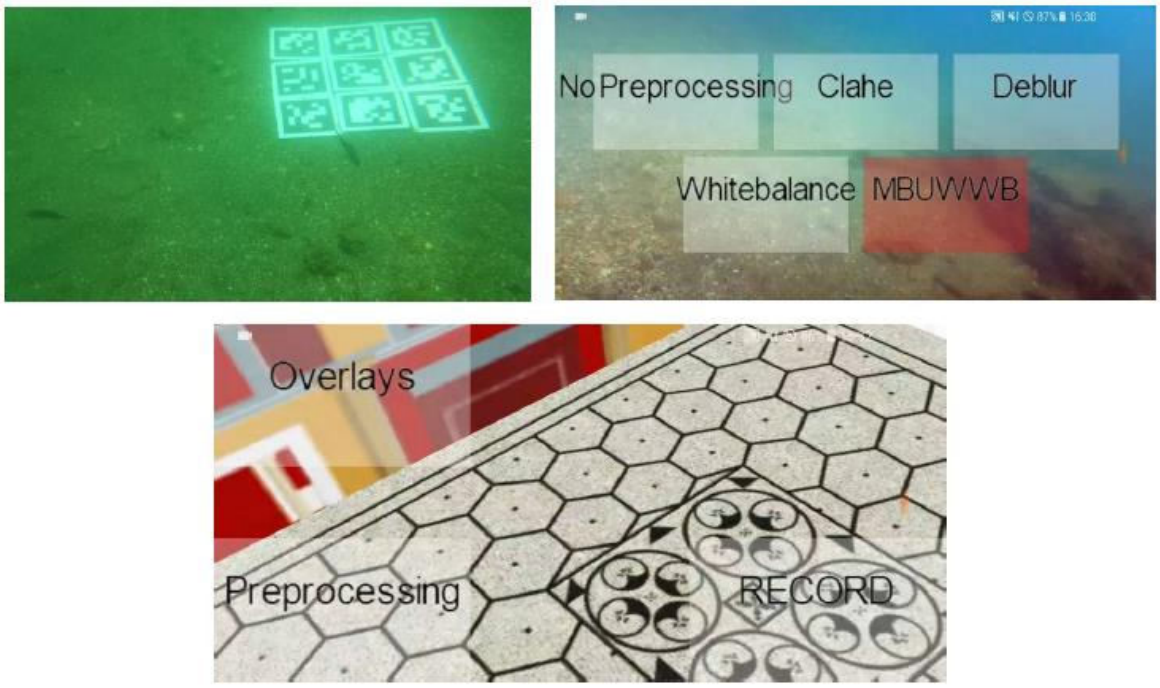


Fig. 5: Upper left: markers detected by iMARE Demo June18, placed in the grid of 3x3 markers. Upper right: multiple image processing methods, selected Marker Based Underwater White Balancing. Lower: 3D model of Villa placed on the location of markers.

4.2. MARKER-LESS AR

The marker-based UWAR approach requires to prepare the environment by placing fixed visual markers on the seabed, in order to estimate the orientation and position of the device with respect to the real world and to perform the superimposition of the virtual elements in the scene. During the i-MARECulture activities, a marker-less approach that employs a more general underwater localization and eliminates the need of markers for the localization of the device has been developed too. The Global Positioning System (GPS) is capable to provide geolocation and time information almost everywhere there is an unobstructed line of sight between a GPS receiver and four or more GPS satellites. Unfortunately, the radio GPS signal is strongly attenuated by the water and thus it cannot be employed for underwater localization. Instead, localization systems based on acoustic signals are used in this context. These systems employ the trilateration technique to calculate the position of a target using the distances calculated between the target and three or more acoustic transponders placed in known locations. The quality of the augmented visualization provided through a marker-less approach is strictly related to the precision of the underlying diver's position tracking, and consequently to the underwater acoustic positioning systems which suffer from low update rate and low accuracy. Since AR visualization requires a high frame rate to operate properly, it is quite evident that such acoustic localization systems alone are inadequate for this purpose. In fact, the update rate of the acoustic positioning system alone is around 0.2 Hz, and this is too low to deliver a seamless AR experience due to the long delay between two subsequent positions provided by this system. In order to overcome this limitation and improve the performance of the proposed UWAR technology, the acoustic positioning system has been integrated into a hybrid tracking system which merges positioning data, generated by the acoustic system, with data coming from a Visual Inertial Odometry (VIO) framework. In particular, given the low update rate of the acoustic system, it has been implemented a data fusion strategy aimed to fill the gaps between two consecutive acoustic positioning data. This enables a consistently high frame rate and provide to the user a consistent and smooth AR visualization.

The hybrid tracking system has been integrated in a cross-platform application made using Unity 3D, a game engine developed by Unity Technologies mainly used to develop videogames and simulation for several devices. This application, namely the UWAR app, exploits the hybrid tracking to help the divers to locate themselves during the exploration of an underwater archaeological site, allowing to obtain information about some point of interests and to see the original structures superimposed on the current status of the seabed. The UWAR app runs on an underwater tablet which is composed of a waterproof housing where a commercial tablet is placed. The app is provided with an Augmented Reality (AR) feature that enables the diver to live a new and more immersive experience compared to a classic recreational dive. The AR allows the diver to view the hypothetical reconstruction of the structures and artifacts that are superimposed on the present status of the underwater archaeological site. The diver can switch from the actual state of the archaeological site to the hypothetical reconstruction using a dedicated button in the User Interface (UI). For the sake of clarity, this button has been highlighted in **Fig. 6**a; the label "Present" suggests to the user that he is visualizing the actual state of the underwater site. In this case, the actual state of the underwater site is rendered through a planimetry where the different areas of the villa are easily recognizable.

(a) **(b)**

Fig. 6. UWAR app UI. (a) Top-view visualization of the underwater site planimetry; (b) First-view visualization of the hypothetical reconstruction.

Once the user pushes the button highlighted in **Fig. 6**a, the concerning label switches its text to "Past" indicating that the user is visualizing the hypothetical reconstruction of how probably the site looked in the past. The diver can choose the type of visualization between the top-view (**Fig. 6**a) and the first-person view (**Fig. 6**b). The top-view is especially suitable to orientate in the underwater environment whereas the first-person allows to fully enjoy the AR view modality. While in AR modality and first-person view, the user can move around the tablet, rolling and pitching, in order to change the point-of-view of the camera.

A validation test on the field of the UWAR application has been performed both before and during the official test session held in Baiae in June 2018 and June 2019 (**Fig. 7**). Different users that belong to the partnership of the i-MareCulture project tested the UWAR application by employing it for the augmented exploration of the underwater archaeological site of "Villa con ingresso a Protiro". All these users have been requested to evaluate the overall usability of the application, the ease of use of the UI and the interactions with the AR features.

Fig. 7. Pictures from the official test session held in Baiae in June 2019.

5. CONCLUSIONS

The paper has presented novel VR and AR systems that can improve the accessibility of the submerged archaeological sites by both divers and non-divers tourists. In particular, the VR dry visit application, developed in the H-2020 funded iMARECulture project, and here presented, provides to the large public the possibility to enjoy a dry dive in the Italian pilot site of the project that is the "Villa con ingresso a protiro" in the underwater archaeological park of Baiae. The VR experience is enriched with 360-degrees videos for providing additional contents through the storytelling approach.

The tablet-based AR system is addressed to support the divers' visits by showing them their position over the 3D map of the underwater archaeological site. The tablet also provides an augmented visualization representing the hypothetical 3D reconstruction of the archaeological remains as they appeared in the past during the Roman era.

Two different tracking technologies are described: the first uses an acoustic localization device and the second an optical maker-based approach. Although the latter is the most cost-effective solution, since it does not need the acoustic device, it requires the area to be populated by artificial visual markers and to keep them clean since just a few days are sufficient to be covered with a thin layer of biofouling that makes them completely unintelligible.

Acknowledgment: This work has been supported by the i-MARECULTURE project that has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 727153.

6. REFERENCES

[1] Skarlatos, D., Agrafiotis, P., Balogh, T., Bruno, F., Castro, F., Petriaggi, B.D., Demesticha, S., Doulamis, A., Drap, P., Georgopoulos, A. and Kikillos, F., 2016, October. Project iMARECULTURE: advanced VR, iMmersive serious games and augmented REality as tools to raise awareness and access to European underwater CULTURal heritagE. In Euro-Mediterranean Conference (pp. 805-813). Springer, Cham.

[2] Bruno, F., Lagudi, A., Ritacco, G., Agrafiotis, P., Skarlatos, D., Čejka, J., Kouřil, P., Liarokapis, F., Philpin-Briscoe, O., Poullis, C. and Mudur, S., 2017, June. Development and integration of digital technologies addressed to raise awareness and access to European underwater cultural heritage. An overview of the H2020 i-MARECULTURE project. In OCEANS 2017-Aberdeen (pp. 1-10). IEEE.

[3] Elmezeny, A; Edenhofer, N.; Wimmer, J. Immersive Storytelling in 360-Degree Videos: An Analysis of Interplay Between Narrative and Technical Immersion. Journal For Virtual Worlds Research, [S.l.], v. 11, n. 1, Apr. 2018. ISSN 1941-8477

[4] Museum H., VIDEOFABRIKA: The hermitage vr experience. http://www.inavateonthenet.net/case-studies/article/immersive-history-russia-s-hermitagemuseum-embraces-vr, 2017. Accessed: 2018-06-14

[5] Pietroni E., Forlani M. and Rufa C., "Livia's Villa Reloaded: An example of re-use and update of a pre-existing Virtual Museum, following a novel approach in storytelling inside virtual reality environments," 2015 Digital Heritage, Granada, 2015, pp. 511-518.

[6] A night in the Forum, educational game launched by H2020 REVEAL project https://www.vrtron.com/a-night-in-the-forum/

[7] O'Dwyer, N.; Johnson, N.; Bates, E.; Pags, R.; Amplianitis, K.; Monaghan, D.; Smolic, A.. (2018). Samuel Beckett in Virtual Reality: Exploring narrative using free viewpoint video. Leonardo. 1-10.

[8] Selmanovic E., Rizvic S., Harvey C., Boskovic D., Hulusic V., Chahin M. and Sljivo S., VR Video Storytelling for Intangible Cultural Heritage Preservation, In: Proceedings of 16th EUROGRAPHICS Workshop on Graphics and Cultural Heritage 2018

[9] Anderson, E.F., McLoughlin, L., Liarokapis, F., Peters, C., Petridis, P., de Freitas, S. 2010. Developing serious games for cultural heritage: a state-of-the-art review, Virtual Reality, Springer, 14(4): 255-275.

[10] Blum L., Broll W., Müller S. Augmented Reality Under Water. In SIGGRAPH '09: Posters (New Orleans, Louisiana, August 03 - 07, 2009). SIGGRAPH '09. ACM, New York, NY, 2009.

[11] Bruno, F., Lagudi, A., Barbieri, L., Muzzupappa, M., Cozza, M., Cozza, A., Peluso, R. 2016. A VR system for the exploitation of underwater archaeological sites. Proc. of the International Workshop on Computational Intelligence for Multimedia Understanding (IWCIM), IEEE Computer Society, Reggio Calabria, Italy.

[12] Čejka, J., Bruno, F., Skarlatos, D., Liarokapis, F. Detecting Square Markers in Underwater Environments, Remote Sensing, Special Issue Underwater 3D Recording & Modelling, MDPI, 11(4), 459, 2019.

[13] Čejka, J., Žuži, M., Agrafiotis, P., Bruno, F., Skarlatos, D., Liarokapis, F. Improving Marker-Based Tracking for Augmented Reality in Underwater Environments, Proc. of the Eurographics Workshop on Graphics and Cultural Heritage, The Eurographics Association, Vienna, Austria, 21-30, 2018.

[14] Doležal, M., Vlachos, M., Secci, M., Demesticha, S., Skarlatos, D., and Liarokapis, F. 2019. Understanding Underwater Photogrammetry for Maritime Archaeology Through Immersive Virtual Reality, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLII-2/W10, 85-91, https://doi.org/10.5194/isprs-archives-XLII-2-W10-85-2019.

[15] Gallagher D.G. Development of miniature, head-mounted, virtual image display for navy divers, OCEANS '99, MTS/IEEE Riding the Crest into the 21st Century, vol. 3, pp. 1098-1104, Sep. 1999.

[16] Kouřil, P., Liarokapis, F. 2018. Simulation of Underwater Excavation using Dredging Procedures, IEEE Computer Graphics and Applications, IEEE Computer Society, 38(2): 103-111.

[17] Liarokapis, F., Kouřil, P., Agrafiotis, P., Demesticha, S., Chmelík, J., and Skarlatos, D.: 3D MODELLING AND MAPPING FOR VIRTUAL EXPLORATION OF UNDERWATER ARCHAEOLOGY ASSETS, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLII-2/W3, 425-431, https://doi.org/10.5194/isprs-archives-XLII-2-W3-425-2017, 2017.

[18] Morales R., Keitler P., Maier P., Klinker G. An Underwater Augmented Reality system for commercial diving operations, MTS/IEEE Biloxi - Marine Technology for Our Future: Global and Local Challenges, IEEE Computer Society, 1-8, 2009.

[19] Oppermann L., Blum L., Lee J.Y., Seo J.H. Areef multi-player underwater augmented reality experience. In 2013 IEEE International Games Innovation Conference (IGIC), IEEE Computer Society, 199-202, 2013.

[20] Oppermann L., Blum L., Shekow M. Playing on AREEF: evaluation of an underwater augmented reality game for kids. In Proceedings of the 18th International Conference on Human-Computer Interaction with Mobile Devices and Services. ACM Press, 330-340, 2016.

[21] Sylaiou, S., Liarokapis, F., Kotsakis, K., Patias, P. 2009. Virtual museums, a survey and some issues for consideration, Journal of Cultural Heritage, Elsevier, 10(4): 520-528.

[22] Rizvic S., Boskovic D., Bruno F., Davidde Petriaggi B., Sljivo S. and Cozza M., Actors in VR storytelling, 11th International Conference on Virtual Worlds and Games for Serious Applications VSGames 2019 (accepted for publication)

[23] Davidde Petriaggi B., Petriaggi R., Bruno F., Lagudi A., Peluso R., Passaro S., (2018). A digital reconstruction of the sunken "Villa con ingresso a protiro" in the underwater archaeological site of Baiae. In IOP Conference Series: Materials Science and Engineering, Vol. 364, No. 1, p. 012013. IOP Publishing. doi.org/10.1088/1757-899X/364/1/012013.

[24] Bruno F., Barbieri L., Muzzupappa M., Tusa S., Fresina A., Oliveri F., Lagudi A., Cozza A., Peluso R. (2019) "Enhancing learning and access to Underwater Cultural Heritage through technologies: the case study of the Cala Minnola shipwreck site", Digital Applications in Archaeology and Cultural Heritage, Elsevier.

Results of the "Sommergiamoci" Project in the MPA Gaiola Underwater Park

M. Simeone[1], P. Masucci[1], C. De Vivo[1]
[1]Gaiola onlus Centro Studi Interdisciplinari, CeRD A.M.P. Parco Sommerso di Gaiola

***Abstract*:** This work is aimed at presenting the results of the "Sommergiamoci" (Let's dive) project carried out in the Marine Protected Area Gaiola Underwater Park (Bay of Naples, Italy). The project started in 2015 and it was focused on the implementation of a new sustainable and non-invasive system for the visit of the underwater archaeological and environmental heritage of the Park. Particularly, the Gaiola Underwater Park preserves the remains of a I century BC Roman Villa (part of the Pausilypon archaeological complex) and a very rich marine fauna. The goals were to both develop a system that could guarantee a sustainable and not invasive access to the underwater ruins, and, at the same time, to allow those that will never SCUBA dive to experience something that otherwise would be totally un-accessible. Thanks to the development of an innovative technology, which allows the direct audio/visual communication between a SCUBA diver and public on land, now 35 visitors per time can enjoy a dry dive experience. The result was obtained through the realization of a highly technological room in the visitor center of the Underwater Park, where a 3D immersive audio-visual communication with the SCUBA diver is obtained thanks to the use of wireless technologies. The project was realized by the Centro Studi Interdisciplinari Gaiola onlus in collaboration with the Campania Archaeological Superintendence, the Universities of Naples Parthenope and Federico II. In this work, we will present both the results in terms of public accessibility and in terms of technological development, explaining the difficulties and the challenges and how they were solved.

Keywords: Underwater Park, sustainable tourism, SCUBA diving, accessibility, dry dive experience.

1. INTRODUCTION

The "Sommergiamoci" (Let's dive together!) Project was carried out in the Marine Protected Area "Gaiola Underwater Park" in Naples (Italy). This Marine Protected Area (MPA), instituted in 2002 with the Inter-Ministerial Decree 78/2002, is the smallest in Italy and it is named after the two small islands located in the North-Western side of the Bay, along the Posillipo Coastline.

The Gaiola MPA is characterized by relevant biological and geological evidence, moreover, because of the intense geomorphological activity of the area, which caused the lowering of the coastline throughout the centuries, the seabed of the MPA is rich in archaeological ruins, part of a rich Roman villa dating to the I century B.C. "Simeone and Masucci (2016)". Since 2005, the Centro Studi Interdisciplinari (CSI) Gaiola onlus, in agreement with a local body of the Ministry of Culture, is in charge of the preservation, scientific dissemination and promotion of the important environmental, geological and archaeological heritage of the Park. The CSI Gaiola onlus is a National NGOs instituted to promote scientific research, preservation and dissemination of the environmental and archaeological heritage, with a special focus on the Northwestern side of the Bay of Naples and the Posillipo area.

The Gaiola MPA, in fact, is located in the densely inhabited city of Naples and still today the main challenge in managing the Park is to find a balance between sustainable accessibility and preservation of the environmental and archaeological heritage "Simeone and Russo (2005)". Even if, since 2007 a positive trend on the registration of illegal activities in the MPA has been recorded, the difficult social and economic context of the city is still characterized by a general lack of awareness on the importance of this Underwater Park. In fact, in 2015 it was demonstrated how there still was a lack of awareness on the existence of the underwater heritage in the Gaiola MPA, because of the difficulty in accessing what lies underwater and in recognizing to the underwater heritage the same value of the onland sites "De Vivo (2015)". This problem is obviously not related only to the Gaiola MPA, but to any underwater site preserving environmental and archaeological heritage and this is the reason why many studies and strategies have been carried out to find solutions and to make underwater heritage more accessible "Davidde (2004)".

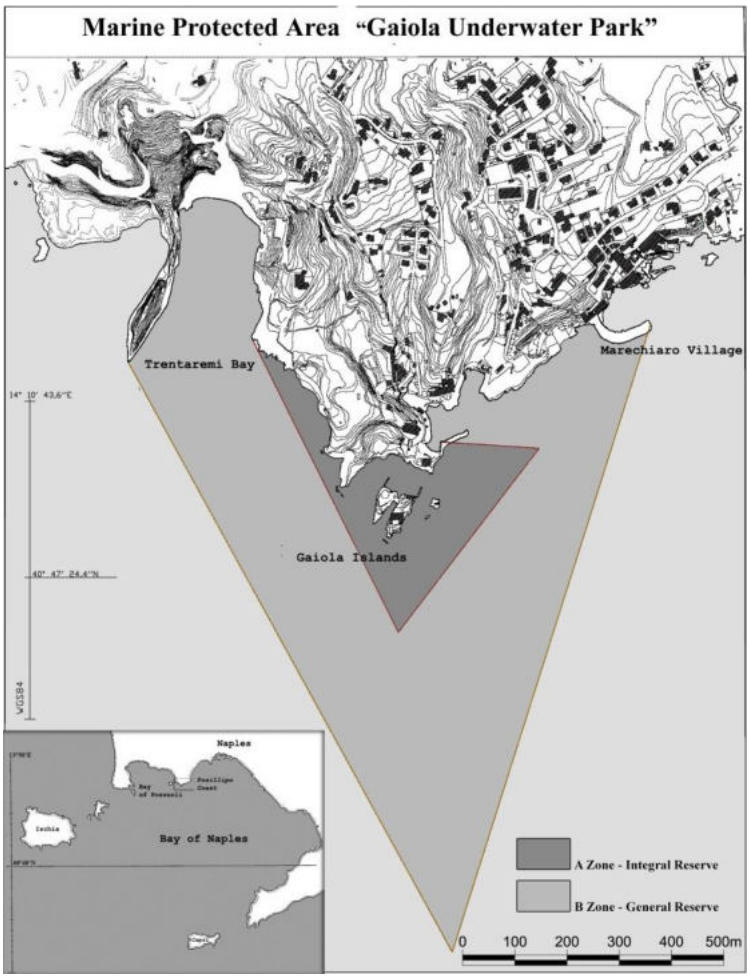


Fig. 1: Map of the Marine Protected Area Gaiola Underwater Park

Being aware that public awareness and participation are fundamental to guarantee the protection of this kind of site, as also prescribed by the 2001 UNESCO Convention on the Protection of Underwater Heritage "UNESCO (2001)", it is crucial to work on the awareness of the new generations. In fact, since 2006 the CSI Gaiola onlus carries out the environmental and heritage education project "The Sea of Naples" addressed to schools and, at the same time, collaborates to study programs with Neapolitan universities. Since 2006 an always increasing interest of students and teachers it has been recorded for educative programs aimed at the acquisition of competences through a "learning by doing" approach (Chart 1).

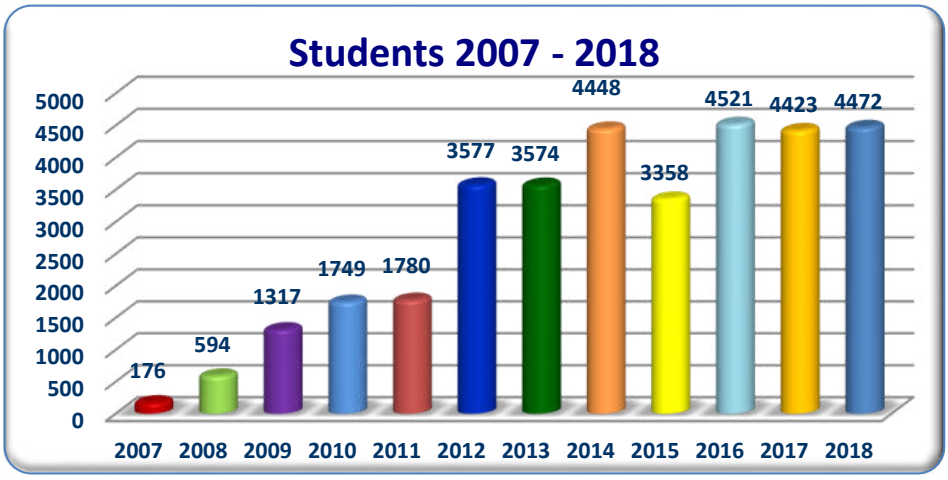


Chart 1

Despite this need of the schools, the accessibility of the MPA is limited because of logistic problems. In fact, the accessibility of the underwater heritage requires a confidence with the marine environment that not all the students naturally have. Particularly, snorkeling and SCUBA diving still have a limited audience and most Italian teachers would not feel comfortable to let students practice these activities under their responsibility. Moreover, due to climatic conditions, the request for didactic programs in the MPA is mostly concentrated in the late spring and summer months, which is a problem for the sustainable accessibility of the site.

At the same time, if it is true that the underwater heritage is still considered difficult to access, it is also true that the increasing of the underwater tourism is always more in conflict with the preservation needs of MPAs "Hawkins and Roberts (1992)2; "Agnesi et al. (2001)"; "Cattaneo-Vietti and Tunesi (2007)", especially as regards special biocoenosis, Total Reserve Areas and areas particularly at risk of damages related to mass tourism. As regards underwater archaeological ruins, there is deep knowledge of the damages caused by human impact on archaeological heritage "Palumbo (2002)".

Therefore, the Project "Sommergiamoci" was aimed at increasing the level of awareness, especially of the young generations, on the archaeological and environmental heritage of the Park, by using innovative technologies and methodologies which allow to have a direct dry dive experience of the underwater environment in a non-invasive way. Moreover, the project allowed to experience and to discover underwater areas where it is necessary to limit the access of the public for preservation needs and could be a useful research tool both in the fields of archaeology and marine biology.

Partners of the Project were the Soprintendenza Speciale per i Beni Archeologici di Napoli e Pompei (a local body of the Italian Ministry of Culture), as manager authority of the MPA; the Science and Technology Faculty of the University of Naples Parthenope and the C.d.S. on Biology of the Marine Production of the University of Naples Federico II.

2. MATERIALS AND METHODOLOGY

The Project was aimed at testing an easy to use, high quality and low cost wireless audiovisual transmission system from the underwater environment and a special room in the Researchand Visitor Centre of the MPA (CeRD) from where students and visitors can virtually visit the underwater environment of the MPA by observing in real time and with a 3D perspective the images filmed by

SCUBA divers. During the observation, the visitors can interact directly with SCUBA divers guided by archaeologists and biologists that are in the room in the Visitors' Centre (Fig. 2-2). The audiovisual signals coming from the SCUBA divers can be seen in streaming, with the possibility to create a direct connection with video conferences in Universities, schools,etc..

The Project started in 2015 and it was developed in three steps: 1) development of the audiovisual transmission system and set up of the "underwater room" in the CeRD; 2) testing of the system with target groups (visitors, school and university students, researchers;3) dissemination of the results. During the first step, several transmission tests were carried out by using several wireless systems (over IP, up-link dsng, JSCC) trying to guarantee the SCUBA diver to move easily in the space and to easily use the transmission tools.

As regards the typology of the video signal, the aim was to use full HD 3D to give the audience a better experience. The setting of the room was planned trying to give the audience the best possible experience. For the second part of the project school and university students were involved; after the test,the students had to answer an appreciation questionnaire, the answers were then used to improve the system. The third step of the Project was the realization of a webpage, www.sommergiamoci.it, through which it will be possible, by entering a reserved section, to connect and to give students and everyone who cannot access the MPA's Visitor Center the chance to experience the underwater environment.

3. RESULTS

3.1. Didactic activities

The test and set up part of the Project lasted 2 years, involving 1296 school students and 468 university students. At the end of the 2 years, the audiovisual 3D wireless system and the "Room under the Sea" were ready to be used.

The technological tests lead to the development of a modular system constituted of: 1) SCUBA diver with a 3D video cameralocated in a water proof diving case and full-face communication system; 2) floating transmission module, connected to the SCUBA diver with a wire on which it is installed the audiovisual system; 3) receiving station located on the roof of the CeRD and connected to the "Room under the Sea" and equipped with a domotic system for the synchronization of the light and audio effects of the underwater images (Fig. 2).

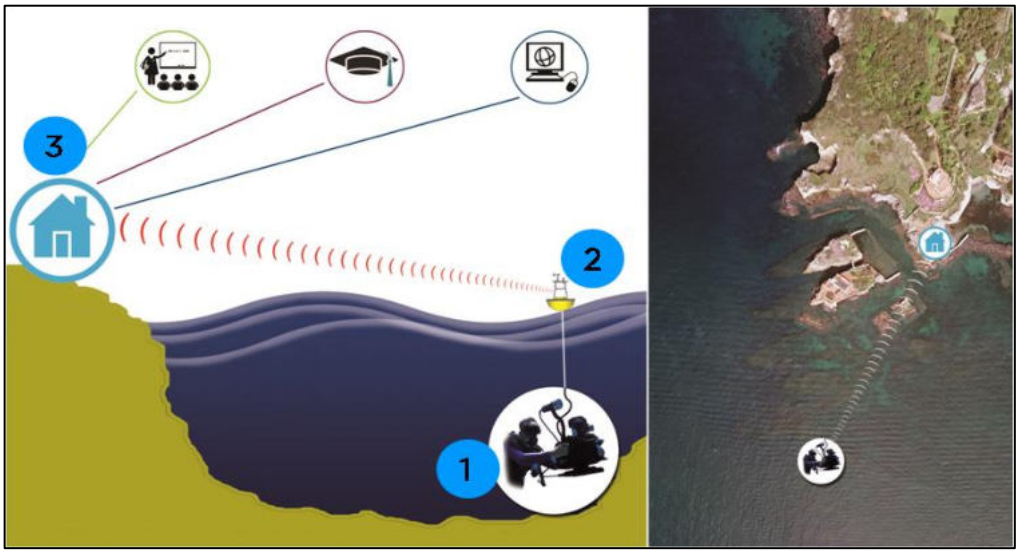


Fig. 2: Synthetic representation of the transmission system "Sommergiamoci"

For the long distance wireless transmission of the 3D video signal the Connex FPV was used. The system, created for drone flights, well adapted to the Project's need, guaranteeing high quality (1080p/60), transmission stability and very low signal latency (less than 1 ms). For the wireless audio transmission from the underwater environment, an already existing Bluetooth system was adapted which is connected to a mobile phone located in a water proof floating case. The whole system is located in a small and light floating module connected to the SCUBA diver by a wire, which allows the SCUBA diver to move around easily (Fig. 3).

Fig. 3: SCUBA diver using the floating module

The tests of the system gave excellent results. To all the students participating to the tests were distributed questionnaires framed to evaluate the appreciation levels and to help to better implement the system.

In the following charts the results of the surveys will be discussed.

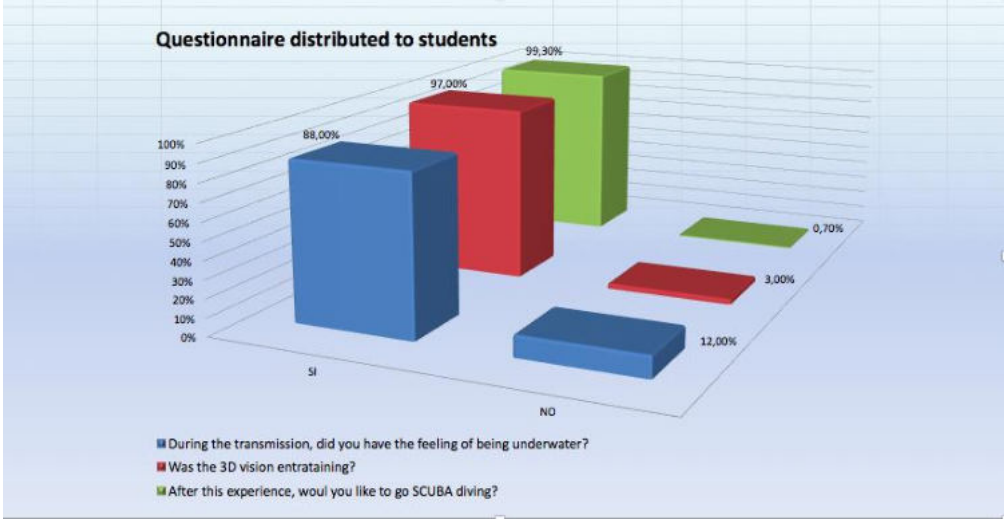


Chart 2

Chart 2 shows the answers to the questions on the perception of the 3D transmission and on the appreciation level. 88% of the participants had the feeling of being for real with the SCUBA diver; the 97% of the students declared that the 3D vision helped to improve the experience and the 99,30% stated that the experience let them think about the possibility to take the SCUBA diver licence. Also the sounds and light effect implemented through a demotic technology helped to genereate a real immersive experience.

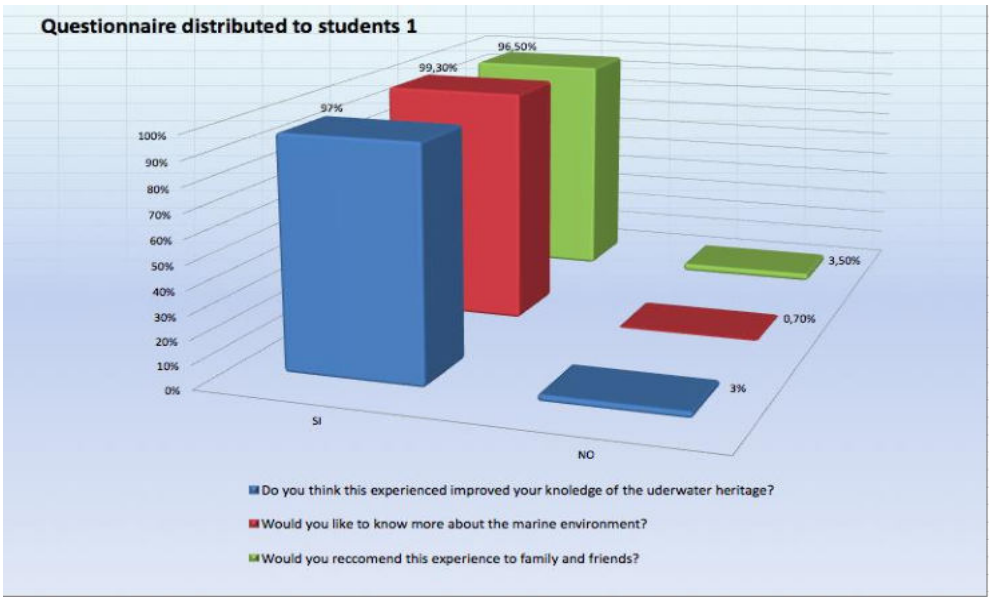


Chart3

Chart 3 shows the results on the increase of knowledge and awareness on the underwater environment of the participants to the tests.99,30% of the participants stated that the curiosity towards the marine environment increased, and this is a very important result, since, often, as previously stated, the marine environment is perceived as unaccessible and distant.

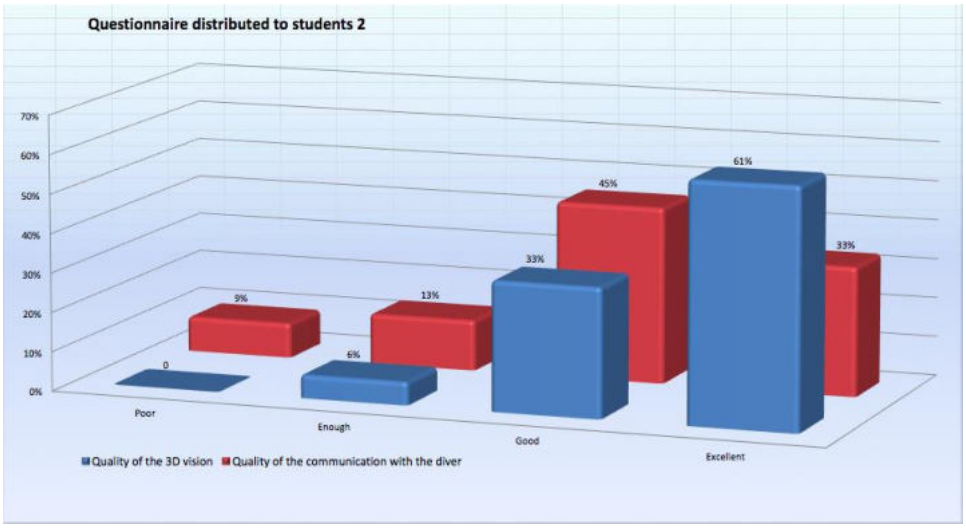


Chart4

The last chart (Chart 4) shows the results to questions specifically addressed to test the technological development and the transmission system. It is evident how, if the video transmission was excellent since the beginning, there were some problems with the audio transmissions. In fact, it was necessary to add an audio mixer in the room, to clean the sounds coming from underwater. It was evident that SCUBA divers with a higher voicetimber could transmit a better sound than those with a lower voice timber.

Fig. 4: Students participating to the "Sommergiamoci" Project

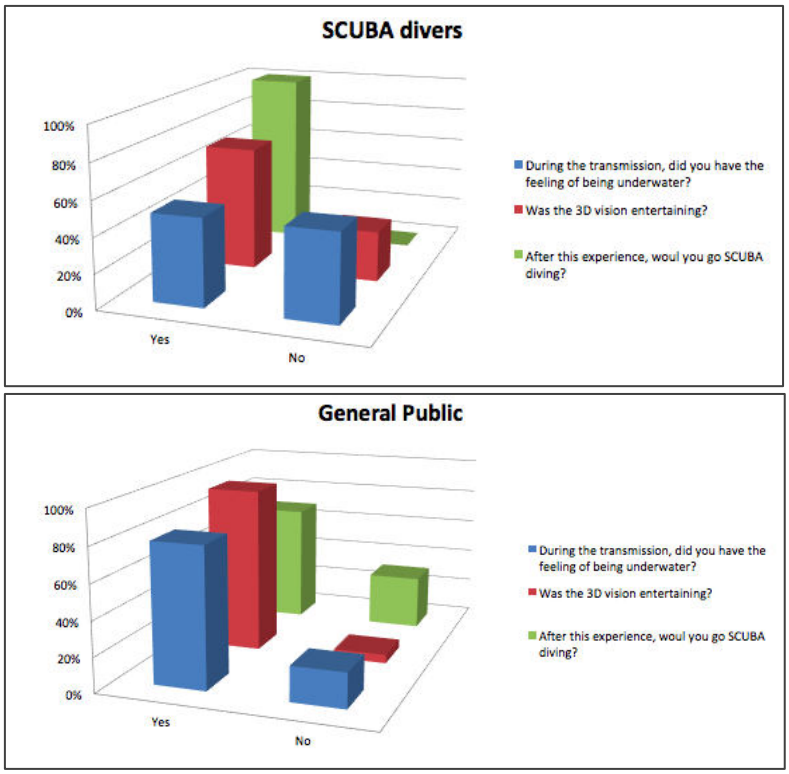
3.2. Research

The system was mainly developed to let young citizens discover the marine enviroment, but it proved to be extremely useful also for research purposes. In fact, it is now normally used during the monitoring campaigns of the MPA's seabed, allowing the SCUBA divers to directly communicate with the collegues on the surface. This system allows to improve the quality of the collected data during the monitoring campaings, to produce higher quality images and to lose a lower quantity of data.

3.3. Cultural and Tourism activities

The last test was targeted to a more general audience made of normal visitors, in order to evaluate if the system can be used also with this kind of public to develop a less invasive system to let people

visit the MPA. The target was made of both general visitors and SCUBA divers who well know the feeling of a real SCUBA diving experience.The results of the two targets were very different (Charts5-6).



Charts5 - 6

In fact, the answer to the question "Did you have the feeling of being underwater" was negative for many of the SCUBA divers; nevertheless, a high percantage of the SCUBA divers enjoyed the experience.

4. CONCLUSIONS

The project "Sommergiamoci" gave the Gaiola MPA an easy to use, low cost and innovative system to improve the accesibility of the MPA in a non-invasive and sustainable way. Thanks to the "Room under the Sea" there is the chance to have just 1 SCUBA diver for 35 people that do not have any impact on the underwater environment and can experience and discover the underwater heritage of the MPA. Moreover, the possibility to use the streaming allow to increase the people that can enjoy the underwater environment with just 1 person SCUBA diving. Nevertheless, it is evident that the full 3D HD system and the other technological tools help to have a better experience especially for those that are in the "Room under the Sea".

The system proved to be a very effective tool to let students almost directly experience the marine environment and develop their level of awareness on the underwater environment, but it also proved to be a very interesting solution to give all the people that not feel comfortable with the marine environmentor that, will never be able to direct access the marine environment for health issues, to experience the underwater environment.

Moreover, the deveoped system can be a valid solution to make the underwater archaeological and environmental heritage accessible, even if, for special preservation needs, people cannot have a direct contact with it. Finally, the system proved to be extremely useful as a support for the scientific and monitoirng activities constantly carried out in the MPA.

The hope is that the development of this kind of approach will increase, also by sharing the results of this project, since the need for a more sustainable way to approach our heritage is highly needed, especially in very delicate and fragile environments. Moreover, it has been proved, also by other experiences, as the one of Arles "De Vivo (2018)", that increasing the awarness of local population on the importance of preserving the underwater heritage is fundamental for the sake of its preservation and that, very often, the lack of awareness is simply due to a lack of knowledge that can be solved, even for difficult to access sites, thanks to models as the one presented with the "Sommergiamoci" project.

Finally, it is important to remark that the "Sommergiamoci" Project could be considered a good practice to fulfill one of the prescription of the 2001 UNESCO Convention on the Protection of the Underwater Heritage. In fact, as written in Rule 1: "The protection of the underwater cultural heritage though in situ preservation shall be considered as the first option. Accordingly, activities directed at underwater cultural heritage shall be authorized in a manner consistent with the protection of that heritage and subject to that requirement may be authorized for the purpose of making a significant contribution to protection or knowledge or enhancement of underwater cultural heritage", "UNESCO (2001)". The project also fulfills the aims of the Council of Europe 2005 Faro Convention on the Value of Cultural Heritage for Society, which insists on the importance that cultural heritage is recognized as such by the living communities.This is a point we totally share, since it is fully recognized that aware and well informed citizens are the best guardians of both environmental and cultural heritage. Moreover, cultral heritage, without a communithy that appreciate and understands its value simply becomes none's heritage.

The "Sommergiamoci" Project proved to have very good results in terms of increasing of the in situ accessibility of the site, sustainable access of the heritage and increasing of the awareness on the local population. Further studies will be carried out to test, through the years, the positive effects of the increase of citizens' awareness on the preservation of the environmental and archaeological heritage.

5. REFERENCES

Agnesi S., T. Di Nora and L. Tunesi (2001). "The study of diving tourism to support the adaptivemanagement in an Italian marine protected area (Ustica Island)", Rapport de la Commission Internationale pour l'ExplorationScientifique de la MerMéditerranée, Vol. 36: 347.

Cattaneo-Vietti R., L. Tunesi(2007). Le aree marine protette in Italia: problemi e prospettive. AracneEditore, Roma: 252 pp.

Hawkins J., C.M. Roberts (1992). "Effects of recreational scuba diving on fore-reef slopecommunities". Biological Conservation, Vol. 62; pp. 171-178.

Davidde B. (2004). Methods and Strategies for the Conservation and Museum Display In Situ of Underwater Cultural Heritage. ArcheologiaMaritimaMediterranea - An International Journal on Underwater Archaeology, Vol. 1: pp-135-150.

De Vivo C. (2015). "Revealing the Invisible: the Heritagization Process of the Underwater Environment". Annals of Marine Sociology,Vol. 25; pp. 4-20.

De Vivo C. (2017). "The case of the Arles Rhône 3 Project: an example of underwater heritage communication". Archeostorie Journal of Public Archaeology, Vol. 1; pp. 119-133.

Palumbo G. (2000). "Threats and Challenges to the Archaeological Heritage in the Mediterranean", Management Planning for Archaeological Sites. An International WorkshopOrganized by the Getty Conservation Institute and Loyola Marymont University, (J.M. Teutonico and G Palumbo eds), pp. 7-8.

Simeone M. and G.F. Russo (2005). Il Parco Sommerso di Gaiola. - In Carrada G.C., Coiro P., Russo G.F. (a cura di) "Le aree marine protette del Mediterraneo" (I quaderni di Uomo e Natura II) – Electa Napoli.

Simeone M. and P. Masucci (2016). "Nuove indagini sulle strutture archeologiche sommerse del Parco Sommerso di Gaiola a Posillipo". Rendiconti della Accademia di Archeologia Lettere e Belle Arti, Volume LXXVII 2014-2015 - Giannini Editore.

UNESCO (2001). Convention on the Protection of Underwater Cultural Heritage. UNESCO, Paris. http://unesdoc.unesco.org/images/0012/001260/126065e.pdf. Last retrieved on June 10th, 2019.

An innovative platform for virtual underwater experiences targeting the cultural and tourism industries

Nomikou P.[1], Karantzalos K.[2], El Saer A.[3], Pehlivanides G.[4], Tsoris P.[5], Stentoumis Ch.[3], Dura A.[1], Ioannidis G.[4], Sarantinos M.[5], Antoniou V.[1], Vlassopoulos O[3], Katopodis G.[4], Plessa K.[3], Kalisperakis I.[3], Bejelou K.[1], Monastiridis K.[4]

1Department of Geology and Geoenvironment, National and Kapodistrian University of Athens, Panepistimioupoli Zografou, 15784 Athens, Greece

2Remote Sensing Laboratory, National Technical University of Athens, 15780, Athens, Greece

3up2metric P.C., Computer Vision Engineering, Michail Mela 21, GR-11521, Athens, Greece

4TETRAGON, 2B, Karaiskaki str. 54641, Thessaloniki, Greece

5STEFICON, Perikleous 7 Neo Psychico, Athens, Greece

***Abstract*:** Although, the underwater environment is of great scientific interest regarding all fields of marine research, it has not been exploited broadly yet for cultural and tourism purposes. At the same time, technology in the fields of virtual and augmented reality has undergone considerable development by providing technical solutions for environments that their modelling has been problematic or non-operational for a variety of spatial scales. To this end, we report on our recent progress in developing an integrated interactive framework for exploring natural (augmented reality) and virtual (virtual reality) environments in regions of touristic and environmental interest (eg. Submerged cities, shipwrecks, sunken harbors and diving parks, marine parks etc.) in order to enrich travel experience and promote specific and diverse forms of tourism. In particular, the designed solution combines high-resolution data acquired and processed with state-of-the-art technologies (swath mapping systems, underwater vehicles, unmanned aerial vehicles) so as to create a synthetic topographic relief basemap and to analyze all its particular geomorphological and ecological structures as well as anthropogenic interventions. Moreover, through a set of special designed tools for multimedia content management, it is possible to write narrative scenarios and produce interactive experiences in virtual reality. In this way, users are able to assimilate to real (or even imaginary) environments through different media (e.g., tablets, virtual reality glasses, etc.). The integration of research knowledge into interactive narrative systems will furthermore result into the development of innovative research and teaching products to promote the complex, challenging, magnificent underwater environment and also to attract tourists of general or special interest. The developed digital platform, named VIRTUALDIVER, will enable users to navigate virtually in environments accessible only by underwater vehicles and in cost-intensive, research and scientific missions and make known the underwater cultural heritage.

Keywords: digital platform, underwater experience, virtual reality, cultural heritage

1. INTRODUCTION

The Greek seabed is rich in biodiversity and has intense geomorphological structures, while numerous shipwrecks exist there as well as immersed infrastructure and ancient harbours, which, although are of huge touristic interest and are the subject of specialized scientific research, have not yet been highlighted. Although there have been attempts to promote submarine areas in the past, most of them are audiovisual productions such as documentaries, which are usually implemented by foreign

corporations (for example, the underwater village of Pavlopetri in Laconia, the shipwreck of Antikythera etc.) (Mahon et al., 2011; Christopoulou et al., 2012).

The use of new research knowledge and innovative technologies to promote the Greek seabed, as well as the free access to scientific data and the transfer of scientific knowledge to the general public, is now possible and can lead to the development of new tourism products, services and activities, which can later attract tourists of general and / or special interest. At the same time, the introduction of virtual and augmented reality technologies into the particularly interesting and hardly accessible underwater environment is a challenge for the niche market and creates new investment opportunities.

VIRTUALDIVER aims at designing and developing a complex Digital Platform -initially- for the promotion of the underwater wealth of Greece using new technologies. This product will be a tool for supporting businesses and professionals operating in the field of Culture and Tourism, enhancing special aspects of tourism such as cruises, diving, scientific and other. The platform will use digital bathymetric data, data from Remotely Operated Vehicles (ROVs), as well as topographic terrestrial photogrammetry data from unmanned helicopters (drones) to synthesize 3D digital images of specific areas of tourist interest in high resolution. We will write narrative scenarios and produce interactive experiences. The platform will be able to assimilate real (or virtual) environments with the help of different media such as tablets or virtual reality glasses, as well as more specialized peripherals.

The Santorini volcanic complex was chosen for the application of the interactive platform, for several reasons. It is one of the most visited destinations in Europe. It is a unique "open geological museum" with the largest caldera in the world. The Minoan eruption that took place in 1615 BC is the largest of the last 10,000 years and is among the most famous eruption across the world (Freidrich et al., 2006). The caldera has always concealed the legend of the "Lost Atlantis" and gives birth to new volcanic eruptions. The Kolumbo submarine volcano, 7 km NE of Santorini is the most active in the entire Mediterranean Sea today (Nomikou et al., 2012).

This project aims at the following:

- The development of an innovative product for the provision of specialized services in tourism, with emphasis on marine, diving and cruise tourism.
- The combination of research results of underwater surveys along with terrestrial data and their exploitation in the creative – cultural industry.
- The creation of a complex Digital Platform for the realization of Virtual Experiences and the narration of various narrative scenarios.
- The development of a Mapping System and 3D Visualization of the underwater area, emphasizing on the interpretation of the geological / geomorphological structures of the Greek seabed and its spatial connection to the coastal surface for the needs of Virtual and Augmented Experience.

2. METHODOLOGY

Within the framework of the proposed project, Geomorphology, Photogrammetry, Computer Vision and Human-Computer Interaction will be combined.

Until today, a typical problem with adoption of technologies (VER) in mass applications is the cost as well as the simulator sickness, which is due to the lack of visual preciseness of the virtual environment and the poor computing capabilities of portable devices that cause image and conception incongruity.

In VIRTUALDIVER, we will deal with specific conditions in relation to the current level of innovation due to the underwater environment, which we will work out through single bottom mapping in areas of interest, accurate 3D reconstruction of details and high-resolution texture.

For the Mapping System and the visualization in VR the following will be developed : i) methodology and the system of collecting heterogeneous-bathymetric, visual and multi-spectral data, ii) novel Structure-from-Motion algorithms taking into account the refraction for 3D reconstruction of underwater images and adopting incremental approaches to deal with a large number of images, iii) co-registration algorithms to combine heterogeneous data for the creation of novel texture for the reconstructed 3D models and photomosaics, iv) classification of multispectral data using deep learning algorithms for recognizing geological materials. In addition, Augmented Reality applications will be developed for the coastal areas, the quality of which is a function of the detection process and "rendering" on a screen.

In particular, the extensive mapping of the seafloor will be conducted with high-resolution bathymetric systems (multibeam systems), whereas the acquisition of optical and multispectral data with submarine and aerial remote-controlled vehicles (ROV and UAV), which can accurately capture the volcanic geomorphology and the steep internal slopes of Santorini's caldera. The 3D Virtual Representations (single elevation model, 3D detailed models and RGB and geological maps) will be of a high-resolution but simplified geometric structure in order to constitute the detailed background of the Interactive Platform for the implementation of Virtual Experiences (Fig.1).

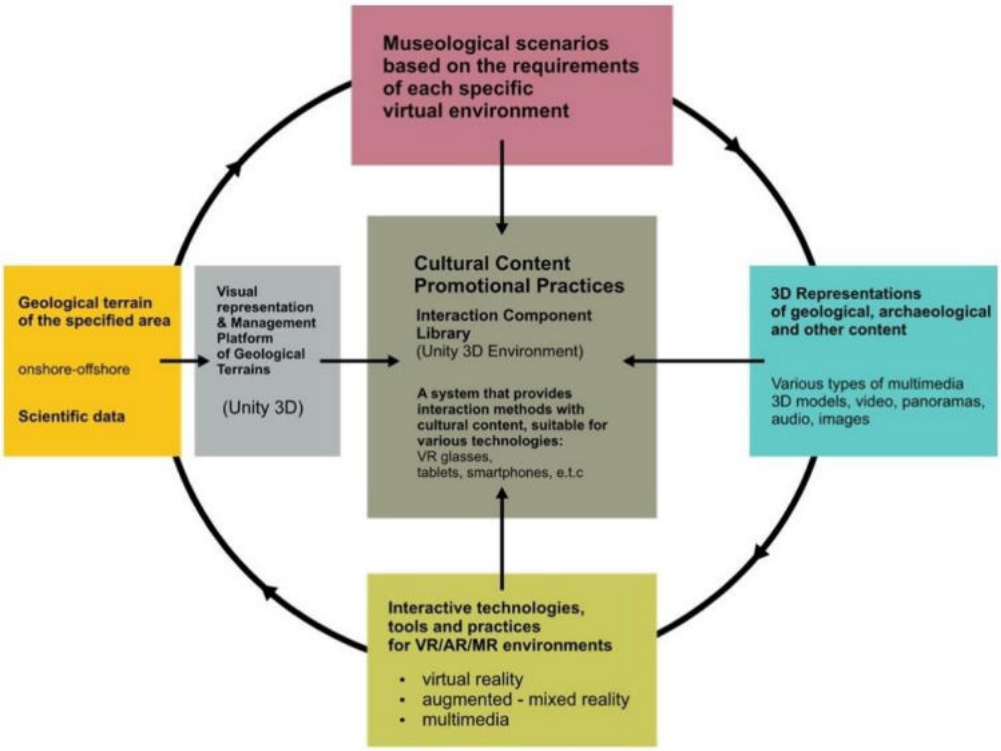


Fig. 1. The overall structure of the developed VIRTUALDIVER framework

Aiming to a both photorealistic and accurate digital representation of the Santorini's terrain in a VR environment, our team have developed a robust and fast workflow to capture, integrate and combine geospatial data of different modalities. The proposed methodology initially considers the needs of the User and the essential characteristics of the desired geospatial background, the 3D models on it and

the other required figurative products. Existing geospatial data were also exploited. In particular, bathymetric data (Nomikou et al., 2014;2016; Hooft et al., 2017) and imagery from ROV missions (Carey et al., 2013; Camilli et al., 2015), both provided by previous works of the team, and open source data as well (EMODnet data) were used for the off shore 3D model. Regarding the on shore, SRTM, satellite imagery from the WorldView4 and LIDAR data describing Kameni Island were combined (Nomikou et al., 2014). The mentioned dataset was exploited in order to create a truly detailed and of high accuracy 3D model of Santorini Island which later was processed in Unity3D (Fig. 2).

Innovative methods developed by our team for drone imagery collection and processing were applied and ROV missions with top-notch camera equipment are on-going. This will lead to a more accurate 3D reconstruction of high interest scenes. In addition to this, GNSS measurements provide the necessary georeference of the 3D models and later will assist the matching between the Points of Interest in real world and the VR environment. Finally, panoramic images and videos add a rather realistic point of view for the User into the VR environment.

The methodology developed by our team consists of three main steps. Initially, bathymetric and SRTM data were scaled down to meet the smallest resolution of our dataset (LIDAR). Afterwards, the elevation data is combined based on the slope of the relief which also considers a buffer area aiming to a smoother terrain. Although this minimizes the spikes and the steep effects on the terrain, it can lead to ambiguities, so particular attention is required. Finally, the surface data and the WorldView4 imagery are combined applying the well-known nearest neighbour matching technique leading to the final terrain background (Figure 3).

Then, images captured by drone and ROVs using open-source 3D reconstruction software (Colmap, Meshroom), combined with algorithms which our team's team have developed in the past, were processed. The result is exceptional and gives a detailed representation of parts of the island's points of interest (Figs 4 and 5). Panoramic views and videos complete the visual representation of the Santorini Island.

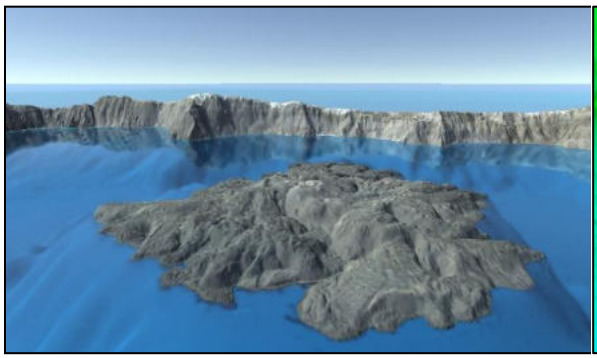


Fig. 2. WorldView4 imagery combined with surface data.

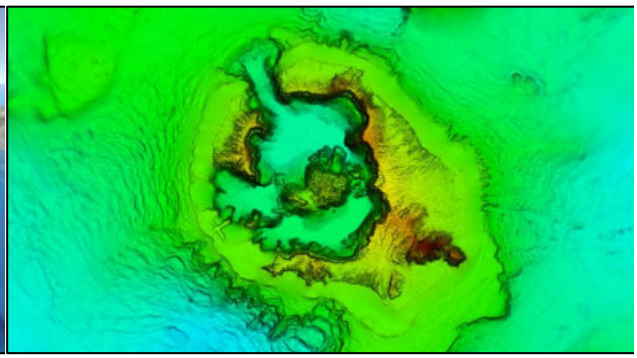


Fig. 3. Combination of bathymetric (Nomikou et al., 2016; Hooft et al., 2017), LIDAR and SRTM data.

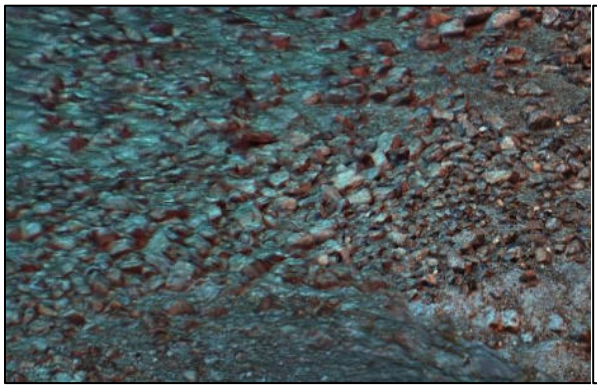


Fig. 4. 3D reconstruction of ROV images.

Fig. 5. 3D reconstruction of Oia village.

In VIRTUALDIVER, the platform is being developed on the Unity 3D technology, one of the most widespread platforms for designing, development, and implementation of interactive 3D environments, and will consist of two interconnected systems:

(i) management of 3D terrains and their relevant metadata

(ii) implementation of narrative scenarios. The aim is the management unit of the 3D terrains to be able to import and manage single seabed and terrestrial topography, while subsequently the interactive platform will be able to provide a range of tools to produce interactive experiences. These tools will offer the ability to manage multimedia content in a simplified way without requiring specialized programming skills. For this purpose, a methodology for implementing an interaction template library (interaction templates) will be developed based on the use of visual programming scripting (drag- n-drop visual scripting).

The most important advantage of using visual programming is the commonly accepted way of managing multimedia by an experienced design team composed of many different scientific fields. The library will offer the possibility of managing (add new / edit / delete) the ways of interaction with visual material both on different media (tablets, virtual reality glasses, as well as more specialized peripheral devices) and in different environments (virtual reality, augmented reality, etc.).

VIRTUALDIVER aims to: i) massive development and dissemination of virtual experiences of coastal and underwater space by creating a composite digital Interaction Platform, ii) differentiate the product in relation to the international standards, and iii) promote the underwater environment and innovative technologies as essentials to map the coastal and, above all, the marine space, enhancing experiences through the geological interpretation of the volcanic relief of Santorini.

3. DEVELOPMENT PROGRESS AND RESULTS

3.1. Defining Functional and Technical Specifications of the Platform

The functional requirements of the end users of Virtual Experience have been recorded and analyzed based on international experience, the Companies' experience in related projects, and the Advisory Committee's view. Within this frame, the expectations of the User related to his virtual Tourism-Cultural interests and the forms of interaction that are currently available with Virtual and Enhanced Reality devices have been recorded.

3.2. Technical Specifications of VIRTUALDIVER Platform

The technical specifications of the Interaction Platform and the Geomorphological Mapping System and 3D Visualization System have been determined. In this delivery, one-to-one operational requirements of the Functional and Technical Specifications of the Platform have been met, as well as the technical requirements for accurate and spatial data analysis, interaction files connecting the work packages, device capabilities, etc.

3.3. Website

For the dissemination and publicity needs of VIRTUALDIVER, an appropriate Project Website has been created, to promote the activities and outputs of the project (www.virtualdiver.gr) and also all public deliverables. Additionally, website will communicate directly a Twitter, Slideshare and Facebook page, using the "Network Publisher" plugin for WordPress.

3.4. Planning and collection of heterogeneous data

Planning and collection of heterogeneous seafloor, coastal and onland data (ROV, UAV). The main data is multi-spectral and RGB, and at the same time other receivers for georeferencing and mapping of heterogeneous file data (EMODNET data, Copernicus Marine Services, etc.) have been deployed as well as geological data.

3.5. User Interface Design

This section concerns the concept, the design and the development of a user interface (GUI), taking into account best practices of User Experience (UX) modelling in the sectors of 3D interactive representations and story-telling. This task refers both to the "3D World" management and scenario implementation modules of the platform, as well as to the part of the platform with which end-users will interact with. It includes the set of widgets that appear on the screen of each digital device (e.g. PC, Tablet, VR Headset) and can be used to interact with this device.

3.6. Creation of geo-ecotourism scenarios, educational material and productions and their interconnection through the interactive platform

Narrative scenarios, multimedia educational material for selected points of interest, and a series of dramatized productions are being created to be used to produce interactive experiences.

4. DISCUSSION AND CONCLUSIONS

VIRTUALDIVER intends to promote technical and financial constraints on the creation of Virtual Experiences in the exciting submarine world, in order to be an attractive entertainment and cultural product that will be deployed by tourism and cultural institutions in Greece. The proposed approach concerns the development of an Interaction Platform that will simplify the process of implementing the Integrated Virtual Experience - narrative scenarios, productions and educational material – on the one hand for non-experts and, on the other hand, the creation of geospatial backgrounds and 3D visual information. The Interaction Platform will be fed by the innovative Mapping System and 3D visualization of submarine areas with an emphasis on the interpretation of geological/geomorphological structures and the spatial connection to the coastal area for the needs of Virtual and Extensive Navigation. The digital platform is based on the unique, complex and extremely interesting volcanic area of Santorini, which is of great value as a tourist product.

The contribution of VIRTUALDIVER to the sector of "Tourism, Culture and Creative Industries" is crucial, as it addresses private (or non) operators with an innovative B2B service in order to boost their commercial value through the creation of a unique tourist product - experience of impressive virtual environments. Moreover, it will establish a new approach to promoting the cultural and environmental supplies through enhancing special forms of tourism. Regarding the underwater environment, which is hardly accessible to the average visitor in Greece, VIRTUALDIVER will serve as a mediator for the perception of this particular aspect of the world that surrounds us.

5. REFERENCES

Camilli R., Nomikou P., Escartín J., Ridao P., Mallios A., Kilias S.P., Argyraki A. and the Caldera Science Team (2015). The Kallisti Limnes, Carbon Dioxide-Accumulating Subsea Pools. SCIENTIFIC REPORTS | 3:2421.

Carey S., Nomikou P., Croff Bell K., and Ballard D. (2013). Exploration of the Santorini volcanic group, southern Aegean Sea: Oceanography (Washington, D.C.), v. 26, no. 1, supplement, p. 44–49.

Christopoulou Al., Gadolou An., Bouyia P. (2012). "The Antikythera Shipwreck. The Technology of the ship, the cargo the Mechanism". Trans. M.A. Fowler, Athens: National Archaeological Museum.

Friedrich WL., Kromer B, Friedrich M, Heinemeier J, Pfeiffer T, Talamo S. (2006). "Santorini eruption radiocarbon dated to 1627-1600 B.C.". Science. 2006 Apr 28;312 (5773):548.

Hooft E.E., Nomikou p., Toomey D.R., Lampridou D., Getz C., Christopoulou M-E., O'Hara D., Arnoux G.M., Bodmer M., Gray M., Heath B.A., VanderBeek B.P. (2017). Backarc tectonism, volcanism, and mass wasting shape seafloor morphology in the Santorini-Christiana-Amorgos region of the Hellenic Volcanic Arc. Tectonophysics 712–713 (2017) 396–414.

Mahon I., Pizarro O., Johnson-Roberson M., Friedman A., Williams S.B., Henderson J.C. (2011). "Reconstructing Pavlopetri: Mapping the World's Oldest Submerged Town using Stereo-vision". 2011 IEEE International Conference on Robotics and Automation Shanghai International Conference Center.

Nomikou P., Carey S., Papanikolaou D., Croff Bell K., Sakellariou D., Alexandri M., Bejelou K. (2012). "Submarine Volcanoes of the Kolumbo volcanic zone NE of Santorini Caldera, Greece". Global and Planetary Change 90-91, 135-151.

Nomikou, P., Parks M., Papanikolaou D., Pyle D., Mather T., Carey S., Watts A., Paulatto M., Kalnins M., Livanos I., Bejelou K., Simou E., Perros I. (2014). The emergence and growth of a submarine volcano: The Kameni islands, Santorini (Greece). GeoResJ., Vol.1, 8-18.

Nomikou P., Druitt T.H., Hubscher C., Mather T.A., Paulatto M., Kalnins L.M., Kelfoun K., Papanikolaou D., Bejelou K., Lampridou D., Pyle D.M., Carey S., Watts A.B., Weib B. & Parks M.M. (2016). "Post-eruptive flooding of Santorini caldera and implications for tsunami generation". NATURE COMMUNICATIONS | 7:13332 | DOI: 10.1038/ncomms13332.

Deep-Sea archaeology in the Exclusive Economic Zone (EEZ) of Cyprus

Achilleas Iasonos [1]

[1] Oxford Centre for Maritime Archaeology, Institute of Archaeology, University of Oxford, 36 Beaumont Street, Oxford, OX1 2PG, UK, achilleas.iasonos@arch.ox.ac.uk

***Abstract*:** Conducting deep-sea surveys beyond the Territorial Waters of a state for Underwater Cultural Heritage (UCH) is often beyond the capacity of national heritage agencies and university-based researchers due to its great expense. The result of this is that research in maritime archaeology has largely been focused in more 'convenient' and 'accessible' areas such as the shallower waters of the Territorial Seas. This is unfortunate as several pioneering projects have demonstrated that UCH finds are possible both in the waters of the Exclusive Economic Zone (EEZ) and beyond. Many more are likely to exist, the majority of which either remain unexplored or are potentially under threat from illegal salvagers and other commercial-sector companies. Nevertheless, it is the intention of this paper to demonstrate that is possible to conduct research, and hence disclose new and unpublished information regarding UCH in the deep seas by taking advantage of datasets produced by the oil and gas industry and other commercial sector companies. This approach is in its infancy and as a result of this, national heritage agencies are yet to fully exploit the potential in fully utilising deep-sea UCH datasets for outreach purposes. Consequently, the second element of this article is to present previous projects pertaining to the management, accessibility and outreach for deep-sea UCH sites.

Keywords: UNESCO, "in situ" visits, sport divers, raising awareness, Roman Shipwrecks

1. INTRODUCTION

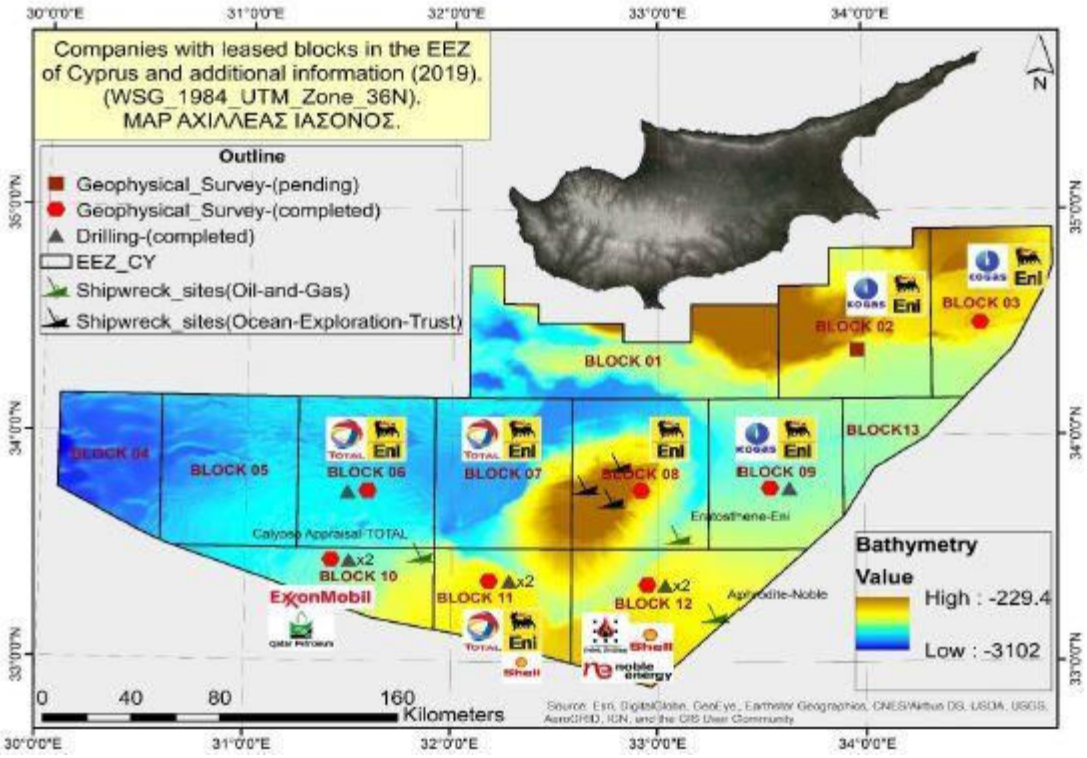
Deep-sea exploration for the purpose of detecting natural resources in the EEZ of Cyprus and the wider Eastern Mediterranean Sea is on the rise. This is principally because it is now economically and technically feasible to exploit oil and gas fields situated in more extreme, hostile, and hard-to-reach environmental conditions (Shukla and Karki, 2016). Consequently, the oil and gas industry has been increasingly focusing on detecting untapped deep-water fields to keep up with the ever-increasing demand for energy. In the Eastern Mediterranean Sea, this has been ongoing since Israel discovered the first natural deposit in 2009 (Ratner, 2016). Subsequently, a series of deep-sea Natural Resource Surveys (NRSs) have followed, leading to the discovery of the Aphrodite and Glafcos-1 deposits within the EEZ of Cyprus in 2011 and 2019 respectively (Fig. 1, blocks 10 and 12), as well as the Zohr deposit of 2015 in the EEZ of Egypt (ibid., 1). This is currently a rapidly developing field—in the EEZ of Cyprus alone, from a total of 13 blocks available, 8 blocks are now licensed, and one is pending geophysical survey. In addition, announcements in 2019 suggest that there are plans for at least five additional geophysical surveys, in blocks 6, 7, 8, 10 and 11 (Fig. 1).

The discovery of two exploitable deposits so far, and the probability of discovering more, has significantly enhanced the role of Cyprus in the Eastern Mediterranean Sea as an emerging energy hub (Karbuz, 2012). From a maritime archaeological perspective, this raises the probability of new discoveries of UCH in these deep waters and the opportunity for scholars to investigate them and publish their results. For example, recent deep-water surveys for exploration and education purposes have discovered UCH (Ballard, et al, 2017), demonstrating the potential for the extensive and systematic NRS to reveal further sites of importance.

Unfortunately, while discoveries are made in the context of these surveys, a disconnect exists between the wider offshore industry and academia that results in information about them not making the

transition from data producer to the academic and public consumer. This has a negative impact on the field of maritime archaeology since valuable information are either 'lost' within unreleased corporate datasets or else are bound to remain 'unknown', concealed by confidentiality agreements between companies and coastal States. This article concerns the EEZ of Cyprus and seeks to evaluate what the current state of knowledge of discoveries of UCH are in this area. In addition, I will give account of previous projects pertaining to the management, accessibility and outreach for deep-sea UCH sites.

Fig. 1



shows the state of oil and gas explorations in 2019 in the EEZ of Cyprus. Additional information about deep-sea UCH discoveries. The information presented here is subject to alterations.

2. OCEAN EXPLORATION TRUST (OET) UCH DISCOVERIES IN THE EEZ OF CYPRUS

In 2010 the American OET, whose president and principal investigator is Robert Ballard, conducted two survey seasons in the EEZ of Cyprus for the purpose of recording the bio-ecological and geological nature of the Eratosthenes Seamount1 (Fig. 2). Although archaeology was not part of the survey agenda, a wide array of scattered archaeological materials (mainly amphoras) were accidentally recorded. In total, 70 isolated amphoras were surveyed (Ballard et al, 2017, 1), out of which 38 were securely identified; the earliest amphora dated to the Iron Age (8th to 7th centuries BC) and the latest to the Byzantine period (Cornwell, et al, 2013, 42). Adding to the catalogue of discoveries, two shipwreck sites were noted and dated approximately to the 19th century (ibid., 30). From the results of the 2010 survey expedition, it became clear that the Eratosthenes Seamount not only offered ideal conditions for the preservation of UCH, but also confirmed it as an area of archaeological importance. The result of this was that the 2012 survey agenda was expanded to encompass the recording of archaeological materials, which marked the first deep-sea survey within the EEZ of Cyprus where archaeological documentation was officially part of a project's agenda. The survey lasted for nine days, taking place between the 14th and the 25th of August of 2012, where the underwater seabed was further surveyed via a deep-tow long-range side-scan-sonar (SSS), with the most promising targets

being visually assessed using an ROV (Mitchell, et al, 2013, 37). As a result, 149 isolated amphoras were revealed, out of which 91 were successfully dated from the Hellenistic to the Byzantine periods (Cornwell, et al, 2013, 42). Additionally, a Hellenistic shipwreck, named Eratosthenes C, with roughly 100 visible amphoras and two pithoi was discovered and dated to the 4th to 5th centuries BC (ibid., 43). The results of both expeditions of the OET were published (Wachsmann, et al, 2011; Cornwell, et al, 2013; Ballard, et al, 2017), with Ballard's article 'Deep-water archaeological discoveries on Eratosthenes' being the only one to present all of the results in a coordinated manner. The generated data from both of the expeditions were submitted to the author, by the Department of Geology Cyprus (DoGC) and are included in a developing ArcGIS geodatabase of UCH finds in Cypriot deep waters (Figs. 1 and 2). For further information about wreck-sites of Eratosthene C and Ottoman Pistol may be found on YouTube2. Although it is clear that these videos introduce some information intothe public domain, there are much more evidence and datasets remaining unpublished, understudied and unseen.

As these pioneering projects have demonstrated, UCH finds are possible in the waters of the EEZ of Cyprus. Yet, it is important to note that despite the potential demonstrated by these projects deep-sea UCH investigations in the Levantine Sea are rarely mounted. One possible reason for this is that deep-sea investigations for the purpose of surveying UCH are notoriously expensive. Ballard in 2008 stated that the operational cost for using an ocean-class research vessel starts from $20,000 cost per day (CPD)' (Ballard, 2008, 3), and increases by $10,000 CPD, depending on how many different geophysical technologies are used (ibid., 3). More recently, Søreide proposed that the cost of a work-class ROV vessel and its crew begins at $50,000 CPD (Søreide, 2011, 21) and in some cases, depending on the complexity of the job, the cost can average up to $250,000 CPD (Krieger and Buxton, 2012, 272). Bearing these figures in mind, it is clear that cost constitutes the principle obstacle to the development of deep-sea UCH investigations. For this reason, Bass accurately points out that 'because of the expense of excavating (or surveying) at great depth, however, perhaps a new model is needed' (Bass, 2013, 16): his statement is ground-breaking and acts as a reference point for this study.

2.1 UCH discoveries in the EEZ of Cyprus during NRSs

Besides deep-sea UCH discovered as a result of exploration activities by universities and research institutes, many more important sites have been surveyed in recent years during the exploration, development, and production of oil and gas resources. Globally, it is estimated that between three hundred and four hundred shipwrecks have been discovered during oil-and-gas-related activities (Søreide, 2011, 27; Ford, et al, 2010). This was first demonstrated in the Gulf of Mexico, when Warren in 2007 published in detail the results of the geophysical survey of the Mardi Gras shipwreck (Warren, et al, 2007). The site was accidentally discovered during offshore pipeline reconnaissance and was then partly excavated as a part of a mitigation agreement between Okeanos Gas Gathering Company and the US Minerals Management Service, with the results published in detail by Ford in 2010 (Ford, et al, 2010; BOEM, 2008). Since then several new shipwreck sites have been discovered in the area as a result of NRS and other pipeline activities, with some of the results mentioned in Warren et al (2007). With that in mind, it is worth asking: How does the oil and gas industry conduct NRS and at which phase is UCH confirmed? Naturally this leads on to the question: Is the oil and gas industry in the EEZ of Cyprus coming across more deep-sea UCH sites than have already been published?

A NRS, in general, has two main phases to its workflow. Phase 1 entails a seismic survey (or seismic data interpretation), which aims to narrow down specific locations where prospection drilling will take place. For the specific locations selected during phase 1, a second phase of supplementary hydrographic surveys via various geophysical means is undertaken. Technically, these include surveys using multibeam-bathymetry-echosounder (MBES) with or without backscatter-data (Woods Hole Coastal and Marine Science Centre, 2019, website), SSS (Burguera and Oliver, 2016), and sub-bottom-profiler (SBP) (Woods Hole Oceanographic Institute, 2019, website). The purpose of these localized-hydrographic-surveys is to determine the nature and character of the seabed and the subsoil, and secondly to note, and hence avoid, any potential nearby geohazards. In addition, Quinn suggests that these supplementary surveys are also conducted in order to define a wider 'clear zone' that is topographically and geologically suitable for the installation of the anchors of the drilling platform and any succeeding pipeline to connect the oil and gas field to a landfall site (Quinn, 2004, 26). Upon the completion of this supplementary hydrographic phase, any potential unidentified or peculiar anomalies (i.e. acoustic shadows and topographical irregularities) are noted and visually inspected either by Remotely Operated Vehicles (ROV) or Autonomous Underwater Vehicles (AUV). It is in this ground truthing phase that sites of UCH are confirmed.

The potential to conduct deep water research using geophysical and visual datasets derived from NRS is an exciting one that offers a low-cost solution to a notoriously expensive form of maritime research (Calvo, et al, 2009; Trobbiani, et al, 2018). This is because the data are already being produced by companies operating in the oil and gas sector to which archaeologists and heritage managers simply need to gain access. To demonstrate the potential of this approach, accidental finds from oil and gas companies operating in the EEZ of Cyprus since 2011 have revealed three new shipwreck sites (Fig. 1) and approximately 30 scatters of materials. These wreck-sites along with the additional scatters of materials are examined in the author's DPhil thesis, where a detailed analysis of the observable cargo is undertaken to propose an approximate date for the wrecking of the ships. The composition of the cargo also provides information pertaining to the ship's original route and possible destination. The location of the sites as well as associated visual, photographic and geophysical data are managed in an ArcGIS geodatabase, developed by the author on behalf of the Department of Antiquities Cyprus (DoAC). For further information about the wrecks see the author's DPhil thesis (Iasonos, forthcoming)

The interest of the oil and gas sector in deep-sea explorations will increase as new exploitable deposits are discovered. Hence, this means that more surveys for natural resources, or other oil and gas related activities (i.e. pipelines, cables etc.), are more likely to occur in the near future. Therefore, we are facing a scenario where deep-sea explorations may lead potentially to new environmental, geological, biological and archaeological discoveries. From that it can be stated that the size of the developing ArcGIS-database of the author is expected to grow in the following years. So far, the DPhil thesis '*Deep-sea Archaeology in the Exclusive Economic Zone of Cyprus*' has gathered a total of **1Terabyte** of data and includes: **A)** Data on six shipwreck-sites (of which five in the EEZ of Cyprus and one in the EEZ of Egypt), **B)** Approximate 26 side-scan-sonar targets of high archaeological potential, in the seas of Egypt, Cyprus and Israel, **C)** Environmental, geological and biological data (i.e. photographic material) displaying the diverse nature of the Eratosthenes Seamount, **D)** Photographic material on 300 scatter materials (i.e. amphoras) and **E)** 290Gigabyte of geophysical datasets (i.e. multibeam-bathymetry, SSS and Subbottom-profiler).

3. MAKING THE INACCESSIBLE ACCESSIBLE. DEEP-SEA UCH AND OFFERING A DRY DIVE EXPERIENCE TO A WIDER AUDIENCE

The remoteness of the deep-sea leads to a heavy reliance on technology to provide the information needed to carry out forefront research, and as equipment has improved over the years, we have begun to see the deep-sea environment with increasing clarity' (Cochonat, et al, 2007, 5). This is an ever-changing field due to advances in control platforms such as Autonomous Underwater Vehicles (AUV's) and ROV's, geophysical sensor machinery and software technology – much of it generated within the oil and gas sector – and thus, has enabled higher resolution mapping in previously inaccessible parts of the ocean, at depths up to 6000 m. This brings around 98 % of the world's ocean floor within reach and dramatically increases the possibility of discovering deep-sea shipwreck sites (Foley and Mindell, 2002). From an outreach perspective, the very same technology used for scientific deep-seabed surveying (i.e. ROV video recording or AUV geophysics) has also been utilised to provide in situ public access to deep-sea UCH (Ballard, 2008).

3.1. Live streaming and underwater CCTV

ROV technology for outreach purposes was first utilised in 1989, in the central Mediterranean Sea, when Robert Ballard conceived and directed the JASON Project for the education of students in the sciences and archaeology (McCann and Oleson, 2004; Abbott, et al, 1997). The JASON Project involved the survey and excavation of a 5th century Roman trading ship sunk in approximately 1000 metres of water, at an area known as the Skerki Bank. The live broadcast was presented through the lens of the most up-to-date communication technology and was transmitted through a network of universities, museums, research institutions and other centres to an audience of schoolchildren. According to McCann and Oleson, the broadcast reached some 225,000 children in both USA and Canada, and inspired the education of students through real science and exploration during a period when 'it was not fashionable to study science at school' (Abbott, et al, 1997, 111; JASON Learning, 2019, website). From a technical point of view, the JASON Project has successfully demonstrated that deep-sea UCH can reach out to a wider audience via telepresence technology; to this day, it remains an invaluable concept and has been successfully applied in numerous deep-sea UCH exploration projects (i.e. Nautilus Live, 2019, website; Ballard, 2008; Schmidt Ocean Institute, 2019, website). Since 2018, live streaming has been implemented in social media platforms (such as YouTube, Facebook and Instagram), providing deep-sea survey teams the opportunity to combine both live streaming and social media presence. As such, deep-sea survey companies such as the R/V Petrel3 and the Schmidt Ocean Institute4 have adopted this model and have been broadcasting their expeditions live through

social media pages, reporting an overall public following of more than one million, with an average audience ranging roughly around forty to fifty thousand people per live streaming (R/V Petrel, 2019, personal communication with author; Schmidt Ocean Institute, 2019). Such outreach is impressive for companies with only thirty-five thousand followers; and implies that Ballard's idea of live streaming, provides a new opportunity for public relations and outreach. Indeed, social media live streaming makes it possible to outreach to a wider audience, yet it also makes it necessary to redirect the audience keen in knowing more to other educational and possible interactive platforms (i.e. virtual museums and thematic maps).

With advancements in satellite communications, live broadcasting from the deep seas has become mainstream. Since 2003, scientists of the Institute for Exploration have been capitalising on the potential of live streaming, in an attempt to develop new ideas for public access, management and monitoring (Ballard, 2008). In 2004, after rigorous research and systematic planning the Immersion Institute project installed the first underwater CCTV in approximately 15 m of water at the National Marine Sanctuary in Monterey Bay, California. The project began when two stanchions were placed underwater to support the setting up of a small ROV which carried LED lights and a colour video camera. A fibre-optic cable powered the ROV and enabled live transmission and operation from a shore-side hub. According to the OpenOceans Global website, the CCTV system was installed to monitor the kelp forest in order to identify and better understand potential changes in the ecosystem (OpenOceans Global, 2019, website). The overall goal of the National Marine Sanctuary telepresence network is to ensure long-term preservation of the site, as well as to provide public access for both natural and cultural sites beneath the sea (Ballard, 2008). Due to the project's success, a new collaboration with the OpenOceans Global5 non-profit organisation and the National Oceanic Atmospheric Administration (NOAA)6 in 2006 authorised similar telepresence networks on coastal locations, underwater and deep seas sites, on research vessels, aquariums and other ocean-related places. The live network is accessible via OpenOceans Global website under the tab 'Ocean Web Cams' and provides live streaming access to roughly 70 different sites, with approximately half of them related with marine life or the underwater environment. The potentials of underwater CCTV are enormous and can lead to new strategies for safeguarding UCH. As the technology develops further, we can only be optimistic that live streaming and CCTV will be used to monitor deep-sea heritage sites, so as to ensure long-term safeguarding, preservation and public accessibility to imperative sites such the RMS Titanic, the Thermal Dome of Costa Rica, the hydrothermal vents of Pescadero and the Eratosthenes Seamount.

3.2. Thematic Maps and Databases

Besides live-broadcasting and CCTV monitoring, outreach projects have effectively demonstrated that Geographic Information Systems (GIS) can recreate an informative and educational experience for a wider audience. Rooted in the science of geography, GIS allows users to explore thematic maps by selecting spatial attributes (i.e. coordinates) and reviewing non-spatial data/information (i.e. videos, photographs, reports etc.), while navigating in an interactive environment as presented from satellite imagery and geophysical data (Conolly and Lake, 2006).

There are several shipwreck databases online, with each one of them offering a different interactive experience. This depends on parameters such as: what is the purpose of the database, what is the target audience, as well as what technologies were available when the database was developed. For instance, *The Oxford Roman Economy Project7* is the largest and most informative open-access shipwreck database on ancient wrecks, listing more than 1,700 sites. It was developed from 2005 to 2010 and addresses the fundamentals of the Roman economy using quantifiable bodies of archaeological data from the Mediterranean world (The Oxford Roman Economy Project, 2019, website). Furthermore, it