DIVE IN BLUE GROWTH

2nd INTERNATIONAL CONFERENCE ON THE PROMOTION OF ACCESSIBLE UNDERWATER CULTURAL HERITAGE SITES

Under the Auspices of the Hellenic Ministry of Culture & Sports

Online May 12-14, 2021

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MeDryDive

Co-funded by the COSME programme of the European Union

2nd International Conference on the Promotion of Accessible Underwater Cultural Heritage Sites "Dive in Blue Growth"

Conference Proceedings

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Organized by MeDryDive project, COSME Programme

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With the support of:

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FOREWORD

The 2nd International Conference "*Dive in Blue Growth*" on the Promotion of the Accessible Underwater Cultural Heritage Sites (AUCHS) was organised in the framework of MeDryDive project, co-funded by COSME Programme (www.medrydive.eu). It was held under the auspices of the Hellenic Ministry of Culture and Sports, with the support of the National Superintendence of the Underwater Cultural Heritage and the Central Conservation Institute of the Italian Ministry of Culture, the University of Calabria, and the Region of Thessaly.

The conference was held online from 12 to 14 May 2021 and included 3 sessions daily with 40 presentations in total. The 2nd Dive in Blue Growth brought together international researchers, scholars, policy makers and stakeholders, who exchanged views and experience on the responsible in-situ promotion of AUCHS and the broad accessibility of Underwater Cultural Heritage to both divers and non-divers through innovative technologies, as a means of their protection.

The 1st Dive in Blue Growth International Conference, organized by BLUEMED in October 2019 in Athens, had focused on the Protection and Management of the Accessible Underwater Cultural and Natural Heritage.

We are grateful to our supporters, the participants, the speakers and authors, the moderators and the committee members, who have contributed the most to the success of the conference.

The Organizing Committee

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COMMITTEE MEMBERS

The Scientific & Steering Committee

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

Dr. Barbara Davidde Petriaggi, Superintendent of the National Superintendence for Underwater Cultural Heritage of Italy.

Prof. Fabio Bruno, Associate Professor at the Department of Mechanical, Energetics and Management Engineering at the University of Calabria.

Dr. Dimitris Kourkoumelis, Underwater Archaeologist, Ephorate of Underwater Antiquities of the Hellenic Ministry of Culture and Sports.

Mr. Angelos Manglis, Founder of Atlantis Research.

The Organizing Committee

Aggeliki Veneti, Region of Thessaly

Dimitra Papadopoulou, Atlantis Consulting S.A.

Anastasia Fourkiotou, Atlantis Consulting S.A.

Anastasia Mitsopoulou, Ephorate of Underwater Antiquities of the Hellenic Ministry of Culture and Sports

Antonio Lagudi, University of Calabria

SESSION CHAIRS

Fabio Bruno is Associate Professor at the Department of Mechanical, Energy and Management Engineering (DIMEG), University of Calabria (UNICAL). He is cofounder of 2 spin-off companies: 3D Research s.r.l. and Tech4Sea s.r.l.. His research interests include the development of new technologies and systems for the documentation, preservation, and exploitation of underwater cultural and natural heritage.

He has been and is currently in charge of the UNICAL and 3D Research teams in various European projects including: INTERREG MED – BLUEMED, H2020 – iMARECULTURE, EASME - "Underwater Cultural Route in Classical Antiquity", EASME/EMFF Lab4Dive, EASME/EMFF DiveSafe; EASME MeDryDive.

He has been and is the principal investigator of the following projects: MSCA-RISE TECTONIC, "VISAS – Virtual and augmented exploitation of Submerged Archaeological Sites" and MOLUX "MObile Lab for Underwater eXploration". He is co-author of more than 100 scientific papers.

Barbara Davidde Petriaggi is an underwater archaeologist of the Italian Ministry of Culture (MiC). In 1993 she was the first female Underwater Archaeologist of the MiC, authorized by a Ministry Decree to direct underwater excavation and underwater documentation. Since December 2020 she is Superintendent of the National Superintendence for Underwater Cultural Heritage (Taranto) and since February 2021 she is also Superintendent ad interim of the Soprintendenza per i beni archeologici artisti e storici per le province di Brindisi e Lecce (Lecce).

2019 to present she is Member of the Scientific and Technical Advisory Body (STAB) - the 2001 UNESCO Convention on the protection of the Underwater Cultural Heritage (UCH)-UNESCO, Paris, France. 2009 to present she is adjunct professor of "Underwater Archaeology" at Roma TRe University (Rome)

2017 -2020 she was Official in charge of Underwater Archaeology - ICA - Central Institute for Archaeology (MiC). Since 1993 she worked for the Underwater Archaeology Operation Unit of the Central Institute for Restoration (ICR) and since 2011 to 2020 she Directed the Archaeology Operation Unit of the ICR.

She is author of numerous more than 130 scientific and popular papers on underwater archaeology and a manual on Underwater Archaeology with Roberto Petriaggi.

PETRIAGGI, R., DAVIDDE PETRIAGGI, B., Archeologia sott'acqua. Teoria e pratica, Second Edition, Pisa - Roma 2015.
https://media.beniculturali.it/mibac/files/boards/388a5474724a15af0ace7a40ab3301de/file_pdf/CV/CV_DAVIDDE_BARBARA_2021.pdf
Scopus Author ID: 6506123060; https://www.scopus.com/authid/detail.uri?authorId=6506123060
https://icsr.academia.edu/BarbaraDavidde orcid.org/0000-0002-7642-6791

Dr. Pari Kalamara is the Director of Maritime Antiquities, currently on a year leave, during which is the Deputy Director of Collections & Conservation of the NMoQ.

She studied history and archeology at the University of Athens and carried on doctoral studies at the School for Advanced Studies in the Social Sciences in Paris, in the sector "History and Civilizations". She works in the Hellenic Ministry of Culture since 1988. From 2006 till 2021 she was head of the Division of Public Archeological Museums and Collections and director of the Ephorates of Antiquities of Euboea and Beotia, and of the Ephorate of Underwater Antiquities. She has also worked as lector of the University of Peloponnese, and since 2003 she works as associated professor in the Open University of Greece. Her publications focus on the byzantine dresses, on byzantine archaeology issues of Messenia, Laconia, Euboea and Boeotia, and on museum subjects. She has also published a children book dealing with byzantine textiles, which obtain the 1st State Award of 2003.

Dimitris Kourkoumelis – Rodostamos was born in Corfu-Greece. He holds a PhD from the University of Aix-en-Provence (France - 1988), on a subject regarding trade, economy and transport amphorae of ancient Corfu. Since 1999, he is working at the Ephorate (Department) of Underwater Antiquities of the Hellenic Ministry of Culture and Sports. Since 2018 he is charge of the Northern Greece Section of the Department. From 2000 - 2011 he taught "Maritime Archaeology" as adjunct faculty at the University of Thessaly. Since 1975 he participates in land excavations in Crete and Corfu as well as to the underwater archaeological excavations of the Hellenic Institute of Marine Archaeology at Dokos and Iria prehistoric wrecks. He directed (1993-2001) the underwater survey and excavation of the 4th c. B.C. shipwreck at Kythera of the Hellenic Institute of Marine Archaeology, as well as the survey at the ancient harbor of Kythnos (Cyclades) (2005-2011), as co-director, along with Professor Al. Mazarakis-Ainian. Since 2011, he is directing the underwater excavation at the historical shipwreck MENTOR (1802) at Kythera, and he is co-directing the excavation at the ancient harbor of Lechaion (Corinth) (2013-2018) as co-director, along with Dr. Bjorn Loven. He has participated in a number of archaeological symposia and congresses and published papers on the transport of amphorae, ancient trade and economy as well as the results of his excavations. Also in 2019 was official evaluator, as expert, of the 2001 UNESCO Convention for the Protection of the Underwater Cultural Heritage.

Angelos Manglis is a member of the Hellenic Institute of Marine Archaeology, an experienced diver and sailor, as he has participated in numerous underwater archaeological expeditions in the last 17 years. He is a strong supporter of maintaining in situ the underwater cultural heritage and operating Accessible Underwater Cultural Heritage Sites in an inclusive way which contributes to their protection and to local sustainable growth. He has been actively engaged in the implementation of a number of European, National and Regional R&TDI Projects concerning the promotion and protection of the underwater cultural heritage; some of the most significant ones have been the Awarded project "Ano Magniton Nisi", the Awarded project "BlueMED, the UCRCA, the Lab4Dive, the DiveSafe, the MeDryDive, the MAR-e-Box, the Awarded project 4Helix+ See the Sea and the i-blueculture. Mr. Manglis has studied on a Master's Level at the Department of History and Archaeology of the Aristotle University of Thessaloniki with a focus on Prehistoric Archaeology. He holds an MSc in

"Technical Change & Industrial Strategy" from PREST Institute of the University of Manchester and a Bachelor's degree in Civil Engineering from the Democrition University of Thrace. Angelos Manglis has over a 30 year of consulting experience providing consultation to large portfolio of HiTech/IT Startups and Industrial and Non-Industrial SMEs. He is considered, amongst his colleagues, an expert in RTD project management, as he has contributed to the formation of strategies for technology and business development and has developed strong working relationships with many companies, organizations, institutions, academics as well as policy makers globally.

Aggeliki Veneti is a Rural & Surveying Engineer, with postgraduate studies (MSc) in Urban, Spatial Planning, Urban & Regional Development, and 26 years of professional experience. The last 5 years holds the position of the Director of Industry Energy and Natural Recourses in the Region of Thessaly.

She has extensive experience in preparing and evaluating sectoral and regional development plans and operational programs, as well as in the implementation of Operational Programs and projects co-financed by EU funds, policy analysis and programming interventions in the areas of regional development.

She also communicates with many people in different roles: politicians, administrators, stakeholders, NGOs, citizens. She has participated in conferences representing the Region as well as presented of its activities with different groups and people in various parts of Thessaly or outside Thessaly.

Combining the scientific background with a management position in a public authority, combining scientific and policy issues, she is able to understand what the community and its demands are looking for, and to harness the benefits and results of a European project at local, regional, national and European level, as well as to the public and to the private / local end-users of the projects.

She was the Coordinator of the MED project BLUEMED.

KEYNOTE SPEAKERS

Igor Kalinić, PhD
Head of Sector – Competitiveness and Internationalisation
Unit I-02: Singel Market Programme / COSME Pillar
European Innovation Council and SMEs Executive Agency (EISMEA)
European Commission

Currently, I work for the **European Commission** at the **European Innovation Council and SMEs Executive Agency** (EISMEA) where I am Head of Sector for Competitiveness and Internatinalisation within Single Market Programme / COSME Pillar Unit. Over last 20 years, as a policy officer of the European Commission and outside the EU institutions I have accumulated a substantial practical knowledge, academic experience, and policy-making understanding in international relations, focused on **international business, circular economy** and **entrepreneurship**.
Previously, I have covered academic positions at University of Groningen (Assistant Professor) and University of Leeds (Marie Curie fellow) and am currently collaborating with University of Turku (Senior Research Fellow). I earned my PhD from University of Padova (in collaboration with King's College London and Darden School of Business (USA). I have integrated the policymaking and academic experience with 10+ years in the private sector focused on the support to the entrepreneurship and internationalisation.

Alan Vella
Project Adviser - European Innovation Council and SMEs Executive Agency (EISMEA) Established by the European Commission

Alan Vella has extensive institutional experience, and currently works as project manager at the European Innovation Council and SMEs Executive Agency (EISMEA). His previous experiences include six years at the European Commission and an additional two years at the United Nations Framework Convention on Climate Change. Outside the institutions, he also occupied important positions relating to public administration, marketing and communications, strategic planning and procurement.

Alan`s main area of expertise is tourism, and he has lectured in tourism related fields across Europe, such as at the Sorbonne University in Paris, France. Alan Vella also acted as UNESCO National Focal Point for Periodic Reporting and was an award-winning journalist, having won the Tourism Journalist of the Year in his country of origin (Malta).

Associate Prof. Dr.-Ing. Dimitrios Skarlatos
Vice Dean School of Engineering, Dept. of Civil Engineering and Geomatics
Cyprus University of Technology, Photogrammetric-Vision Lab

Dimitrios Skarlatos is Associate Professor of Geoinformatics at the Department of Civil Engineering and Geomatics of the Cyprus University of Technology (CUT). He currently serves as Vice Dean of the School of Engineering and Technology. He has coordinated iMARECULTURE a H2020 Research and Innovation Project, for underwater XR museums, with 11 partners from Europe and Canada. His research interests and publication record include UAV mapping, optical bathymetry of coastal areas, underwater 3D modelling, and CH applications of the afore mentioned topics. Recent areas of interest include mobile mapping and use of small ROVs for 3D recording.

For 12 years he worked as free-lance land surveyor in Greece, court expert and technical consultant in geoinformation companies in nationwide projects. During that period, he has participated in research projects for archaeological site and monument recording, copies of museum exhibits, real time quality control applications using machine vision, AUAVs for mapping. During his post in CUT, he has participated or coordinated in research projects with UAV mapping, UAV coastal mapping and bathymetry, Parthenon frieze precise 3d modelling, mobile mapping platforms and satellite imagery processing.

He is the lead surveyor in Mazotos shipwreck, underwater excavation, since 2010, Nisia excavation since 2014 and Protaras shipwreck since 2019.He is the academic representative of Cyprus in EuroSDR (since 2010) and co-chair in International Society of Photogrammetry and Remote Sensing, Commission II (2016-2021), Working Group 9, about underwater photogrammetry. He has Chair of the organizing committee for the Underwater 3D Recording and Modelling Workshop, organized in Limassol, Cyprus, in May 2019 under ISPRS and CIPA auspices.

Panagiotis Tripontikas, Commander in Hellenic Navy, Hellenic Ministry of National Defence, Directorate of Military and Technological Support, Department of Infrastructure and Environmental & Cultural ProtectionCommander

Panagiotis Tripontikas was born in Athens on March 18, 1972 and comes from Velanidia Voion Lakonias (Municipality of Monemvasia). He graduated from the Hellenic Navy Academy in 1995 as an Ensign of the Hellenic Navy. He is married to Irakleia Schoina and is the father of a son named John.

His operational service includes more than 12 years of deployment at sea onboard surface units, one year as the Commanding Officer of Mine Hunter HS KALYPSO. He was assigned as Director of the Floating Naval Museums Battleship "GEORGIOS AVEROF" and HS VELOS. His staff assignments include the Hellenic Fleet Command and Hellenic Navy Minewarfare Command. He was designated from Hellenic Fleet Command, Hellenic Navy General Staff and finally, Hellenic National Defence General Staff as "Friend of the Environment" on an individual level for the year 2019. From September 2020 until the present day, he is a staff officer of the Department of Infrastructure and Environmental Protection of Directorate of Military and Technological Support at the Hellenic Republic Ministry of National Defence. He has received medals and distinctions commensurate with his rank. He has completed the diving training in Underwater Demolition Command. He is a graduate of the Hellenic Joint Staff College, the Supreme Joint War College and the Hellenic National Defence College. He is a researcher and a writer and has published the following books: 1. "1900: The Adventures of Pavlos Kountouriotis during the first transatlantic voyage onboard masted cruiser "NAVARCHOS MIAOULIS" ISBN:978-960-88509-3-4 (https://www.1900thebook.com) 2. Wrecks In The Greek Seas 1830-1951-The Underwater Heritage Of Navy's Stakeholding Fund & Mariners' Pension Fund (www.seathewrecks.com)

SPEAKERS 1st Day (May 12, 2021)

Dr. Pari Kalamara, Director of Maritime Antiquities, Hellenic Ministry of Culture and Sports (on a year leave, during which is Deputy Director of Collections & Conservation of the NMoQ)

Pari studied history and archeology at the University of Athens and carried on doctoral studies at the School for Advanced Studies in the Social Sciences in Paris, in the sector "History and Civilizations". She works in the Hellenic Ministry of Culture since 1988. From 2006 till 2021 she was head of the Division of Public Archeological Museums and Collections and director of the Ephorates of Antiquities of Euboea and Beotia, and of the Ephorate of Underwater Antiquities. She has also worked as lector of the University of Peloponnese, and since 2003 she works as associated professor in the Open University of Greece. Her publications focus on the byzantine dresses, on byzantine archaeology issues of Messenia, Laconia, Euboea and Boeotia, and on museum subjects. She has also published a children book dealing with byzantine textiles, which obtain the 1st State Award of 2003.

Darko Kovacevic, Maritime archaeologist, Heritage Malta's Underwater Cultural Heritage Unit

Darko is a maritime archaeologist at Heritage Malta's Underwater Cultural Heritage Unit. He obtained his B.A. and M.A. in History at the University of Novi Sad, which was followed with an M.A in Maritime Archaeology and Underwater Cultural Heritage at the University of Alexandria in Egypt. Over the last decade, Darko has been involved in a number of collaborative research projects across the Mediterranean, participating in numerous surveys with various institutions, such as the Hellenic Institute for Ancient and Medieval Alexandrian Studies, Egypt and survey campaigns off the Fourni Islands, Greece. Other projects include excavations of Mycenaean Shipwrecks off the island of Poros, and a number of archaeology projects in Croatia, Montenegro, Lebanon and Malta. Darko is an active scuba diving instructor and technical diver.

Angelos Manglis, Founder of Atlantis Consulting S.A. & Skopelos Diving Center

Angelos Manglis is a member of the Hellenic Institute of Marine Archaeology, an experienced diver and sailor, as he has participated in numerous underwater archaeological expeditions in the last 17 years. He is a strong supporter of maintaining in situ the underwater cultural heritage and operating Accessible Underwater Cultural Heritage Sites in an inclusive way which contributes to their protection and to local sustainable growth. He has been actively engaged in the implementation of a number of European, National and Regional R&TDI Projects concerning the promotion and protection of the underwater cultural heritage; some of the most significant ones have been the Awarded project "Ano Magniton Nisi", the Awarded project "BlueMED, the UCRCA, the Lab4Dive, the DiveSafe, the MeDryDive, the MAR-e-Box, the Awarded project 4Helix+ See the Sea and the i-blueculture. Mr. Manglis has studied on a Master's Level at the Department of History and Archaeology of the Aristotle University of Thessaloniki with a focus on Prehistoric Archaeology. He holds an MSc in "Technical Change & Industrial Strategy" from

PREST Institute of the University of Manchester and a Bachelor's degree in Civil Engineering from the Democrition University of Thrace Angelos Manglis has over a 30 year of consulting experience providing consultation to large portfolio of HiTech/IT Startups and Industrial and Non-Industrial SMEs. He is considered, amongst his colleagues, an expert in RTD project management, as he has contributed to the formation of strategies for technology and business development and has developed strong working relationships with many companies, organizations, institutions, academics as well as policy makers globally.

Young-Hwa Jung, Researcher & Conservation Scientist, National Research Institute of Maritime Cultural Heritage, Republic of Korea

Young-Hwa Jung is a Researcher & Conservation Scientist of Underwater Cultural Heritage in the WEST SEA Cultural Heritage Division (2017s-present) & Underwater Excavation & Conservation Division (2002s-2017s) of the National Research Institute of Maritime Cultural Heritage of South Korea. He is conservation the wooden ships and ceramics excavated in underwater. He completed his PhD in 2008 at Kongju National University and graduated from Korea National Open University with a Bachelor of Laws in 2016. He has been involved in several maritime research projects including: Analysis of Manufacturing Technology and Production Area of Underwater Excavations Ceramics(2005-present), Exploration Project of Underwater Cultural Heritage by the EOS3D-A(3D Seismic Survey System), Development Project of Underwater Cultural Heritage Research Technology Using Crabster CR200, Development Project of Underwater Cultural Heritage Exploration Techniques Underwater Archaeology Vessel 'NURIAN(G/T 290ton)' Ship building, Underwater Cultural Heritage Protection Policy in Korea. In August 2019, the International Program for Protection of Underwater Cultural Heritage was organized. Currently, he is in charge of planning and evaluating various projects of NRIMCH.

Dr Panagiota Galiatsatou, Diving Archaeologist, Ephorate of Underwater Antiquities, Hellenic Ministry of Culture and Sports

Dr Panagiota Galiatsatou has completed her postgraduate studies (Master's Degree and Phd: Grade 'Excellent') in the field of burial customs and pottery (Classical Archaeology). She has worked as an archaeologist in various departments of the Ministry of Culture and Sports since her graduation from the Department of History and Archaeology of the University of Athens in 2000 and since 2014 has been working as a diving archaeologist in the Ephorate of Underwater Antiquities conducting archaeological surveys and research in the Peloponnese and islands of the Argosaronic Gulf. Since 2018 she has been co-director (along with Dr B. Davidde) of a collaborative underwater archaeological project in Ancient Epidaurus of the Ephorate of Underwater Antiquities, the Italian Archaeological School in Athens and ISCR. She has published a number of articles on Classical burial customs and pottery, Underwater Archaeology and Cultural Management.

Carlota Pérez-Reverte Mañas, Researcher, University of Cadiz.

Carlota is a Ph.D. student in Maritime Archaeology, with a degree in History and a Master's degree in cultural business management. She has developed her research activity focusing on the processes of communication, awareness-raising, and public access to underwater cultural heritage. She has participated in various projects aimed at the

preservation and knowledge of both maritime heritage and biodiversity.

Rita Auriemma, Archaeologist and Researcher, Department of Cultural Heritage, Salento University

I am archaeologist, researcher in the Department of Cultural Heritage at the Salento University, where I teach Underwater Archaeology and Coastal and Underwater Seascapes Archaeology. I have held teaching positions in other universities, as well as for PhD and extra-university courses. Furthermore, I carry out terrestrial and underwater archaeological excavation and survey projects and coordinate national and international research projects. The focuses of my research are archaeology (or geoarchaeology) of coastal landscapes and aspects of ancient economic history, in particular maritime routes and transport, goods and markets; other my own area of interest is the valorization and communication of the underwater cultural heritage, through exhibition and museum projects.

Dr Gunnar Liestøl, Professor, Dept. of Media & Communication, University of Oslo

Gunnar Liestøl is professor at the Department of media and Communication, University of Oslo. He has conducted research and development in digital media for more than 25 years, starting with hypermedia designs for The Kon-Tiki Museum and The Viking Ship Museum. He as authored and edited numerous books and articles on rhetoric, narrativity and digital media design, among them Digital Media Revisited (MIT Press). Liestøl has spent the last decade exploring the potential of location–based media, especially Augmented Reality (AR). He is particularly interested in AR storytelling on location at Cultural Heritage sites. Recent experiments include AR applications for use at Ancient Phalasarna in Crete, on Omaha Beach in Normandy, the Calmecac Museum in Mexico City, and Old Narva in Estonia (the latter won a GLAMi–award at MW2019).

Dr Michael James Bendon, Independent Scholar and Researcher

Dr Michael James Bendon is now an independent scholar and researcher. He holds post-graduate qualifications in Archaeology, History, Education, Linguistics, Maritime Archaeology and Cultural Heritage Management. He has worked for a great number of years as an archaeologist on numerous sites around the Mediterranean and Europe including Israel, Portugal, Germany and Greece, with extended survey in Turkey, Syria and Jordan. Michael first started as a field archaeologist in Israel before moving briefly onto Portugal and then on to directing a Medieaval church and cemetery excavation in Northern Germany for four years. For the last ten years, he has been assisting a colleague, Dr Elpida Hadjidakis, in investigations on Phalasarna, a large Classical/Hellenistic maritime city in Western Crete, as well as working, also with Dr Hadjidakis, on the excavation of the first Minoan shipwreck to be discovered. More recently his research has revolved around two British WWII wrecks located offshore from the ancient Phalasarna site. His newly published book, The Forgotten Flotilla, details this particular story. Michael is concurrently carrying out research to compile the first-ever nominal roll for Australian service personnel who served in the Greek and Cretan campaigns of 1941.

Marco Cozza, Senior Software Engineer, Project Manager and CTO at 3D Research

Marco Cozza (male, 32) received his Master's Degree in Computer Science in 2015 at the University of Calabria,

with a thesis entitled "Mining and Recommendation Techniques for museums tours". He is a Senior Software Engineer, Project Manager and CTO at 3D Research since 2014. He has experience in design and development of interactive applications for environmental protection and the exploitation of the Cultural Heritage. In particular, he has considerable experience in VR and AR applications, assisted underwater navigation and mission planning software tools. Marco is in charge of the management for the following research projects: EACEA – MarEBox "Culture Underwater, Time Capsules at the bottom of the sea" (https://www.marebox.eu/), EASME/COSME MeDryDive "Creating personalized dry dive experiences for the promotion of Mediterranean Underwater Cultural Heritage sites as distinctive tourism destinations" (https://medrydive.eu/), SmartCal "Smart Tourism in Calabria", funded by the Italian Ministry of Economic Development (http://www.smartcal.eu/), SMILE "Smart methods and tools for the Digital Enterprise" – funded by the Italian Ministry of Economic Development, MOLUX "MObile Lab for Underwater eXploration". Moreover, he coordinates the 3DR team and manages private contracts. He is co-author of 14 scientific papers and publications.

Felipe Cerezo Andreo, Post-doc researcher, University of Cádiz

Doctor in Archaeology at the University of Murcia (Spain - 2016), since 2017 held a post-doctoral position at the University of Cádiz (Spain). He currently directs or collaborates in several research projects in underwater archaeology that contemplate objectives related to social participation and public access to Underwater Cultural Heritage. He has worked at the University of Murcia (2012-2016), the National Museum of Underwater Archeology. ARQUA (2009-2011). He also actively collaborates with the UNTWIN network and UNESCO in seminars and training courses in Underwater Archeology.

Elia Vlachou, Archaeologist - Museologist M.A.

Museum & Cultural Management Consultant, co-founder and Gal Secretary of the Hellenic Steam Institute, a nonprofit association dedicated to the preservation and valorization of industrial heritage. From 2003 to 2017 she worked at the Piraeus Cultural Foundation. Head of the Museums Department since 2007, she has coordinated the Department's E.U.-financed projects and the Network's numerous temporary exhibitions, educational programmes and various activities. She gives lectures on cultural management at graduate and postgraduate level. Member of the international juries for the prizes Živa Award and Heritage in Motion, of the European Museum Academy (Museum Expert), ICOM and TICCIH. Main research interests: cultural management; innovative methods of interpretation of material and intangible culture; analysis of the visitors' experience; protection and promotion of the technological heritage

Javier Rodríguez Pandozi, Instituto Balear de Estudios en Arqueología Marítima (IBEAM), Co-founder, Project Manager

Co-founder of the Instituto Balear de Estudios en Arqueología Marítima (IBEAM), he has been dedicated for more than ten years to the research, protection, and dissemination of the Maritime Cultural Heritage of the Balearic Islands. Within IBEAM he combines his work as Project Director with that of filmmaker. He has been director and participated in the main projects developed in recent years in the Balearic Islands, such as the excavation of the Late Roman shipwreck of Ses Fontanelles, (Palma de Mallorca) the excavation of the Early Imperial shipwreck of Porto Cristo (Manacor), the survey of the Late Roman shipwreck

Cabrera XIV located in the National Park of Cabrera (Mallorca) or the Underwater Archaeological Sites Catalogue for the islands of Formentera, Ibiza, and Mallorca.

Cristina Canoro, project manager and member of board of Campi Flegrei Diving s.r.l. , President of Legambiente Pozzuoli Città Flegrea Association

Cristina Canoro, is project manager and member of board of Campi Flegrei Diving s.r.l. Ph.D in Business Administration and Management, Postdoc Campania University Luigi Vanvitelli Department of Economics and Management.

She is involved in national and international projects to promote archaeological diving tourism throw technology innovations, actually she is project coordinator for MeDryDive project. Guide of the Underwater Archaeological Park of Baia, Cristina founded the environmental association Legambiente Città Flegrea with the aim to protect the environment and to promote sustainable development of Campi Flegrei Area. As Expert environmental educator she works with schools in labs and projects to transfer knowledge to the young generation about the touristic development opportunities of the area and the use of new technologies for the promotion and valorization of the cultural patrimony. Main field of studies are: tourism marketing, archaeological diving tourism the cultural patrimony. Main field of studies are: tourism marketing, archaeological diving tourism, promotion and valorization of underwater cultural heritage.

SPEAKERS 2nd Day (May 13, 2021)

Foteini Vlachaki, Architect - Msc Protection of Monuments & Sites, National Technical University of Athens (N.T.U.A)

Paraskevi Nomikou, Associate Professor, Dep. of Geology & Geoenvironment, National and Kapodistrian University of Athens

Paraskevi Nomikou is a marine geologist who studies the morphology of the seabed with extensive experience in marine volcanic and seafloor extruding processes. She is an Associate Professor at the Dep. of Geology and Geoenvironment of National and Kapodistrian University of Athens (Greece). She has participated in more than 80 oceanographic cruises that focused on active fault zones, submarine volcanism, landslides and slope stability and the exploration of seafloor mineral deposits. Her studies on underwater volcano areas where new earthquakes and deformations have been taking place are critical to the ongoing evaluation of future eruption scenarios. She effectively transfers her enthusiasm for sea floor exploration using innovative marine technologies to younger students through her educational lectures at the university creating a high-profile role model for young women thinking of pursuing careers in oceanography. She is an author of 135 peer review papers with h-index:22 (SCI) and is a PI (Virtual Diver, www.virtualdiver.gr) and co-PI in many national and international projects. She was also awarded by the Academy of Athens in 2017.

Dr Kalliopi Baika, Associate Professor in Mediterranean Maritime Archaeology, Master of Maritime and Coastal Archaeology (MoMArch) - Scientific Coordination, A*Midex - Académie d'Excellence, Centre Camille-Jullian, CNRS, Aix-Marseille Université, Maison Méditerranéenne des Sciences de l'Homme

Josep Quitana Plana, Coronis Computing, Spain

Caterina De Vivo Archaeologist, Member of Centro Studi Interdisciplinari Gaiola onlus

I am an archaeologist with a PhD in management and development of Cultural Heritage, obtained with a research developed between France, Italy and Spain.

Since 2009 I've been working in the fields of cultural heritage presentation and community engagement, collaborating with many no profit organizations and institutions. I am a member of the Centro Studi Interdisciplinari Gaiola onlus, a non profit organization Manager Authority, on behalf of the Italian State, of the Marine Protected Area Gaiola Underwater Park in Naples, Italy. My research interests are related to public archaeology and heritage interpretation and since 2009 I have been working on creating awareness on the importance of preserving underwater cultural heritage.

Valeria Li Vigni Tusa, Superintendent of the Sea, Department of Cultural Heritage Regione Siciliana

Valeria Li Vigni Tusa is the Superintendent of the Sea, the special office created in 2004 by the Regione Siciliana's

Department of Cultural Heritage. She is an Ethno-Anthropologist and diver, her curriculum is rich in many different assignments: she was director of the multidisciplinary Museum Palace d'Aumale, the regional Museum "Agostino Pepoli" in Trapani, the Museum Palace Riso for Contemporary Arts in Palermo at moment works are in progress to realize in the Palermo's ancient Arsenal a new Museum of the Sea and Navigation, following an Center of Excellence for the Underwater Cultural Heritage of Sicily. She carried out exhibitions concerned in art, anthropology, underwater archaeology and teaching too in Naples University as Museologist. She is the author of essays and publications dedicated to the interconnection of the sea in different fields of culture: archaeology, biology, life, fishing, shipbuilding, worship and religious ceremonies.

Floriana Agneto, Diver and functionary of the Superintendence of the Sea, Department of Cultural Heritage Regione Siciliana

Floriana Agneto works in the Regione Siciliana's Department of Cultural Heritage as Superintendence of the Sea's functionary and diver. She takes part in all missions and underwater activities: studies, researches, surveys and archaeological excavations, drawings and concerned publications. Specialist in planning and realizing underwater itineraries, she provides the meetings and conferences organization too.

Prof Timmy Gambin, Associate Professor in Maritime Archaeology, Dept of Classics & Archaeology, University of Malta

Dr Luciana Randazzo, Post-doc researcher, Department of Biology, Ecology and Earth Sciences (DiBEST, University of Calabria)

Luciana Randazzo is a post-doc researcher at the Department of Biology, Ecology and Earth Sciences (DiBEST, University of Calabria). She graduated in Geological Science in 2004 at the University of Palermo. In April 2009 she got Petrography and Petrology PhD in at the University of Catania. The research activity of Dr Luciana Randazzo has dealt mainly with topics in the field of applied Mineralogy and Petrography to Cultural Heritage. Her research concerns subjects focused on technical knowledge and conservation features of natural and artificial stone materials used in monuments as well as archaeometric characterization of archaeological ceramics (production and provenance).

Helen-Margarita Bardas, Ephorate of Underwater Antiquities (EUA) & Korseai Institute of Historical and Archaeological Research (Korseai Institute)

Helen-Margarita Bardas studied "Conservation of Antiquities and Works of Art" at the Technological Educational Institute of Athens, specializing in conservation of marine artifacts. She worked as an intern for the "Ephorate of Underwater Antiquities" in Athens and "The Mary Rose Trust" in Portsmouth. Throughout her studies she had the opportunity to participate as a conservator-diver in numerous underwater archaeological projects in Greece and abroad. An important milestone was the Fourni Underwater Survey, where she became one of the founding members of the "Korseai Institute of

Historical and Archaeological Research". During this time, she gained experience in lifting techniques, first-aid interventions and in-situ conservation of underwater archaeological finds. She is currently attaining an MSc in "Conservation of Cultural Heritage" at the University of West Attica whilst working as a contract conservator-diver for the Ephorate of Underwater Antiquities.

Massimo Capulli, Università di Udine, Dipartimento di Studi Umanistici e del Patrimonio Culturale

Vasilis Mentogiannis, Commercial diver, technical director of UFR team

Vasilis Mentogiannis, born in Athens in 1973, studied Mechanical Engineering at the Technological Educational Institution of Athens. Since 2005, he is technical director of UFR team, specialized as a commercial diver, in underwater services and documentation, covering a wide range of projects from marine construction industry to maritime cultural heritage. Among his main interests is the direction of historical and archaeological documentaries, some of which are awarded at international film festivals, as well as the writing and publishing of scientific articles connected to cultural heritage surveys and marine life. He is one of the co-founders of the Korseai Archeological Institute, founder of Hippocampus Marine Institute and one of the designers of the uNdersea visiOn sUrveillance System (NOUS). He lives in Athens, he is married and has 2 children.

Dr. Sergey Fazlullin, Associate Professor, Russian State University for Humanities, Moscow

Associate Professor Dr. Sergey Fazlullin graduated from the Faculty of Geography of the M. V. Lomonosov's Moscow State University with a degree in marine geochemistry in 1981. There he defended his PhD dissertation in 1995. From 1981 to 2001, he worked at the Institute of Volcanology of the Russian Academy of Sciences, where he

specialized in underwater volcanism, the study of volcanic lakes, the impact of volcanism on the environment, and the geochemistry of volcanic gases. Participant of 15 sea expeditions on scientific vessels and many land expeditions on volcanoes of Kamchatka, the Kuril Islands, Japan, Indonesia, New Zealand, and the Philippines. Since 2001, Dr. Fazlullin has been working in Moscow at the P.P. Shirshov's Institute of Oceanology, where he is engaged in the geochemistry of coastal marine geographical systems in the seas surrounding Russia.Since 1984, Dr. Fazlullin began to study underwater archaeology. First, in Kamchatka and the Kuril Islands. And since 2000, on the Black, Baltic, White and Barents Seas.

Since 1982, Dr. Fazlullin has been collaborating with leading Russian universities as a supervisor of field marine practices and theses. This work was continued in Moscow with the M. V. Lomonosov's Moscow State University. Since 2010, in parallel with the Russian Academy of Sciences, he began working at the Department of Museology of the Russian State University for the Humanities, where he currently conducts a series of disciplines on marine archaeology, underwater cultural heritage, methods of scientific research, conservation and restoration, world cultural and natural heritage.

In 2001, Dr. Fazlullin was elected Vice-president of the Russian Underwater Activities Confederation, and in 2018 its president. Since 2002, he has been a member of the CMAS Scientific Committee. He represented Russia at several meetings of the Convention for the Protection of the Underwater Cultural Heritage of UNESCO. Participated as an expert in international seminars on underwater cultural heritage in Turkey and Kazakhstan. He is the author of more than 250 scientific and methodological publications.

Dionisia Koutsi, PhD Student, Department of Geography and Regional Planning, School of Surveying Engineering, NTUA

Dionisia Koutsi is a PhD Student in the Department of Geography and Regional Planning, School of Surveying Engineering, NTUA. She is and Urban Planner graduated from the University of Thessaly and also holds a master degree on "Environment and Development", NTUA. She has participated in international and national conferences and has published work in academic magazines and books. Her research interests focus on the following areas: Integrated and sustainable land and underwater cultural heritage management, Maritime spatial planning, Participatory planning, Island development issues, Urban and regional development. She also works as a project manager in the private sector on co-financed projects by EU programs and is responsible for both their financial management as well as proposal writing and submission.

Yuri Tkachenko, Filmmaker

Yuri graduated the Moscow Aviation Institute with a technical specialization and worked as a programmer in the space industry. Later was engaged in the development of mobile TV centers for the leading TV channels of Russia. Currently he is a filmmaker, making films about sea travel and underwater archaeology. His hobbies include diving and yachting, and he is interested in researching in underwater archaeology as a member of the ANO "Underwater Archaeological Society" www.intersea.ru . Yuri lives in Russia, Moscow.

Ahmet Bilir, Asst. Prof., Director of the Duzce University Underwater Studies Application and Research Center

Ahmet Bilir gives courses in the Department of Archaeology at Duzce University where he is appointed. He received his PhD degree from Selcuk University, Institute of Social Sciences, Classical Archeology Department with his thesis entitled "The Importance of the Cilicia Region in the Eastern Mediterranean Maritime Trade in the Roman Period" in 2014. He is the Director of the Underwater Studies Application and Research Center and the Head of the Medieval Archeology Department at Duzce University. Bilir also manages the North East Marmara Sea Underwater Research (The NEMSUS Project) in Istanbul. Nowadays he also provides scientific consultancy to the Acheron Necropolis excavations in Herakleia Pontika

SPEAKERS 3rd Day (May 14, 2021)

Matteo Collina, Research fellow University of Calabria

Matteo Collina, a graduated in Cultural Heritage Photography, his main studies have included a dissertation project on photogrammetric reconstruction of San Pietro in Bevagna's sarcophagi shipwreck located in Manduria (Taranto, Italy) in collaboration with the National Institute for Conservation and Restoration (IsCR). From June 2018 he works as a research fellow at the University of Calabria on tridimensional underwater technical imaging surveys developing innovative methodologies for scientific diving. He has been involved in the MOLUX (MObile Laboratory for Underwater eXploration) and ScienceDIVER projects. From November 2019, he is an Adjunct Professor for Belle Arti Academy University in L'Aquila (Italy) teaching "Cultural Heritage Photography" and "Scientific Photography" courses. Experienced technical diver with a strong passion for shipwrecks and cave diving, Matteo has collaborated in several European projects leading underwater photogrammetric activities in different submerged archeological sites in the Mediterranean.

Paraskevi Nomikou, Associate Professor, Dep. of Geology & Geoenvironment, National and Kapodistrian University of Athens

Paraskevi Nomikou is a marine geologist who studies the morphology of the seabed with extensive experience in marine volcanic and seafloor extruding processes. She is an Associate Professor at the Dep. of Geology and Geoenvironment of National and Kapodistrian University of Athens (Greece). She has participated in more than 80 oceanographic cruises that focused on active fault zones, submarine volcanism, landslides and slope stability and the exploration of seafloor mineral deposits. Her studies on underwater volcano areas where new earthquakes and deformations have been taking place are critical to the ongoing evaluation of future eruption scenarios. She effectively transfers her enthusiasm for sea floor exploration using innovative marine technologies to younger students through her educational lectures at the university creating a high-profile role model for young women thinking of pursuing careers in oceanography. She is an author of 135 peer review papers with h-index:22 (SCI) and is a PI (Virtual Diver, www.virtualdiver.gr) and co-PI in many national and international projects. She was also awarded by the Academy of Athens in 2017.

Alessio Calantropio, PhD Student in Architectural and Landscape Heritage, Laboratory of Geomatics for Cultural Heritage, Politecnico di Torino

I graduated in Architecture at Politecnico di Torino, with a thesis on the use of UAV for safety application in construction sites and in technical measures for seismic emergency response. I currently work as a researcher in the Department of Architecture and Design. Along with the Lab G4CH (Laboratory of Geomatics for Cultural Heritage) and the student team DIRECT (DIsaster RECovery Team) I've carried out mapping research in earthquake-hit regions in central Italy and other relevant projects in collaboration with the firefighters and first responders. Since 2017 I have been working at PIC4SeR (PoliTO Interdepartmental Centre for Service Robotics) as industrial representative for

DJI, the world's leader in commercial and civilian drone industry. From 2019 I am pursuing a PhD in Architectural and Landscape Heritage, with a thesis focused on Photogrammetric multisensor application for the documentation of the Underwater Heritage. I have an extensive knowledge of drones and their application for research, mapping, humanitarian relief, public safety, built heritage monitoring and damage assessment.

Sergey Khokhlov, Director in LLC "Laboratory of Network Technologies"

Sergey graduated the Moscow Engineering Physics Institute in technical specialization and worked as IT- engineer and programmer. Currently he is the director in LLC "Laboratory of Network Technologies" www.nt-lab.ru . He is responsible for direction building robotic sea and underwater vehicles. His hobbies include diving, yachting and he is interested in researching in underwater archaeology as a member of the ANO "Underwater Archaeological Society" www.intersea.ru Sergey lives in Russia, Moscow.

Barbara Barbaro, Underwater Archaeologist of the Italian Ministry of Culture

Underwater Archaeologist of the Ministry of Culture. Head of the Quality Service of cataloging processes for the Central Institute for Catalog and Documentation. Control the cataloging and inventorying processes through the SIGECweb; promotes the establishment of the network of national cataloging bodies; supports the cataloging bodies in the management of the operational planning phases; supports the integration between the systems used by the Ministry and those of the Bodies that cooperate in the protection and cataloging through interoperability services. Director of the underwater excavations in the lake of Bolsena.

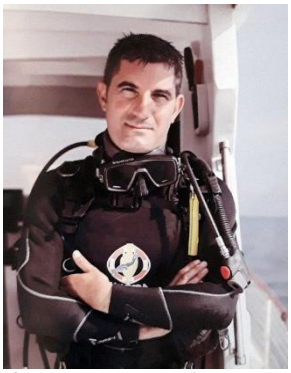
Marco Medici, Assistant Professor, University of Ferrara, Department of Architecture

Marco is part of the DIAPReM-TekneHub research center since 2013, where he has been involved in several research and training projects, as well as technology transfer activities. He developed advanced skills in the digitization of the built environment, focusing in particular on BIM modeling applied to Cultural Heritage. On these topics, he took part in international conferences, published several scientific papers, and since 2020 he's one of the founding members of the INCEPTION company, an innovative start-up. In the last years, he's also developing research activities on web-based technologies, virtual environments, and algorithm-aided design for architectural modeling.

Despoina Koutsoumba, Underwater Archaeologist, Ephorate of Underwater Antiquities, Hellenic Ministry of Culture and Sports

Despoina Koutsoumba is a graduate of Archaeology of the University of Athens with a Master's degree from the National Technical University of Athens in the program "Protection of Monuments - Conservation and restoration of historical buildings and complexes". Since 2006, she has been working at the Ephorate of Underwater Antiquities of the Hellenic Ministry of Culture as an underwater archaeologist and has participated in various underwater archaeological projects. She has

paricipated in the marine excavation of the Pavlopetri prehistoric settlement in 2011 (cooperation of the Ephotare of Underwater Antiquities and the British Archaeological School of Athens) and co-wrote the ministry-approved Master Plan for the managing of the archaeological site and its surrounding ecosystem. She is responsible for the Aigina Harbour Project 2019-2023, a cooperation programme of underwater research conducted by the Ephorate of Underwater Antiquities and the French School of Athens. She has written, translated, and scientifically edited many archaeological publications.



GianPaolo Colucci, Professional underwater archaeologist, President of L'ANFORA, Cultural and Amateur Sports Association

Professional underwater archaeologist since 2002. Outside collaborator of the Superintendency and the General Directorate of Apulia Museums. He works for public authorities and private entities making archaeological evaluation required for the design and realization of public works to be carried out both on land and underwater. He is a founding member and the president of L'ANFORA, Cultural and Amateur Sports Association, intended to promote the underwater archaeological heritage through educational and popularization activities. Since 2016 he has been an external contact person responsible for matters relating to underwater archeology of the National Museum and Archaeological Park of Egnazia and also he has been in charge of conducting underwater tours. Underwater Instructor, Pediatric Basic Life Support-Defibrillation instructor. In 2020 he became an instructor of ASBI, Albatros Scuba Blind International Disabled dive School, and then he qualified as a Disabled Diver Instructor, becoming the first archaeologist and instructor certified to accompany blind divers to underwater archaeological sites.

Barbara Davidde Petriaggi, Superintendent of the National Superintendence for Underwater Cultural Heritage (Taranto), Superintendent ad interim of the Soprintendenza per i beni archeologici artisti e storici per le province di Brindisi e Lecce (Lecce).

Barbara Davidde Petriaggi is an underwater archaeologist of the Italian Ministry of Culture (MiC). In 1993 she was the first female Underwater Archaeologist of the MiC, authorized by a Ministry Decree to direct underwater excavation and underwater documentation. Since December 2020 she is Superintendent of the National Superintendence for Underwater Cultural Heritage (Taranto) and since February 2021 she is also Superintendent ad interim of the Soprintendenza per i beni archeologici artisti e storici per le province di Brindisi e Lecce (Lecce). From 2019 to present she is Member of the Scientific and Technical Advisory Body (STAB) - the 2001 UNESCO Convention on the protection of the Underwater Cultural Heritage (UCH)-UNESCO, Paris, France. 2009 to present she is adjunct professor of "Underwater Archaeology" at Roma TRe University (Rome). From 2017-2020 she was Official in charge of Underwater Archaeology - ICA - Central Institute for Archaeology (MiC). Since 1993 she worked for the Underwater Archaeology Operation Unit of the Central Institute for Restoration (ICR) and since 2011 to 2020 she Directed the Archaeology Operation Unit of the ICR. She is an author of numerous more than 130 scientific and popular papers on underwater archaeology and a manual on Underwater Archaeology with Roberto Petriaggi.

Vasiliki Kyprouli,

Maritime Archaeologist, Ephorate of Underwater Antiquities, Hellenic Ministry of Culture and Sports.

Vasiliki was born in 1982. In 2007 she graduated in Archaeology from Athens University and in 2011 she received her master's degree in Maritime Archaeology from the University of Southern Denmark. Since then she collaborates with the Greek Ministry of Culture in several archaeological projects, surveys, excavations and supervisions, both on land and underwater. She is currently working in the Ephorate of Underwater Antiquities for the project "ANDIKAT" (INTERREG V-A Greece-Cyprus 2014-2020), concerning the Development of Diving Tourism Network in Greece and Cyprus, and specifically in the islands of Fournoi and Leros.

Athanasios E. Zlatoudis, Authorised Councillor of Sporades R.U. (for Tourism, Culture, Ferry Connections and Transport)

Athanasios Zlatoudis is elected Board Member of Region of Thessaly, Authorised Councilor for the exercise of the responsibilities of Tourism, Culture, Ferry Connections and Transportation, of the Regional Unity of Sporades. He is a business consultant in Tourism, certified adult trainer and member of National Center of Public Administration and Local Government (EKDDA) Teaching Personnel. He holds a Master's Degree in Spatial Planning, Urban Planning and Development with a focus on Spatial Analysis and Policy (University of Thessaly, Department of Spatial Planning, Urban Planning and Regional Development). He holds a Diploma in Management (University of Surrey, Surrey European School of Management), with a Bachelor's degree in International Hospitality and Tourism Management (University of Surrey, School of Management Studies for the Service Sector). As elected official, he has served the first degree of Local Government from 2007 to 2019 in the Municipality of Skiathos (chairman of the Municipal Council and chairman of the Municipal Committee for Tourism Development and Promotion), while from 2019 he serves the second degree of Local Government in Region of Thessaly. As member of Chamber of Magnesia Board, he represents the Chamber in INSULEUR, the Network of Insular Chambers of Commerce and Industry of the European Union and in EOAEN. As member of Chambers Group for the Development of Greek Isles (EOAEN) Board, he is an alternate member of the Insular Policy Council (SYNIPO) Board of the General Secretariat of Aegean Sea and Insular Policy of the Ministry of Maritime Affairs and Insular Policy. As permanent resident of Skiathos and insular businessman, along his systematic involvement with the Municipal, Chamber and Regional public affairs, he possesses deep knowledge of the disparities related to insularity, that enables him to work effectively on insular policy, on integrated smart and sustainable insular development, through stakeholder' participatory planning.

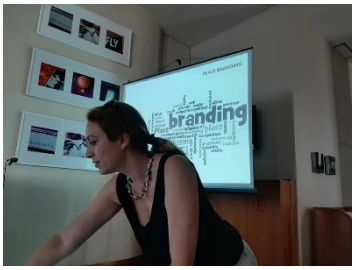
Paschalina Giatsiatsou, Maritime Archaeologist

Paschalina holds a master diploma in Maritime Archaeology from the University of Southern Denmark. She has also completed her training as a Commercial Scuba Diver in Denmark in 2017 and since then she has participated in maritime excavations as an underwater archaeologist and as a teaching assistant in the university's diving courses. She is part of the Underwater Survey Team (UST) that collaborates with members of the diving community for the research, the documentation, the study and the promotion of maritime features, whilst taking over information and awareness of public. She knows English, Italian and Danish and she is involved in the implementation of several EU co-funded projects (BLUEMED, ScienceDIVER).

Vedran Dorušić, Foka Ltd. Founder and Director.

Vedran Dorušić is the owner and director of Dive Centre FOKA Ltd. Always fascinated by the sea, in 1998 he became a SKIN Diving Instructor and decided to follow a professional diving career. In 1999 he obtained the title of NAUI Instructor and earned great experience in the navy service, as a navy diver. In 2002 he opened his own dive center based in Šimuni on the island of Pag. In 2005 and 2006 he experienced commercial diving services, working for the Italian company RANA (Ravenna, Italy), which provides underwater services for the oil and gas industry. Over the last decade, he has participated in underwater archaeological research in the quality of permanent team member of the University of Zadar maritime archaeology team. He also cooperates with other institutions from Croatia and abroad, engaged in research and protection of cultural and natural heritage of the Adriatic Sea. He is the co-founder and current president of the association NAVALIS, and active member of Institute for Maritime Heritage ARS NAUTICA.

Dr. Maria Vrasida, Architect, Planner, Tourism Development Consultant



Dr. Maria Vrasida holds a PhD in Planning Policies for the Development of Tourism from the University of Thessaly. She received an MA in Town and Regional Planning with Specialization in Destination Development from the University of Liverpool and a BA in Architecture and Building Engineering from the University of Liverpool. Within the research interest of Dr. Vrasida are the spatial aspect of sustainable tourism development, the integrated tourism destination management and relationship between culture, tourism and the environment. More than 25 original research papers have been presented and published in accredited refereed international conferences and journals. She has worked as an adjunct lecturer in the University of Thessaly and Technical Institute of Sterea teaching undergraduate courses on tourism development, urban development and culture, cultural tourism and more and at a postgraduate level she has taught in the University of West Attica, Tourism Destination development and in an Intensive Socrates Program between Greece, Germany and Spain. She has cooperated as an independent consultant for tourism development and promotion with Municipalities in Greece (Poros, Amarousion and more), with European Grouping for Territorial Cooperation Amphictyony, and the Hellenic Agency for Local Development and Local Government (E.E.T.A.A.). She has participated in many tourism development projects for the development and management of tourism and cultural destinations (Venice, Magnesia, coast of Lebanon). She is appointed add hock expert in strategic tourism planning by the URBACT European initiative and has participated in many research and development European funded proposals.

Under the Auspices of the Hellenic Ministry of Culture & Sports

2nd Virtual International Conference on the Promotion of Accessible Underwater Cultural Heritage Sites

"Dive in Blue Growth"

May 12-14, 2021

CONFERENCE AGENDA

All times listed in CET hours.

DAY 1: Wednesday 12 May 2021

09:30 – 10:00	**Late Registration / Technical Support**
10:00 – 10:30	**WELCOME & OPENING STATEMENTS** **Welcome by: Angelos Manglis**, Member of the Steering Committee **Opening Statements addressed by:** **Lina G. Mendoni**, Minister, Hellenic Ministry of Culture and Sports **Nikolaos Panagiotopoulos**, Minister, Hellenic Ministry of National Defense **Lucia Borgonzoni**, Senator of the Italian Republic, Undersecretary of State at the Ministry of Culture **Kostas Agorastos**, Regional Governor of Thessaly **Angela Gerekou,** President of the Greek National Tourism Organization
10:30 – 10:50	**Keynote Speeches** **"The COSME experience"** **Igor Kalinić,** Head of Sector of COSME Programme **"MeDryDive: The Project and its European context"** **Alan Vella,** MeDryDive Project Officer
10:50 – 12:30	**SESSION 1: The promotion and protection of Accessible Underwater Cultural Heritage Sites (AUCHS)** **Session Chair: Barbara Davidde Petriaggi**

10:50 – 11:10	**Different approaches for the protection and enhancement of Underwater Archaeological sites: acquirements and aspirations** Pari Kalamara
11:10 – 11:30	**The Innovative and State of the Art Public Access Management of Malta's Underwater Cultural Heritage** Darko Kovacevic
11:30 – 11:50	**A Roadmap for the sustainable valorization of Accessible Underwater Cultural Heritage; Integration of BLUEMED model for Open and Accessible to all sites** Angelos Manglis, Anastasia Fourkiotou, Dimitra Papadopoulou
11:50 – 12:10	**Laws, Policies, Techniques, and Utilization for the Protection of Underwater Cultural Heritage in Republic of Korea** Jung Young-Hwa
12:10 – 12:30	**Protection and promotion of the submerged "Villa of the dolia" off ancient Epidaurus: methods and strategies of an international project** Barbara Davidde Petriaggi, Panagiota Galiatsatou
12:30 – 13:30	**Lunch Break & Networking Lobby**
13:30 – 14:50	**SESSION 2: Dry dive technologies: dematerializing Underwater Cultural Heritage to make it accessible to everybody** **Session Chair: Pari Kalamara**
13:30 – 13:50	**Dry Dive experiences on the far side of the Mediterranean. VR and live video applied for making UCH accessible** Carlota Pérez-Reverte Mañas, Felipe Cerezo Andreo, Pablo Osorio López, Luis Mariscal Rico
13:50 – 14:10	**The underwater wonderland of ancient Puglia** Rita Auriemma, Italo Spada, Giuseppe De Prezzo, Nicoletta Spisso, Andrea Picciolo, Cosimo Buccolieri, Simone Parizzi, Elisa Costa
14:10 – 14:30	**Dry Diving and Augmented Reality Simulations of Historical Events and Artefacts** Gunnar Liestøl, Michael Bendon, Elpida Hadjidaki-Marder
14:30 – 14:50	**Dive in The Past: A Serious Game to promote the Underwater Cultural Heritage of the Mediterranean Sea** Marco Cozza, Salvatore Isabella, Paola Di Cuia, Fabio Bruno
14:50 – 15:10	**Coffee Break & Networking Lobby**
15:10 – 16:30	**SESSION 3: Accessible Underwater Cultural Heritage Sites (AUCHS): reaching the public** **Session Chair: Aggela Veneti**

15:10 – 15:30	**4 sites and 2 little museums. Raising awareness through Accessible Underwater Cultural Heritage Sites (AUCHS). Protecting and promoting Underwater Cultural Heritage on the Algeciras Bay, The Herakles Project** Felipe Cerezo Andreo, Carlota Pérez-Reverte Mañas, Raúl González Gallero, Alicia Arévalo González
15:30 – 15:50	**SoPHIA meets BLUEMED: A new Holistic Impact Assessment Model** Despoina Koutsoumba, Elia Vlachou
15:50 – 16:10	**Formentera Project: Conservation and integration of Underwater Cultural Heritage in the island community** Javier Rodriguez Pandozi, Enrique Aragon, Andrea Sanz
16:10 – 16:30	**Dry dive experience in the Underwater Archaeological Park of Baiae: gamification to promote Underwater Cultural Heritage destinations** Cristina Canoro, Fabio Bruno, Marco Cozza, Francesco Izzo
16:30 – 17:15	**Conclusions & Discussion** Concluding Discussion Panel: Pari Kalamara, Barbara Davidde Petriaggi, Aggela Veneti, Angelos Manglis

DAY 2: Thursday 13 May 2021

10:00 – 10:30	**Late Registration / Technical Support**
10:30 – 10:50	**Keynote Speech** **"iMARECULTURE project: From 3D documentation to VR Visits"** **Dimitrios Skarlatos**, Associate Prof. Dr.-Ing. Vice Dean School of Engineering, Dept. of Civil Engineering and Geomatics Cyprus University of Technology, Photogrammetric-Vision Lab
10:50 – 12:30	**SESSION 1: Technologies and approaches for the in-situ promotion of Accessible Underwater Cultural Heritage Sites (AUCHS)** **Session Chair: Fabio Bruno**
10:50 – 11:10	**Design and implementation of signage for the first Accessible Underwater Cultural Heritage Site in Greece** Elianna Kolyva, Foteini Vlachaki
11:10 – 11:30	**NEANIAS innovative services for Underwater Cultural Heritage Sites** Paraskevi Nomikou, Kalliopi Baika, Paul Wintersteller, Konstantinos Karantzalos, Josep Quitana, Danai Lampridou, Effie Zafeirakopoulou, Jafar Anbar and NEANIAS team members

11:30 – 11:50	**The MPA Gaiola Underwater Park: towards a new and more sustainable model of management of an underwater Park.** Maurizio Simeone, Caterina De Vivo, Paola Masucci, Martina Defina, Gianmarco Di Pace
11:50 – 12:10	**Underwater itineraries in Sicily: submerged museums and new technologies** Valeria Li Vigni Tusa, Floriana Agneto, Pietro Selvaggio
12:10 – 12:30	**From discovery to public consumption: The process of mapping and evaluating underwater cultural heritage in Malta** Timmy Gambin
12:30 – 13:30	**Lunch Break & Networking Lobby**
13:30 – 15:10	**SESSION 2: The promotion and protection of Accessible Underwater Cultural Heritage Sites (AUCHS)** **Session Chair: Angelos Manglis**
13:30 – 13:50	**MaTaCoS project outcomes: innovative products and electromechanical tools for supporting the restoration of underwater CH** Luciana Randazzo, Michela Ricca, Natalia Rovella, Silvio Antonio Ruffolo, Fabio Bruno, Alessandro Gallo, Emanuele Marino, Marco Lupia, Gianni Cario, Mauro Francesco La Russa
13:50 – 14:10	**Protection and promotion of coastal archaeological sites, with the application of soft shore protection methods against erosion, in the context of sustainable environmental protection of the coastal zone. The case of ancient Asopos (Plytra)** Foteini Vlachaki
14:10 – 14:30	**Creating a practical tool for monitoring the preservation state of ancient shipwrecks** Helen M. Bardas, Angelos Tsompanidis, Aggeliki Bei
14:30 – 14:50	**CAORLE 1 Shipwreck (II-I B.C.). The ongoing project for a remote protection of the site** Massimo Capulli, Alessandro Asta, Stefano Furlani, Mirko Loghi
14:50 – 15:10	**NOUS - uNdersea visiOn sUrveillance System at the sea wreck of Peristera, Alonnisos** George Papalambrou, Vasilis Mentogiannis, Kostas Katsioulis, Pari Kalamara, Despina Koutsoumba
15:10 – 15:30	**Coffee Break & Networking Lobby**
15:30 – 16:50	**SESSION 3: The promotion and protection of Accessible Underwater Cultural Heritage Sites (AUCHS)** **Session Chair: Pari Kalamara**

15:30 – 15:50	**Underwater Parks of the Northern Black Sea Region and Sustainable Development of Tourism** Sergey Fazlullin, Elena Ezhova
15:50 – 16:10	**Sustainable and Resilient Management of Underwater Cultural Heritage (UCH) in Remote Mediterranean Islands: A Methodological Framework** Dionisia Koutsi, Anastasia Stratigea
16:10 – 16:30	**Promotion of Accessible Underwater Cultural Heritage Site (AUCHS) on the example of an XVIIIth-century frigate that sank in the Aegean Sea** Yury Tkachenko, Sergey Khokhlov, Michael Bardashov, Valeria Shemyshevskaya, Ivan Gorlov, Rolan Sadekov
16:30 – 16:50	**An Archaeopark proposal in the Black Sea in the light of underwater research of Ancient Calpe Port** Ahmet Bilir, Serkan Gedük, Günay Dönmez, Ramazan Sayim
16:50 – 17:30	**Conclusions & Discussion** Concluding Discussion Panel: Pari Kalamara, Barbara Davidde Petriaggi, Fabio Bruno, Angelos Manglis

DAY 3: Friday 14 May 2021

10:00 – 10:30	**Late Registration / Technical Support**
10:30 – 10:50	**Keynote Speech** **"Environmental, Energy and Climate Change Adaptation Policy of the Hellenic Ministry of National Defence and the Underwater Cultural Heritage – From where we are now to where we must get to."** **Panagiotis Tripontikas,** Commander in Hellenic Navy, Hellenic Ministry of National Defence, Directorate of Military and Technological Support, Department of Infrastructure and Environmental & Cultural Protection
10:50 – 12:30	**SESSION 1: Dry dive technologies: dematerializing Underwater Cultural Heritage to make it accessible to everybody** **Session Chair: Fabio Bruno**
10:50 – 11:10	**Exploring modern shipwrecks using digital technologies: the case study of the Christoforos Shipwreck** Fabio Bruno, Matteo Collina, Antonio Lagudi, Anastasios Ktistis, Nicolas Sidiropoulos, Angelos Manglis
11:10 – 11:30	**Introducing Virtual Interactive Navigation in the submarine environment of Santorini**

	Paraskevi Nomikou, George Pehlivanides, Christos Stentoumis, Alexandros Arapantonis, Maria Douza, Varvara Antoniou, Michalis Sarantinos, Konstantina Bejelou, Othonas Vlassopoulos, Ilias Kalisperakis, Kostas Monastiridis, Anna Dura, Giotis Ioannidis, Vasiliki Pierrou, Elli Karyati, Alexandros Tourtas, Konstantinos Karantzalos
11:30 – 11:50	**Photogrammetric techniques for digitalization of underwater cultural assets: The case study of the Torre Santa Sabina's Shipwreck** Rita Auriemma, Alessio Calantropio, Filiberto Chiabrando, Luigi Coluccia
11:50 – 12:10	**Use of cheap surface and submarine automated vessels for research and promote Accessible Underwater Cultural Heritage Site (AUCHS)** Sergey Khokhlov, Ivan Gorlov, Yury Tkachenko, Michael Bardashov, Rolan Sadekov
12:10 – 12:30	**Towards an innovative system for the cataloguing of underwater cultural heritage: the case of "Gran Carro" of Bolsena (Viterbo, Italy)** Barbara Barbaro, Elena Musumeci, Marco Medici, Egidio Severi, Chiara Veninata
12:30 – 13:30	**Lunch Break & Networking Lobby**
13:00 – 13:30	**Parallel Session** [through the Networking Lobby link] **"DiveSafe - Integrated system for scientific and environmental underwater surveys, with advanced health & safety features"** Polyvios Raxis, DiveSafe project coordinator, R&D Dept. ATLANTIS Consulting
13:30 – 14:50	**SESSION 2: The promotion and protection of Accessible Underwater Cultural Heritage Sites (AUCHS)** **Session Chair: Dimitris Kourkoumelis**
13:30 – 13:50	**The ancient shipwreck of Peristera, Alonissos, as the first accessible underwater cultural heritage site in Greece** Pari Kalamara, Dimitris Kourkoumelis, Despoina Koutsoumba
13:50 – 14:10	**ACCESSIBLE UNDERWATER TOURISM: archaeology at your fingertips** GianPaolo Colucci
14:10 – 14:30	**Archaeological sites open to visits in the marine environment: the case of the so-called "Terme del Lacus" in Baiae (Italy)** Barbara Davidde Petriaggi, Enrico Gallocchio, Salvatore Medaglia
14:30 – 14:50	**Different approaches for the protection and promotion of ancient and WWII, Accessible Underwater Cultural Heritage Sites (AUCHS). The cases of Fournoi and Leros wreck sites under the ongoing INTERREG V-A Greece- Cyprus2014-2020 project "An.Di.Ka.T."** Vasiliki Kyprouli, Foteini Vlachaki, George Koutsouflakis

14:50 – 15:10	**Coffee break & Networking Lobby**
15:10 – 16:30	**SESSION 3: The promotion and protection of Accessible Underwater Cultural Heritage Sites (AUCHS)** **Session Chair: Aggela Veneti**
15:10 – 15:30	**The importance of_Stakeholders' participation in the management of Accessible Underwater Cultural Heritage Sites (AUCHS) towards local sustainable development of Alonissos** Athanasios E. Zlatoudis
15:30 – 15:50	**Implementing multi-criteria analysis in the selection of AUCHS for the integration of digital technologies into the tourism offering; the case of MeDryDive** Angelos Manglis, Paschalina Giatsiatsou, Dimitra Papadopoulou, Vasiliki Drouga, Anastasia Fourkiotou
15:50 – 16:10	**Comparison of economic and tourist factors in the protection of underwater cultural heritage in the Republic of Croatia: a case study on the ancient shipwrecks protected by metal cages and shipwreck from the bay Letavica on the island of Pag** Vedran Dorušić, Matko Čvrljak
16:10 – 16:30	**Underwater Cultural Heritage Tourism and Alternatives to Diving Tourism** Maria Vrasida
16:30 – 17:15	**Conclusions & Discussion** Concluding Discussion Panel: Fabio Bruno, Dimitris Kourkoumelis, Aggela Veneti, Angelos Manglis

CONFERENCE PAPERS

The papers included in this volume are organized by day and sessions, as in the conference agenda.

Different approaches for the protection and enhancement of Underwater Archaeological sites: acquirements and aspirations

Pari Kalamara[1]

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Keywords: Accessible Underwater Archaeological Sites; Underwater cultural heritage; Cultural management; Ephorate of Underwater Antiquities

Abstract

This paper presents aspects of underwater cultural heritage management in Greece, focusing mainly on accessibility to the diving community and the general public. More specifically, it discusses different approaches to the protection and enhancement of Underwater Archaeological Sites, already put into practice over the last years (2018-2021) by the Ephorate of Underwater Antiquities, the public service of the Hellenic Ministry of Culture and Sports responsible for the management of underwater heritage. Moreover, it analyses the aspirations for the future, as these took shape already at the beginning of 2021. Lately, cultural management has turned into a fast-growing sector with multilevel developmental prospects. In order to tap into the underwater cultural heritage potential, we must always take into consideration the identity and special characteristics of each underwater site as well as the different possibilities of access —physical or virtual—that are rapidly changing because of new technological achievements. All these parameters affect significantly decision making and the undertaking of relevant initiatives. Examples of pilot implementation of the opening of underwater archaeological / cultural sites to the public will be presented. Through them, preliminary conclusions concerning the efficacy of the selected managerial approaches can be drawn, while at the same time domains where more should be done will be highlighted.

The Innovative and State of the Art Public Access Management of Malta's Underwater Cultural Heritage

Darko Kovacevic

Underwater Cultural Heritage Unit, Heritage Malta

Keywords: Public access, Maritime archaeology, Underwater Cultural Heritage Management, Collaboration, Management framework

This paper was published on the Special Issue of *Heritage* (ISSN 2571-9408) "Dive in Blue Growth – Protection and Promotion of Accessible Underwater Cultural Heritage Sites" available here: https://doi.org/10.3390/heritage4040187

A Roadmap for the sustainable valorization of Accessible Underwater Cultural Heritage; Integration of BLUEMED model for Open and Accessible to all sites

Angelos Manglis[1], **Anastasia Fourkiotou**[1], **Dimitra Papadopoulou**[1]

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Keywords: Roadmap, Accessible Underwater Cultural Heritage Sites, Knowledge Awareness Centres, sustainability

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Laws, Policies, Techniques, and Utilization for the Protection of Underwater Cultural Heritage in Republic of Korea

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National Research Institute of Maritime Cultural Heritage, Republic of Korea

Keywords: Korea, Underwater Archaeology, Law, Policies, Techniques, Utilization

Abstract

South Korea's underwater archaeology has been for 45 years since it began with the underwater excavations of the Sinan shipwreck, which began in 1976. Since then, a total of 28 underwater excavations have taken place, with 14 shipwrecks and about 100,000 of relics being excavated. The investigation and protection of the Underwater Cultural Heritage (UCH) of Korea are managed by the national government. The National Research Institute of Maritime Cultural Heritage (NRIMCH) is dedicated to the investigation and protection of UCH. Also, NRIMCH enacts a wide variety of activities, from Conservation and Analysis of UCH, Restoration and Research regarding traditional Korean wooden ships, Research and Study on Maritime Cultural Heritage (MCH), MCH Exhibition, Activation of tailor-made Public Participation Education, and Promotion related to maritime historical relics. It introduces laws and policies related to the protection and investigation of underwater cultural heritage.

The Sea of south Korea has low visibility and strong currents. In this environment, an exploration of the use of the optical camera and the diver is limited. To solve this problem, The NRIMCH has promoted projects for the precise exploration of Underwater Cultural Heritage. Various equipment is being developed in Korea. seabed-mounted 3D Scanner, Underwater Metal Detection System (EOS-Mado1), underwater walking robot Crabster (CR-200), 3D seismic survey system (EOS3D-A). Recently, VR, AR, and MR contents are produced using the results obtained from such research and research. This content is being used for exhibition and education on underwater cultural heritage. Due to the difference in maritime and underwater environments, it is possible to compare with each other what policies and laws should be used to investigate and protect underwater cultural heritage.

Protection and promotion of the submerged "Villa of the dolia" off ancient Epidaurus: methods and strategies of an international project

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Abstract

The submerged "*Villa of the dolia*" extends for about 1600 square meters below sea level off ancient Epidaurus, and it is characterized by the presence of several rooms mostly connected with the processing of the agriculture products, including a warehouse with twenty dolia still preserved *in situ*.

Since 2018 this archaeological complex has been the object of a Project conducted by the Ephorate of Underwater Antiquities, the Istituto Centrale per il Restauro of Rome and the Italian Archaeological School of Athens. After a brief overview of the results of the 2019 excavation and restoration campaign, the paper will present the activities conducted by the international team to document, conserve and protect this very significant archaeological site. Particular attention will be given to the photogrammetric techniques in shallow water used to the 3D documentation of the site; to the innovative materials used for *in situ* restoration of architectonical remains and of one of the dolia (specially formulated hydraulic mortars, methodologies and tools etc.) and the enhancement plan, in progress, that involves guiding in a glass-bottom boat, which is intended to increase the opportunities for the public to visit the site.

May 12|Session 2: Dry dive technologies: dematerializing Underwater Cultural Heritage to make it accessible to everybody.

Dry Dive experiences on the far side of the Mediterranean. VR and live video applied for making UCH accessible.

Carlota Pérez-Reverte Mañas[1], Felipe Cerezo Andreo[1], Pablo Osorio López[1], Luis Mariscal Rico[1]

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Keywords: VR experiences, Dry Dive, Underwater video streaming, public archaeology

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The underwater wonderland of ancient Puglia

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Keywords: Puglia, underwater photogrammetry, underwater 360° video, 3D modeling, wearable VR device

Abstract

The projects Puglia Seascapes - looking at Apulia from an underwater perspective – and UnderwaterMuse, Immersive Underwater Museum Experience for a wider inclusion, both coordinated by Puglia Region, aim to make a significant contribution to better understanding of the underwater cultural heritage; the study cases concern different sites in the Marine Protected Areas of Porto Cesareo and Torre Guaceto: a cargo of columns from Evia island and another cargo of amphoras scattered in the shallow waters of Torre Chianca (Porto Cesareo, Lecce) and the remains of a Late Antique cargo (V-VI century AD) found in the waters of Torre Guaceto (Brindisi). The interpretation of the archaeological and geoarchaeological data about the sites, their formation process and the coastal landscape evolution, as well as the 3D models obtained through photogrammetry techniques based on SfM (Structure from Motion) and underwater 360° and 5K videos, allowed us to develope a methodological and technological protocol based on the use of a software (App), i.e. Puglia Seascapes VR. It provides suggestive scenarios through advanced 3D modeling and animation techniques and results in interactive videos shoot that reconstruct and above all narrate in an emotional way the last journey of the ship in the ancient seascape, deeply different from the current, and the formation of underwater context. Moreover, the application of immersive techniques accessible from a single VR application for wearable devices allows the large public to discover new environments and the scholars to face to a new approach for rewriting the history of ancient Italy.

1. Introduction

Virtual reality applications, which allow the user to visualize and interact with multimedia data of different nature, are still very rare on the market. Most of the applications developed for devices such as Oculus visors are characterized by artificial 3D contents or 360° spherical photos that only capture the current state of an archaeological evidence. This modality of virtual experience does not allow users to understand the history of

the archeological context and the profound evolution of the landscapes, but it represents just a picture of what history has preserved.

The collaboration between CETMA, University of Salento, University of Venice and Marine Protected Area Porto Cesareo in the framework of the project *Puglia Seascapes - looking at Apulia from an underwater perspective* by Regione Puglia, allowed to design and develop a virtual reality application (*Puglia Seascapes app*) aimed at transporting users virtually into the historical events and into the landscapes/seascapes related to two ancient ships and their last seafaring in an immersive way through high-impact multimedia contents and an immersive data fusion. With the application it is possible to go back in the past before the sinking and then explore the shipwrecks at the actual state under the sea. The digital scenes have been realized using advanced 3D modelling techniques for the real time interaction.

2. Materials and Methods

- The activity planning has foreseen this workflow:

- context analysis and survey of the archaeological evidence

- Collection of technical documentation: photogrammetry and 3D model reconstruction

- Archaeological databased interpretation of the historical events: storytelling

- 360° digital scenes set up

- Virtual Reality application

2.1. The first context/case study: the columns shipwreck of Torre Chianca (Porto Cesareo, Lecce)

Between seventeen or eighteen centuries ago, in the sea of Porto Cesareo, between the promontory of Torre Chianca and the islet of Malva, a ship carrying a monumental marble cargo ended its journey that had begun in the Aegean Sea (fig. 1a-b)[1]. The cargo made up of 5 monolithic columns, in a perfectly parallel position, oriented in the N-S direction and about 50 cm apart, encrusted with limestone deposits; little less 9 m long, with a diameter ranging between 85 and 97 cm, they are made of Cipollino marble[2] from Karistos, on the Evia island (samples were taken and analyzed). Between the first and the second monolith (from the east) there is probably a lead artefact, triangular in shape, with numerous grooves, flattened under the columns. The second presents a long transversal gap (which Congedo considers recent). All are presented unfinished or half-worked. A parallelepiped block lies perpendicular to the columns, immediately N of them, while another, uncovered only for a length of 60 cm, is located next to the metal artifact, always below the column, arranged in the N-S direction. In 1964, 14 marble fragments of various sizes and qualities, mainly slabs, were recovered (n. inv. 205177), together with many ceramic sherds. Noteworthy are two amphoras fragments, pertaining the types of Africana II (presumably) and Tripolitana III, both consistent with the presumed chronology to the end of 2nd – 3rd cent. AD. The 1994 survey in the surrounding area, with the use of the water dredge, identified only ceramic material, mostly amphorae and bricks, fragmented and heterogeneous (both "classical" and late antiquity productions were recognized). Marble was noted under the columns. The photogrammetric survey carried out in 2017 by the team from Ca' Foscari university (project '*The routes of the antique marble*' led by

[1] Auriemma 2004, II, 13-14 (SR 6), with references.
[2] So called due the color but especially the layered surface that recalls the onion, that is "cipolla" in Italian.

C. Beltrame) achieved more precise data about dimension, volume and weight of the cargo, and also a reconstructive hypothesis.

Although it was also carried out in the most ancient age, the trade in marble, both raw, simple quarry blocks, and half-worked or finished items (columns, capitals, sarcophagi, slabs, statues, basins, etc.) took on in Roman times, especially Imperial, considerable relevance, with a clear peak in the third century AD: since the 1st century AD there is a state organization for the collection and use of marble, which involved the Imperial property of the quarries and the private contractors. The transport obviously took place by sea: the marbles, embarked on ships of private owners, reached Rome or other metropolises of the Empire, were deposited in warehouses, processed and used in large, monumental works[3].

Although the reconstruction of the routes of these ships is not easy, because of the scarcity of indications available from pottery, it is possible to state that the cargoes, for example of Proconnesian marble, were destined for huge – probably public – monuments[4].

It has already been reported the "marble road" which from the Aegean, after having rounded the fearsome Capo Iapigio, current Capo di Leuca, crossed the Ionian Sea south of Taranto, probably at level of Gallipoli/Porto Cesareo[5]: this is attested by the literary sources[6], but also by the number of the wrecks found both along the Salento coasts in Porto Cesareo, S. Pietro in Bevagna and Torre Sgarrata[7], and, at the same height, along the Calabrian coasts; these are the deposits of Punta Scifo A, the "imperial" marble wreck, probably headed for Porto[8], Punta Scifo D[9], Capo Cimiti, twin - in terms of composition and size of the load - of that of Torre Chianca[10], Cala Cicala[11] and Secche di Capo Bianco[12].

Some of these ships carrying marble were very large vessels which had a particularly strong structure (such as a double layer of mortise and tenons joining the planking), comparable only with the large *onerariae* of the Late Republican period, such as the Madrague de Giens (France) (320-350 tons of cargo) and the Albenga (Italy) (about 500 tons) wrecks[13], but others – such as the one of Torre Chianca, show standard “medium” size, around 80-100 tons.

Nevertheless, the dimension of the five columns suggest they were destined to important and probably public buildings, as it is suggested by C. Beltrame[14] for the column from Marzamemi I shipwreck, however shorter even if wider (6.4 long and m 1.85 wide) of the Torre Chianca ones.

[3] Russell 2011, 2013a, 2013b.
[4] Beltrame 2021.
[5] Gianfrotta, Pomey 1981, 215 ff.; Gianfrotta 1988, 122.
[6] *Liv*. XXVI, 42.
[7] Auriemma 2004, II, 18-9 (SR 7, S. Pietro in Bevagna); 41-42 (SR 48 – Torre Sgarrata), in both cases with references. Further data related to T. Sgarrata wreck in Gabellone at al. 2009; Calia et al. 2009; for S. Pietro. Petriaggi, Davidde 2010 (intervention of Central Institute for Restoration aimed at the site enhancement).
[8] Pensabene 1978; Pensabene 2002, 36-37, 45; Medaglia 2010, 290-293..
[9] Medaglia, Beltrame, Lazzarini 2014.
[10] The cargo consists in 6 column shafts of green cipollino marble: Pensabene 2002, p. 40, n. 9.
[11] It is a cargo of marble in the form of just-hewn blocks from the Greek island of Thasos, in the northern Aegean Sea, very similar to that of Torre Sgarrata near Taranto: Antonelli et al. 2020.
[12] The marble cargo dates back to modern age, between 18th and 19th cent.: Beltrame, Medaglia 2012; Beltrame, Lazzarini, Medaglia 2012.
[13] Gianfrotta 2016; Beltrame, Lazzarini, Parizzi 2016; Parizzi, Beltrame 2020; Beltrame 2021.
[14] Beltrame 2021, 455.

In the case of the Torre Chianca shipwreck we can easily postulate that the ship, like the others that mainly transported columns – Capo Taormina (Taormina I), Giardini Naxos[15] and Capo Cimiti - could be directed to Rome, to the warehouses of Ostia and Porto, or to other Italian ports, to supply public, "imperial" monumental building programs, along a direct route but could also respond to private clients, as cipollino marble was frequently used in "civil" building[16].

As far as the distribution and storage are concerned, two hypotheses have been proposed: Russell[17] suggests, following a “modernist” model, that blocks and raw columns were destined to specific architectural programmes, they were never stocked and that the items visible at Portus (Fiumicino) and Rome were discarded and abandoned in the harbour. Pensabene, on the other side, considers those items what remains of stocks required by a prevision of use[18].

2.1. The photogrammetry and 3D model

Specifically, the mission of Ca’ Foscari University was aimed at conducting the following operations:

1. measurement of lithics;
2. free photographic documentation;
3. positioning and measuring of targets;
4. 3D photogrammetry;
6. testing an underwater miniRov.

Following the best practice conducted in different underwater marble context[19], the field has been set to carry out the survey by trilateration and with digital photogrammetry, placing numbered targets on the columns (fig. 2a). These were detected with the DSM (Direct Survey Method) technique, measuring the direct length between the points and the depths by underwater computer. The data were then managed with Site Recorder software which made it possible to check any errors of the trilateration and to create a net of points with 3D coordinates, that have been used to insert the 3D model in a metric reference system and to define the correct scale of it (fig. 2b).

The photogrammetry consisted of a photographic documentation performed with a Nikon D610 reflex camera with a fixed 20 mm lens with streaks conducted both from above, in a nadiral position with respect to the columns, and at 45° along the sides of the various marble elements and the images were processed with Agisoft's Photoscan software (fig. 3).

The 3D reconstruction makes it possible to better appreciate the position of the cargo of the ship compared with a two-dimensional survey. In fact, from the textured three-dimensional model it is possible to obtain perspective views of the entire cargo or of some individual elements depending on the needs of study and visualization of the site (fig. 4a). In addition, an orthophotography of the column cargo plan was created (fig. 4b).

[15] Capo Taormina I: 37 columns (max lenght 6.65 m) of Marmor Scyreticum and 2 blocks of green marble; 2nd cent. AD (Kapitän 1971, 304); Giardini Naxos: 14 blocks of Cipollino marble and 24 columns of white marble; 3rd cent. AD (Basile 1988, 138); see also Tusa 2016, 196-197.

[16] Pensabene 2002, 45; a cargo like that of Camarina, with two shafts, even if monumental, associated in the same ship with another one of amphorae, would indicate "a single private buyer".

[17] Russel 2013a DA VD.

[18] Pensabene 2015. DA VD.

[19] Balletti et al 2016, Beltrame, Costa 2018.

Furthermore, the site has been the subject of experiment in the use of an underwater MiniRov for photographic and video shooting, using innovative instrumentation for the application of the photogrammetric technique that had given excellent results in previous archaeological missions. Video and photo shooting were carried out with the mini OpenROV. Photogrammetric strips were carried out in the same way carried out by the diver in order to compare the potential of this instrument and of the GoPro cameras mounted on the ROV for the realization of photogrammetric surveys (fig. 5)[20].

The 3D model obtained by photogrammetric survey was finally used to calculate the volume and the precise weight of each single column and has been compared with the manual measurement of the columns, as referred to in the following table.

The calculation and the model of the columns has been employed by the engineer to reconstruct the size of the carrying ship.

The final elaboration of the shape of the boat starts from the 3D model of a boat processed for the shipwreck of Capo Taormina[21] that carried a cargo of marble block that has a weight similar to Torre Chianca (fig. 6). Then, thanks to engineering calculation, the shape the boat has been modified for this particular cargo of columns.

COLUMN	LENGHT m	DIAMETER m		VOLUME m^3	WEIGHT t
1	8,55	0,97		6,32	17,21
2	8,7	0,97		6,43	17,52
3	8,6	0,85		4,88	13,30
4	8,77	0,87		5,21	14,20
5	8,6	0,92		5,71	15,58
6				0,135	0,37
			TOTAL	**28,68**	**78,18**

2.3. The reconstruction of the Columns' shipwreck of Torre Chianca

The reconstruction of ship starting from the shipwreck's evidence available at the end of archaeological investigation relevant both cargo and ship structure (if available). This process is divided in the next two stages, one preparatory for the follow one:

- *stage 1 cargo reconstruction*
- *stage 2 definition of ship's*

In the stage 1 the stone blocks laying on the seabed (blocks could show a different level of scattering based on the number of blocks itself, the sinking *scenario* and the seabed morphology) are assessed taking into consideration:

[20] Costa et al. 2018

[21] See above, note 15. According to the reconstruction by Beltrame, Parizzi 2020 (figs. 5-6): length overall 30.54, max width / main section 9.26; depth (fully loaded, below the waterline): 3.03; draft 2.14; total weight of the load: 81 t (max 85); cargo area, without deck (with gangway): length about 12 x 7.5 width.

1. The actual level of scattering
2. The actual position on the seabed
3. The best practices for proper stowage of cargo on board in term of stability and ergonomic aspect to ease and speed up the loading and unloading operations

Based on the above points, the original arrangement of the cargo onboard is hypothetically reconstructed, following the steps shown in fig. 7.

Following the completion of the cargo reconstruction and its stowage on board, it is possible to start the stage 2 of the process. This second stage used as input data the hypothetical reconstruction of the cargo on board, defined in the stage 1, and estimates the main ship's dimensions ensuring the arrangement of the cargo does not interfere with the ship's structures, and allowing enough space for handling the cargo during loading and unloading. This preliminary definition of the main ship's dimension based only on geometric and ergonomic criteria provide a rough approximation which could underestimate/overestimate the dimensions of the vessel. In order to obtain the correct dimension of the vessel, ensuring the suitable space for cargo handling as well as the buoyancy of the vessel according to Archimedean principle, a further process to refine and adjust the dimension to be carry out. The further step based on hydrostatic calculation, verifies that:

1. the equilibrium draught, ensure the hull's buoyancy necessary to support both the weight of the hull structure and cargo, according to the Archimedean principle;

2. the freeboard associated to the equilibrium draught, ensuring it is sufficient to guarantee safety margins during sailing.

In addition to the calculation of the above-mentioned parameters also the displacement and other parameter such as metacentric position and geometrical coefficients are calculated. These additional parameters provide information about the nautical behaviour of the vessel and allow us to better understand the suitability of the vessel for assigned purpose. The above-mentioned process is summarized in fig. 8.

On completion of the above-mentioned process, the ship main dimensions are properly defined, and the hull shape completely defined.

2.4 The second context/case study: the ghost boat of Torre Guaceto (Carovigno, Brindisi)

In the MPA the Underwater Archaeology group of the University of Salento, supported by the same MPA, has launched since the beginning of 2000 an intensive research programme aimed at the reading and understanding of the dynamics of the coast changes. The archaeological contexts and finds showed a relevant frequentation form Protohistorical age to the Mediaeval[22].
This site has been well known as a safe harbour ever since ancient times supplying abundant freshwater from springs fed by large marshes and two main streams (Canale Apani and Canale Reale) (Scarano et al., 2008). Currently, archaeological remains dated back to the Bronze Age are the most important testimonies identified in this area, such as protohistoric evidence of a stretch of coast about 3.5 km long, including five islets (namely, Torre Guaceto and Scogli di Apani) as well as large sea bottom areas (fig. 9).

As regards the Late Antique phase, on the S side of the third islet (marked by a small but evident inlet), the remains of a structure with large squared blocks are preserved (30 blocks have been found; max dimensions 150x40x50 cm) inside which we recognized the collapsed layer of the tiled roof and the floor with ceramic

[22] Scarano et al. 2008; Scarano et al. 2017; Mastronuzzi et al. 2017.

materials (Late Roman 1 and 2 oriental amphorae, African Red Slip ware D, small *spathia*) dated back to the 5th-6th cent. AD. These foundations - given the monumentality of the blocks and the position - have been hypotetically referred to a tower-lighthouse, being in use during the centuries of Late Antiquity (fig. 10).

Significant is the discovery, on the seabed immediately in front of the spur on which the structure stands, of an archaeological deposit (at depth between -2.8 and -3.5 m) consisting of the remains of ballast and sporadic materials: sherds of presumably Late Antique amphorae, roof tiles and a millstone, probably belonging to the onboard equipment (fig. 11). Unlike the previous wreck, we don't know much about the original cargo of this phantom vessel; the few fragments of amphorae found suggest that the goods were transported in other containers, which have not been preserved - sacks, skins, barrels, for example - or traveled loose in the hold, as happened with cereals. However, in spite of some inconsistencies with the previous reports, this context could be identified with the wreck Torre Guaceto 1 or Torre Guaceto 2[23] but, in the light of the survey campaign, would be considered coeval with the presumed tower-lighthouse[24] and would indicate that in the Late Antiquity the islet, once coincident with a tip, a promontory of the coast high on the sea, was separated from the land by an arm of sea (a sort of strait), due to the relative sea level rise and consequent marine ingression that had caused the detachment of this protruding part of the coast.

2.5. Archaeological data-based interpretation of the historical events: storytelling

CETMA production team and the University of Salento led by Rita Auriemma focused on the contents to be narrated; such activity was very important because it has permitted to define the production phases of digital contents for the realization of the app.

At the same time, part of the team worked on the construction of the storyboards, that are important elements for the 3D production (fig. 12).

In this creative phase designers, archaeologists and 3D animators work together on the technical data as surveys, photos, archaeological documents, in order to build up the storytelling of the digital scenes.

The scenes were conceived as frames of a movie sequence that tells the final act of the last journey of the ships, the passage from the tranquillity of navigation to the explosion of the storm and again to the silence of the sea bottom. The first scene is the appearance of the ship in navigation, the second one the crescendo of the sea and the stranding in the water shallows or crushing against the reef, the third one the formation of the underwater deposit, that is transformation of the ship into the shipwreck and, the last scene, the current underwater real situation, as we can see it.

The first scene of the two app shows the waterscape, very characterized, of the two contexts, reconstructed since the geoarchaeological data. In the case of Torre Chianca Columns' shipwreck of Porto Cesareo MPA the setting includes on background the coastline and, also, the close Malva islet, meanwhile the ones of Torre Guaceto app focus the presence of the presumed lighthouse standing on on what has now become an islet. Furthermore, the scenes of the stranding or destruction against the reef hidden by the storm are very realistic, with an accurate rendering of the rough and then stormy sea and the scattering of the objects through the leak.

[23] Auriemma 2004, II, 28 (SR 21); 45 (SR 57, presumed), with references; probably the first discoveries and reports caused some errors and duplications.
[24] On the same islet a quarry (about 1000 m2) seems compatible, at least in the most ancient phase, with the blocks just described.

2.6. Virtual Reality application

The VR application allows users to interact with the following different types of digital contents:
- Photogrammetric models of the current state of the archaeological evidence
- 4K 360° video of the two submerged sites.
- 3D reconstruction of the scenes of the two shipwrecks of Torre Guaceto and Porto Cesareo;

After collecting the data, the production team worked on the definition of the optimization processes to apply on the photogrammetric data realized by Ca' Foscari University in previous survey campaigns. For each site the 3D models have been optimized in terms of geometry, reduced numbers of polygons, surfaces cleanup and tangents alignment. Finally, the optimized 3D models have been translated in a real-time format and uploaded into the application framework.

After the optimization of the photogrammetric data has been completed, CETMA focused on the realization of the video shooting campaigns in collaboration with the University of Salento and the AMPs of Porto Cesareo and Torre Guaceto. With the objective to obtain high resolution 360° video a GoPro Hero 4 Camera and a Go Pro Hero 5 360° fixed on ballasted tripod have been used. Thanks to the collaboration with the AMP'S professional photographers, CETMA has achieved 4K video footages of the archeological evidence and a stock of 360° frames to post-product (fig. 13).

After the conclusion of the underwater campaigns, the team worked on the production of the scenes of the sinking through advanced 3D modelling and animation techniques.

The CETMA production team developed the underwater digital scenarios for the two archeological areas using dedicated 3D tools as Autodesk Maya. At the same time, part of the production team concentrated on the creation of wrecks 3D models. This activity was very difficult but the collaboration between CETMA, University of Salento and Ca' Foscari University has resulted in a very detailed integral models of the wrecks (fig. 14).

Subsequently, the models were adapted to the virtual scenarios and modified in relation with the different scenes of the sinking to be represented.

3. Results and discussion

In a couple of months, the project team has been able to:

- Optimize and re-utilize previous photogrammetric data and translate them in a real-time model for virtual reality applications;
- Obtain video and photo in 4K resolution and 360° of the two archeological sites at the actual state;
- Reproduce through advanced 3D modelling techniques two virtual scenarios and two digital wrecks (integral models and damaged models).

The produced materials were uploaded in the application framework. The application has been developed with Unity 3D framework and it is available for Oculus Devices, Go and Quest model:
- *The ship of the columns of Porto Cesareo (Lecce, Italy): the unfinished journey*
- *The ghost boat of Torre Guaceto (Carovigno, Brindisi, Italy)*

The control interfaces designed for the VR application are user friendly and accessible. A recorded voice support users in the correct interaction with the digital contents, menus and buttons. The user is completely immersed in a virtual scenario mixed with 360° video of the real environment. That is an easy way to understand the history and interact with the past (fig. 15).

Obviously, only the strict synergy between various competences and an exhaustive archaeological investigation and interpretation made it possible to create a plausible storytelling, that doesn't manipulate and distort the evidence, sometimes scarce and little eloquent, at our disposal.

In the case of Columns shipwreck, after the stranding/getting stranded, the decomposition and transformation of the hull on the seabed took place, mainly due to the wave motion. In addition, the strong water absorption caused the sides to decompose, and the wood was attacked by fungi, bacteria and a mollusc, the teredo navalis, which feeds on it. In the end, only those parts of the hull survive "sealed" by the cargo (when this is composed of non-perishable material: for example, ceramic, metals or, as in our ship, marble or stone). This makes us understand why we no longer see the remains of the ship of the columns: what remains of the wood is hidden by the gigantic marble shafts.

In the second case the ship was shipwrecked in the strait between the coast and the islet, probably during a strong storm, perhaps running aground against the rocks due to the lower sea level at the time, by about one and a half meters. A large leak probably caused the objects that were on board to escape. The hull, already broken up and without the protection of a load, gradually decomposed, mainly due to the wave motion, the water imbibing and the attack of marine organisms. We can think that some remains are still under the stones, which was the ballast present at the bottom of the hold.

In the case of the Columns shipwreck the app implementation represented an added value, because the reconstruction and simulation of the dynamics which caused the formation of the archaeological site make us understand that the ship probably didn't sink but was thrown towards the shore by a storm and ran aground there, also due to the heavy load and perhaps to the broken hull. Today it is 4.5 m deep but at the time there was only 3 meters of water at this point, as much as its draft, that is the height of the submerged part of the hull. In fact, we know that the sea level has risen by a few meters since the second millennium BC, due to various geological phenomena that have affected both the sea and the land. The beached wrecks are, like other archaeological sites, valuable clues to reconstruct the ancient coastline and the evolution of maritime landscapes.

4. Conclusions

The close connection between scientific research and enhancement, the synergy between different skills and the narrative and communicative use of virtual reality and augmented reality have made it possible to satisfy the series of ambitious objectives that the Puglia Seascapes project aimed at:

- identify submerged paths in the MPAs that are emblematic of the cultural and natural values that water landscapes/seascapes can offer;

- make the data of systematic surveys carried out with the holistic, contextual, diachronic, multi and transdisciplinary approach typical of landscape archaeology, in this case coastal and underwater landscapes, therefore characterized by a particular dynamism, available to the community;

- enrich the experience of submerged landscape through the use of multimedia technologies and the production of audio-visual information material in Italian and English, accessible free of charge via the Internet;

- contribute to a more aware and informed visit by tourists who intend to know the peculiarities and assets of the territory that hosts them;

- inform and sensitize the various social actors to the natural and cultural landscape heritage of the area in which the AMP falls, its conservation, management and enhancement;

- to make the actors themselves responsible for forms of co-management of heritage, which once again becomes a common good, capable of increasing the cultural, moral, social and economic well-being of the community and individuals.

The process involved the preliminary collection, analysis and study of the scientific, graphic and photographic documentation available for both the sites, the revision and possible completion of the same, by the Department of Cultural Heritage of the University of Salento.

As regards, in particular, the wreck of the columns of Torre Chianca, the photogrammetric survey and the 3D model of the original ship have been reviewed by the Ca 'Foscari University of Venice and, on the basis of this, it has been proposed a hypothetical reconstructive model of the navis marmorum based on the calculation of tonnage and engineering analysis.

A fundamental step was the drafting of the subject and the script and the creation of the storyboard of the app, by the Department of Cultural Heritage, which saw the creation of the different interactive scenarios: navigation, storm, sinking or stranding, creation of a new body at the bottom of the sea, and, at the end, the current situation.

The CETMA creative modeling experts optimized the 3D model of the Imperial age ship with the load of cipollino marble columns from Evia island and fine-tuned that of the boat shipwrecked close to the islet of Torre Guaceto on the basis of archaeological and iconographic data available; they also took care of the development of both models in a navigable and interactive sense also through the design of 10 POIs (Points of interest) that animate the application in virtual reality, allowing the user to interactively deepen some details of the boat and the load in virtual reality usable through immersive viewers. The user is also able to switch from the digitally reconstructed scenario (the past) to the real underwater environment (today), thanks to the interaction with 4K/3D/360° videos of the sites.

The productions lend themselves to a vast dissemination intervention, first of all through direct use with viewers in the centers of the Marine Protected Areas, home to a permanent archaeological exhibition and a section of environmental education, true access gate to the MPAS. The project also envisaged the publication of the app on the websites of the two Marine Protected Areas involved and the dissemination to all stakeholders of the same content, downloadable from the website, through a communication and awareness campaign on the network.

Link to the video of two apps:
1. The ship of the columns of Porto Cesareo (Lecce, Italy): the unfinished journey
https://www.youtube.com/watch?v=HSGKBKnAcqY
2. The ghost boat of Torre Guaceto (Carovigno, Brindisi, Italy)

https://studio.youtube.com/video/CwZHXxzO93g/edit

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Turismo, Economia della Cultura, Valorizzazione del Territorio, through Teatro Pubblico Pugliese – Consorzio per le Arti e la Cultura.
The authors would like to thank the Porto Cesareo and Torre Guaceto MPA direction and staff, as well as theCoordination of Environmentalists Pro Porto Cesareo onlus for the generous support to the operations.

References

1. Antonelli F., Bloise A., Bruno F., De Luca R., Allegretta I., Medaglia S., Taliano Grasso A., Terzano R., Miriello D. 2020, *Archaeometric approach to identifying the provenance of white marbles from the shipwreck of Cala Cicala (Crotone, Calabria, Italy)*, Journal of Archaeological Science: Reports 30, 102204.
2. Auriemma R. 2004, *Salentum a salo. I. Porti, approdi, merci e scambi lungo la costa adriatica del Salento. II. Forma Maris,* Università di Lecce, Dipartimento di Beni Culturali, 9-10, Lecce.
3. Balletti C., Beltrame C., Costa E., Guerra F., Vernier P. 2016, *3D Reconstruction of Marble Cargos Shipwreck Based on Underwater Multi-Image Photogrammetry,* Digital Applications in Archaeology and Cultural Heritage, 3, 1-8.
4. Basile B. 1988, *A roman wreck with a cargo of marble in the bay of Giardini Naxos (Sicily)*, IntJNautA 17, 2, 33-142.
5. Beltrame C. 2021, *The contribution of four shipwrecks to the reconstruction of the trade dynamics of proconnesian marble in the Roman period*, Archeologia Classica LXXII - n.s. II, 11, 437-462.
6. Beltrame C., Costa E. 2018, *3D survey and modelling of shipwrecks in different underwater environments,* Journal of Cultural Heritage, 29, 82-88.
7. Beltrame C., Medaglia S. 2012, *Il relitto di Capo Bianco (Isola di Capo Rizzuto, Crotone): un caso di trasporto transmarino di marmo tra '700 e '800,* in Archeologia e Memoria storica, Atti delle Giornate di studio (Viterbo 25-26 marzo 2009), "Daidalos" 13, Viterbo, pp. 371-388.
8. Beltrame C., Lazzarini L., Medaglia S. 2012, *Underwater Investigation on a Marble Cargo Wreck at Capo Bianco near Isola di Capo Rizzuto, Crotone, Italy,* in IJNA, 41, 1, pp. 3-16.
9. Beltrame C., Lazzarini L., Parizzi S. 2016, *The Roman Ship 'Punta Scifo D' and its Marble Cargo (Crotone, Italy)*, Oxford Journal of Archaeology 35, 295-326.
10. Calia, A., Giannotta, M.T., Lazzarini, L., Quarta, G., 2009, *The Torre Sgarrata wreck: Characterization and provenance of white marble artefacts in the cargo*, in Y. Maniatis (ed.), Asmosia VII. Actes du VIIe Colloque International de l'Asmosia (Thasos, 15–20 Septembre 2003) BCH Suppl. 51, Athène, 333-342.
11. E.Costa, F. Guerra, P. Vernier, 2018, *Self-assembled ROV and photogrammetric surveys with low cost techniques*, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLII-2.
12. Gabellone, F., Giannotta M.T., Alessio A. 2009, *The Torre Sgarrata wreck (South Italy): Marble artefacts in the cargo*, in Y. Maniatis (ed.), Asmosia VII. Actes du VIIe Colloque International de l'Asmosia (Thasos, 15–20 September 2003). BCH Suppl. 51, Athène, 319–331.
13. Gianfrotta P. A. 1988, *Archeologia sottomarina in Puglia*, in C. Marangio (ed.), *La Puglia in età repubblicana*. Atti del I Convegno di Studi sulla Puglia romana (Mesagne 20-22 marzo 1986), Galatina, 119-125.
14. Gianfrotta, P.A., Pomey, P., 1981. *Archeologia subacquea. Storia, tecniche, scoperte, relitti*, Arnoldo Mondadori editore, Milano.
15. Gianfrotta P.A. 2016, *Relitti con marmi (naves lapidariae?): trasporti di stato, maestranze itineranti e coincidenze ostiensi*», Archeologia Classica LXVII, 341-359.
16. Kapitän G. 1971, *Esplorazioni su alcuni carichi di marmo e pezzi architettonici davanti alle coste della Sicilia orienta*le, in *Atti del III Congresso Internazionale di Archeologia Sottomarina* (Barcellona 1961), Bordighera, 296-309.
17. Mastronuzzi G., Antonioli F., Anzidei M., Auriemma R., Alfonso C., Scarano T. 2017, *Evidence of relative sea level rise along the coasts of central Apulia (Italy) during the late Holocene via maritime archaeological indicators,* Quaternary International 439, 65-78 http://www.sciencedirect.com/science/article/pii/S1040618216301550;
18. Medaglia S. 2010, *Carta archeologica della provincia di Crotone. Paesaggi storici e insediamenti nella Calabria centro-settentrionale dalla Preistoria all'Altomedioevo*, Cosenza.

19. Medaglia S., Beltrame C., Lazzarini L. 2014, *La* navis marmorum *di età romana "Punta Scifo D" (Crotone). Risultati preliminari della prima campagna di indagini subacquee*, Rivista di Archeologia 37, 137-165.
20. Parizzi S., Beltrame C. 2020, *Calculating the Tonnage and the Dimension of the Cargos of Marble of Roman Period*, Digital Applications in Archaeology and Cultural Heritage 18, online.
21. Pensabene P. 1978, *A Cargo of Marble Shipwreck at Punta Scifo near Crotone (Italy)*, International Journal of Nautical Archaeology 7.2, 105-118.
22. Pensabene P. 2002, *Il fenomeno del marmo nel mondo romano*, in M. De Nuccio, L. Ungaro (eds.), I Marmi colorati della Roma imperiale, Venezia, 3-67.
23. Pensabene P. 2015, *Marmi pubblici e marmi privati. Note in margine ad un recente volume di Ben Russell*, ArchCl LXVI, 2015, 575-593.
24. Petriaggi R., Davidde B. 2010, *The sarcophagi from the wreck of San Pietro in Bevagna (Taranto): the subject of new works by the Istituto Superiore per la Conservazione ed il Restauro*, Archaeologia Maritima Mediterranea, 7, 131-137.
25. Russell B. 2011, *Lapis transmarinus: stone-carrying ships and the maritime distribution of stone in the Roman empire*, in D. Robinson, A. Wilson (eds.), *Maritime Archaeology and Ancient Trade in the Mediterranean*, Oxford, 139-155.
26. Russell B. 2013a, *The Economics of the Roman Stone Trad*e, Oxford.
27. Russel B. 2013b, *Roman and late-antique shipwrecks with stone cargoes: a new inventory*», Journal of Roman Archaeology 26, 331-361.
28. Scarano T., Auriemma R., Mastronuzzi G., Sansò P. 2008, *L'archeologia del paesaggio costiero e la ricostruzione delle trasformazioni ambientali: gli insediamenti di Torre Santa Sabina e Torre Guaceto (Carovigno, Br)*, in *Atti del Secondo Simposio Internazionale "Il monitoraggio costiero mediterraneo: problematiche e tecniche di misura"* (Napoli 4-6 giugno 2008), CNR-IBIMET, Firenze, 391-402.
29. Scarano T., Auriemma R., Alfonso C. 2017, *Approccio geoarcheologico per la ricostruzione dei paesaggi costieri e delle dinamiche insediative nel Salento del II millennio a.C.*, in F. Radina (a cura di), *Preistoria e Protostoria della Puglia.* Atti XLVII Riunione Scientifica dell'Istituto Italiano di Preistoria e Protostoria (Ostuni, 9-13 ottobre 2012), Studi di Preistoria e Protostoria 4, Istituto Italiano di Preistoria e Protostoria, Firenze, 977-982.
30. Tusa S. 2016, *Le navi lapidarie in Sicilia*, in F. Agneto, A. Fresina, F. Oliveri, F. Sgroi, S. Tusa, *Mirabilia maris. Tesori dai mari di Sicilia*, Palermo, 195-204.

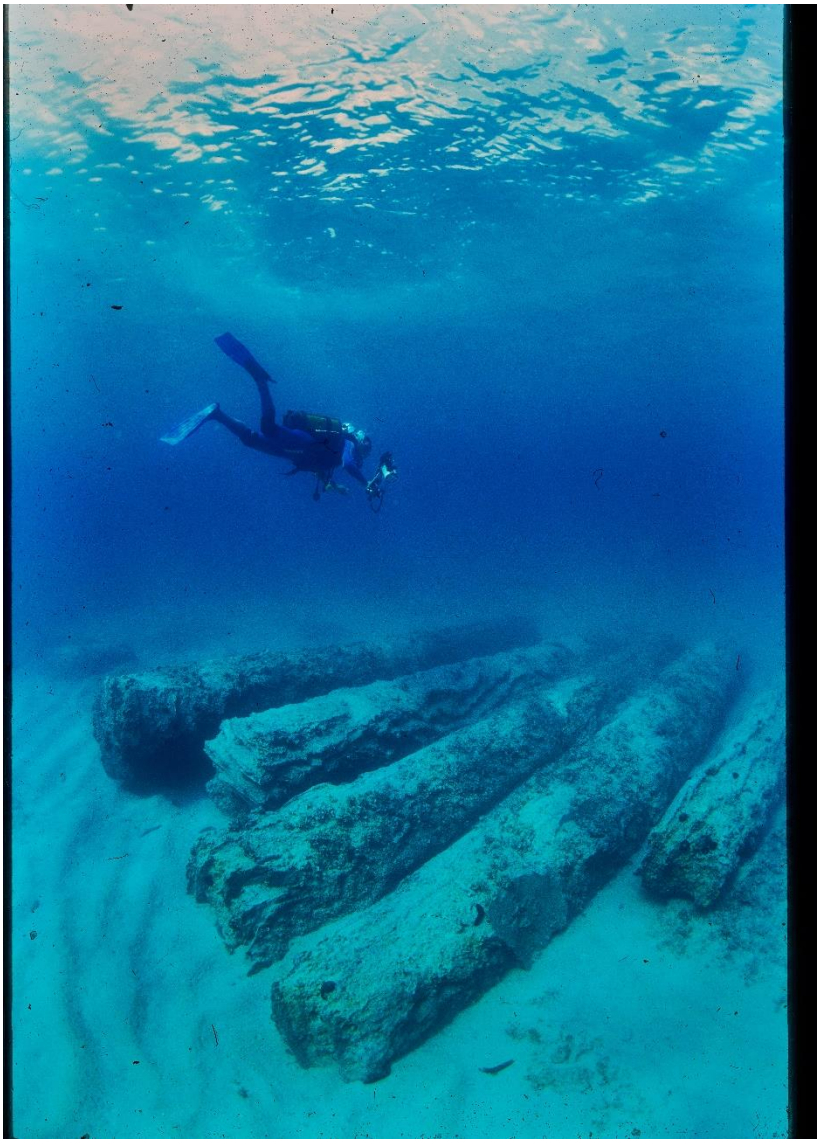

Figure 1a-b. Torre Chianca di Porto Cesareo. Column shipwreck (photo:).

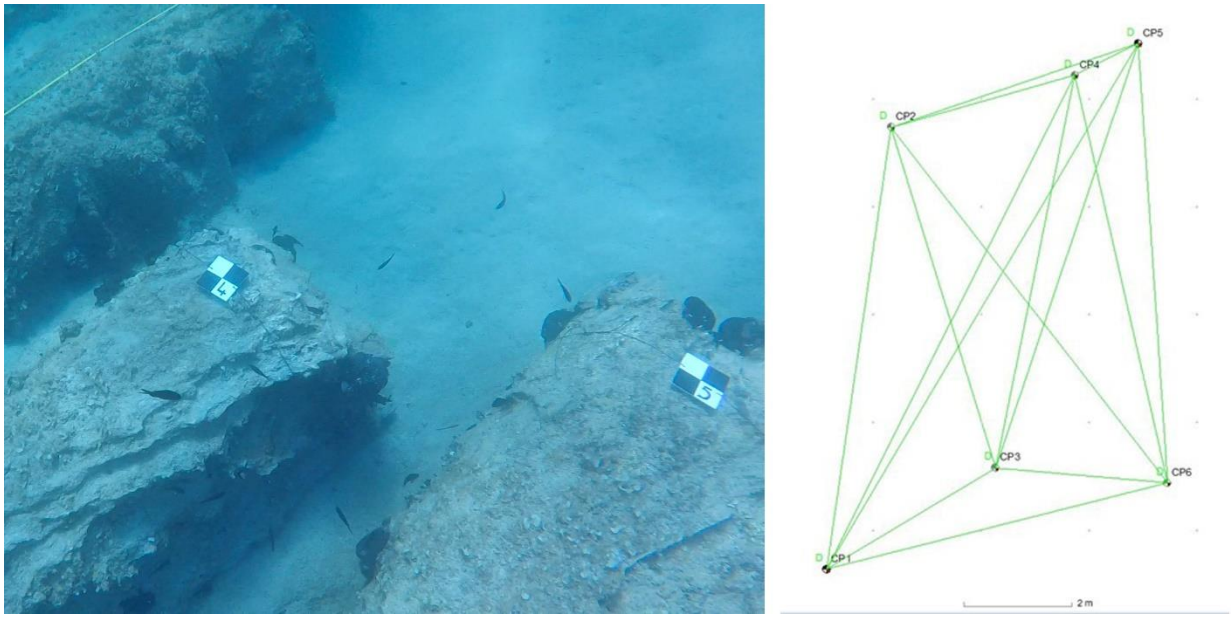

Figure 2a. Detail of the targets positioned on the columns; b. Plan of the survey of the targets with the linear measurements (photo and elaboration E. Costa).

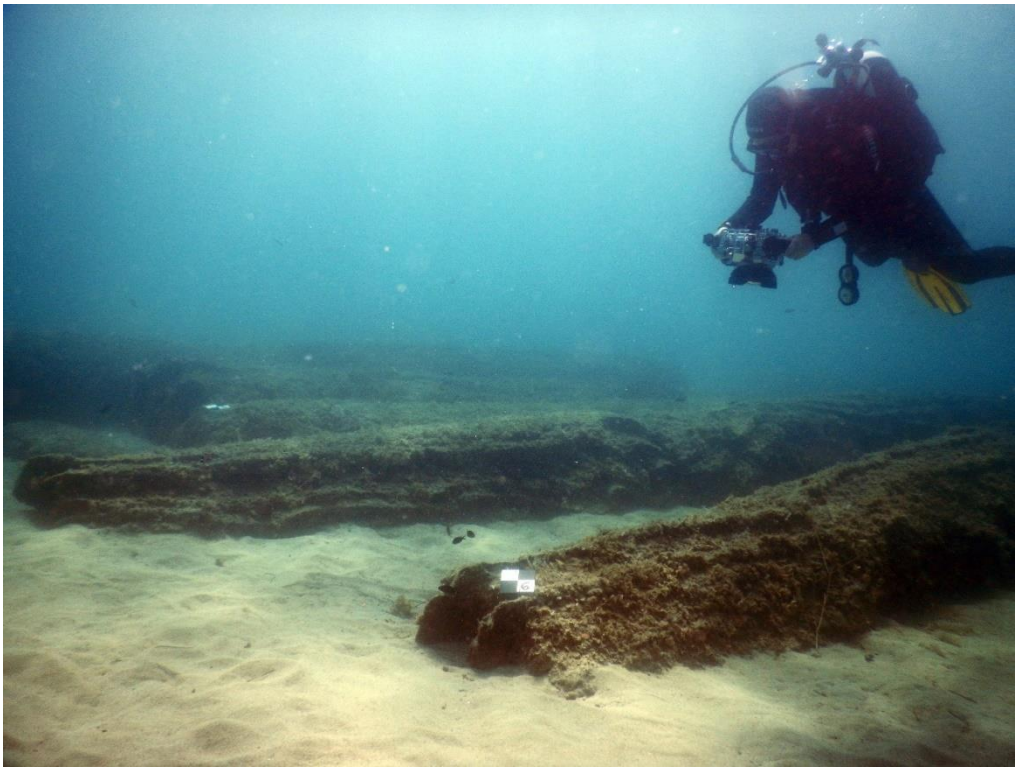

Figure 3. A moment of the photogrammetric survey with the reflex camera Nikon D610 (photo. M. Secci).

Figure 4a. Perspective view of the 3d model. Plan ortophoto of the 3d model (elaboration: E. Costa)

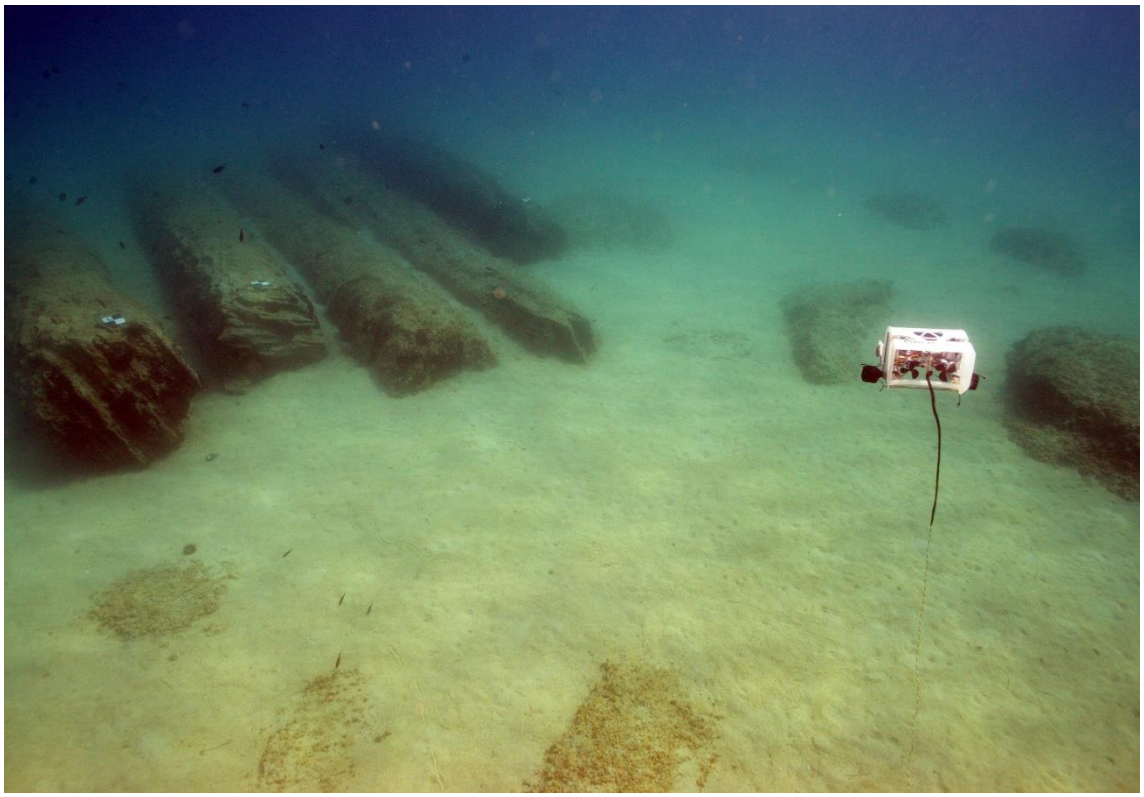

Figure 5. The photogrammetric survey realized with the go pro mounted under the OpenROV. (photo M. Secci).

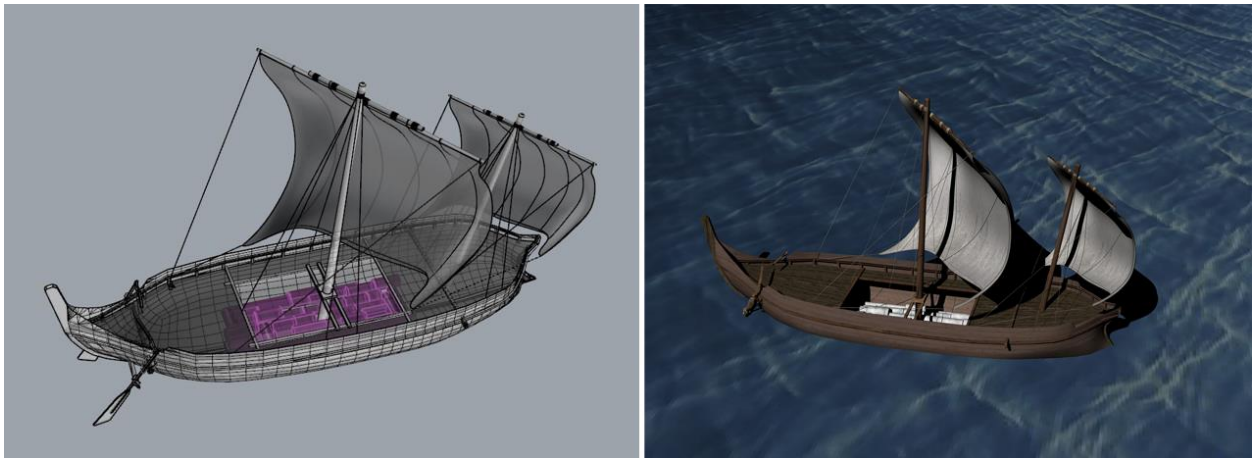

Figure 6. The reconstruction of the shipwreck of Capo Taormina: a. wireframe model, b. rendered model (elaboration: E. Costa).

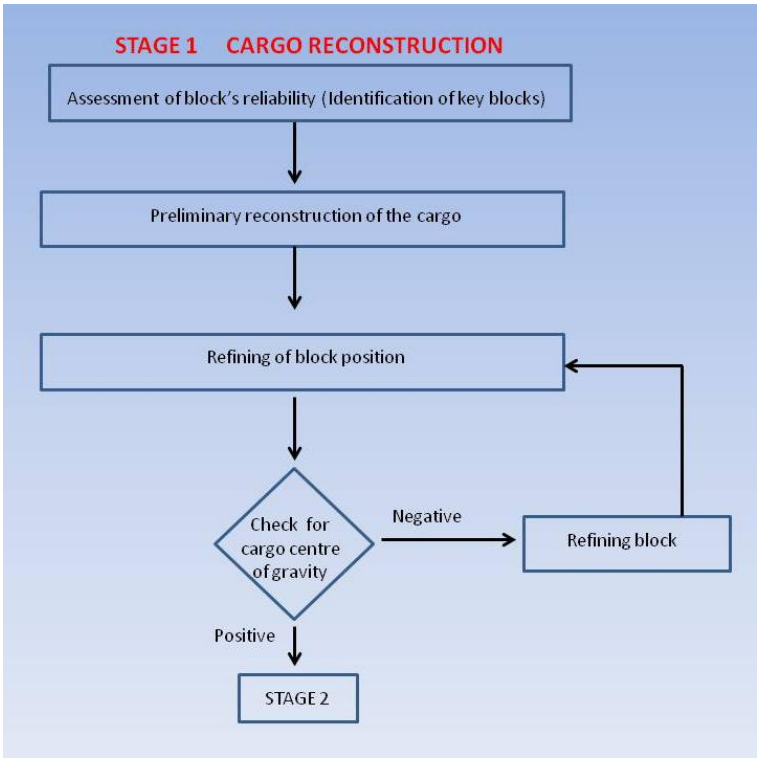

Figure 7. Stage 1. Cargo reconstruction (elaboration: S. Parizzi).

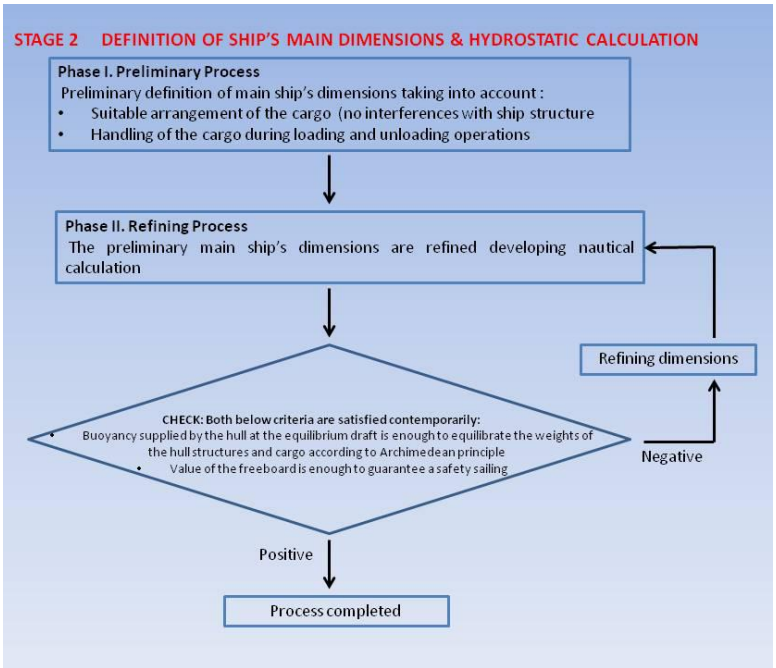

Figure 8. Stage 2. Definition of ship's main dimensions and hydrostatic calculation (elaboration: S. Parizzi).

Figure 9. Torre Guaceto (Carovigno, Brindisi): the promontory and the islets; in the foreground the third islet (photo: courtesy Poli Bibliomuseali Regione Puglia).

Figure 10. Torre Guaceto, third islet. Foudations of the presumed tower-lighthouse (photo: Dipartimento Beni culturali, Università del Salento).

Figure 11. Torre Guaceto. Remains of the ghost shipwreck: millstone and ballast (photo: Dipartimento Beni culturali, Università del Salento).

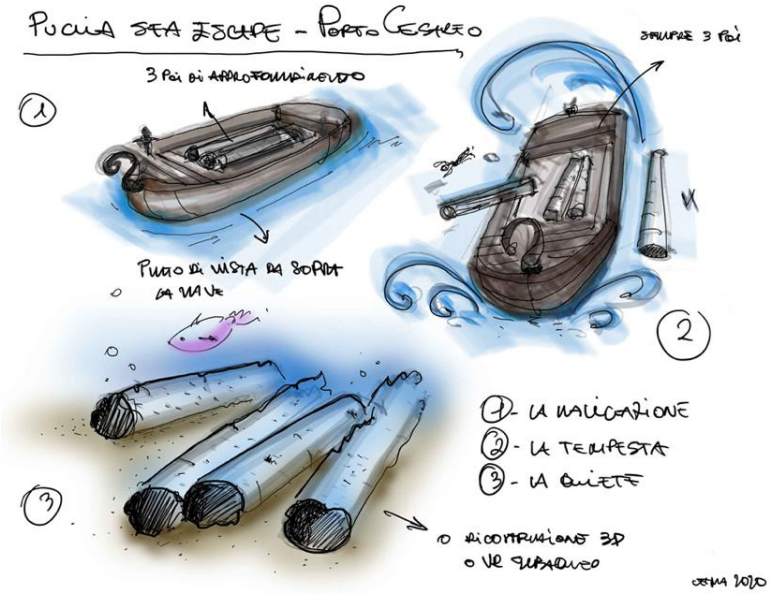

Figure 12. - Storyboard realized for the site of Torre Chianca - Porto Cesareo (drawing: CETMA)

Figure 13 - Briefing and video campaigns realized by CETMA in collaboration with AMP Porto Cesareo and Torre Guaceto, Coordination of Environmentalists Pro Porto Cesareo onlus and University of Salento (photo: CETMA)

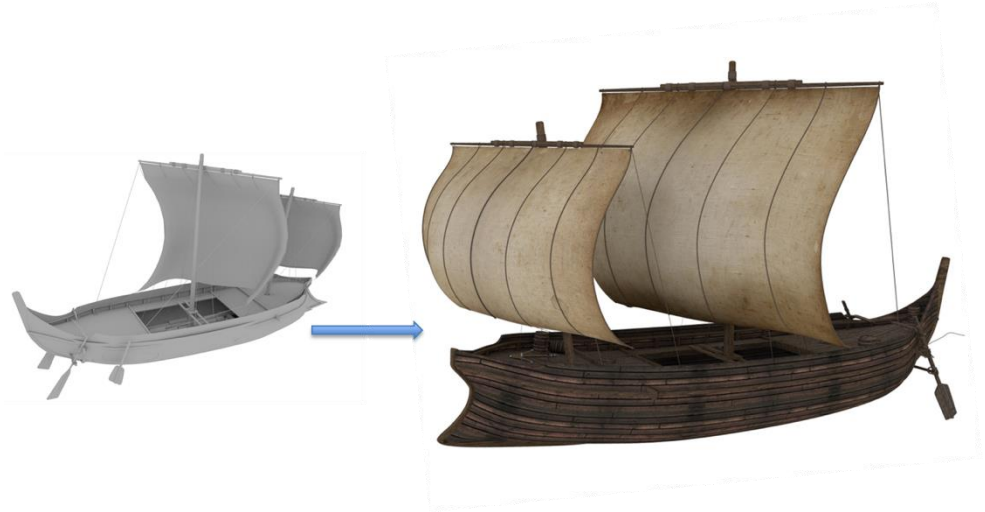

Figure 14 *- Off-line 3D and optimized 3D models of the Torre Chianca Wreck (elaboration: CETMA)*

Figure 15 *– Images of the Puglia Seascapes application virtual scenarios (elaboration: CETMA)*

May 12|Session 2: Dry dive technologies: dematerializing Underwater Cultural Heritage to make it accessible to everybody.

Dry Diving and Augmented Reality Simulations of Historical Events and Artefacts

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Keywords: Dry diving, Augmented Reality, Digital Cultural Heritage, AR

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Dive in The Past: A Serious Game to promote the Underwater Cultural Heritage of the Mediterranean Sea

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Keywords: Serious Game, Gamification, Underwater Cultural Heritage, Virtual Reality, Accessibility

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4 sites and 2 little museums. Raising awareness through Accessible Underwater Cultural Heritage Sites (AUCHS). Protecting and promoting Underwater Cultural Heritage on the Algeciras Bay, The Herakles Project

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Keywords: Public Access to UCH, public studies, Underwater trails, interpretation for protecting UCH, public response

Abstract

The Herakles project (FEDER-UCA18-107327) was created to research the UCH of Algeciras Bay (Spain), but also with the commitment to disseminate the results and make this heritage accessible to the public through different experiences. Here we present the first results of the three experiences that we are developing in close collaboration with local stakeholders, ranging from public institutions such as the Museum of Algeciras, the Port Authority of Algeciras Bay, or the Natural Park of the Strait of Gibraltar to several active tourism and diving companies.

The Herakles project is based on three lines of work that address 3 different audiences or communication problems.
1 - Establishment of various underwater trails in 16th, 18th, and 19th-century shipwrecks. Accessible Underwater Cultural Heritage Sites (AUCHS).
2 - Creation of two centres for the interpretation of the Maritime and Underwater Cultural Heritage of the Strait Natural Park (including historical information, virtual models, and VR Glasses) as an educational complement to the underwater trails.
3 - Study of the impact of tourism based on virtual or direct access to the UCH in the Bay of Algeciras, analyzing parameters linked to the conservation of heritage and the effectiveness of the transmission of values and the rise of awareness among divers and other audiences.

SoPHIA meets BLUEMED: A new Holistic Impact Assessment Model

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[2] *Ephorate of Underwater Antiquities, Hellenic Ministry of Culture and Sports*

Keywords: AUCHS, public opinion, survey, Peristera shipwreck, holistic impact assessment

Abstract

In this paper, a new Holistic Impact Assessment Model (HIAM), currently under development in the framework of SoPHIA, a Horizon 2020 project, is presented and assessed in relation to the opening of the first Greek AUCHS, the shipwreck of Peristera.

SoPHIA's HIAM, aiming to assess the cultural, social, economic and environmental aspects of cultural heritage interventions, found an ideal case study in the AUCHS of BLUEMED: the first pilot site, Peristera, aspires to promote a sustainable and responsible model for the protection of both cultural and natural underwater heritage, while empowering local communities and boosting economic development.

In view of the assessment, available qualitative and quantitative data from BLUEMED-Peristera (ex-ante and ex-post surveys, number of divers, KAC visitors etc) have been collected. Moreover, a public opinion survey has been conducted on Alonissos island. All data have been reviewed and evaluated using the HIAM, while extensive focus group discussions with the project's stakeholders have provided useful feedback for both testing the model and developing relevant indicators for the AUCHS.

Formentera Project: Conservation and integration of Underwater Cultural Heritage in the island community

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Keywords: Underwater Archaeology, Community engagement, Accessibility, Training and Education

Abstract

IBEAM was established in 2012 for research, protection, preservation and dissemination of the richness of the underwater cultural heritage (UCH) in the Balearic Islands (Spain); in line with the 2001 UNESCO Convention. This organisation aims to cooperate with the local authorities improving human well-being and social equity, while significantly reducing risks and impact on the coastal and sea cultural environment. Over the last 5 years IBEAM has provided critical information to local authorities essential for informed decision-making and adaptive management. The protection of all kinds of cultural heritage is a very important aspect to safeguard cultural diversity and reinforces society's sense of identity, strengthens social cohesion and facilitates mutual understanding, as well as bringing economic benefits. Formentera Project: Conservation and integration of Underwater Cultural Heritage in the island community, is an action program developed in the Balearic Islands (Spain) since 2015. This initiative aims to fill the gap between the protection of underwater cultural heritage and the accessibility of the general public. In this case, our efforts aim to cover three types of audience 1. children's education 2. university students 3. divers by proposing experiences generating integrative experiences that allow a basic understanding of best practices in their interaction with the UCH.

1. Introduction

The island of Formentera is the smallest of the four islands that comprise the Balearic archipelago and is one of the most popular tourist destinations in the West Mediterranean. Not in vain is it known as the last paradise in the Mediterranean (Figure 1). Every year, it receives tens of thousands of tourists who come to enjoy its clear waters, its white sandy beaches and the range of nautical leisure activities (kayaking, kite surfing, diving, windsurfing) that the island has to offer. With an area of just 83.24 km2, Formentera has a rich terrestrial cultural and archaeological heritage that spans 4,000 years of history (Figure 2). This cultural heritage has been studied through numerous archaeological projects led by scientific teams from different universities and research centres, almost uninterruptedly from the 1960s to the present day. However, while its terrestrial cultural heritage has been extensively studied, it is clear that there was a gap in the research of Formentera's

underwater cultural heritage (UCH) until 2014. In this context, Instituto Balear d'Estudis en Arqueologia Marítima (IBEAM) was founded, a non-profit organisation that aimed to research, preserve, protect, and disseminate the UCH of the Balearic Islands. The initiative was developed in a six-year project (2015-2020) aimed at creating the Formentera Island's entire UCH catalogue that, before 2015, was still waiting to be completed.

During this time, we have significantly expanded our knowledge of the maritime history of the islands [1,2,3]. We have included fourteen new sites in the Archaeological Catalogue that cover a broad chronological and cultural spectrum and show the historical role and important connectivity of the Balearic Islands from the 2nd century BC to the 19th century. However, the most significant challenge that this research program faced was another. To change the way the local community think and perceive of their underwater cultural heritage.

2. Formentera Island as a case study

For decades, the UCH has been systematically affected by divers and fishery. These actions have not always been done for profit but often from a response to curiosity or a form of "interest" in the "treasures" hidden in the sea. Proof of this perception about the UCH is that even today, a visitor to the island can still find amphorae or anchors or other objects from underwater provenance as decorative elements in private collections or exhibited in local businesses.

From this background, IBEAM understood that as a part of the research project that intended to protect the UCH of the entire island of Formentera, it was necessary to add an important educational component to ensure a social awareness within the local community and provide evidence for the relevance of preservation for future generations.

In this sense, as part of the Formentera project, IBEAM proposed an educational program that was run parallel to the systematic research of the UCH focused on the following research question: How does the UCH contribute to constructing the concept of identity and belonging to the island cultural environment? The project proposed a longitudinal action at three different educational levels: local schools, groups of local divers and university students. This project intended to cover two aspects: 1) monitor the construction of the concept of identity and belonging to the maritime cultural environment in the local community over the research period (2015-2020) and 2) to analyse how the UCH can be used as an educational tool that favours the development of the concept of identity, belonging and conservation to the cultural seascape.

3. Materials and Methods

As part of the Formentera Project, the research presented in this paper looked to understand educational phenomena by analysing the perceptions and interpretations of the subjects involved in educational activities. In this way, the aim is not to arrive at universal abstractions but concrete and specific universalities for the case under consideration. The theories generated have a comprehensive and guideline character, with constant interactions and influences between researchers and the object of research [4]. It is also framed within a descriptive methodology. The entire process applied to this research experience is considered longitudinal based on specific characteristics. Firstly because the description of the different concepts (e.g. identity through maritime and underwater cultural heritage) was permanently based on the same profile of participants; the local community, whether considering direct people (students, local divers) or representative institutions (local council, police). Secondly, this research used specific cases of study, and all the topics were studied during different moments and taking place constantly in the context of Formentera island [5].

The first step in the educational program was to bring UCH out of the water to be closer to the divers of the future, the children. Children demonstrate every day that their capacity for empathy, emotional intelligence, and common sense is much higher than that of an adult. This action had three stages: Activities with local schools, a camp dive experience and local divers engagement program.

First, informative talks in schools. Archaeologists from IBEAM went to the local schools to explain face to face what the activity of Underwater Archaeology consisted of and what the archaeologists' objective was (Figure 3). These talks were accompanied by didactic activities in which, in a fun and dynamic way, we made them live the experience of archaeological work without having to get wet. This activity consists of the development of a circuit that simulates an underwater exploration area. The perimeter of the space is marked with string lines that help to recreate a route to follow. The students are then provided with skateboards that will allow them to experience horizontal displacement in the working space. The students are provided with 'fake' scuba tanks and diving masks to complete the working environment. Finally, a large-scale printed image of the wreckage of a sunken ship is divided into pieces organised like a jigsaw puzzle and distributed throughout the work area. The participating children move from point A to B to C to D etc., collecting the different pieces of the puzzle, which they will then put back together as a group in the 'work area'. This activity was having a successful response and has been replicated favourably by other research groups in other parts of the world, for example, in New Zealand by the HMS Buffalo Re-examination project directed by Kurt Bennett, Matthew Gainsford and Rebecca Cox [6].

The second stage within the schools wa as a visit to the fieldwork. The previous theory/practice experience was completed with a visit from the students at the same time as team members of IBEAM carried out fieldwork. This was an opportunity for the children to get closer to a real experience having access to the diving material and the additional documentation and, in some cases, artefacts from an actual shipwreck. This step was critical to demonstrate the preventive conservation process, cataloguing, and the information archaeologists can obtain from artefacts. This activity was highly engaging, considering the important component of storytelling and attraction that a shipwreck and its biography contains (Figure 4).

Finally, as part of our experience with local schools, the third activity was a dive camp. Although the previous activities were wide open to students of different ages, this third educational activity focused on a group aged between 12 and 14 years old as part of their first diving experience. During their training, we introduced the visit of a shipwreck together with a workshop to cover two different objectives: 1. Attach a very first diving experience to a respectful visit to a controlled shipwreck environment to enhance the respect of UCH and 2. explain to young divers what they should do if they find archaeological remains during one of their dives. The experience was developed using the so-called Es Cap 1 shipwreck (Aragon et al. 2016). This underwater archaeological site comprises a group of cannons dated to the 18th century, and that was identified and studied as part of IBEAM's research project. The archaeological site was also selected based on the ideal condition that demonstrates the proposed activity: limited depth, highly recognisable archaeological features (cannons and anchors), and low/nil risk of impact due to the nature of the artefacts themselves (Figure 5). A number of organisations were part of this experience including the local council, Formentera Diver (Diving club) as well as the police (Especial Diving Unit), which guaranteed that the whole activity would be carried out with the highest security standards and with the presentation of the role that both the local authority and the police play in the protection of the UCH. The ultimate goal of this Diving Camp was not for the young participants to play at being archaeologists, but for them to understand what our work entails and to value it.

On a different level, a second group was selected to participate in an educational experience, the local adult divers. An introductory course was programmed to introduce them to the protection of the UCH. This activity, as in the children's workshop, aimed to help them to understand the importance and reason why this heritage should be preserved and, on the other hand, to give them the necessary tools to be able to recognise and report any archaeological finds. The Es Cap 1 shipwreck was used again for this activity. This educational experience is considered vital to bring respect and value to the UCH within the local community. It could potentially play a pivotal role as part of a sustainable tourism program for the island in the near future.

Finally, at the university level, the educational effort was focused on reinforcing training in conservation and restoration in underwater archaeology. Although today, many universities are offering Maritime Archaeology programs focussing on maritime and underwater archaeology, it is evident that there is still the need for the development of studies in underwater conservation. For this reason, in 2016, IBEAM started a practical course on the preservation of metals of underwater provenance, taught by Dr Jean-Bernard Memet from the company A-Corros and Victoria Folgueira, which, in two editions, brought together 27 students from different parts of Spain. Furthering this direction, in 2019, the 1st International Symposium on Conservation in Underwater Archaeology (ISCUA) was organised. ISCUA was possible thanks to the collaboration with the Council of Formentera and brought together more than forty conservators from four continents, including prominent figures such as Dr Ian Mclaeod, Dr Barbara Davidde, Dr David Gregory and Dr Jean-Bernard Memet, among others. For three days, the ISCUA was used as a platform to disseminate leading research in the conservation of our maritime cultural heritage. This Symposium aimed to continue the training of younger generations in the field and create future links between the different institutions and invited specialists (Sanz et al. 2021).

4. Results

Formentera Project: Conservation and integration of UCH in the island community, has directly resulted in the implementation of a strategic framework, approved by the Local Government of Formentera in partnership with IBEAM as a non-profit organisation, to consider the underwater cultural heritage as a base for sustainable development bringing together economy, environment and society. The vision from the Formentera Project was to develop actions centred on the UCH to stimulate the local community as a means of realising the island's development potential through an innovation knowledge-led approach, being mindful of the need to conserve the integrity of Formentera's UCH. The diverse educational initiatives undertaken as part of the project have ended in several collateral results such as: Economic efficiency– strengthening the role of Government as regulator and encouraging underwater cultural sector engagement; Sustainability– Ensuring sustainable use of marine and coastal resources embedded in the cultural background that identifies local communities and their relationship with the ecosystem; Social equity– Bridging the inequality gap through access to high quality education and local investment opportunities; Research and innovation– towards a knowledge of the underwater marine space for management and technology-based economy, creative business solutions; and high value products; and finally Partnerships– This project integrated local Government and the private sector with regional and international partnerships. The Formentera Project has positively impacted the community by creating an awareness that unites values around the island's underwater cultural heritage and its marine environment. Along the same lines, the Formentera Project has managed to gain a commitment from a significant number of local businesses to reorient tourist activities (the island's main economic activity) in a broader sense, organising their capacities to promote resources directly related to the promotion of the cultural value of the island. Finally, the collaboration with the local Government has made it possible to generate awareness of its responsibility for the maritime framework of

the island and the role it will play for future generations. As a direct outcome of the Formentera Project experience IBEAM was granted with the ESD Okayama Award, which recognises outstanding Education for Sustainable Development practices.

5. Discussion

The cultural coastal/island realities are intrinsically interconnected with their economies and their environments. The more diverse and productive the economic system, the greater the degree of interconnectivity. There are relevant issues about the precursory role that the conservation and sustainable environment exploitation use of cultural resources have in enabling responsible management of coastal/island economies. This statement is particularly true in countries where economies are more directly related to environmental exploitation. In the islands, tourism is identified as the most relevant economic activity that directly affects the local communities through their culture and the interconnected blue environment. Enhancing the relevance of UCH in these communities can underline the overall interconnectivity and the need for an integrated approach. To this end, the research/education must underpin all aspects incorporating inter-relationships for better management of cultural and, consequently, blue environmental resources.

Psychological responses to landscapes have been treated as a line of research extensively. In the literature, we find an adequate framework to create a theoretical context for the proposed project. In this sense, the identification of affective and aesthetic evaluation patterns has been mainly addressed by lines of research [7,8]. The proposed project aimed to contribute to the UCH evaluation. This perspective is based on the so-called "subjective" evaluation of landscapes, which is perceptual. It is opposed to the "objective" evaluation of landscapes, which is concerned with their capacity to provide a set of ecosystem benefits [9]. The notions of belonging to a cultural landscape with different cultural characteristics are defined by physical boundaries (e.g. spaces touched by the sea). This concept contrasts with the idea of continuous change that our society experiences [10]. Indeed, the development of the community's identity with its cultural landscape must be an element to overcome cultural, economic, social, political, linguistic and religious barriers between existing structures within the social and economic framework that have historically determined conflicts. In this sense, from Habermas' [11] point of view, we can allude to the "unity in diversity", the unique variety of cultural landscapes - and we add in this research - that reflect common geography, history and culture, can be helpful to reinforce community identity by awakening a sense of belonging. In the case of the populations near the coast, as in our case study, tourism appears as a critical economic niche that directly affects the local communities through their culture and the interconnected blue environment. Enhancing the relevance of Underwater Cultural Heritage in these communities can underline the overall interconnectivity and the need for an integrated approach and improve the value of what the authors of this paper identify as 'blue culture'. A term that needs to be understood as the cultural value of the Blue Economy that conforms to a fundamental social element within that system [12]. This blue culture is stated as a central piece; when we talk about maritime cultural landscape and how it can help create a sense of belonging to the territory, it is through the immediate underwater, maritime and coastal environment and its historic-archaeological context [13]. This belonging to a coastal/island cultural landscape, encompasses more than just marine economic resources. Following this, spiritual, rituals, cosmological and religious meaning also plays an important role as well as the traditional knowledge about surrounded seafaring knowledge, seabed topography, reefs, beaching and launching areas, seasonal changes, raw material locations, food sources such as shellfish beds, fishing and seaweed, and in general, ecological diversity that overlaps with ritual associations, meaning, sites, place names and ownership [14,15,16]

6. Conclusions

The primary innovative approach of this project, has been to build up a sense of identity by closely connecting the Underwater Cultural Heritage with the local communities.This vision has helped the local Government set up a strategic and policy framework, making changes to their institutional arrangements to ensure that more respectful and sustainable principles and objectives are considered during activities such as tourism or fishing in relevant policy-making processes. To conclude, it is argued that to achieve an optimal degree of protection in UCH while making it accessible to the general public, it is necessary to continue working along two main lines: education and involvement of the local community along with conservation and preservation. These are mandatory factors when considering UCH as a tourist asset that adds value to tourism.

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References

1. Aragon, E., S. Munar, J. Rodríguez and K. Yamafune 2018 Underwater photogrammetric monitoring techniques for mid-depth shipwrecks. *Journal of Cultural Heritage* 34:255–260.
2. Aragón, E., J. Rodriguez and S. Munar 2016 Investigación y gestión del patrimonio cultural subacuático en las Islas Baleares: La carta arqueológica subacuática de Formentera y el pecio romano de Porto Cristo. *Riparia*(2):21-53.
3. Rodriguez, J., E. Aragon and S. Munar 2017 *La carta arqueológica subacuática de Formentera (2015-2019)*. VII Jornades d'Arqueologia de les Illes Balears:(Maó, 30 de setembre i 1 i 2 d'octubre de 2016): Consell Insular de Menorca.
4. Colás, M.P. 1994 Los métodos de investigación en Educación. In M.P. Colás and L. Buendía (eds), *Investigación Educativa*, pp.43–68. Sevilla: Ediciones Alfar.
5. Cardona, M.C. 2002 *Introducción a los Métodos de Investigación en Educación (EOS Universitaria)*. Madrid: Giuntieos Psychometrics SL.
6. Bennet, K, M. Gainsford and R.Cox 2021 HMS Buffalo Re-examination Project update. Archaeology in New Zealand 63(2):34–38
7. Kaplan, R. and S. Kaplan 1989 *The experience of nature: A psychological perspective*: Cambridge university press.
8. Kaltenborn, B.P. and T. Bjerke 2002 Associations between environmental value orientations and landscape preferences. *Landscape and urban planning* 59(1):1-11.
9. Aretano, R., I. Petrosillo, N. Zaccarelli, T. Semeraro and G. Zurlini 2013 People perception of landscape change effects on ecosystem services in small Mediterranean islands: A combination of subjective and objective assessments. *Landscape and Urban Planning* 112:63-73.
10. Guarracino, S. 2007 *Mediterraneo: immagini, storie e teorie da Omero a Braudel*: Bruno Mondadori.
11. Habermas, J. 1998 *Three normative models of democracy: In The inclusion of the other. 239–252*: Cambridge, MA: MIT Press.
12. Martínez-Vázquez, R.M., J. Milán-García and J. de Pablo Valenciano 2021 Challenges of the Blue Economy: evidence and research trends. *Environmental Sciences Europe* 33(1):1-17.
13. Westerdahl, C. 1992 The maritime cultural landscape. *International Journal of Nautical Archaeology* 21(1):5-14.
14. Cooney, G. 2004 Introduction: seeing land from the sea. *World Archaeology* 35(3):323–328.

15. McNiven, I. 2004 Saltwater people: spiritscapes, maritime rituals and the archaeology of Australian indigenous seascapes. *World Archaeology* 35(3):329-349.
16. Fowler, M. 2020 *Aboriginal Maritime Landscapes in South Australia: The Balance Ground*. Abingdon, Oxon: Routledge, Taylor & Francis Group

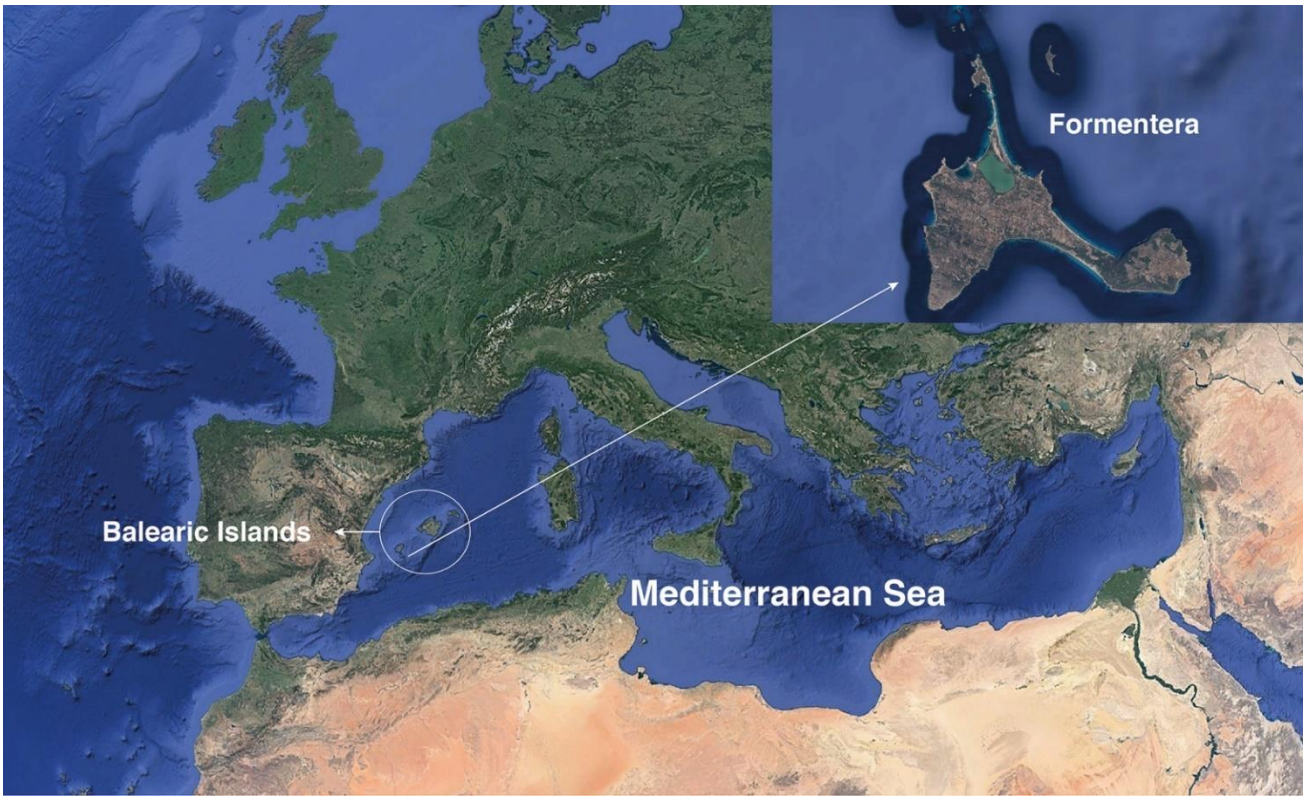

Figure 1. Location of Formentera Island (Source: Google Earth).

Figure 2. Panoramic view of Formentera Island W coast (Source: J. Rodriguez).

Figure 3. Children from local schools of Formentera participating in the activity of introduction to underwater archaeology. (Source: J. Rodriguez).

Figure 4. Young divers of Formentera participating in the activity camp diving (Source: Jose Arribas).

Figure 5. Young divers of Formentera participating in the activity camp diving (Source: Jose Arribas).

Figure 6. Participants of the 1st international symposium on underwater archaeological conservation, Formentera 2019 (Source: J.Rodriguez).

Dry dive experience in the Underwater Archaeological Park of Baiae: gamification to promote Underwater Cultural Heritage destinations

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Keywords: gamification, UCH destinations, serious game, VR experience, tourism marketing

Abstract

In the last years gamification has become a focus in the research field in a multidisciplinary perspective (Xu, Buhalis and Weber, 2017), many scholars underline the lack of research in marketing and service industry field (Huotary and Hamiri, 2012; Lucassen and Jasen, 2014; Xu et al. 2014). In particular only few researchers highlight the use of gamification in tourism sector (Sigala, 2015; Xu et al., 2014; Correa and Kitano, 2015; Negrusa et al., 2015). Actually, gamification can be an effective method to digitally engage visitors with a use of their smartphones, tablets or other digital devices. In tourism industry, gamification is useful not only for engaging visitors, but also for increasing customer loyalty or promote destination, cultural sites and tourist attractions.

In such a perspective the paper aims to analyse how gamification can promote UCH destinations and how it would influence users experiences. A case study about dry dive experience in the Underwater Archaeological Park of Baiae is presented to show how serious games, AR and VR experiences can benefit tourism marketing in UCH destinations, supporting the promotion of the targeted destinations by attracting and educating visitors. This study also provides managers and policy makers with some implications useful to exploit the new development opportunities provided by serious game and VR experience for promoting UCH destinations. In particular for young generation gamification may become a powerful tool to combine education and entertainment and also to look at UCH destinations in a new perspective (Bakhsheshi and Ghaziani, 2019).

Design and implementation of signage for the first Accessible Underwater Cultural Heritage Site in Greece

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Keywords: underwater signage, underwater museum, archaeological diving routes

Abstract

A Signage Design and Implementation project was carried out for the Underwater Archaeological Site of Peristera Alonissos, in the context of the INTERREG MED Program "Plan/test/coordinate Underwater Museums, Diving Parks and Knowledge Awareness Centers in order to support sustainable and responsible tourism development and promote Blue growth in coastal areas and islands of the Mediterranean - BLUEMED". The project is based on the perspective of the diver/visitor that was already designed by the EUA for the diving public during the preliminary planning of the UAS visit and the purpose of the signs is to facilitate that visit. The object of the Signage Design included the design of the form of the signs, the selection of materials and support system, the design of the layout and the form of the content on the plates that were to placed at specified general view stops of the shipwreck as well as individual points of archaeological interest. The implementation of the Signage Design on the Peristera Shipwreck of Alonissos was a welcomed by the diving public and also yielded several construction aspects that were to be taken into account for the next projects of Underwater Archaeological Signage.

NEANIAS innovative services for Underwater Cultural Heritage Sites

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Abstract

NEANIAS project engages Open Science practices, through the European Open Science Cloud (EOSC) ecosystem, aiming at a wide variety of scientific and professional communities emanating from the Underwater, Atmospheric and Space domain. The Underwater thematic services are designed to deliver user-friendly and cloud-based solutions with respect to bathymetry processing, seafloor mosaicking and seafloor classification, addressing the needs of the end-users. This service will exploit cutting-edge technologies and hub infrastructures in order to be easily accessible and attain highly sophisticated and accurate results, regardless the level of expertise of the end-users. Geologists, archaeologists, and people involved in offshore industry could incorporate the aforementioned services into their research and work, reducing time and costs or efforts. Throughout efficiently designed and tested workflows the users would be able to securely upload and process their data, therefore would have the ability to produce bathymetry and seabed classification maps from acoustic data and seafloor mosaics from optical data, therefore achieve precise *in situ* photogrammetric documentation of archaeological and geological underwater heritage sites. Moreover, accessibility to sophisticated services and high accuracy of results will facilitate and promote the correlation of interdisciplinary data towards a comprehensive interpretation of the geoarchaeological context. Finally, NEANIAS underwater service offers the possibility to the users to expand and advance their activities by consolidating *ad hoc* techniques and a simplified user interface. The contribution of these innovative services is expected to be of high value to the marine geoarchaeology community.

The MPA Gaiola Underwater Park: towards a new and more sustainable model of management of an underwater Park.

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Keywords: accessibility, sustainability, underwater heritage, monitoring, awareness

Abstract

The Marine Protected Area (MPA) Gaiola Underwater Park is an underwater archaeological park located along the densely inhabited coastline of Naples, in Italy. This MPA is not only environmentally relevant, but it also preserves the underwater remains of a I century B.C. Roman villa; nevertheless, the anthropic pressure on the site has always been high and has always undermined the preservation of the site itself. As data collected throughout the years prove, despite the many awareness creation campaigns, the common perception of the Park as a sun-and-bathe destination has always been misleading and represented a threat for the preservation of the MPA's heritage. During the recent Covid-19 pandemic, the problems related to the overcrowding of the Park became even more evident; the chance was taken to change the paradigm of management of the MPA and to study a new model of accessibility that guarantees a more respectful preservation of the underwater heritage and, at the same time, a better experience for the visitors. This work shows the results of the monitoring activities on the visitors carried out during the experimentation of the new management model. This paper is a good case study for facing the issue of preserving fragile heritage, either underwater or on land, in densely visited or urban sites.

1.Introduction

Finding a balance between preservation and accessibility is one of the main problems related to cultural and environmental heritage management and the threats of high touristic presence on heritage sites has been constantly debated in the last 30 and more years (Millar, 1989). In fact, many international authorities developed guidelines aimed at promoting a respectful access to heritage sites, like the 1999 ICOMOS International Cultural Tourism Charter (ICOMOS, 1999) that with Principle 2 states that "the relationship between Heritage Places and Tourism is dynamic and may involve conflicting values. It should be managed in a sustainable way for present and future generations". The problem of the relation between accessibility and preservation in heritage sites is even more relevant when it comes to underwater and marine heritage; in fact the heritagization process (De Vivo, 2015) of the marine environment is a relatively recent phenomenon dating to the second half of the XX century, therefore, many people are still attracted by marine heritage sites only

for sun-and-bathe purposes, without being aware of the heritage value of the sites themselves (Secci, 2011). In this perspective, it is relevant that the 2001 UNESCO Convention on the Protection of the Underwater Cultural Heritage with art. 2.5 clearly states that "the preservation *in situ* of underwater cultural heritage shall be considered as the first option before allowing or engaging in any activities directed at this heritage"; at the same time, art. 2.10 states that "responsible non-intrusive access to observe or document *in situ* underwater cultural heritage shall be encouraged to create public awareness, appreciation, and protection of the heritage except where such access is incompatible with its protection and management"(UNESCO, 2001), which means that public access to underwater cultural heritage shall be promoted as far as it doesn't become a threat for the preservation of the heritage itself.

In this panorama, the MPA Gaiola Underwater Park (Figure 1), in the Bay of Naples, was established exactly with the aim of both protecting and making accessible valuable archaeological and environmental heritage unknown to most citizens.

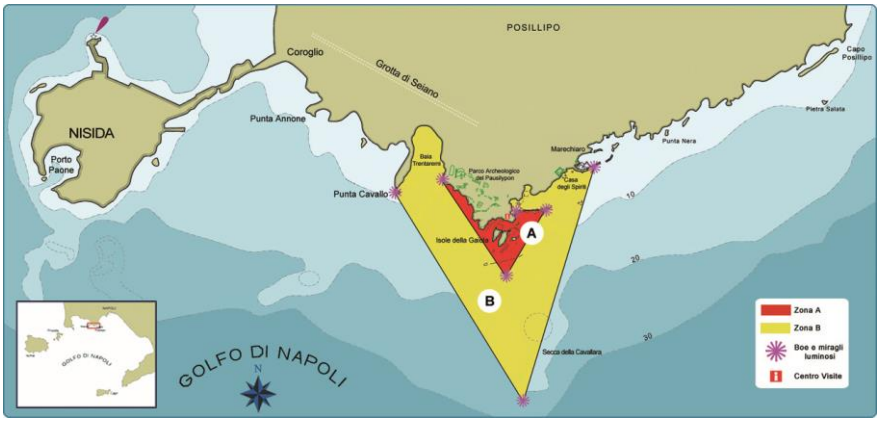


Figure 1: Map of the MPA Gaiola Underwater Park.

Because of its archaeological and environmental relevance, it was instituted in 2002 by the Italian inter-ministerial Decree 07/08/2002, signed by the Italian Ministries of the Environment, of Cultural Activities and Goods, of Infrastructures and Transportation, and of Agricultural and Forests in agreement with a territorial authority, Campania Region. Besides being a Marine Protected Area under the Protected Areas' Framework Law 394/92, the Gaiola Underwater Park is also a Cultural Site, as established by the Decree n. 42, 22/01/2004 and is part of a Special Zone for Conservation (ZSC – IT8030041) as established by the Habitat Directive (92/43/CEE). The MPA Gaiola is divided into two zones: the Integral Reserve A Zone and the General Reserve B Zone (Figure 1). In the B Zone, a free-access and public beach is located.

However, it is important to know that before the institution of the MPA, until 1980s, the majority of the coastal stretch was part of a private property of very wealthy owners and of a small fishermen' village. After the 1980s the private property was abandoned. Since then, the whole area fell into decay, exploited only for summer bathing activities without any essential service (cleaning, public safety) or any protection to the archaeological and naturalistic heritage. Since the MPA creation, working with citizens to raise awareness on the importance of the heritage of the area had always been the most important focus of the MPA, especially due to the difficult social context (a densely inhabited city) and to the challenge of engaging the community on the preservation of underwater heritage that is invisible by definition (De Vivo, 2015). Since 2002 consistent efforts to let people accept the restrictions aimed at heritage protection, especially in the A Zone, had been undertaken by the Manager Authority of the MPA. In 2019, Centro Studi Interdisciplinari Gaiola onlus (CSI Gaiola), a no profit

organization working in the area since 2004 (Simeone, Masucci and De Vivo, 2012) in collaboration with the previous Manager Authority (a local body of the Italian Ministry of Culture), was entrusted as Manager Authority of the MPA.

As regards its heritage, the area is of both archaeological and environmental interest; in fact, within the borders of the MPA there are preserved the underwater ruins of a I century BC Roman *villa*, the Pausilypon complex, firstly studied at the beginning of the XX century by Günther (Günther, 1913). Particularly, the ruins are submerged because of a geo-volcanologic phenomenon called bradyseism which had caused the slow lowering of the coastline (Simeone & Masucci, 2009). As demonstrated also by more recent studies (Simeone & Masucci, 2015), in the area (Figure 2) there are preserved remains of a Roman quay, columned and banquet halls and a complex system for fish farming.

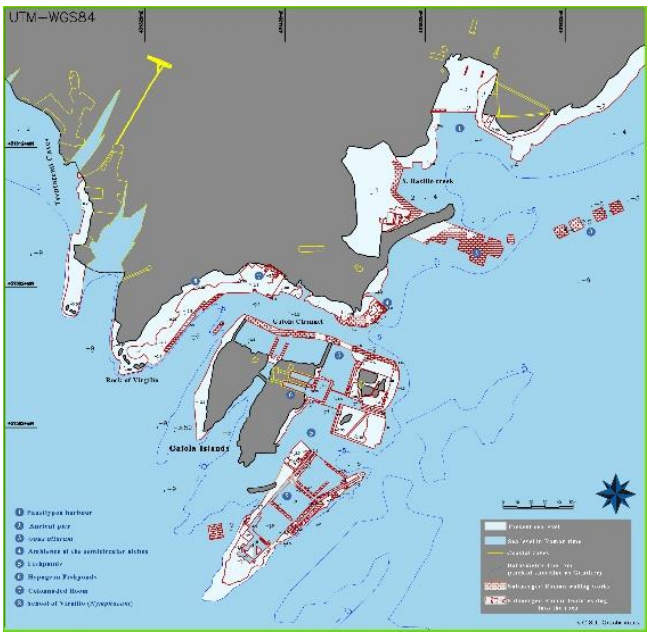


Figure 2: Map of the Underwater structures of the MPA (Simeone&Masucci, 2015).

At the same time, the area is also characterized by a very rich marine environment and it is particularly suitable for the flourishing of the marine life (Simeone et al., 2016). Also the landscape of the area is relevant, since it is the result of remodeling activities of the tuff coast due to natural erosion, volcano-tectonic activities and more than 2000 years of human activities (Simeone et al., 2008). Given this very special context, the goal of this paper is to prove how the difficult situation imposed by the Covid-19 pandemic contributed to generate a change in the paradigm of fruition to the MPA Gaiola; the strategy plan and the results of the monitoring activities of the strategic plan will be presented as a good practice to balance preservation and accessibility in a fragile heritage site located in a complicated social context.

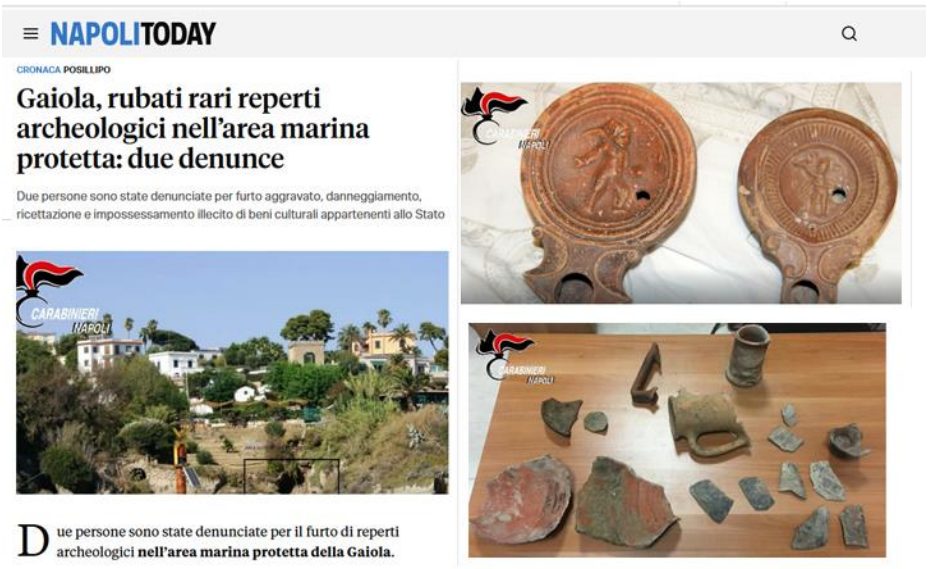
2. The problem of overcrowding in the MPA Gaiola Underwater Park

As previously stated in the B Zone of the MPA is located a little harbor with a small beach (called S. Basilio Bay) that until 2019 was considered by many Neapolitans as a simple bathing place and that, consequently, was extremely overcrowded during summer months. To give an idea of the inflow into the area, as an instance, on a sunny summer day, up to 2000 people could be counted in the MPA on approximately a 100 mt long stretch

of coastline, as it is visible from Figure 3. The situation was more or less the same every summer (CSI Gaiola onlus-b, 2020). This enormous inflow of people was in clear contradiction with any public safety prescription and the preservation goals of the MPA itself. In fact, this exasperated overcrowding of the area, in addition to hindering any control and protection of the archaeological and naturalistic heritage (on average about 100 kg of waste were produced per day), caused a high frequency of accidents, with enormous problems related to rescue operations, since the bathing area, located at the end of a long pedestrian staircase, is not directly accessible by emergency vehicles.

Figure 3: B Zone beach on a summer holiday day before 2020.

As regards the protection of the archaeological heritage, it is important to mention that the crowded beach of the B Zone corresponds to the area where the ruins of the ancient Roman port (Simeone&Masucci, 2015) are preserved. This is an area where, due to natural movements of the sea and of the sandy seabed, ancient artifacts can become quite easily visible. This is what happened in 2017, when two people, hiding in the crowd, were luckily caught while they were running away with two bags filled with ancient Roman finds, as also reported by local press (Figure 4).



≡ NAPOLITODAY

CRONACA POSILLIPO

Gaiola, rubati rari reperti archeologici nell'area marina protetta: due denunce

Due persone sono state denunciate per furto aggravato, danneggiamento, ricettazione e impossessamento illecito di beni culturali appartenenti allo Stato

Due persone sono state denunciate per il furto di reperti archeologici **nell'area marina protetta della Gaiola.**

Figure 4: Local press reporting archaeological looting in MPA Gaiola in 2017

As a matter of fact, the majority of the archaeological evidence of the last few years happened to be found in the B Zone, as it is visible from Figures 5 and 6. In figure 5, particularly, we can see a detail of the S. Basilio Bay in the B Zone: the grey area is the emerged coastline; the white area is the submerged rocky substratum modified in Roman times whereas the red lines show the submerged Roman structures of the port. The pink dots show the areas where, in the last decades, archaeological artifacts were recovered.

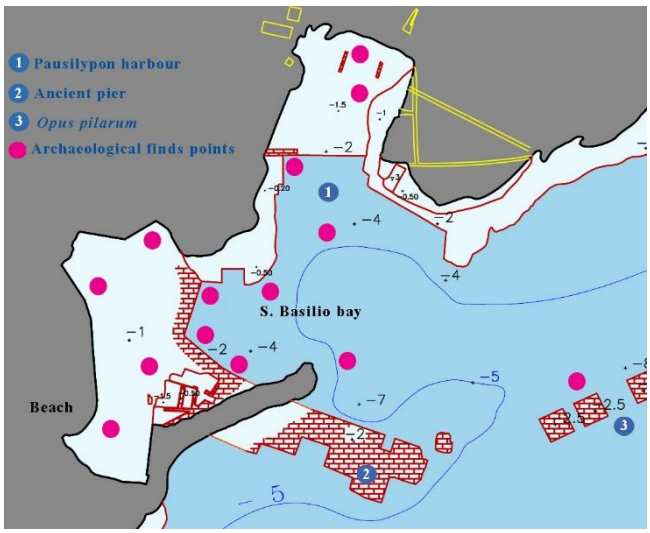


Figure 5: Detail of the S. Basilio Bay in the B Zone where most of the recent archaeological finding occurred

Figure 6: Archaeological find from the S. Basilio Bay in the B Zone

Particularly, in Figure 6 we can see an example of an archaeological find from S. Basilio Bay in the B Zone: a Roman wine amphorae with pictogram found in 2017 by the MPA Gaiola staff in the area shown in Figure 5 after natural movements of the seabed. The amphorae, currently object of an ongoing research, was found at only 2 mt. of depth, in an area easily accessible by sun-bathers.

As explained, to reduce the anthropic impact on the site without completely limiting the entrance and, at the same time, to create awareness on the heritage of the site, turning the sun-bathers into real visitors has always been one of the main challenges for the MPA. Nevertheless, as in many other sites, the challenge of controlling the access in the area became particularly meaningful during the Covid-19 pandemic (Montanari, 2020), as

also witnessed by a call of UNESCO experts (UNESCO, 2020) to change the paradigm of tourism in heritage sites as a challenge to be faced in the post-pandemic era.

Particularly, the critical condition of environmental and safety emergency due to overcrowding was likely to become a relevant sanitary problem during the Covid-19 pandemic in MPA Gaiola (CSI Gaiola onlus-a, 2020). In 2020 the access to the MPA Gaiola was closed to the public as it happened in all the cultural sites of Italy after the lockdown imposed by the Italian Government; due to the lockdown, the situation in the MPA radically changed: from a situation of intense anthropic pressure, the MPA turned to be completely empty. The contrast was so strong that it was immediately evident that, also to respect the prescriptions related to the Covid-19 pandemic, it would have been impossible to return to the pre-pandemic situation. Consequently the development of a new strategic plan for the accessibility of the site was developed after February 2020 during the 4 months lockdown, before the re-opening on July 2020.

3. Development of a new model

In order to reach the goal of balancing preservation and public access, as well as the social distancing rules imposed by the Covid-19 pandemic, in 2020 a new strategic plan for the management of the MPA Gaiola was developed. The aim of the strategic plan was to guarantee the re-opening of the MPA, not only following all the safety prescriptions imposed by the Covid-19 pandemic, but also reducing the number of people entering the bathing area in the B Zone of the MPA keeping an inclusive approach. The idea was to keep the MPA accessible for everyone, but at the same time, to reduce the anthropic impact on the heritage and to make sun-bathers more responsible towards heritage preservation. The strategic plan was developed at the peak of the Covid-19 pandemic, therefore the first need was to develop a strategy for ensuring people safety. Consequently, the Manager Authority of the MPA entrusted a private agency “Ecotecnica Srl” to develop the technical safety protocol for the reopening and public fruition of the Park, applying all the guidelines for people safety required by the Italian Governmental protocols for Natural Parks, Cultural Sites and public bathing areas. This Protocol was approved by the Italian Ministry of Environment and Sea and Territorial Safeguard.

The Protocol was developed thanks to the implementation of an agreement between the Manager Authority of the MPA, the Municipality of Naples and the Port Authority. Thanks to this agreement, on July 3rd 2020 it was possible to reopen MPA Gaiola to the public. During the redaction of the protocol, a strategy was developed based on collaboration and cooperation among local private and public institutions to re-affirm the cultural identity of the area, considering it for its cultural, archaeological and natural values and not just as a recreational site where to have free access to the sea. Consequently, the CSI Gaiola, as Manager Authority of the MPA, promoted the creation of a round table that included all the public bodies that, with different competences, are involved in the management of the coast. Particularly, were invited to participate:

- City of Naples;
- Coast Guard;
- Municipality 1;
- Port Authority;

Carabinieri Corps for the Protection of Cultural Heritage.

The aim of the round table was to study how each one of these entities could contribute to the re-opening of the area as well as to the re-affirmation of its value as a cultural site. This networking activity was particularly important to carry out a significant awareness campaign to change Neapolitans’ perception of the MPA. The institution of the round table was fundamental especially to highlight once again the problems related to the

preservation of the archaeological and environmental heritage (Figure 5 and 6) in the area due to the uncontrolled anthropic pressure on the site.

As a result of the networking activity, the Director of the National Archaeological Museum of Naples (Figure 7) wrote an open letter to the Naples citizens and launched an online public appeal to sustain the CSI Gaiola in the struggle for the affirmation of the cultural value of the site which is much more than a free beach. The appeal was first signed by 53 directors of local and National cultural institutions and then by hundreds of citizens.


Per la Gaiola 50 intellettuali «Un patrimonio da salvare»

Il Manifesto chiede un nuovo paradigma di fruizione. Il sito apre domenica

Primo Piano Napoli

La mobilitazione

Gaiola: cultura, non tuffi L'appello parte dal Mann

▸Lettera aperta del direttore Giulierini ▸Sottoscrizioni aperte online, sono già «Aiutiamo il Csi a tutelare quel tesoro» centinaia i firmatari del documento

Figure 7: Publication on local newspapers of the open letter to Naples' citizens.

In fact, the new strategy was aimed at limiting the number of people that could access the bathing area in the B Zone at the same time; this was a radical change and to make it acceptable by local community, it was fundamental the support of all the local institutions, as well as this preliminary awareness campaign. As a result of the work carried out during the lockdown, an online booking system to access the public beach in the B Zone of the MPA Gaiola was created. The new booking system allowed the access to the bathing area in the B Zone to 75 people at the same time without any entrance fee. Two turns were organized in order to welcome the highest possible number of people in the area in a day (150 people in total): one turn in the morning (from 9 a.m. to 1 p.m.) and one in the afternoon (from 2 to 6 p.m.). The number of people accepted in the area was calculated considering the rule, imposed by the Italian Government, to keep a 1,5 mt. distance from one person to another. To avoid queues at the entrance gate of the MPA, due also to anti-contagion prescriptions, it had been necessary to implement an online booking platform. Reservation started from 8 am each day for the day after. In this way people needed to reserve one day in advance, choosing between the morning or afternoon turn and booking a maximum of 5 places per time, registering all the identification data of the bathers. Bathers ID cards, reservation tickets and body temperature were checked by a guardian at the entrance gate before the pedestrian street that leads to the MPA. The regulation of the access system developed during the Covid-19 emergency had provided the opportunity to solve the problem of overcrowding and unsustainable fruition in the B Zone bathing area. As a matter of facts, with the new regulations, bathers' flows to the B Zone drastically reduced and the situation in the MPA radically changed with the introduction of the new access model, as it is visible by comparing Figures 3 and 8.

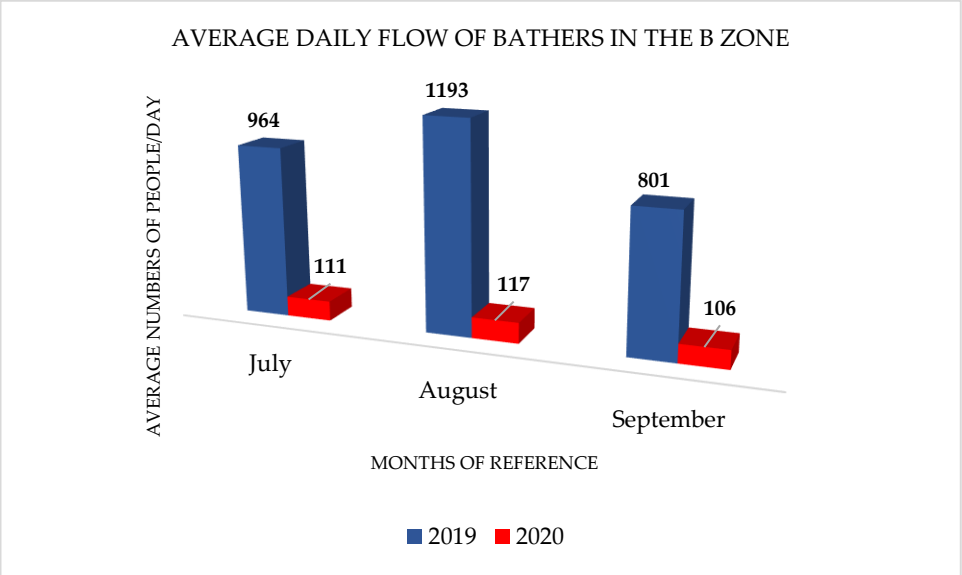
Figure 8: B Zone bathing area after the application of the new protocol in 2020.

4. Monitoring activity

In order to monitor the impact of the new strategic plan on both the preservation of the site and on the change in perception of the sun-bathers, a monitoring campaign was carried out in 2020; particularly, a questionnaire to be supplied to bathers was developed to evaluate the impact of the new access regulation and of the new strategies adopted to safeguard the MPA. The questionnaire was created to be addressed to people through direct interviews; the questions were delivered through a structured questionnaire made of closed-ended questions plus two open-ended questions added in order to monitor the quality of the experience of the visitors and their suggestion for the improvement of the new system. The questions were divided into four sections according to their typology. The first section was focused on collecting demographic data of the people accessing the MPA (age, gender and provenience). The second section was aimed at monitoring the quality of the experience of people entering the MPA. People were asked whether they had already visited the area in the past or if it was the first time. People who declared to have already visited the area during the previous years were asked to compare the 2020 conditions to the past considering four main criteria (general context, livability, cleanliness and security). By contrast, new users of the area were asked to rate livability, cleanliness, safety and security. The third section of the questionnaire was focused on the accessibility, to know if people had reached the site by public or private transport and how they had known about the MPA Gaiola. The final section was aimed at understanding people's awareness on the value of the area as an MPA, on the access rules, on the archaeological structures and on the importance of preserving them. Particularly, people were asked if they knew that it is forbidden to introduce one-way packaging in the area; if they knew and could explain the differences between A Zone and B Zone of the MPA and if they were aware that in the B Zone there are archaeological structures and if they thought it is important preserving cultural and natural heritage. Finally, people were asked if they would agree on maintaining the new access system to the area even when the Covid-19 emergency would be over. The questionnaires were directly addressed to a sample of 311 bathers in the B Zone, from July 25t^{h} to September 13th 2020 by two Master level students. Beside the development of the questionnaire, the monitoring activity also analyzed the flows of people entering the MPA during the summer months, as well as the quantity of litter found in the MPA and the general state of preservation of the site.

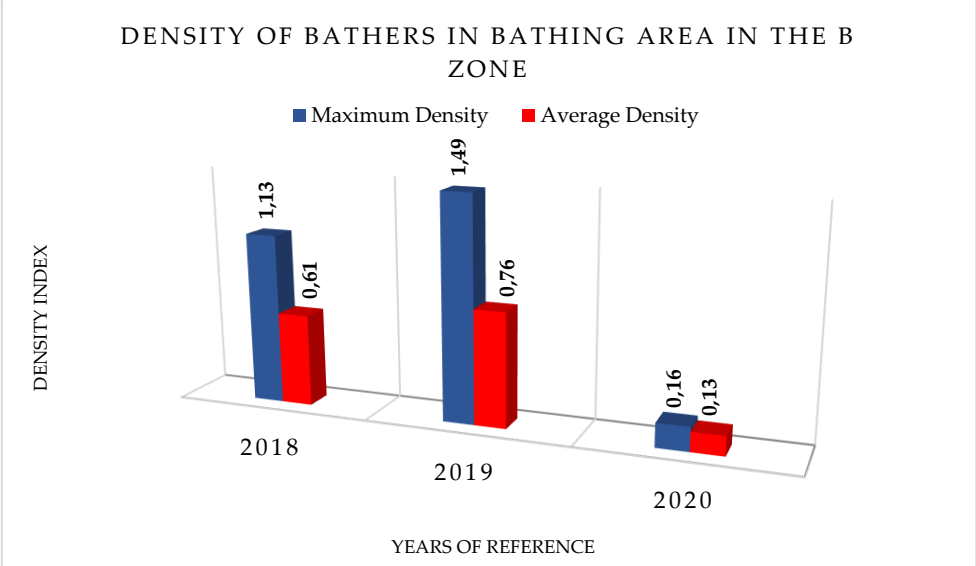
5.Results of the monitoring activity and discussion

At the end of September 2020, the data collected during the monitoring campaign were analyzed to evaluate the impact of the new access system (Defina, 2021). Graph 1 clearly shows the difference of the average daily flow of bathers in the B Zone bathing area between 2019 and 2020, from July to September. The reduction of flows is extremely evident.

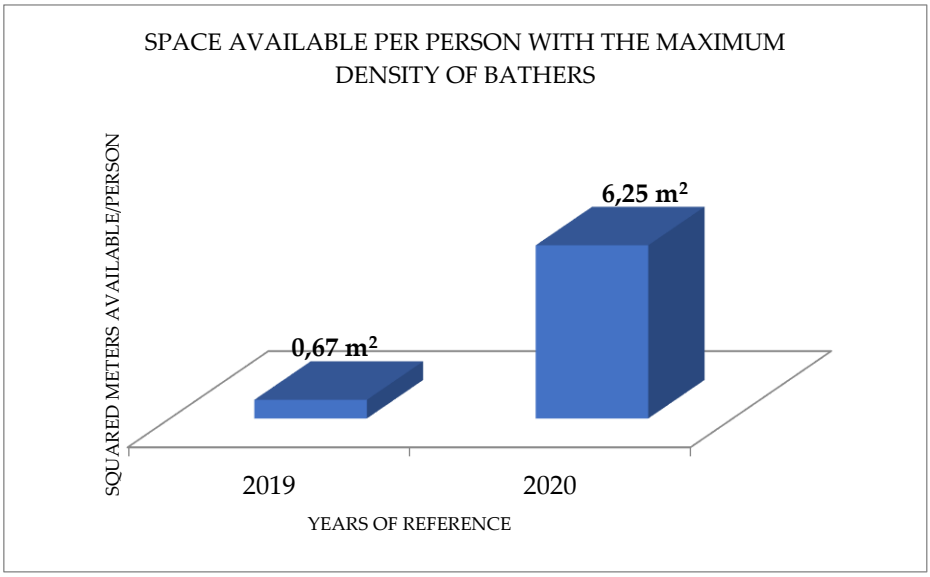


Graph 1: Average daily of sun-bather flow in the B Zone bathing area 2019-2020.

Moreover, Graph 2 shows the difference of density of occupation of space in the B Zone bathing area in 2020, 2019 and 2018. These data are constantly collected by the MPA Gaiola researchers by direct observation campaigns carried out in the summer months (June, July and August), collecting data in specific slot time and days. The density estimate is calculated counting how many people are located in the bathing area in the B Zone and calculating the squared meters available for each person. The difference in space occupation/density is calculated considering both maximum and average density and the density is calculated counting number of persons per squared meter. Whereas, Graph 3 shows the difference in space available per person in squared meters between 2019 before the application of the new rules and 2020 after the application of the new rules.

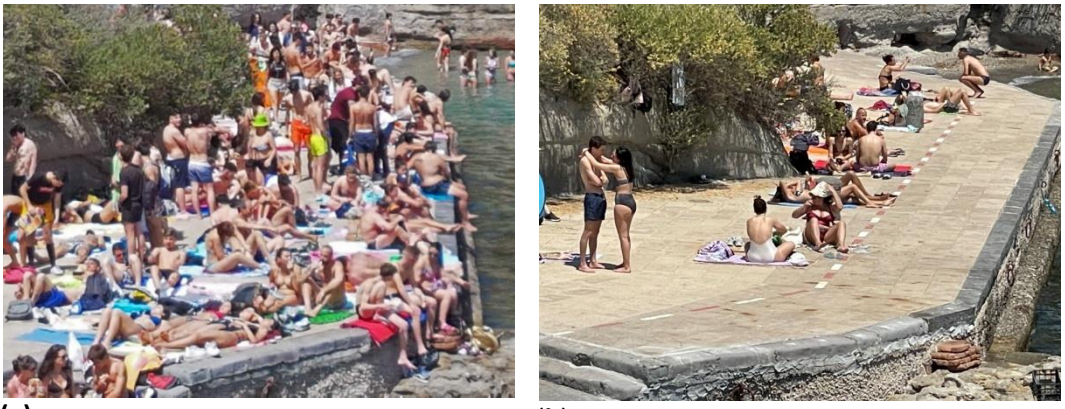


Graph2: Difference in density of bathers in 2018, 2019 and 2020.



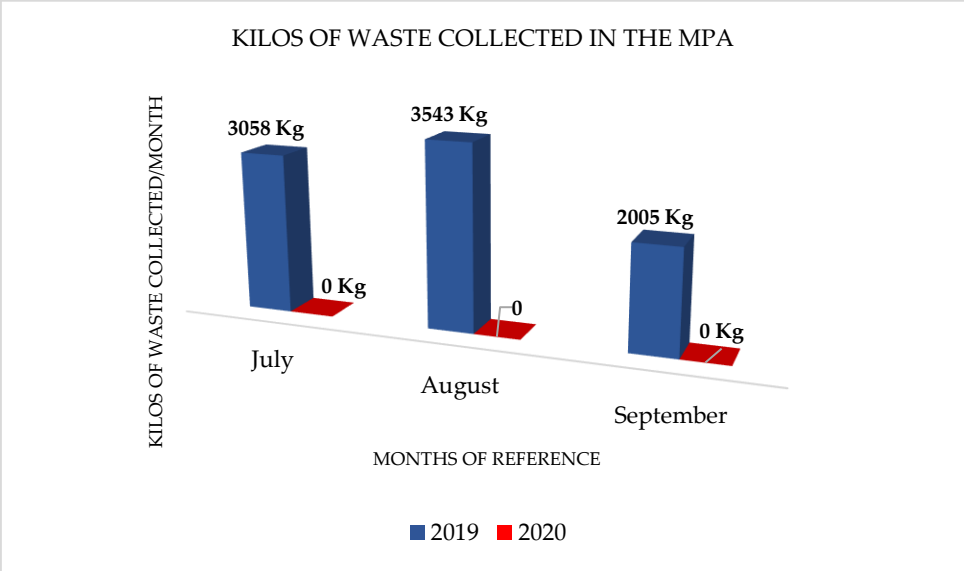
Graph3: Difference in space available per person in squared meters in 2019 and 2020

Besides the problems associated with Covid-19 pandemic, the evident reduction of bathers' pressure (Figure 9) on the bathing area in the B Zone improved users' perception of livability and safety, allowing also the creation of the necessary emergency corridors for rescue operations and for the safe inflow and outflow of bathers. Moreover, it was possible to detect a rapid reduction of negative impacts on the surrounding environment, above all in relation to litter production. In fact, with the new access regulation in the B Zone bathing area, the Manager Authority imposed a ban on the introduction of one-way waste in the area so to implement a more sustainable fruition of the MPA. Therefore, in 2020, the production of waste was reduced to nil (Graph 4). During previous years, due to the overcrowding on the beach, it was impossible for the CSI Gaiola staff and volunteers to control that bathers did not leave litter in the area, besides their efforts to rise people awareness toward the importance not to pollute the environment also through the creation of panels and signals in the area. In fact, in 2019 the majority of litter (70%) in the B Zone was produced by bathers (Graph 5).

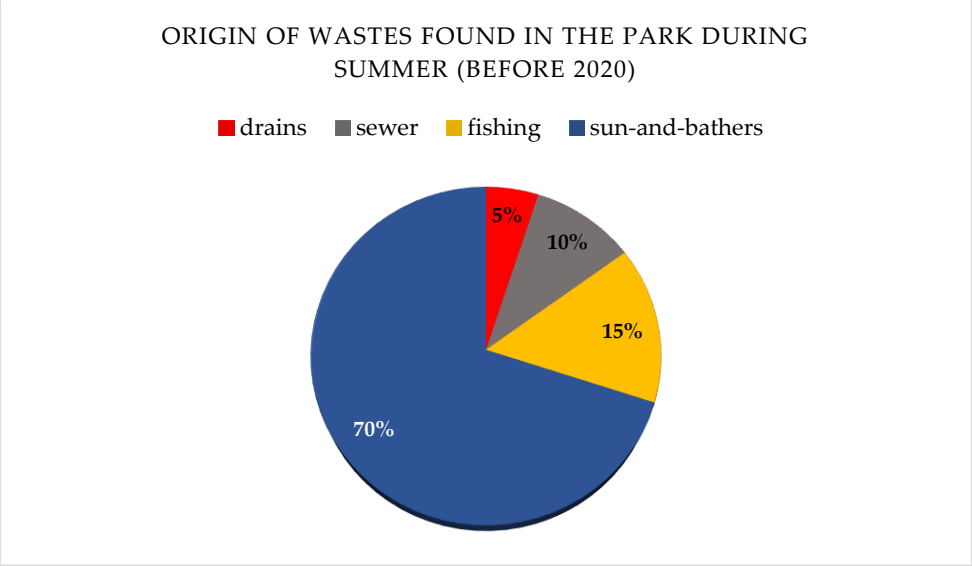


(a) **(b)**

Figure 9: Presence of sun-bathers in 2019 (**a**) and in 2020 (**b**) after the introduction of the new system with the creation of the emergency corridors



Graph 4: Kilos of waste per month collected in the B Zone in 2019 and in 2020.



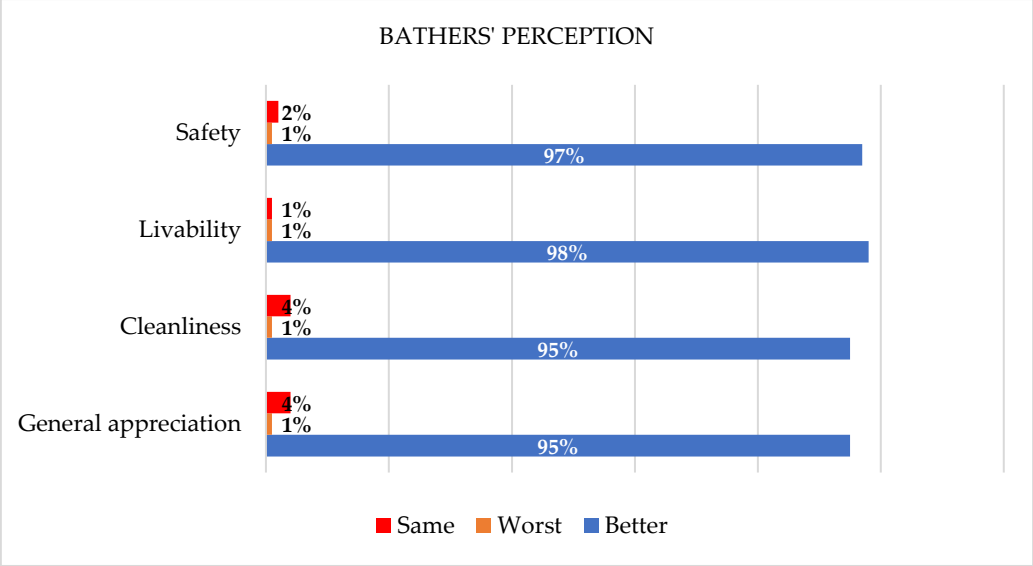
Graph 5: Origin of the wastes found in the MPA during summer - before 2020.

Fortunately, the new system, the consequent reduction of bathers' flows and the ban on the introduction of one-way packaging led to a significant reduction of the environmental impact (Figure 10), as it should be in a protected area and as it already happened since 2010 in the A Zone of the MPA.

(a) **(b)**

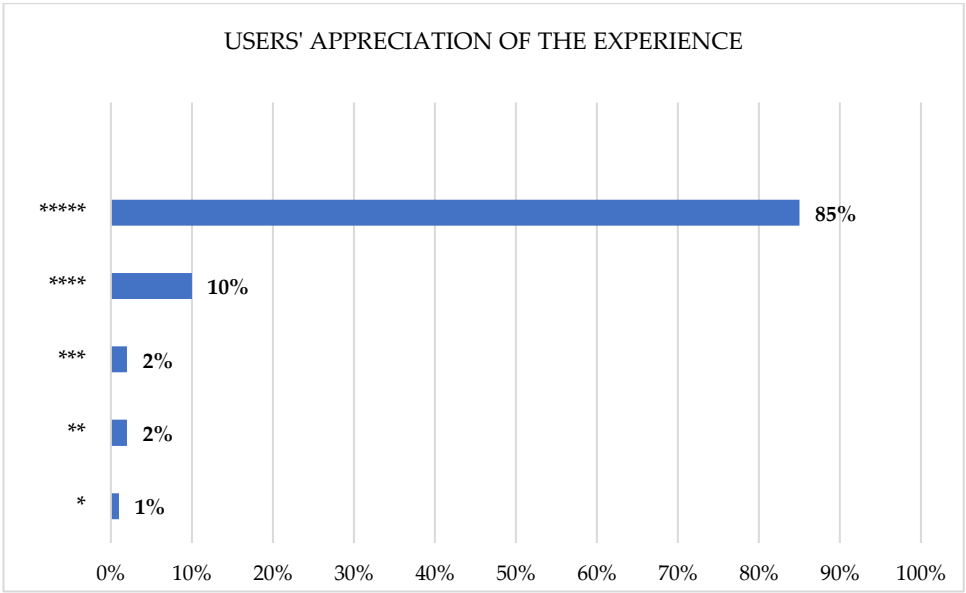
Figure 10: (a) litter on the beach after bathing day before protocol **(b)** beach after the protocol

Through the questionnaire feedbacks on people's perception toward conditions of the bathing area in the B Zone after the introduction of the new regulations in respect to previous years and on people's awareness towards the cultural value of the area were collected. Data demonstrated that the reduction of bathers in the bathing area in the B Zone improved the general experience and particularly of the perception of the habitual bathers on cleanliness, security and livability (Graph 6).



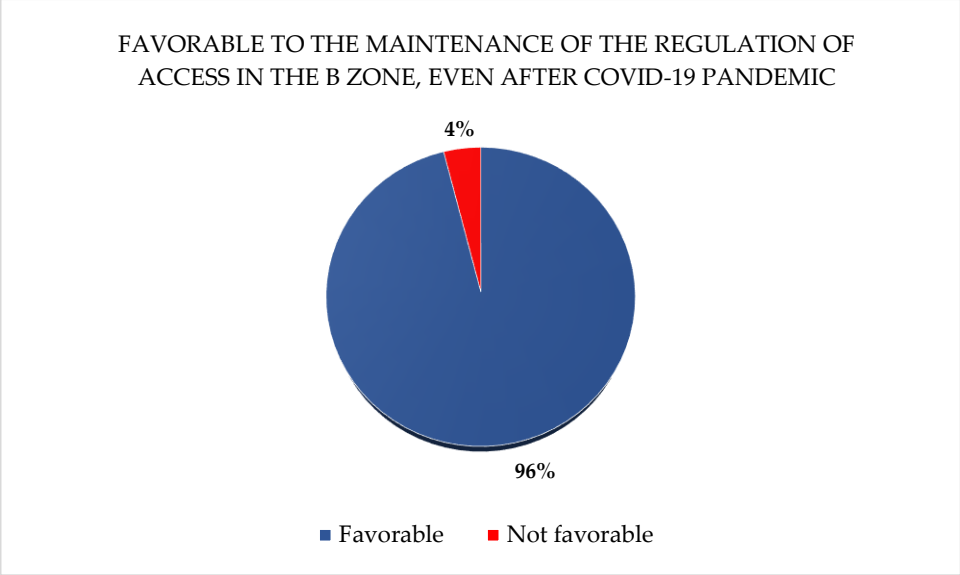
Graph 6: comparison of the users' experience between 2020 and previous years.

Generally, all the bathers had detected an improvement in relation to all the four criteria, and especially to security and livability. Bathers' satisfaction for the new system has also been confirmed by data collected from the booking reservation platform, where it is possible to give a feedback on the service (Graph 7).



Graph 7: Level of satisfaction rated by bathers on the booking system. 1 star is the lowest rate, 5 stars the highest.

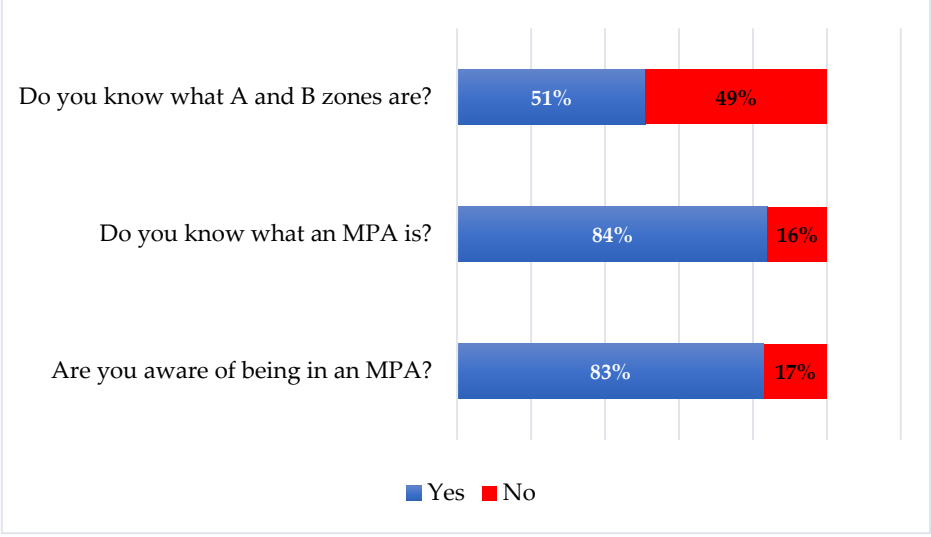
In addition, from the questionnaires it had emerged that almost the totality of the bathers (96%) would agree on keeping the new system, even after the end of the Covid-19 pandemic (Graph 8).



Graph 8: Favorable to the maintenance of the new model in the bathing area in the B Zone, even after Covid-19 pandemic.

Furthermore, the questionnaire had revealed that the new regulation contributed to make people more aware about the cultural and environmental value of the area. In fact, the majority of interviewed people had declared to be aware of the function of MPAs and to be aware to be in an MPA (Graph 9). This awareness was probably due to the new regulation that made it compulsory to go to the website of the MPA and to read its rules before booking the entrance. The information in the area and the guard at the entrance gate of the MPA were other elements that helped people to become aware of the natural and cultural importance of the MPA.

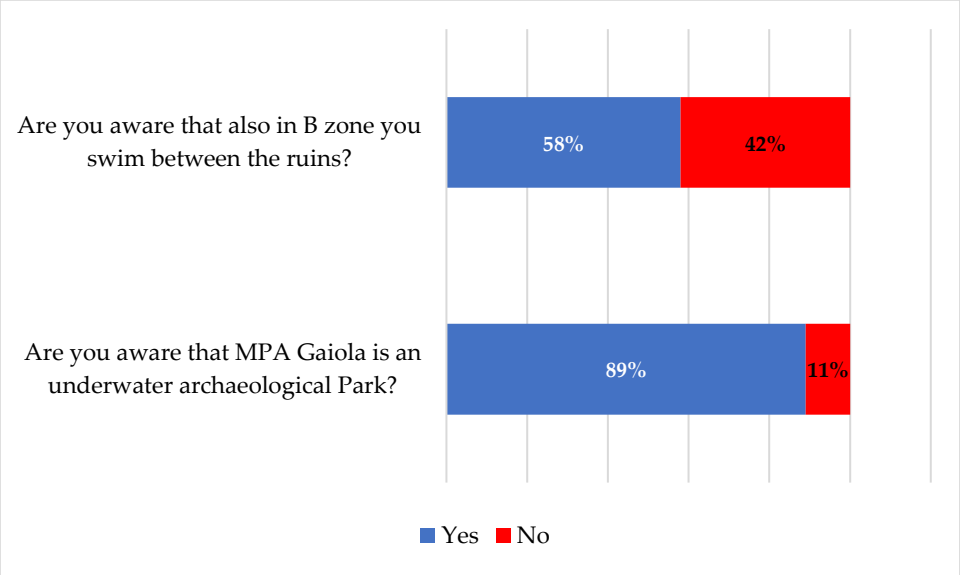
Through the questionnaire, bathers were specifically asked if they were aware that the area is also an underwater archaeological park and if they knew that even in the B Zone there are archaeological structures.



Graph 9: sun-and-bathers' awareness level on the function of an MPA in 2020.

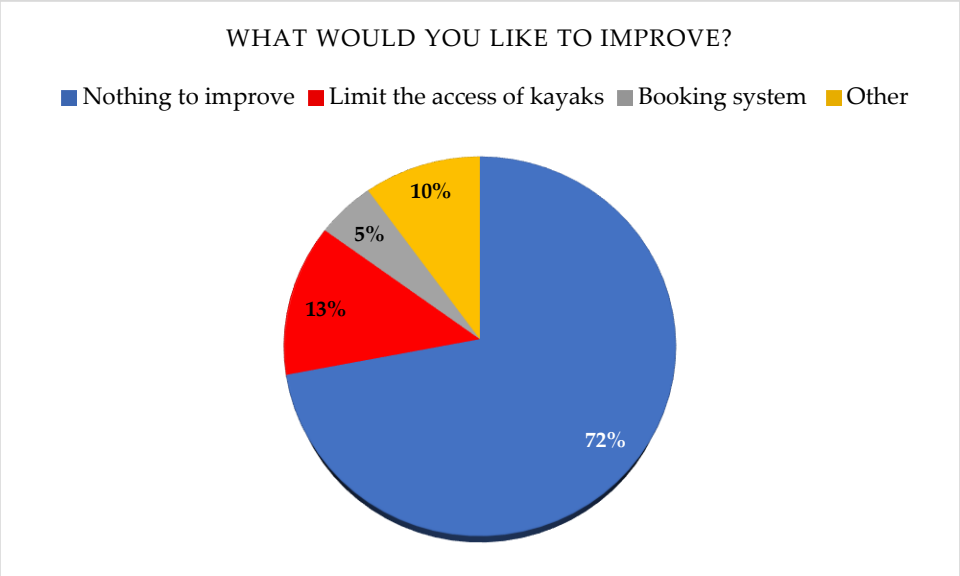
Data reveals that bathers are now more aware of the archaeological importance of the area, even if there is still a lower awareness toward the presence of archaeological structure also in the B Zone (Graph 10). This wrong perception is higher in usual users of the area and it is probably due to the old habit of considering only the A Zone as a protected area. Nevertheless, the survey shows an incredible improvement in awareness if

compared to studies carried out in the previous years that showed a very little awareness on the cultural importance of the area among Neapolitans (De Vivo, 2017).



Graph 10: sun-and-bathers' awareness level on the archaeological heritage of the MPA in 2020.

Finally, the questionnaire was also used as a useful tool to collect advices and suggestions from bathers and visitors, as it is visible from Graph 11.



Graph 11: visitors' feedbacks to improve the MPA services.

On the basis of the visitors' feedbacks, several ameliorations have been planned for summer 2021. First of all, the online booking system has been replaced with a new one to be used starting from June 2021. On the new online booking system, it is possible to reserve a place in the MPA starting at 6 p.m. on each Sunday. People can reserve their access for the following week, from Monday to Sunday. Bathers can only reserve for two turns per week, in order to guarantee users' turnover. Each reservation is connected to the personal Identification Code and if users do not show up without deleting their reservation, they are banned from reservation for two weeks. This change is important because, during the 2020 survey, many bathers declared

that there were too many people reserving a place in the MPA without showing up, reducing other people's right to access. Furthermore, the number of people allowed in the area has been increased from 75 people to 100 per turn, in accordance to the new prescriptions of the Italian Government that require to keep a distance of 1 mt. between one person and the other. In this way, a total of 200 people is allowed in the area ensuring the respect of anti-contagion norms and a sustainable number of people in the MPA. In order to monitor the evolution of the impact of the management model, in 2021 a new monitoring campaign will be carried out.

5. Conclusions

As stated at the beginning of this paper, the Covid-19 pandemic represented a turning point for the management of the MPA Gaiola Underwater Park. If it is true that the pandemic dramatically effected all the cultural institutions (Demartine at al., 2021; Antara et al., 2020), it is also true that it strongly animated the already existing debate about finding a balance between accessibility and preservation in heritage sites. As described, this was particularly true for the MPA Gaiola where, the dramatic lack of visitors in the area was taken as a chance to change the approach of management of the MPA and to solve problems that were impacting the area since its institution. The newly developed access system represented a strategic tool for the management of a sustainable fruition even in the bathing area in the B Zone of the MPA. In fact, access regulations have not only allowed the re-opening of the public beach respecting the anti-contagion norms, but have also generated several benefits from different perspectives. From an environmental perspective, reduction of litter, improvement of seawater conditions and biodiversity preservation were achieved. From a social perspective, better livability, cleanliness and security in visitors' perception were guaranteed. Moreover, from a cultural perspective, the new strategic plan is finally solving the problem of the existing archaeological heritage's safeguard and of perception of the area that is not considered anymore only as a recreational area, but as an archaeological and environmental park. Most probably, these results have been achieved because, by solving the problem of overcrowding of the area, it has been possible to carry out better informative and awareness campaigns, inviting sun-bathers to enter the visitor center of the MPA and engaging children in learning activities, which it was impossible to do in the previous years when the staff of the MPA was constantly busy in trying to limit the damages caused by the presence of many people at the same time within the area. The pandemic crisis created the conditions to look for a new balance and to make the access to the MPA Gaiola more sustainable by keeping an inclusive approach that gives everyone the chance to enjoy the area. Finally, this sustainable fruition method ensures the minimum requirements for visitors and bathers' safety. As previously stated, in 2021 the protocol has been implemented and further studies will be carried out in next years to keep improving the management of the MPA to make it always more accessible and inclusive, without damaging the preservation of its archaeological and environmental heritage.

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References

1. Antara, N. & Sen, S. (2002) The Impact of COVID-19 on Museum and The Way Forward to Be Resilience. *Uluslararası Müze Eğitimi Dergisi*, *2*(1), 54–61.
2. Centre, U. W. H. (2021) Experts call for inclusive and regenerative tourism to build back stronger post-COVID-19. Retrieved from https://whc.unesco.org/en/news/2177/ .
3. Chiarore, A., Fioretti, S., Meccariello, A., Saccone, G. & Patti, F. P. (2017). Molluscs Community Associated with the Brown Algae of the Genus Cystoseira in the Gulf of Naples (South Tyrrhenian Sea). *bioRxiv*, 160200. doi.org/10.1101/160200.
4. Chiarore, A., Bertocci, I., Fioretti, S., Meccariello, A., Saccone, G., Crocetta, F., Patti, F. P., Chiarore, A., Bertocci, I., Fioretti, S., Meccariello, A., Saccone, G., Crocetta, F.& Patti, F. P. (2019).Syntopic Cystoseira Taxa Support Different Molluscan Assemblages in the Gulf of Naples (Southern Tyrrhenian Sea). *Mar. Freshwater Res.*, *70*(11), 1561–1575. doi.org/10.1071/MF18455.
5. CSI Gaiola onlus-a (2020). *Criticità area balneazione pubblica Parco Sommerso di Gaiola e possibile aggravarsi della problematica con l'emergenza Coronavirus*. Technical communication to the Ministries of Environment and Culture.
6. CSI Gaiola onlus-b (2020). *Relazione fruizione pubblica Area Marina Protetta Parco Sommerso di Gaiola*. Technical communication to the Ministries of Environment and Culture.
7. Defina, M. (2021). *Marine Protected Areas and Sustainability in Urban Context. The case study of the Gaiola Underwater Park and a Tourism Proposal for Posillipo*. Master Degree Thesis, University of Bergamo.
8. Demartini, P., Marchegiani, L., Marchiori, M. & Schiuma, G. (2021). *Cultural Initiatives for Sustainable Development: Management, Participation and Entrepreneurship in the Cultural and Creative Sector*; Springer Nature.
9. De Vivo, C. (2015). Revealing the Invisible: The Heritagization Process of the Underwater Environment. *Roczniki Socjologii Morskiej*, XXIV, 4–20.
10. De Vivo, C. (2017). Rivelare l'invisibile: il patrimonio archeologico sommerso della Baia di Napoli, il caso dei Campi Flegrei. In *Atti del Convegno La Baia di Napoli – strategie integrate per la Conservazione e la Fruizione del paesaggio culturale*. Eds by Aveta, A., Marino, B.& Amore, R., vol.1, 353-357.
11. Günther, R.T. (1913). *Pausilypon.The Imperial Villa near Naples*. Oxford: Oxford University Press.
12. Millar, S. (1989). Heritage Management for Heritage Tourism. *Tourism Management*, 10(1), 9–14. doi.org/10.1016/0261-5177(89)90030-7.
13. Montanari, A. (2020). Covid-19 as an opportunity to tackle the phenomenon of overtourism in European historic centres: the case of Rome/Covid-19 un'occasione per affrontare il fenomeno dell'overtourism nei centri storici europei: il caso di Roma. *IL CAPITALE CULTURALE. Studies on the Value of Cultural Heritage*, 11, 285–305. doi.org/10.13138/2039-2362/2542.
14. Secci, M. (2011). Protection Versus Public Access: Two Concepts Compared within the Italian Underwater Cultural Heritage Management System. *Journal of Maritime Archaeology*, 6(2), 113–128.
15. Simeone, M., Masucci, P., Villani, G., Pagliarani, A. & Nigro, F. (2008). Le Grotte di Trentaremi e le altre cavità costiere dell'Area Marina Protetta Parco Sommerso di Gaiola (Golfo di Napoli): aspetti geoarcheologici ed ecologici. *Opera Ipogea ½*, 307-314.
16. Simeone, M. & Masucci, P. (2009). Analisi geo-archeologiche nell'Area Marina Protetta Parco Sommerso di Gaiola (Golfo di Napoli). *Il Quaternario*, 22(1), 25-32.
17. Simeone, M., De Vivo, C. & Masucci, P. (2012). An Interdisciplinary Approach to the Preservation of the Gaiola Archaeological Underwater Park and the Posillipo Coastline, Bay of Naples (Southern Italy). *International Journal of Heritage in the Digital Era*, *1* (1_suppl), 373–378. doi.org/10.1260/2047-4970.1.0.373.
18. Simeone, M. & Masucci, P. (2015) Nuove indagini sulle strutture archeologiche sommerse del Parco Sommerso di Gaiola a Posillipo. *Rendiconti della Accademia di Archeologia Lettere e Belle Arti. Nuova Serie,* Vol. LXXVII, 237-252.
19. Simeone, M., Grech, D., Masucci, P., Pagliarani, A., Moraca, M. & Appolloni, L. (2016). Progetto MedPAN. Analisi Territoriale per la Gestione Integrata della Costa di Posillipo (Golfo di Napoli): rilievi delle biocenosi bentoniche. *Biologia Marina Mediterranea,* 23(1), 255-257.
20. ICOMOS (1999). International Cultural Tourism Charter Managing Tourism at Places of Heritage Significance. Retrieved from: https://www.icomos.org/charters/tourism_e.pdf.
21. Ministero dell'Ambiente e della Tutela del Territorio (2002). Decreto interministeriale 7 agosto 2002. Istituzione del Parco sommerso ubicato nelle acque di "Gaiola", nel golfo di Napoli. (G.U. della Repubblica Italiana n. 285 del 5 dicembre 2002). Retrieved from https://www.gazzettaufficiale.it/eli/id/2002/12/05/02A13718/sg.
22. UNESCO (2001). 2001 Convention on the Protection of the Underwater Cultural Heritage. Retrieved from: http://www.unesco.org/new/en/culture/themes/underwater-cultural-heritage/2001-convention/official-text/

Underwater itineraries in Sicily: submerged museums and new technologies

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Abstract

Underwater itineraries in Sicily start from the 2001 UNESCO Convention, supported by the prof. Sebastiano Tusa's great contribute. The conviction that archaeological finds must remain *in situ* in their original position is the best way to fight against robberies and general indifference, in fact local communities step by step changed their opinions becoming conscious guardians of their underwater heritage, starting at same time a touristic and economic loop by great visibility of media. The Superintendence of the Sea, created and conducted by Sebastiano Tusa carried out during the years many underwater itineraries available for divers: an authorized guide shows to visitors the way to follow above the site rich in ancient finds marked by plastic floating labels identifying type and age of amphorae, anchors, wrecks, etc. Indeed, archaeology meets biology and marine landscapes, an amazing trip for all level of divers. Moreover, dedicated waterproof book-guides provide to visitors further information. The last edition of this system introduced "RFID" technology by "speaking" floating labels that by a microchip contact provide on the display of the small computer on the diver's wrist some more images, text and didactic drawings. Technology gives great emphasis and visibility to underwater finds and in Sicily it has been applied on some cultural underwater itineraries. In particular, at Cala Minnola in Levanzo island and at Cala Gadir in Pantelleria island, a video camera system was installed, in the aim to protect the sites and at the same time allowing the best fruition to visitors. Conceived for non-divers the rapid development of technology allowed in 2006 the installation in Cala Gadir of a new video surveillance and fruition system by 2 webcams, with a big reduction in dimensions of equipment and best quality of images definition. Images are visible online on dedicated website, camera can be moved 24h a day all around the world discovering different points of view, at the same time watching some moments of sea life. Indeed, the site reached in few months the top position among the more visited webcam. Furthermore, underwater tour was expressly realized for handicapped people and for blind people consisting in authentic and tactile replications finds marked whit special labels in Braille language. Technology in progress ever provides new solutions for study, protection and fruition of underwater cultural heritage, so we have to research and experiment new solutions that, applied on underwater archaeology, increase the frontier of human knowledge.

From discovery to public consumption: The process of mapping and evaluating underwater cultural heritage in Malta.

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Keywords: *Remote sensing, Mapping, Heritage Management, Deep-sea exploration, Technology*

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MaTaCoS project outcomes: innovative products and electromechanical tools for supporting the restoration of underwater cultural heritage

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Keywords: Innovative mortars, antifouling, cleaning tool, biofouling detection

Abstract

This work is part of a research project titled MaTaCoS (Advanced materials and technologies applied to the conservation of underwater cultural heritage) funded by the Italian Ministry of Economic Development (MISE), concerning development of innovative tools and methods for the protection of Underwater Cultural Heritage, with particular regard to cleaning and consolidating procedures to be carry out directly in situ. The fishpond of the archaeological site of Castrum Novum (Santa Marinella, Rome, Italy) was chosen as a pilot site for experimentation. Selected mortars' fragments from the fishpond structure were fully characterized and the achieved results allowed the definition of the used "recipe", information needed for the delineation of restoration interventions and for the planning of maintenance protocols (Randazzo et al., 2019). Starting from the acquired textural and minero-chemical features, the formulations of innovative mortars, to be applied directly in situ, preventing mainly the biological growth and the development of electromechanical devices for supporting the restoration of underwater archaeological artefacts were specifically designed. The antifouling efficacy of the different formulations, monitored over time, was investigated on specimens settled both in laboratory and in situ (Randazzo et al., 2020). Three different tools have been designed and manufactured: a brush-based cleaning tool, a percussion-based cleaning system and a tool for the injection of mortar during the consolidation procedures. Regarding the cleaning system tool, preliminary tests were carried out on various mortars' specimens. Several parameters (engine rpm, execution time, pressure on the surface to be cleaned, bristles material) were taken into account in order to assess its performance both in terms of cleaning efficiency and damage effect caused by the bristle-brush contact on the surface of the specimens. The percussion cleaning tool has been developed as part of a more complex tool for core sampling. Experimental tests (impact resistance, surface hardness) have been conducted on different metal alloys to define the best material to manufacture the impact mechanism, capable of 2.6 J of impact energy. The injection tool has been manufactured using state of the art 3D printing technologies. The maximum thrust of 225 Kg, allows using mortars with a wide range of densities. Moreover, an integrated system for biofouling detection and environmental parameters monitoring was designed. The main objective of the monitoring system is to

provide indications on the state of biodeterioration of the archaeological artefacts after the cleaning and mortars application, through appropriate in-situ image processing and environmental parameters acquisition. The system integrates a remote device and a web server. The remote device consists of a multi-parameters probe and NIR camera integrated in one underwater housing. A cleaning method for the camera lens with UV light was also investigated. The web server collects the transmitted data from the remote devices and make the information available for consultation and post-processing, providing information and alert on biofouling growth.

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References:

Randazzo L. Ricca M., Ruffolo S., Aquino M., Davidde Petriaggi B., Enei F., La Russa M.F. An Integrated Analytical Approach to Define the Compositional and Textural Features of Mortars Used in the Underwater Archaeological Site of Castrum Novum (Santa Marinella, Rome, Italy). Minerals (2019), 9, 268, pp. 1-14.

Randazzo L., Ricca M., Pellegrino D., La Russa D., Marrone A., Macchia A., Rivaroli L, Enei F., La Russa M.F. (2020) Anti-fouling additives for the consolidation of archaeological mortars in underwater environment: efficacy tests performed on the apsidal fishpond of Castrum Novum (Rome, Italy). International Journal of Conservation Science, Volume 11, Special Issue 1, 2020: 243-250.

Protection and promotion of coastal archaeological sites, with the application of soft shore protection methods against erosion, in the context of sustainable environmental protection of the coastal zone. The case of ancient Asopos (Plytra).

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Keywords: coastal archaeological sites, erosion, restoration of coastal monuments

Abstract

The issue of protection of coastal archeological sites, possibly more than in-land sites, is intertwined with the protection of the host environment. Any study for the protection and promotion of ancient coastal structures should be part of an overall management plan of the coastal zone that addresses with priority the intense problem of erosion. In Greece there is a large number of coastal archaeological sites that are located in the beach zone and are therefore subject to the action of currents that cause erosion. The action of the waves and currents, on structures that are found above sea level most of the year, results to the transport of aggregates from the shore to greater depths and is actually, a form of gradual excavation - with simultaneous rinsing of preserved mortars and other binding materials.

The coastal and underwater archaeological site of ancient Asopos (modern Plytra) in the Peloponnese - with important structures dating from the Hellenistic to early Byzantine period- having undergone documented destruction through the last 60 years, becomes a pilot site for the establishment of principles for an holistic approach of cultural and environmental protection and promotion of coastal archaeological sites. Through this approach, sustainable growth in the area, promotion and accessibility of UCHS can only be achieved in conjunction with the protection and restoration of the natural environment, using soft methods of intervention.

Creating a practical tool for monitoring the preservation state of ancient shipwrecks

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Keywords: ancient shipwrecks; in situ documentation; preservation; long-term conservation monitoring; Alonissos shipwreck; Fournoi shipwrecks

Abstract

Until recently, visiting ancient shipwrecks in Greece, a breathtaking experience in itself, was not possible for the general public due to concerns about their protection and preservation. Over the last few years, the Ephorate of Underwater Antiquities (EUA) has chosen shipwrecks from the islands of Alonissos, Fournoi, Leros and from the western Pagasetic Gulf and is carrying out preliminary work with the aim to make them accessible to recreational divers. This is a huge responsibility; as well as being accessible, the present state of the shipwrecks has to be ensured for future generations. What are the dangers though, from being accessible and how can the possible degradation of an ancient shipwreck be monitored?

This article aims to present a practical tool of systematic monitoring of the changes and the possible degradation of ancient shipwrecks which will be opened to the public as Accessible Underwater Archaeological Sites (AUAS). This model includes the digital drawing of the shipwreck's cargo, initially categorizing the current preservation state into three categories and subsequently documenting the preservation state of each object separately. The combination of the above data can offer a digital interactive monitoring tool, which can potentially be used with the appropriate means in real time, underwater. Moreover, the field work which has been carried out so far within the framework of the BLUEMED Interreg MED and An.Di.Kat. programmes, at the ancient shipwreck of Peristera in Alonissos and at shipwrecks 4 and 13 of the island complex of Fournoi of Ikaria will be presented.

1. Introduction

Over the last few years, the EUA with the aid of the BlueMed Interreg MED and An.Di.Kat programmes, has chosen shipwrecks from the Greek islands of Alonissos, Fournoi, Leros and the western Pagasetic Gulf and is carrying out preliminary work with the aim to make them accessible to recreational divers. 2020 was the first year that the Peristera shipwreck in the island of Alonissos was open for the public to visit in a pilot programme (Καλαμαρά, 2020). A number of measures were taken to ensure the safety and protection of the site (Κουτσούμπα, 2020), by training diving instructors to guide the divers, restricting the number of visitors in

each dive, while also monitoring each dive via a state of the art underwater and field camera system by NOUS (Papalambrou et al., pending).

Even though all these measures are important, the question is whether they are sufficient. The purpose of these is of course to protect the AUAS for future generations and as M. De la Torre states, "these shipwreck sites must be studied and used very carefully as unique and non-renewable resources that could easily be destroyed and lost forever without some long-term plans" (De la Torre, 1998). Long-term conservation monitoring of possible degradation adds to these measures hence need to find a way to realize this is apparent.

The most common image of an ancient shipwreck in the Mediterranean Sea is its ceramic cargo. The wooden structure of the ship in the Mediterranean underwater environment biodegrades very fast due to the amount of oxygen in the water (Pournou et al., 2001). A shipwreck in the Greek archaeological law is treated as an immovable monument (Δελλαπόρτα, 2005). Practically though, an ancient shipwreck consists of hundreds or thousands of movable objects which make up its total. Deterioration of individual objects have an impact on the whole.

Apart from natural causes such as storms, powerful currents and marine animals, there is a number of potential dangers due to human activity during a visit to an AUAS.

- *Mechanical strain – Fragmentation – Cracking – Total destruction of the object*. Even though a diver's buoyancy is expected to be controlled, unfortunately many times clumsy, unintended movements may cause irreversible damages to the objects (Edney, 2006).
- *Unintended moving of objects.* Spatial awareness is something that is hard to have underwater especially if you are visiting a site for the first time. Disorientation and panic movements may result in unintended moving of objects, especially with the fins. This danger increases as the distance from the objects decreases (Edney, 2006).
- *Looting – Souveniring – Removal of objects.* By opening AUAS their location is made known and become a target for wishful looters. In addition, many desire to take a souvenir from the shipwrecks to remind them of their visit (Edney, 2006). This illegal activity takes place especially in sites where surveillance is poor.

In a site with sufficient surveillance, the first two factors are mostly considered possible, though the third cannot be excluded; as antiquities have been stolen even from inside museums. Small, even insignificant damages caused by human activity, in the long term and working cumulatively could degrade the total image of the shipwreck.
These are some of the factors that measures to protect shipwrecks with a ceramic cargo are taken, such as reburial, coverage with sandbags, use of geotextile and nets, metal nets and metal cages (Zmajic, 2009; Radić Rossi, 2014; Oikonomopoulou, 2018; Capulli, 2019; De Juan, 2020).

In order to monitor these changes, it is necessary to precisely document the shipwreck's current preservation state so as to be compared with the future one. As yet, the documentation of shipwrecks with a ceramic cargo is mainly based on the archaeological point of view; where the collection of archaeological information, typology and location of the finds is priority and not the documentation of their preservation state and degree of degradation. There is no commonly applied method to monitor the preservation state and possible degradation of such shipwrecks from the conservator's point of view.

Drawings, photographs, ortho-photomosaics and 3D models are the most common documentation techniques used. These have been applied in Greece, for example in shipwrecks of the S. Euboean Gulf (Diamanti et al., 2013) (Diamanti & Vlachaki, 2015), Alonissos (Χατζηδάκη, 1992; Bruno et al., 2019), Chios (Foley et al., 2009; Theodoulou et al., 2015), Pagasetic Gulf (Diamanti et al., 2017) and Rhodes (Koutsouflakis & Rieth, 2021), where the condition in which the wrecks were found is documented. Although some information regarding its preservation state is provided, it is not enough to make a detailed assessment.

Objects with cracks and fractures that are visible to the naked eye, are rarely distinguished in an ortho-photomosaic or photograph, especially if covered by seagrass, algae or encrustations (Figure 1). Moreover, whether objects are or are not easily removable is often difficult to assess. M. Secci made an interesting observation about the Mazotos shipwreck in Cyprus where he was able to detect, among other things, “movements of objects due to natural displacement or as a consequence of fieldwork activity” (Secci et al., 2021).

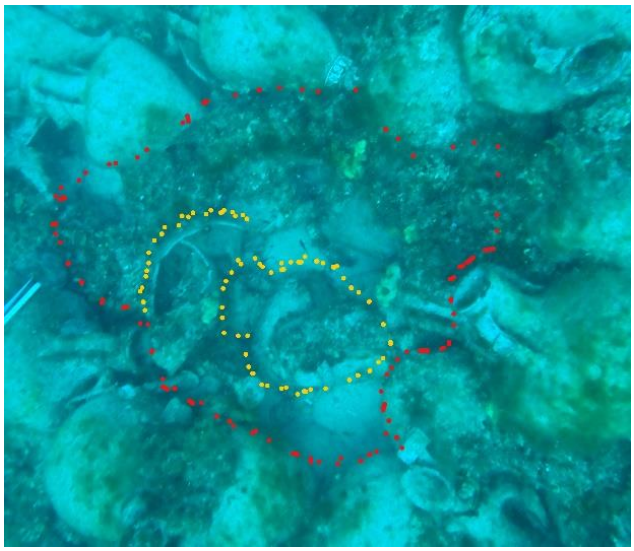


Figure 1. Enhanced ortho-photomosaic image of a shipwreck, where in red is the area where the objects are not easily distinguished and in yellow the possible outlines of the objects

Attempts to obtain such information have been made in the “Fournoi Underwater Project”, where the in situ documentation of the preservation state of the finds in a condition report has been systematized, but it only applies to finds that are to be lifted (Mitsi et al., 2021).

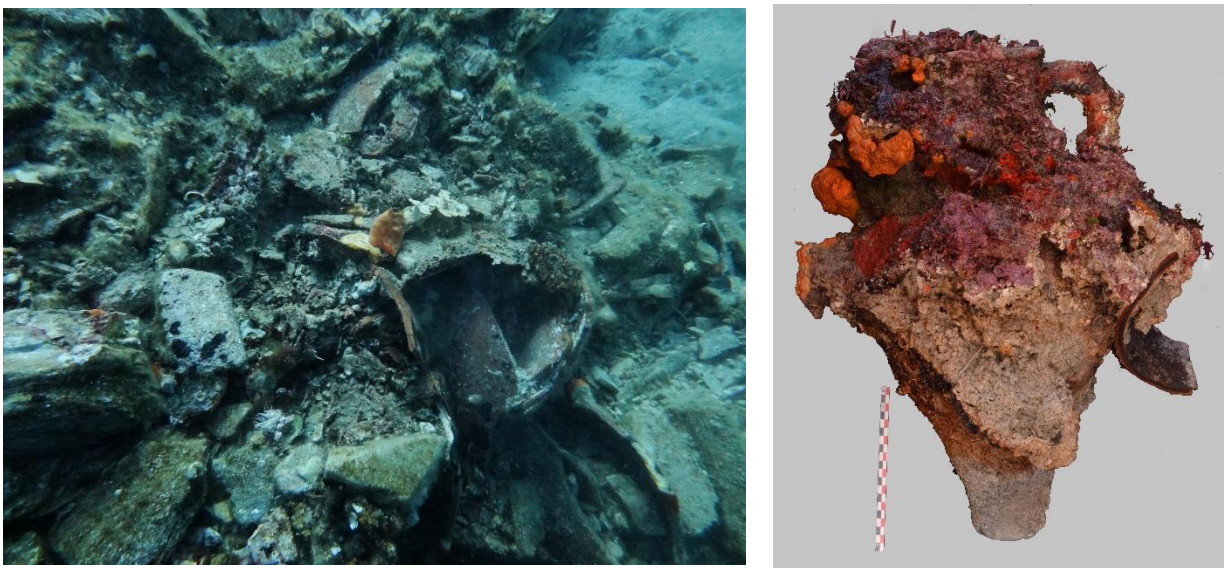
Having the above in mind, this work aimed to create a practical tool to document in detail the preservation state of the finds that consist a shipwreck whilst collecting data that will offer information regarding its condition. This tool will help keep track on and long-term monitor possible changes, deterioration or damage and is kept simple and practical in order to be systematically applied by conservators.

2. Materials and Methods

The methodology proposed includes on-land preparation, underwater application in two phases, digital transfer of acquired data and monitoring changes.

The general idea behind this tool, is initially to categorize the condition of each individual find of the shipwreck into four main categories: a) concreted (which cannot be moved), b) semi-concreted (can be moved with minor intervention), c) loose (which can easily be moved), and d) relocated (which are not in their original position).

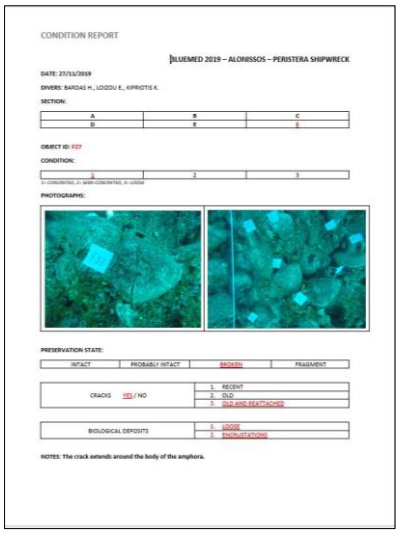
The above categorization of the condition of the objects of the ceramic cargo is based on the existence of encrustations. These encrustations are a formation of biogenic origin; numerous marine organisms with a calcareous structure attach to a stable substrate, remain in the same place after their death and accumulate in time, forming a biogenic rock (Laborel 1987; Αχτύπη, 2015). The ceramic cargo of the wrecked ships, often takes the role of a rigid substrate in order for this procedure to take place. In the long term, this results in loose individual objects to adhere to each other and create a cluster (Figure 2). The degree of encrustation indicates the intensity of the potential dangers mentioned in the beginning. Specifically, an object that is part of a cluster has a very low risk of it being moved. Also the risk of breakage is reduced as the encrustations often act as a protective shield to the object from possible impacts. It also acts as an obstacle in case of looting, as the detachment procedures require special knowledge and time. By categorizing the degree of encrustation of the objects, at the same time, their exposure to the possible dangers is also categorized.



(a) (b)

Figure 2. (a) Ceramic objects that form a strong cluster due to encrustations and (b) an amphora covered in encrustations

Then follows the documentation of the preservation state of each find individually, in order for each object to acquire an identity, by filling in a condition report. The form includes general information such as the date and diving couple and the identity no. of the object. The condition of the object is coded as 1 = concreted, 2 = semi-concreted, 3 = loose. Two photos are then attached - one photo of the object individually and one with the object and its surroundings. In the next section the preservation state is completed: "Intact" – maintains its entire profile, "Probably intact" - maintains its entire profile but some part of it is not visible due to encrustations, aggregates or overlapping objects, "Broken" - maintains part of its profile or is fragmented, "Fragment" – part of an object. In case of cracks, it is noted if they are recent, old or old and reattached. The sediments are then divided into loose (biological deposits or sand) and encrustations (hard agglomerates). Finally, in the "Notes" section, one can write a text for more detailed documentation and/or comments regarding the object (Figure 3).


CONDITION REPORT

BLUEMED 2019 – ALONISSOS – PERISTERA SHIPWRECK

DATE: 27/11/2019

DIVERS: BARDAS H., LOIZOU E., KIPRIOTIS K.

SECTION:

A	B	C
D	E	F

OBJECT ID: F27

CONDITION:

1	2	3

PHOTOGRAPHS:

PRESERVATION STATE:

INTACT	PROBABLY INTACT	BROKEN	FRAGMENT

CRACKS YES / NO	1. RECENT 2. OLD 3. OLD AND REATTACHED
BIOLOGICAL DEPOSITS	1. LOOSE 2. ENCRUSTATIONS

NOTES: The crack extends around the body of the amphora.

Figure 3. Example of a completed condition report

All the above information is transferred digitally to a data base in order to repeat the procedure and detect changes that may occur in an accessible underwater ancient shipwreck.

2.1 In the field

On-land preparation includes the use of an ortho-photomosaic image of the shipwreck as a digital record of the current preservation state (if it does not already exist from the archaeological documentation, then it is necessary for one to be produced). The image is processed in a computer-aided design software, in this case, AutoCAD 2017 by Autodesk, by digitally dividing the shipwreck into equal sectors and every object is outlined. Each section of the photomosaic of the shipwreck is printed in A3 size and laminated for underwater use. Also, on semi-transparent waterproof paper, the digital design of the outlined objects is printed in black and white and on a scale to match each section. The two sheets of each sectors overlap, are attached to a slate and transported underwater (Figure 4).

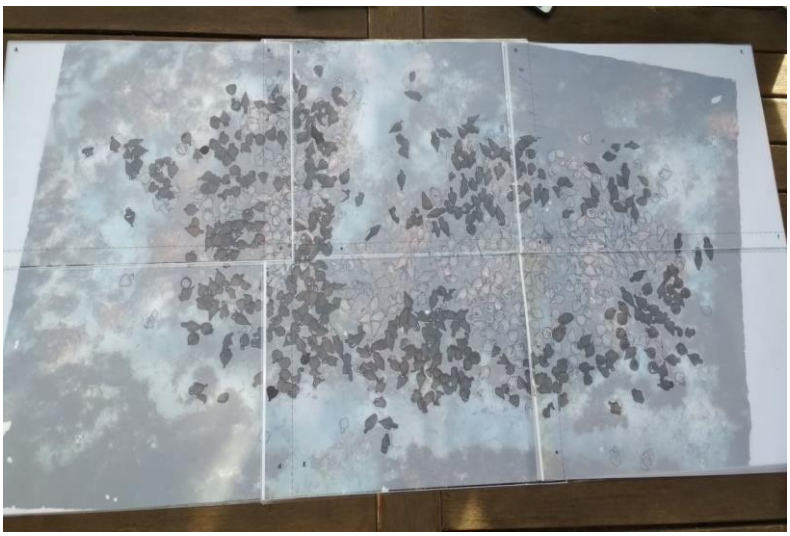


Figure 4. Six sections of the ortho-photomosaic laminated and overlapped with the drawing of it in semi-transparent waterproof paper

Underwater, the area of the shipwreck is divided into the pre-determined sections by creating a temporary grid with ropes and weights; mainly to facilitate the diver and the documentation process.

For Phase 1, the most efficient system to gather the information is for one diver to determine if each object was concreted, semi-concreted, loose or relocated and for the other to direct and document on the board. Thus, two diving couples operate simultaneously in two or more sections, in one dive. As for the communication in terms of passing on the information non-verbally, the diver who assesses the situation points to the other who documents on the board, the number 1, 2 or 3 with his or her fingers corresponding to the above conditions. At the same time, the diver who documents on the slate, corrects any errors in the design by drawing the correct outlines of the object with a pencil (Figure 5).

(a) (b)

Figure 5. (a) Two diving couples working on two separate sections of the shipwreck simultaneously and (b) diver indicates number "2" with his fingers implying that the respective amphora is semi-concreted

Passing on to Phase 2, the next part of the more detailed documentation, the divers number and temporarily label each object on the surface layer of the sector they will be working on. The conservator then proceeds to complete the condition report for each object, by documenting micro damages and photographing them (Figure 6).

Figure 6. Phase 2 of the documentation process; Labeled amphorae and detailed documentation

After the end of each dive, the information is transferred digitally and corrections to the drawing are made in places where the outlines of the objects are not easily distinguished in the photomosaic. Each find is filled with a colour which corresponds to one of the following conditions (Figure 7):

- GREEN – concreted, which cannot be moved
- YELLOW – semi-concreted, can be moved with minor intervention
- RED – loose ones, which can easily be moved
- GREY – relocated, which are not in their original position

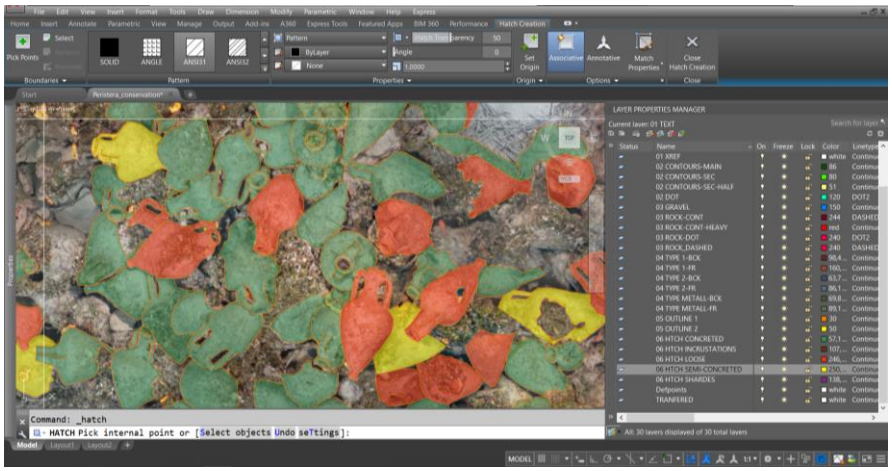


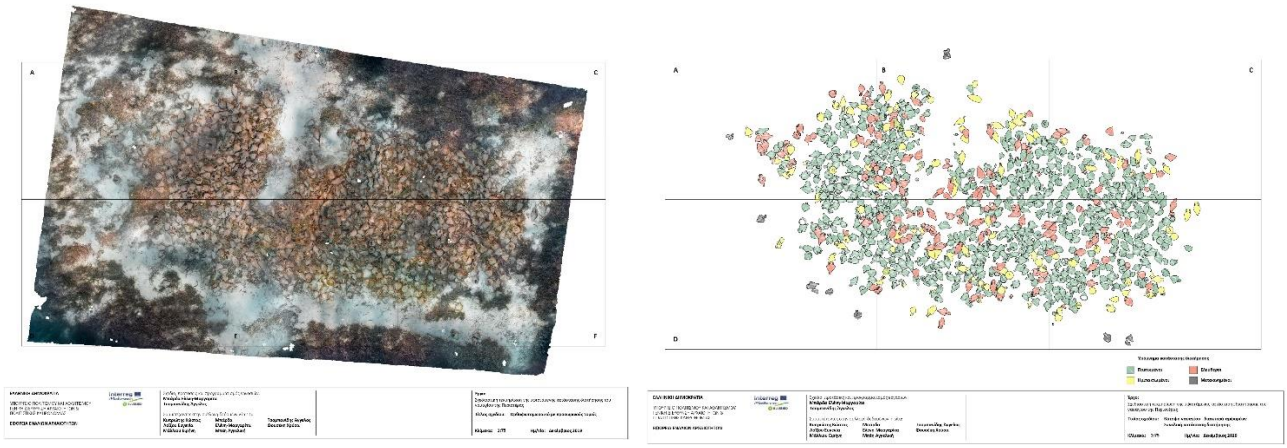
Figure 7. Screenshot of the documentation process in AutoCAD

Finally, distinctive objects or characteristic elements are labeled permanently in a reversible way to help the conservator navigate when they return to re-assess the condition and preservation state of the shipwreck. When returning to the site to monitor, all objects are checked in a line of priority.

3. Results

3.1 Alonissos - Peristera shipwreck

Peristera shipwreck in the island of Alonissos is the first AUAS opened to visitors in Greece. This 5th century shipwreck lies at a depth of -22 m to -30 m. It consists of well-preserved amphorae (types *mendis* and *peparithos*) in an area of 25 m x 12 m forming the shape of a ship. The upper layer is disturbed but underneath it still preserves another three rows of amphorae (Hadjidaki, 1996). The shipwreck was separated into six sections and named A, B, C, D, E and F. We then continued drawing the outlines of each amphora we were able to distinguish in AutoCAD, before printing out the sections in A3 size and taking them underwater. After completing Phase 1, concreted, semi-concreted, loose and relocated amphorae are presented (Figure 8).



(a) (b)

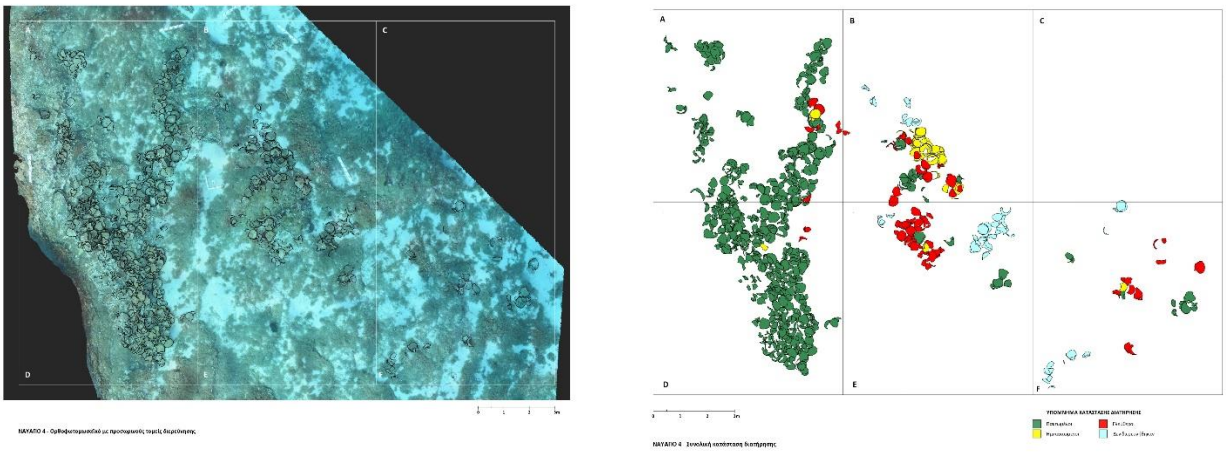
Figure 8. (a) Peristera shipwreck ortho-photomosaic separated in sections and (b) the result of Phase 1 of the documentation process

Sector F was chosen for Phase 2 of the documentation process, where 48 amphorae were temporarily labeled and recorded in the condition report (Figure 9). Amphorae F41, F44 and F45 were chosen to be permanently labeled due to their close proximity to loose amphorae.

Figure 9. Documentation (Phase 2) in Sector F of Peristera shipwreck

3.2 Fournoi - Shipwreck No. 4

Shipwreck no.4 consists of amphorae type Benghazi Late Roman 13; which dates the shipwreck from the 6th - 8th century AD (Campbell & Koutsouflakis, 2021). The shipwreck consists of two elongated concentrations of encrusted amphorae which extend parallel to each other and parallel to the shore; the first at a depth of -9 m to -13 m and the second at a depth of -15 m to -17m, on a seabed of rocky substrate surrounded by sand sockets. In addition to the two main concentrations, there is a large dispersion of peripheral finds. The amphorae are firmly encrusted together and to the seabed. Although intact amphorae were not found in the visible surface layer, a large number of them preserved their profile to a satisfactory amount, making their documentation easier. Shipwreck No. 4 is currently at Phase 1 of the documentation process, so objects that have yet to be documented are shown in blue (Figure 10).

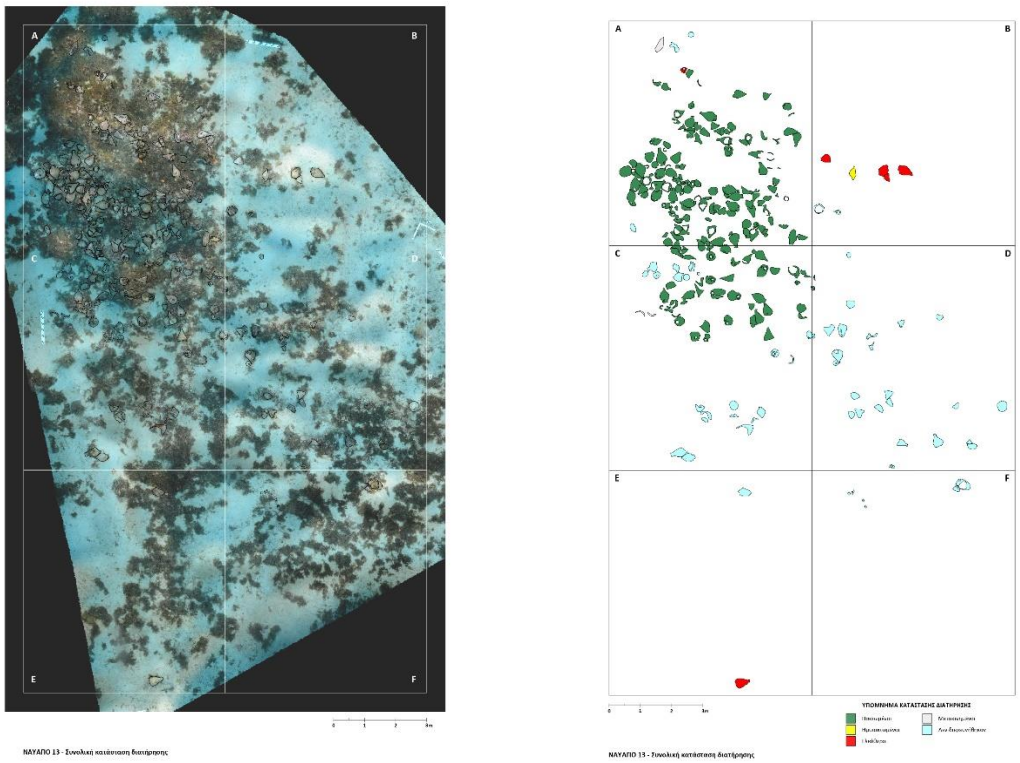


(a) (b)

Figure 10. (a) Fournoi Shipwreck No. 4 ortho-photomosaic separated in sections and (b) the result of Phase 1 of the documentation process

3.3 Fournoi - Shipwreck No. 13

The cargo of this shipwreck consists of Samian/Klasomenian and Lesvos types of amphorae which date the shipwreck to the 6th century B.C. This shipwreck lies at a depth of -34 m to -39 m - which made the documentation challenging. It consists of a main cluster of intact and broken amphorae which are cemented to the rock. The scatter is small and apart from some exceptions, there are not any loose finds around; and gives the impression that part of the cargo has been looted. The rest of the cargo is preserved in situ, most likely because its strong encrustation prevented them from being stolen (Κουτσουφλάκης & Campbell, 2019). Shipwreck No. 13 is also currently at Phase 1 of the documentation process, so objects that have yet to be documented are shown in blue (Figure 11).



(a) (b)

Figure 11. (a) Fournoi Shipwreck No. 13 ortho-photomosaic separated in sections and (b) the result of Phase 1 of the documentation process

4. Discussion

This kind of mapping of shipwrecks shows areas that are more sensitive than the others. Colour coding makes it easy for the user to quickly understand and comprehensively assess the wreck's preservation state. The combination of drawings and condition reports, allows the inspection to be carried out by conservators who had no previous contact with the wreck.

Areas that are in most need are also categorized for future conservation monitoring, setting in this way, priorities.

The condition reports form a database regarding the current preservation state of objects. By numbering the respective amphora and creating its corresponding condition report, it acquires an "identity". Without it, it is not possible to determine whether the damage to an object has occurred after the beginning of the visits.

The results of the conservation monitoring can show us the viability or not of a shipwreck in the long run and indicate possible changes that need to be made in the way and conditions of the visit. This can help plan underwater routes by allowing or limiting the proximity of divers to the respective areas.

It is understood that diving conservators should carry out the monitoring as their perspective is focused on the pathology of the objects. Our experience has also shown that direct visual observation produces different results than just observing a photograph or a photomosaic.

This tool can also be applied to other shipwrecks of a similar kind; the cargo has to ideally consist of intact or almost intact objects in order for them to be individually assessed. It applies easier to shipwrecks lying on a rocky seabed which facilitates the encrustation's process, but does not apply to ceramic cargos consisting of small objects (e.g. tableware or oil lamps) or located on sandy bottoms with intense sediment movement that periodically covers and uncovers the site.

Although this work presented is preliminary, the above way of documenting the shipwreck's conservation state is innovative and can be a prototype, as it successfully responded to the need to find a functional and reliable tool for systematic and long-term monitoring of changes and possible degradation of an ancient shipwreck. This need becomes more urgent with the opening of AUAS to the public.

During the BlueMed programme, we had the opportunity to make pilot use of underwater tablets for touristic purposes. In addition to the touristic benefits offered by the underwater tablet, it can be a useful device for conservation monitoring a wreck.

By transferring the drawing to the tablet and making it interactive, the conservator diver can document the changes he observes and be able to view the condition report of the amphora he selects from a built-in database. At the same time he can photograph the changes observed and add them to the file of the respective amphora. Of course the implementation of the above must clearly be done with the cooperation of experts.

To conclude, the UNESCO 2001 Convention on the Protection of the Underwater Cultural Heritage (UCH) indicates *in situ* preservation of the site as a principal choice and encourages public access, unless it is incompatible with the site's protection and management (Hrsg, I.C.O.M.O.S., 2006). The Ephorate of Underwater Antiquities chose to make the shipwreck of Peristera in Alonissos and shipwrecks No. 4 and No.

13 of Fournoi accessible to the public. Shipwrecks are unique and non-renewable resources that could easily be degraded or lost if unmonitored public access is allowed under uncontrolled conditions. Without underestimating the dangers, but also without demonizing them, we must be able to accurately and measurably monitor the long-term effects of AUAS on the preservation of UCH sites, so that they can be passed on to the next generations. This work is moving towards this direction.

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References

1. Bruno, F., Lagudi, A., Collina, M., Medaglia, S., Kalamara, P., Kourkoumelis, D., Nad, D., Kapetanovic, N., Markovic, M. & Miskovic, N. (2019). Opto-acoustic 3D reconstruction and virtual diving on the Peristera Shipwreck. In *Proceedings of the International Conference in Management of Accessible Underwater, Cultural and Natural Heritage Sites: "Dive in Blue Growth", Athens, Greece*, 332-339.

2. Campbell, P. & Koutsouflakis, G. (2021). Aegean Navigation and the Shipwrecks of Fournoi. The Archipelago in Context, in *Under the Mediterranean I, Studies in Maritime Archaeology* (eds St. Demesticha - L. Blue), 283.

3. Capulli, M. (2019). The in situ preservation as a priority option. Experiments in the upper Adriatic Sea, in: *International Conference in Management of Accessible Underwater, Cultural and Natural Heritage Sites: "Dive in Blue Growth", Athens, Greece*, 138-145.

4. De Juan, C., Geli, R., Cibecchini, F., Mauri, G., Mayoral, J., & Vivar, G. (2020). Els Derelictes Bou Ferrer i Illes Formigues II, dos jaciments extraordinaris per comprendre el comerç naval de la Bètica al període Julioclaudi. *Tribuna d'Arqueologia 2017-2018*, 254-272.

5. De la Torre, M. (Ed.). (1998). *The Conservation of Archaeological Sites in the Mediterranean Region: An International Conference Organized by the Getty Conservation Institute and the J. Paul Getty Museum, 6–12 May 1995*. Getty Publications, 5-14.

6. Diamanti, E., & Vlachaki, F. (2015). 3D Recording of underwater antiquities in the South Euboean Gulf. *The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*, *40*(5), 93-98.

7. Diamanti, E., Georgopoulos, A., & Vlachaki, F. (2013). Geometric documentation of underwater archaeological sites. *Geoinformatics FCE CTU*, *11*(0), 37–48. https://doi.org/10.14311/gi.11.3

8. Diamanti, E., Spondylis, E., Vlachaki, F., & Kolyva, E. (2017). Surveying the Underwater Arcaheological Site of Cape Glaros at Pagasetikos Gulf. *The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*, *42*, 243-248.

9. Edney, J. (2006). IMPACTS OF RECREATIONAL SCUBA DIVING ON SHIPWRECKS IN AUSTRALIA AND THE PACIFIC A Review. Microns. J. Humanit. Soc. Sci. 5, no 1/2, 201, 214-219

10. Foley, B. P., Dellaporta, K., Sakellariou, D., Bingham, B. S., Camilli, R., Eustice, R. M., Evagelistis, D., Ferrini, V. L., Katsaros, K., Kourkoumelis, D., Mallios, A., Micha, P., Mindell, D., Roman, C., Singh, H., Switzer D. & Theodoulou, T. (2009). The 2005 Chios ancient shipwreck survey: New methods for underwater archaeology. *Hesperia*, 269-305.

11. Hadjidaki, E. (1996). Underwater excavations of a late fifth century merchant ship at Alonnesos, Greece: the 1991-1993 seasons. *Bulletin de correspondance hellénique*, *120*(2), 561-593.

12. Hrsg, I. C. O. M. O. S. (2006). UNESCO Convention on the Protection of the Underwater Cultural Heritage. *Heritage at Risk*, 96-104.

13. Koutsouflakis, G. & Rieth, E. (2021). A late-12th-century Byzantine Shipwreck in the port of Rhodes, in: *Under the Mediterranean I, Studies in Maritime Archaeology, Leiden,* 91-110

14. Laborel, J. (1987). Marine biogenic constructions in the Mediterranean, a review. *Sci. Rep. Port-Cros natl. Park*, *13*, 97-126.

15. Mitsi, E., Garras†, M., Agavanakis, G. & Tsompanidis, A. (2021). Condition Reporting of Underwater Archaeological Finds from A to Z with the use of an interactive database. *#ISCUA 2019 Proceedings The 1st International Symposium of Conservation for Underwater Archaeology,* 111-119.

16. Oikonomopoulou, K. (2018). The long-term effects of Underwater Archaeological Parks on the Preservation of Underwater Cultural Heritage. An Overview. *Degree project for Master of Science,* 21-25.

17. Papalambrou, G., Mentogiannis, V., Katsioulis, K., Kalamara, P. & Koutsoumba, D. (pending). NOUS - uNdersea visiOn sUrveillance System at the sea wreck of Peristera, Alonissos. In: *2nd International Conference on the Promotion of Accessible Underwater Cultural Heritage Sites "Dive in Blue Growth" 12-14 May 2021*.

18. Pournou, A., Jones, A. M., & Moss, S. T. (2001). Biodeterioration dynamics of marine wreck-sites determine the need for their in situ protection. *International Journal of Nautical Archaeology*, *30*(2), 299-305.

19. Radić Rossi, I. (2014). Experience in current management of underwater cultural heritage in Croatia; the case of the Protective Cages. *Experience in current management of underwater cultural heritage in Croatia; the case of the Protective Cages*, 45-62.

20. Secci, M., Demesticha, S., Jimenez, C., Papadopoulou, C., & Katsouri, I. (2021). A LIVING SHIPWRECK: An integrated three-dimensional analysis for the understanding of site formation processes in archaeological shipwreck sites. *Journal of Archaeological Science: Reports*, *35*, 102731.

21. Theodoulou, T., Foley, B., Kourkoumelis, D., & Preka-Alexandri, K. (2015). Roman amphora cargoes in the sea of Chios-the 2008 mission. *Per Terram Per Mare: Seaborne trade and the distribution of Roman amphorae in the Mediterranean, ed. S. Demesticha*, 41-54.

22. Zmajic, V. (2009). The Protection of Roman Shipwrecks „in situ". Underwater Museums, in: Bekić, L., & Miholjek, I. (Eds.). (2009). *Exploring Underwater Heritage in Croatia: A Handbook*. International Centre for Underwater Archaeology in Zadar.

23. Αχτύπη, Κ. (2015). Δημιουργία συστήματος αξιολόγησης θαλάσσιων ενδιαιτημάτων τραγάνας (coralligenous) με σκοπό τη διατήρησή τους. *Μεταπτυχιακή διπλωματική εργασία, τμήμα Βιολογίας, σχολή Θετικών Επιστημών, Πανεπιστήμιο Πατρών*.

24. Δελλαπόρτα, Κ.Π. (2005). Υποβρύχια Αρχαιολογική Κληρονομιά στην Ελλάδα: Νομική Προστασία και Διαχείριση, *Νόμος και Φύση*. Retrieved from: https://nomosphysis.org.gr/10093/upobruxia-arxaiologiki-klironomia-stin-ellada-nomiki-prostasia-kai-diaxeirisi-noembrios-2005/ [Accessed on 04/08/2021]

25. Καλαμαρά, Π. (2020). Το ευρωπαϊκό έργο BLUMED από τη σκοπιά της Εφορείας Ενάλιων Αρχαιοτήτων. In: *Το BLEUMED στην Αλόννησο και τον Δυτικό Παγασητικό*, Πρακτικά Ημερίδων, Λάρισα, 25-48.

26. Κουτσούμπα, Δ. (2020). Σεμινάριο για τους επαγγελματίες της κατάδυσης, που πραγματοποιήθηκε στο πλαίσιο του έργου BLUMED. In: *Το BLUEMED στην Αλόννησο και τον Δυτικό Παγασητικό*, Πρακτικά Ημερίδων, Λάρισα, 109-125.

27. Κουτσουφλάκης, Γ. & Campbell, P. (2019). Η αρχαιολογική χαρτογράφηση του αρχιπελάγους των Φούρνων: μία ματιά από το επίπεδο της θάλασσας και του βυθού. In: *Κορσιητών Νήσοι, Αρχαιολογικά ευρήματα και μια προσέγγιση της ιστορίας των Φούρνων Κορσεών*, 168-170.

28. ΥΠΠΟ/ΓΔΑΠΚ/ΑΡΧ/Α1/Φ43/48604/3385 Αρ. φύλλου 1701, 19 Νοέμβριου 2003 και 311/2016 Αριθμός Γνωμοδότησης.

29. Χατζηδάκη, Ε. (1992). Η ανασκαφή του Κλασικού Ναυαγίου της Αλοννήσου. *ΕΝΑΛΙΑ IV, τόμος ½*, 16-25.

CAORLE 1 Shipwreck (II-I B.C.). The ongoing project for a remote protection of the site

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Abstract

The Caorle 1 shipwreck (II-I BC) is located in the upper Adriatic sea at about 28 m under sea level and at 12 nautical miles from the coast of Bibione; so from the legal point of view, it is therefore at the limit of the territorial waters. With the aim of protect this site, the Superintendency has started a collaboration with the University of Udine in order to develop a video surveillance system. The project involves the creation of an apparatus capable of continuously monitoring both the body of water above a submerged site and the actual site. Indeed the system, developed in an energy au-tonomous way, involves sending video streams, collected by underwater cameras installed at various points of the shipwreck, to a management and sorting system located on a buoy, on which additional cameras are placed to also record the surface. The acquired images are also transmitted in real time via satellite to a remote server and recorded. This allows both their distribution for remote use on the web or in a virtual station in the museum. The surface images are instead aimed solely at keeping the area monitored, thus constituting the main element of deterrence.

1. Introduction (M.C.)

The shipwreck of Caorle 1 lies on a flat seabed at a depth of about 28 meters and 12 nautical miles from the nearest point on the coast, which corresponds to Bibione in the municipality of San Michele al Tagliamento (VE). The site is characterized by the fact that the load is contained within a thick concretion rising from the surrounding flat seabed as a small hill. The reading of part of the archaeological deposit was, however, possible in correspondence of two small gashes caused perhaps by the tools used for trawling and in any case enlarged by clandestine tampering [1]. The study of the two amphorae recovered, not necessarily representative of the entire load, are consistent with each other from the point of view of morphological characteristics and fall into the class defined "Lamboglia 2". In particular, the hypothesis has been put forward that these amphorae can

be traced back to a moment of transition from the previous "Greek-Italic" tradition to the Lamboglia 2 class, and can therefore be chronologically framed between the end of the 2nd - beginning of the 1st century BC. On the basis of this information, and especially of the size of the concretion, it seems reasonable to assume that the Caorle 1 shipwreck constitutes what remains of a medium-large onerous ship of the late Republican Age sunk along a sea route that perhaps led to Aquileia. Considering the eco-storica informative potential of this submerged site, in recent years the aspect of its protection has become even more pressing [2].

Figure 1. Caorle 1 shipwreck localization in the northern Adriatic Sea (created by Massimo Capulli; background Image © 2019 Google)

2. Environmental framework (S.F.)

The Adriatic Sea is an epicontinental basin between the Italian peninsula and the Dinaric arc. The strucutral setting is due to the convergence of the African Plate towards Europe and produces the subduction of the Adriatic microplate below the Appennines and Dinarids [3, 4].

The shipwreck lies in the northermost sector of the Adriatic basin. The sea bottom consists of a flat seabed that extends with a slope of about 0.4‰ for an extension of about 300 km from the Gulf of Trieste to the south. The topography of the seabed is quite complex, with undulations of the order of meters and local engravings in the seabed that can deepen by 5 m compared to the surrounding seabed [5, 6, 7].

The northern Adriatic subsoil, in its western part and in the adjacent coastal regions, consists of Quaternary deposits, with thicknesses ranging from a few hundred to a few thousand meters [4, 8]. These deposits are characterized by the alternation of shallow marine and continental sediments that constitute the transgressive system alternating with regressive sequences, a consequence of the glacioeustatic cycles of the late Quaternary [9, 10, 11], and are made up of sands and clays, with all the relative intermediate terms.

After the last interglacial maximum (132–116 ka cal BP) the sea level reached a height of 6 ± 3 m above the current MSL [12]. Then, it dropped with a fluctuating curve, but already below −60 m to 75 ka [13, 14]. This process transformed the Adriatic shelf into a vast alluvial plain that reached its maximum extension during LGM (Last Glacial Maximum), between 29 and 19 ka cal BP [15], when the sea level was 120 m lower than the current level [16, 17].

The geological map in the study area reports continental deposits consisting mainly of overconsolidated gray-yellowish clays containing typical continental faunas. There are also peat bodies and sandy bodies of mainly fine granulometry with variable sorting degree. In this unit, floodplain environments with river channels and marshes are represented. The unit is bordered on the roof by an underwater exposure surface of the MIS5.5 (Map).

The seabed of the Adriatic hosts rock formations that provide a suitable substrate for the development of a peculiar flora and fauna. They are known as tenùe, or trezze [18], that can be divided in "reefs", or organogenic barriers, entirely or almost entirely made by bioconstructing organisms, and "sedimentary rock outcrops", often in the form of plates, on which the organisms create only thin crusts. In any case, any solid body, such as the shells of large bivalves, oysters, or even wrecks, can constitute the core for the development of encrusting organisms that form biostructures. As for the reefs, the main constructing organisms seem to be calcareous algae, then the madreporaries, including *Cladocora caespitosa* and *Astroides calycularis*, bryozoans and serpulid polychaeta. In the case of the covering crusts, the serpulid component appears more reduced in favor of the bryozoans. The algal component varies from area to area and is influenced by the penetration of light, the depth of the outcrop and the turbidity of the water. The concretionary activity is partly balanced by perforator organisms such as clionides and endolytic algae [19].

In the northern Adriatic there is the maximum amplitude of the astronomical tide, 0.81 m. Winds of the second quadrant, such as the Scirocco, which persist for a few hours on the Adriatic basin can cause a sea level rise, while on the contrary, Bora produces a lowering of about 15 cm for an average wind speed of 10 m/s. Meteorological disturbances also produce oscillations in the sea level called sexes. The combined effect of low atmospheric pressure on the Gulf and strong southerly winds can produce a rise in sea level up to about 130 cm above msl, while a high pressure with strong Bora can produce a drop up to about 60 cm below msl. The phenomenon of high water occurs when the maximum of the meteorological tide, with low pressure, strong siroccal winds and the maximum level of the Adriatic seiche, coincides with an astronomical high tide and can exceed two meters above msl.

The northern Adriatic is characterized by two main winds and corresponding wave regimes, strongly influenced by the topography of the basin, stretched in a north-south direction [20]. Surface winds in the Adriatic are also limited by the fetch and duration of the wind. The dominant winds that cause surface waves are the Bora, direction between 23 ° and 67 ° corresponding to the NNE, NE and ENE sectors, and the Scirocco, direction between 113 ° and 157 ° corresponding to the ESE, SE and SSE sectors, in winter and the mistral, from WNW to NW, in summer [21]. Bora and Scirocco can reach levels of storms that can cause extreme waves. The highest wave recorded was 10.8 m during a Scirocco event.

3. The Caorle 1 shipwreck (M.C.)

The shipwreck of Caorle 1, discovered in 1992 and initially called the "algae" wreck [22], as mentioned above, is characterized by the fact that the cargo is contained within a thick concretion; this is 22 m long, 7.5 m wide and rises from the surrounding flat seabed to a maximum height of almost 3 meters. After the first protection activities conducted immediately after the discovery, the site has not been the subject of new actions for over

a decade. For this reason, in the summer of 2006 a new archaeological investigation was started, which had on the one hand the objective of quantifying what happened in the years following the safety operations, which dated back to the period 1992-94, and on the other hand to verify the presence or absence of wooden parts of the hull.

The situation recorded at the beginning of the work highlighted the damage in two distinct areas: one along the northern side of the concretion and consisting roughly in the enlargement of the breakthrough caused before the discovery by the ichthyic activity; the second, instead, represented by a wide gash made on the southern side. A few tens of centimeters from the latter, moreover, there are two small cavities each corresponding to the size of a single amphora. As proof of these hypotheses, it was almost immediately observed that two amphorae were positioned here at the sides of the shell. The intervention promoted by the Superintendence, in all probability, took place in an intermediate phase of the action of spoliation of the site: the clandestines must have proceeded to break the shell and extract the two amphorae, leaving them aside for recovery in a subsequent dive [23].

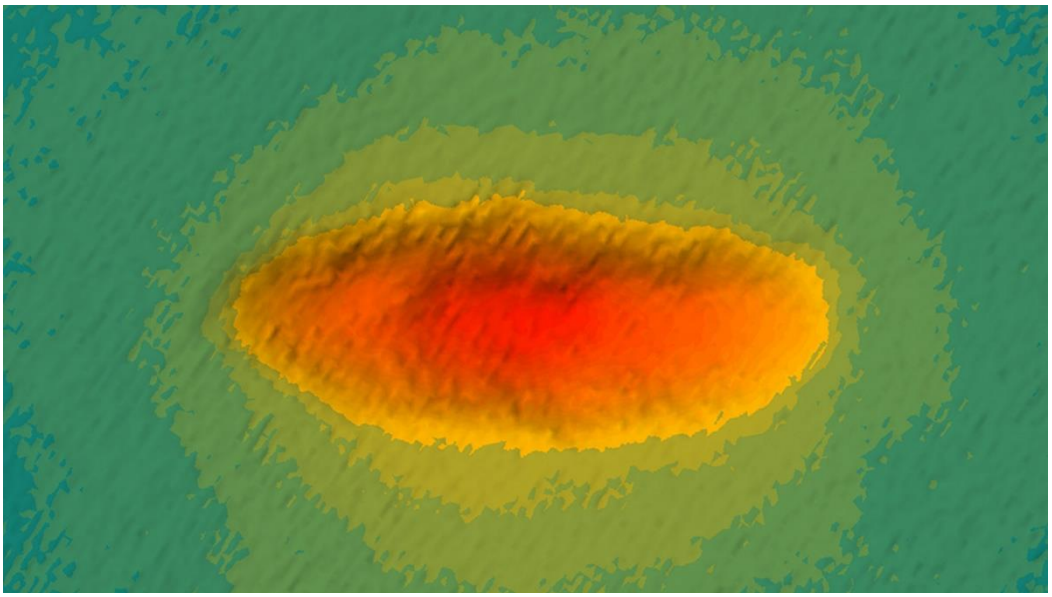

Figure 2. The calcareous concretion detected by multibeam (Elmar s.r.l.)

After proceeding to the recovery of the two decontextualized amphorae and "prepared" for theft, it was decided to exploit the presence of these openings in the concretion and so, before proceeding to their saturation with sandbags, a small excavation essay was opened in the larger one. Already from the observation of this exposed stratification it was possible to better observe how the shell had incorporated the first layers of the amphorae load, as well as the outer edges of the mound until it "melted" with the bottom. However, the surprise came when we dug: in fact, in addition to what was trapped in the large concretion, which we remember as rising almost 3 meters, below the seabed we were able to observe no less than four layers of amphorae with different layouts, all perfectly preserved and obviously free of any encrustation.

The two recovered amphorae are distinguished by a flared rim, with a triangular section, well distinct from the neck and an oval profile body, underlined by a ring found at the connection with the shoulder. The reading of the two transport containers showed a pink colored dough, well baked and compact, with sporadic presence of *chamotte*; on the inside was observed a blackish film that, in absence of analysis, was considered as a circumstantial evidence of wine transportation. As seen these seem to belong to a moment of transition from

the previous "Greek-Italic" tradition to the Lamboglia 2 class, therefore date from the end of the second century BC, early first BC. [24].

The unexpected stratigraphic power found below the concretion and the limited time available for the realization of the exploratory essay, did not allow to reach the sterile layer, nor the desired hull, so it is not possible to confirm the presence or absence of elements of the hull. Nevertheless, it is worth noting the very interesting finding of a fragment of lead sheet of centimeter dimensions in which the presence of a rivet is still clearly legible. This would be an indirect evidence since it was probably part of the system of protection of the living structure from the attack of naval shipworm [25], attested by both literary and archaeological sources.

Figure 3. Amphorae inside the calcareous concretion (Massimo Capulli)

4. Legal framework and protection requirements (A.A.)

From a legal point of view, the wreck lies on the edge of italian territorial waters. On the basis of the international Conventions in force, the 12-mile strip of territorial waters is the concrete territorial extension on the sea of the jurisdiction of a State.

Both the United Nations Convention on the Law Of the Sea (UNCLOS) and the UNESCO Convention for the Protection of the Underwater Cultural Heritage also identify an additional area, up to 24 miles (the so-called "contiguous zone"), in which every State can also protect the underwater cultural heritage. According to national legislation and bilateral agreements for the delimitation of competencies in the Adriatic sector, the wreck can be considered as an integral part of the archaeological heritage of the State and its protection is entrusted to the Ministry of Culture, which operates in the area through the offices known as Superintendencies.

A fairly regular protection of the underwater cultural heritage is carried out mainly in collaboration with the Police forces, equipped with adequate naval means and underwater personnel able to support the archaeologists and technicians of the Ministry of Culture. For the Caorle 1 wreck, at the moment there are no further collaboration agreements with sports or voluntary associations along the coastal strip of Caorle and Bibione.

The calcareous shell that incorporates part of the wreck, if we consider the distance from the coast, has allowed the site to remain in a fairly good state of conservation up to now; the greatest dangers now derive mainly from the numerous anthropogenic disturbances, mainly linked to fishing activities and sporadic forays by divers.

At the time of discovery the wreck appeared intact but with a small gash caused by the tools used for trawling. The Ministry for Cultural Heritage therefore decided to set up a first mechanical protection system by laying tetrapods, sandbags, geotextiles, electro-welded mesh and steel cables. However, this protection system has not discouraged the action of underwater treasures hunters, despite the considerable distance from the coast and the related technical-operational difficulties in diving.

In the last ten years, the wreck has been included in a specific protection program activated by the competent Superintendency. In 2015 some intrusion attempts confirmed the need to realize a more efficient protection system, with the aim of strenghtening the existing protections, thanks to the great advances of communication technologies, and with the aim to be competitive in terms of management costs. The final goal can only be a progressive integration also with the need to broaden the knowledge and enhancement of the underwater cultural heritage of the northern Adriatic.

Based on these assessments the Superintendency has started a collaboration with the University of Udine in order to develop a video surveillance system for this important underwater archaeological site [26].

5. The video surveillance project (M.L.)

5.1. System structure

The whole system will consist of two components: (i) the remote station (henceforth, RS), located near the shipwreck and installed on a buoy or on a beacon, and (ii) the control system (in the following: CS), placed on the mainland.

The RS will be in charge of monitoring the surrounding environment, using several surface cameras, in order to detect any possible danger for the shipwreck. Eventually, as a possible system extension, some other cameras can be placed underwater, to collect images and videos of the shipwreck itself. The RS has to handle two tied issues: the communication with the CS and the limited energy budget. The distance of the shipwreck from the mainland, in fact, does not allow any kind of cable connection. Therefore, the communication must be wireless, and the RS must be energetically autonomous.

All the pictures and videos collected by the RS will be transmitted to the CS which will inspect the images to detect anomalous situations, as a boat approaching the shipwreck location. In that case the system will sends an alert to the administrative staff. The CS has also other tasks, as configuring the RS and recording data. Using configuration command, in fact, the RS will be able to modify the resolution of images (asking more accurate pictures when the environment looks dangerous or reducing the resolution to save energy when the conditions appear safe). Also, configuration commands can also be issued to change the timing of data acquisition, allowing again to choose the best trade-off between sensitivity and energy consumption. The

recording of data will allow a late inspection of events, for eventual investigations aimed to assess intrusions and to identify violators. Moreover, the recorded images and videos can be provided to external users interested to watch the shipwreck as a remote fruition of the site.

5.2. Communication

The communication between the RS and the CS is currently under development. As a first approach, a direct communication as a Wi-Fi connection or a mobile data connection (LTE: 3G or 4G) has been evaluated, but it does not seem viable. Such a solution, in fact, requires a direct sight between the two structures. Considering, for example, a height of 4 meters for the antenna on the RS, given the distance of the shipwreck from the mainland (about 22 km) the antenna of the CS must be placed at least at 18 meters of altitude. Currently, (i) there are no repeaters of mobile data connection at such a height, and (ii) finding a stable point to install a Wi-Fi antenna does not seem an option. Furthermore, for Wi-Fi, a precise pointing of the antennas is mandatory, and this is quite challenging for a system located on the sea. However, it is not excluded that in future phone companies will install a suitable repeater. In that case an LTE solution should be evaluated again.

A satellite connection seems the most adequate in the current setup and it is under evaluation. The overall pictorial representation is shown in Figure 4, where the RS and the CS are both connected to a satellite. We focused on two possible solutions: a motorized antenna and a fixed one. A motorized antenna is able to find the correct pointing to the satellite, hence can leverage the optimal orientation and guarantee a very good transmission channel. However, the pointing motor will require a large share of the available energy, thus reducing the up-time of the RS. On the contrary, a fixed antenna will require much less energy, but the accuracy of the pointing may change over time, hence reducing the quality of the channel and, therefore, the speed of the communication.

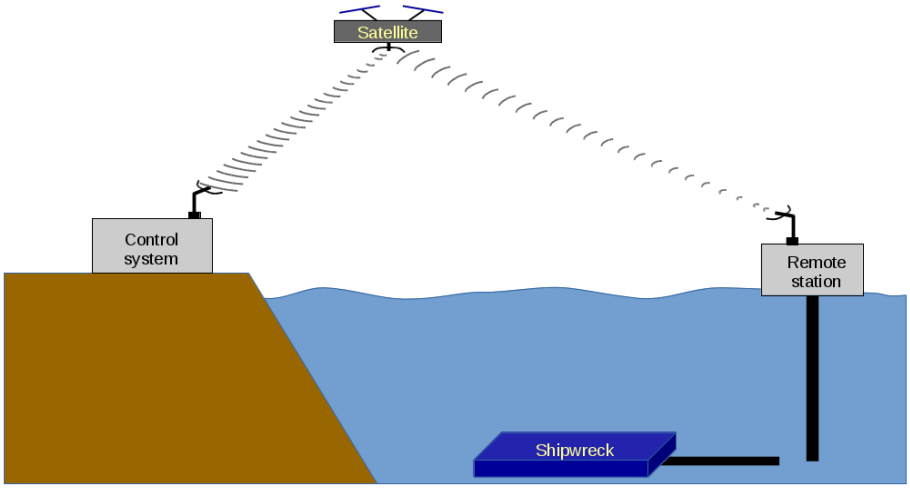

Figure 4. Scheme of the whole system structure with a satellite connection.

5.3. Remote station

The RS will be placed on a beacon, near the shipwreck. As first and low cost installation, we evaluated a buoy that resulted not adequate, since its large rolling and pitching can impact the pointing of the antenna and, therefore, the reliability of the communication. The beacon (actually an “elastic beacon”) is more stable in terms of rolling and pitching, still not being a rigid structure. It consists of a heavy concrete sinker that will keep the structure at a fixed position. To such a sinker a metallic pole is connected through some elastic joints

(from here the name “elastic beacon”). The vertical orientation is ensured by a submerged floater, fixed on the pole. The good stability provided by the beacon solution implies an easier pointing of the antenna, even if not motorized, and, hence, a more reliable communication.

The energy required by the RS will be provided by several photovoltaic cells coupled with batteries that will accumulate the energy surplus, when actually occurring, and provides energy when the solar irradiance is not enough. The energy budget will be affected by the meteorologic conditions and by the seasonal variations of the sunlight. Therefore, the communication and the data acquisition will be regulated by algorithms that will aim at the best possible quality of service.

As stated above, information about the environment will be acquired through some cameras. We will use two cameras for the surveillance: a fish-eye camera and a directional camera. Using the fish-eye camera, the RS can obtain a quick evaluation of the environment, detecting, with a single image, if some anomaly is occurring. The directional camera, equipped with a pointing device, will be in charge of acquiring details at higher resolution. This camera will be pointed to the current most important direction (estimated using the fish-eye camera) or can be occasionally used for a scan of the entire surrounding.

The combined use of these two acquisition units will provide accurate evaluations and a reduced energy consumption, since the (energy expensive) movements of the directional camera will be minimized.

The management of the RS will be implemented with an embedded (programmable) system, equipped with persistent memory storage that acts as a buffer for the acquired images and as an additional backup for data. Such a storage, some simple SD memory cards, is chosen to be cheap and easily replaceable with some fast maintenance operation. The embedded system will be connected to the cameras via PoE (Power-on-Ethernet) connections, in order to reduce the total number of cables required and the complexity of the whole structure. The software running on the programmable board will send, through an Internet connection, the images collected from the camera. Furthermore, after each data transmission, it will expect a command from the CS to regulate its state (rate of data acquisition, resolution of images and videos, communication speed, and so on).

5.4. Control system

The CS will provide storage for all data received from the RS and elaboration of images to detect anomalies. Since it will be placed on the mainland, it will not have energy budget issues, and the computing performance need not be limited.

The software running on the CS will manage the main task of interfacing with the RS. It will receive data and will regulate the operating mode by changing the parameters of the RS. Such a software will also elaborate the images received, by means of image classification features, to detect alarming conditions and, whether needed, it will send alerts to authorities. Moreover, the CS will receive information on the status of the RS, as the health of the hardware components and the ageing of the batteries. Hence, the CS will send notification about the necessity of maintenance (planned or not).

Finally, when the “underwater museum” will be implemented, the CS will also act as a gateway for the access to the stored image. In this way, a remote fruition of the site will be possible by simply connecting to a dedicated web site.

6. Conclusions (M.C.)

The idea of a video surveillance system for the protection of the wreck Caorle 1, and partly also for its valorization, was born in 2013 [27]. Since then, a series of experiments have been carried out and after the promising results, the Italian Ministry of Culture decided to invest in this project developed by the University of Udine.

However, this is still an ongoing project and here we have illustrated the various steps that are being taken to arrive at the final implementation of the system. In the end, this sperimental development of a remote video control system will contribute to a more effective protection action, giving at the same time the possibility for all to observe live images of a submerged site, or better, of a submerged archaeological landscape. This is especially important because cultural heritage, even when submerged, is a public good. Therefore, when it is not possible or proper to recover remnants of the past [28], it is necessary to seek new ways.

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Conflicts of Interest:
The authors declare no conflict of interest.

References

1. Capulli, M. Il relitto Caorle1: problemi di tutela e prospettive future. In *Relitti: che fare? Archeologia subacquea del mare Adriatico e del mare Ionio* (Atti del Convegno, Grado, 4-5 maggio 2010); Fozzati. L., Auriemma, R., Eds.; Aracne: Ariccia, Italy, 2017; pp. 51-56.
2. Capulli, M. Ships of Aquileia. Underwater Archaeological Research for the Study of Marine and Inside Routes in the Upper Adriatic Sea. *Skyllis*, 2013, 13, pp. 18-23.
3. Doglioni, C. Some remarks on the origin of foredeeps. *Tectonophysics* **1993** 228, 1–20.
4. Ghielmi, M.; Minervini, M.; Nini, C.; Rogledi, S.; Rossi, M.; Vignolo, A. Sedimentary and tectonic evolution in the eastern Po-Plain and northern Adriatic sea area from messinian to middle Pleistocene (Italy). *Rendiconti Fis. Accad. Dei Lincei* **2010**, 21. pp. 131–166.
5. Giorgetti, G.; Mosetti, F. General morphology of the Adriatic Sea. *Boll. Geofis. Teor. Appl.* **1969** 11, 44–56.
6. Gordini, E.; Caressa, S.; Marocco, R. New morpho-sedimentological map of the Trieste Gulf (from Punta Tagliamento to Isonzo mouth). *Gortania - Atti Museo Friulano Storia Naturale*. **2003** 25, 5–29.
7. Trobec, A.; Andrej, Š.; Sašo, P.; Marko, V. Submerged and buried Pleistocene river channels in the Gulf of Trieste (northern Adriatic sea): geomorphic, stratigraphic and tectonic inferences. *Geomorphology* **2017**, 286, 110–120.
8. Amorosi, A.; Bruno, L.; Campo, B.; Morelli, A.; Rossi, V.; Scarponi, D.; Drexler, T.M. Global sea-level control on local parasequence architecture from the Holocene record of the Po Plain, Italy. *Mar. Pet. Geol.* **2017**, 87, 99–111.
9. Amorosi, A.; Centineo, M.C.; Colalongo, M.L.; Pasini, G.; Sarti, G.; Vaiani, S.C. Facies Architecture and Latest Pleistocene–Holocene depositional history of the Po Delta (Comacchio area), *Italy. J. Geol.* **2003**, 111, 39–56.
10. Fontana, A.; Mozzi, P.; Bondesan, A. Late Pleistocene evolution of the Venetian-Friulian Plain. *Rendiconti Lincei* **2010**, 21, 181–196.
11. Zecchin, M.; Donda, F.; Forlin, E. Genesis of the northern Adriatic Sea (northern Italy) since early Pliocene. *Mar. Pet. Geol.* **2017**, 79, 108–130.

12. Antonioli, F.; Ferranti, L.; Fontana, A.; Amorosi, A.; Bondesan, A.; Braitenberg, C.; Fontolan, G.; Furlani, S.; Mastronuzzi, G.; Monaco, C.; Spada, G.; Stocchi, P. Holocene relative sea-level changes and vertical movements along the Italian and Istrian coastlines. *Quat. Int.* **2009**, 206, 102–133.
13. Waelbroeck, C.; Labeyrie, L.; Michel, E.; Duplessy, J.C.; McManus, J.F.; Lambeck, K.; Balbon, E.; Labracherie, M. Sea-level and deep water temperature changes derived from benthic foraminifera isotopic records. *Quat. Sci. Rev.* **2002**, 21, 295–305.
14. Benjamin, J.; Rovere, A.; Fontana, A.; Furlani, S.; Vacchi, M.; Inglis, R.H.; Galili, E.; Antonioli, F.; Sivan, D.; Miko, S.; Mourtzas, N.; Felja, I.; Meredith-Williams, I.; Goodman-Tchernov, B.; Kolaiti, E.; Anzidei, M.; Gehrels, R. Late Quaternary sea-level changes and early human societies in the central and eastern Mediterranean Basin: an interdisciplinary review. *Quat. Int.* **2017**, 449, 29–57.
15. Clark, P.; Dyke, A.; Shakun, J.; Carlson, A.; Clark, J.; Wohlfarth, B.; Mitrovica, J.; Hostetler, S.; McCabe, A. The last Glacial Maximum. *Science* **2009**, 325, 710–714.
16. Correggiari, A.M.; Roveri, M.; Trincardi, F. Late Pleistocene and Holocene Evolution of the North Adriatic Sea. *Il Quaternario, It. Journ. of Quat. Sc.* **1996**, 9, 697–704.
17. Amorosi, A.; Maselli, V.; Trincardi, F. Onshore to offshore anatomy of a late Quaternary source-to-sink system (Po Plain-Adriatic Sea, Italy). *Earth Sci. Rev.* **2016**, 153, 212–237.
18. Newton R.S.; Stefanon A. Side-scan sonoar and subbottom profiling in the northern Adriatic Sea. *Marine Geology* **1982**, 46, 279-306.
19. Cerrano, C.; Ponti, M.; Silvestri S., *Guida alla biologia marina del Mediterraneo. Manuale adottato nei corsi della Federazione Italiana Attività Subacquee*. R.D.E.: Milano, 1999; pp. 320.
20. Pomaro, A.; Cavaleri, L.; Lionello, P. Climatology and trends of the Adriatic Sea wind waves: analysis of a 37-years long instrumental data set. *International Journal of Climatology* **2017**, 37, 4237-4250.
21. Favro, S.; Saganić, I. Prirodna obilježja hrvatskog litoralnog prostora kao komparativna prednost za razvoj nautičkog turizma, *Geoadria* **2007**, 12(1), 59–81.
22. Fozzati, L. Il Relitto delle Alghe di Caorle. Relazione Preliminare (1992-1994). *Quaderni di Archeologia del Veneto*, 1995, XI, pp. 48-52.
23. Capulli, M. Il relitto Caorle 1. In *Caorle archeologica tra mare, fiume e terra*; Fozzati, L., Ed.; Marsilio: Venezia, Italy, 2007; pp. 124-131.
24. Toniolo, A. Il relitto Caorle 1. Il carico. In *Caorle archeologica tra mare, fiume e terra*; Fozzati, L., Ed.; Marsilio: Venezia, Italy, 2007; pp. 159-161.
25. Eriksen, A.M.; Gregory, D.; Shashoua, Y. Selective attack of waterlogged archaeological wood by the shipworm, Teredo navalis and its implications for in-situ preservation. *Journal of Archaeological Science*, 2015, 55, pp. 9-15.
26. Capulli, M. The in situ preservation as a priority option. Experiments in the upper Adriatic Sea. In *International Conference in Management of Accessible Underwater, Cultural and Natural Heritage Sites "Dive in Blue Growth"* (Atti del Convegno, Atene, 16-18 ottobre 2019); Kalamara, P., Davidde, B., Eds.; Athens, Greece, 2020, pp. 138-145.
27. Capulli, M.; Rinaldo R.; Asta A.; Boscolo Nale S.; Fozzati L.; Loghi M.; Minguzzi S.; Roberto V.; Saggini S. Siti sommersi in alto Adriatico: un progetto di archeologia e ingegneria per la tutela e valorizzazione in situ. In *Conservazione e valorizzazione dei siti archeologici. Approcci scientifici e problemi di metodo* (Atti del Convegno, Bressanone, 9-12 luglio 2013); Biscontin, G. Driussi, G., Eds.; Arcadia Ricerche: Venezia, Italy, 2013, pp. 1239-1251.
28. Flatman, J. Conserving Marine Cultural Heritage: Threats, Risks and Future Priorities. *Conservation and Management of Archaeological Sites*, 2009, 11 (1), pp. 5-8.

May 13|Session 2: The promotion and protection of Accessible Underwater Cultural Heritage Sites (AUCHS)

NOUS - uNdersea visiOn sUrveillance System at the sea wreck of Peristera, Alonnisos

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The creation of maritime archaeological sites has been an objective of the Ministry of Culture for a long time. One of the main problems that delayed the implementation of the "underwater museums" was the way they were protected.

Usually in ancient shipwrecks, only their cargo is preserved, which is mostly amphorae, that can be easily be stolen. Therefore there was a need and a requirement for a system which should be self-powered (since in most of the places where wrecks are located there is no electrical power supply), should be ableto be connected to the internet with all available technologies for communicationand remote control, should have sensors which can monitor the site of interest continuously and alert appropriately in case of violations, tampering of the siteor other events.

In addition, such a system could have many other useful applications, such as monitoring and surveillance of marine protected areas, realtime scientific observations throughout the day and over long periods of time, monitoring of biodiversity and climate change.

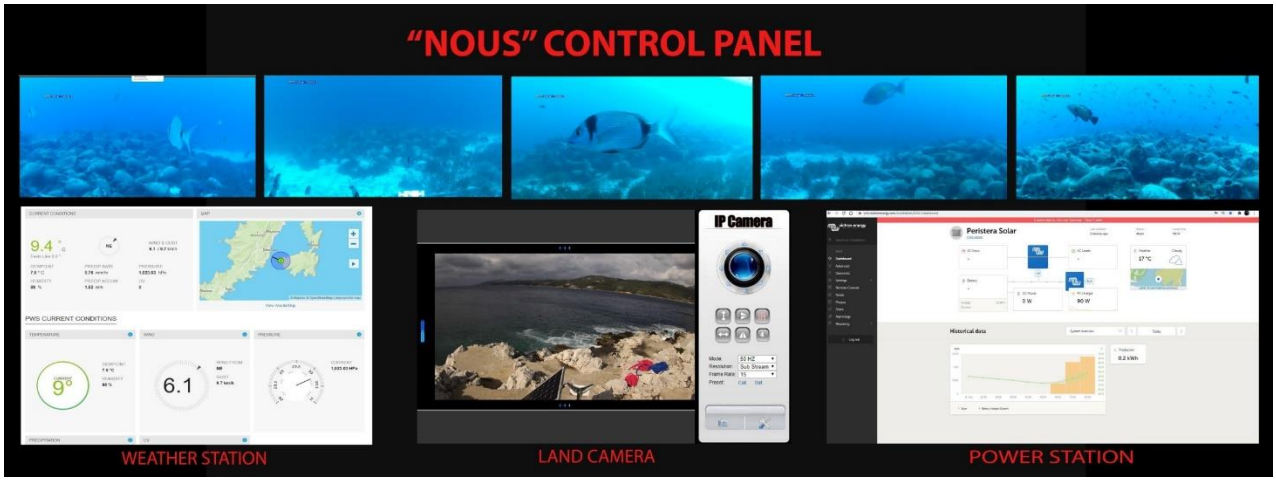
At the beginning of 2019, the design of the Underwater Visual Observation System **"NOUS"** (u**N**dersea visi**O**n s**U**rveillance **S**ystem, which in Greek means **“mind”**) was launched, which was successfully completed a year later.

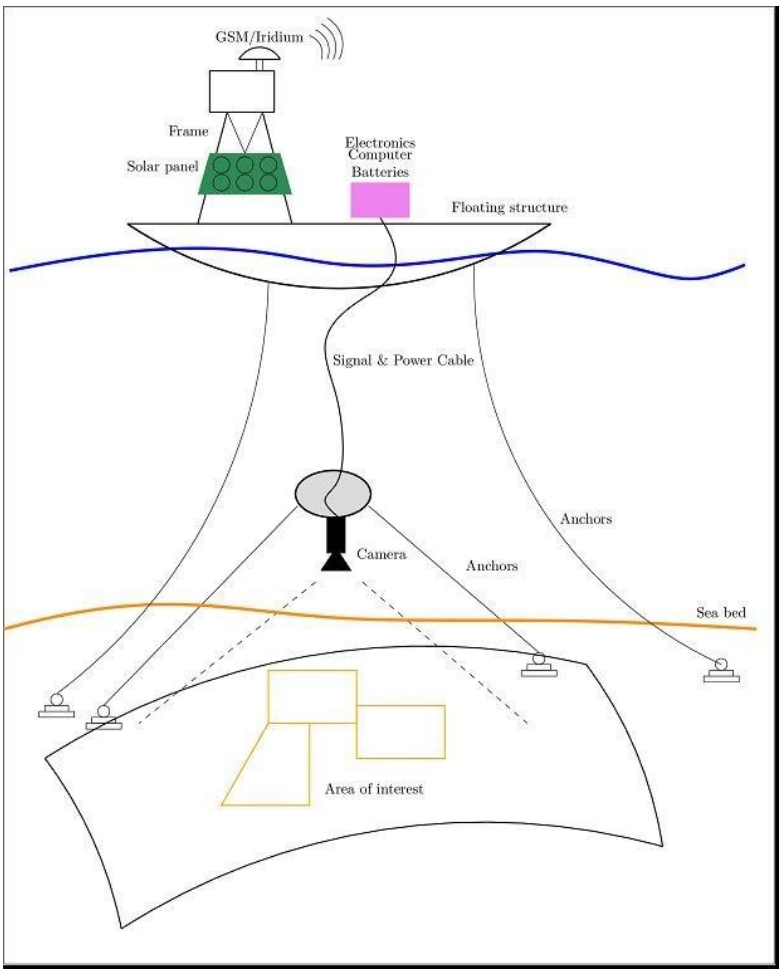
The "NOUS" system allows continuous (24/7) monitoring and protection of an underwater site using machine learning and image and sound processing algorithms.

Briefly, it is a system consisting of an underwater array of self-cleaning cameras and microphones, which are either connected by optical fibre and electrical power conductor to the nearest shore, or to a floating platform on the sea surface.

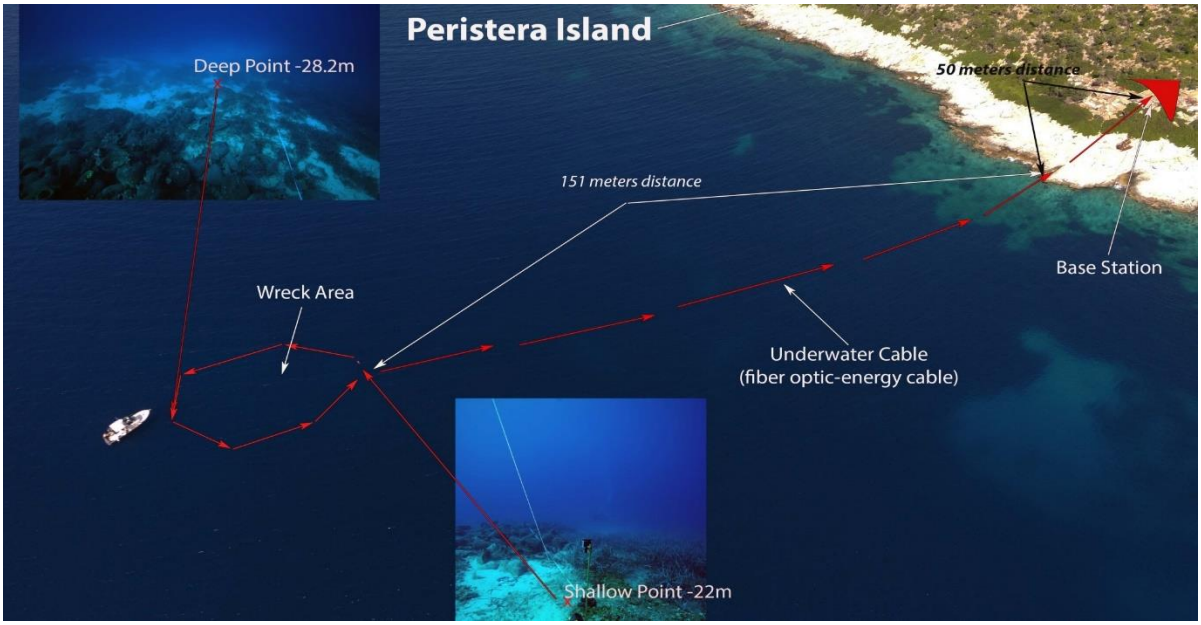
On the shore or on the platform there is a photovoltaic panel power supply and a device for connecting to the Internet with all available technologies.

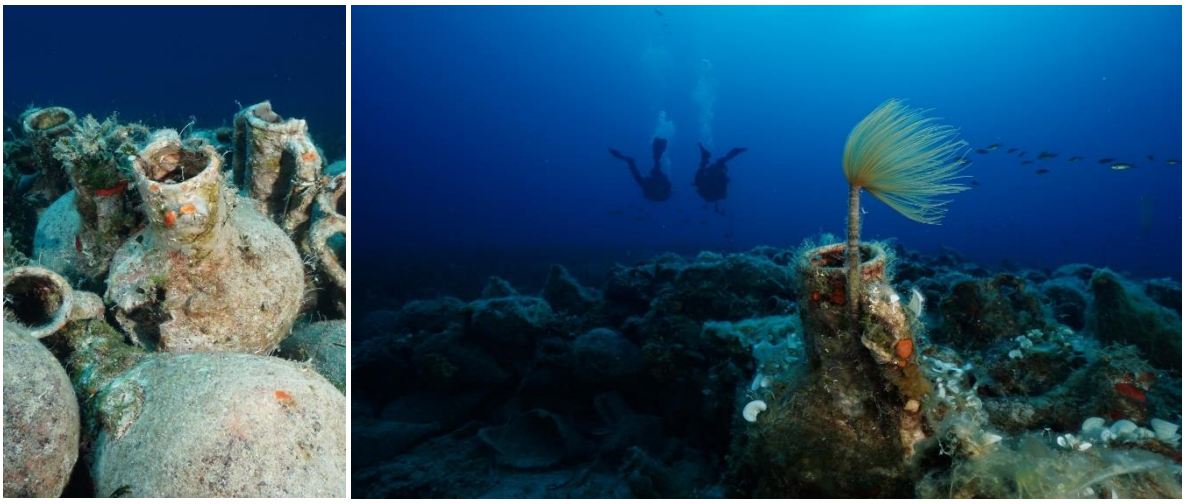
On the occasion of the successful completion of the initial operation phase of the "NOUS" system in Alonissos, more detailed information and perspectives are presented here.

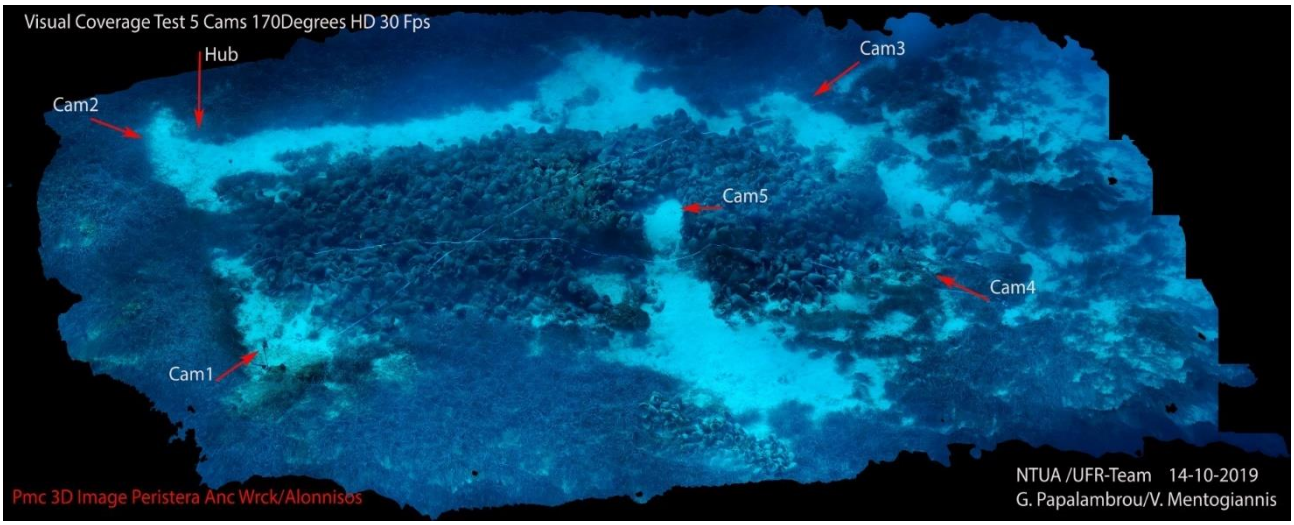




The system was installed in February 2020, at the ancient shipwreck of Peristera, at Alonissos island, Northern Sporades, providing for the first time worldwide the capability for continuous monitoring of an underwater museum. The wreck is located 200 metres from the rocky islet of Peristera and at a depth of 21 to 33 metres.


Peristera Island
Deep Point -28.2m
50 meters distance
151 meters distance
Base Station
Wreck Area
Underwater Cable
(fiber optic-energy cable)
Shallow Point -22m




Visual Coverage Test 5 Cams 170Degrees HD 30 Fps
Hub
Cam3
Cam2
Cam5
Cam4
Cam1
Pmc 3D Image Peristera Anc Wrck/Alonnisos
NTUA /UFR-Team 14-10-2019
G. Papalambrou/V. Mentogiannis

It is a merchant ship loaded with thousands of amphorae from Mendi (the ancient city of Halkidiki) and Peparithos (today's Skopelos), areas known in antiquity for their wine. The pile of amphorae, which extends over a length of 25 metres, gives a sense of the contour and large dimensions of the ancient merchant ship. The ship is described as one of the largest of the classical period in ancient Greece. It is estimated that it could carry about 4,000 amphorae and had a displacement of 120 tons.

The pointed bottom (oxypythmenos in Greek) amphorae are the most common commercial transport vessels of antiquity, weighing about 8-10 kg and having a capacity of 15-25 litres.

They are perhaps one of the most ingeniously invented and practical vessels of antiquity, having two handles to aid transportation, a narrow high neck and a sharp end to allow them to be safely stowed in the hold. The spectacular shipwreck proved that large merchant ships of over 100 tonnes were already sailing in the Medi terranean in the 5th century BC.

The prototype system in Peristera started its pilot operation in March 2020. The project was commissioned and funded by the **Ephorate of Underwater Antiquities / Ministry of Culture & Sports** under the European programme **"BLUEMED MED 2014-2020".**

After the opening on 3 August 2020, divers from Greece and around the world can now dive in Greece's first underwater museum in Alonissos.

The system consists of an onshore section at Peristera and an underwater section at the wreck site. Be- tween the two sections there is an interconnection consisting of an optical fibre and a copper power supply.

Onshore section

The electricity of the system is provided by a fully autonomous system of photovoltaic panels and batteries, installed in Peristera. The sizing of the PV system was based on load requirement estimates, meteorological data for the area and the requirement for electrical autonomy for at least up to 7 days.

In terms of communications, these are wireless of three types. WiFi communication at a frequency of 5 GHz is currently the main form of interface with the remote control station and is carried out via a point-to-point link between Peristera and Steni Vala.

At the land station, visual monitoring of both the site and the sea surface of the wreck is carried out bymeans of a remote-controlled infrared camera.

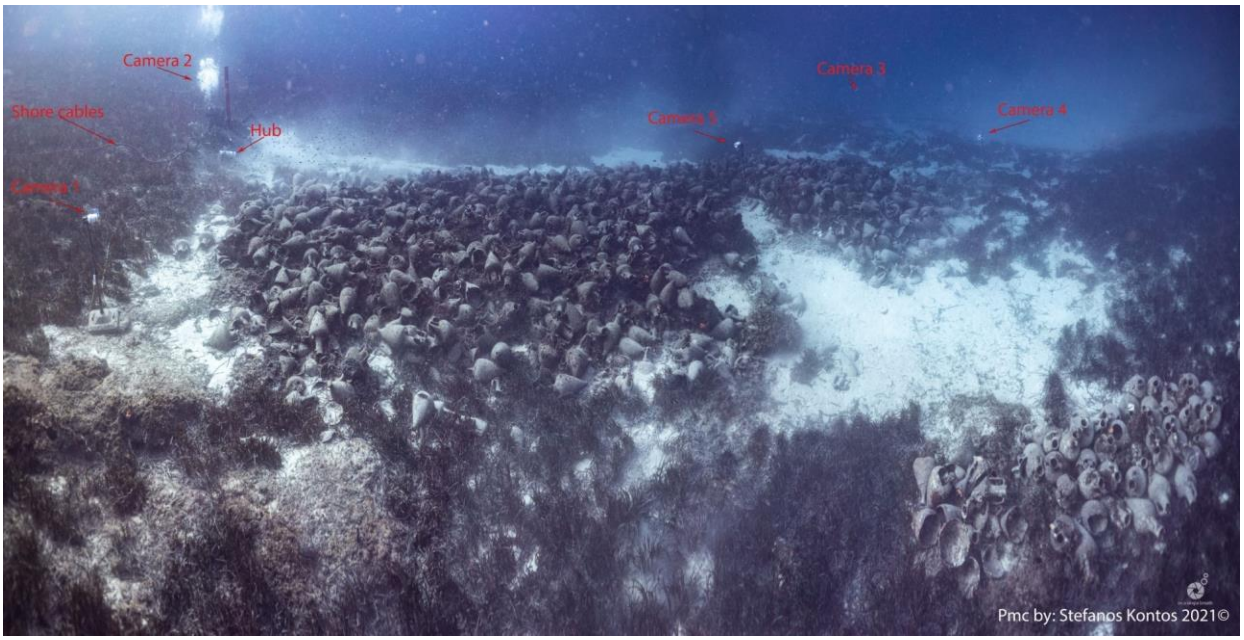
In addition, there is a meteorological station for measuring atmospheric parameters such as air temperature, barometric pressure, relative humidity, wind speed and direction.

There is also an appropriate electrical power distribution and protection circuit and devices for measuring the voltage and current of the power lines, all monitored by the local computer.

Underwater section

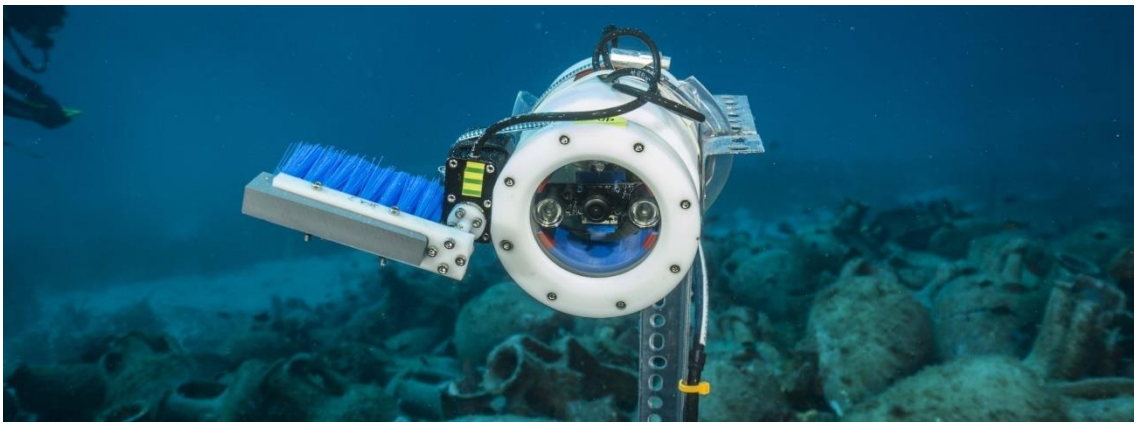
The underwater image transmission system consists of 5 cameras and 1 network switch. Each camera is easily adjusted in height and bearing so that it covers ("sees") the area of interest during the underwater installation.

All cameras send video (stream) in real time over the network for processing to a remote station via the internet.



The underwater cameras are digital, colour, state-of-the-art, with high-resolution technology and have a wide angle lens. Each camera is connected to a local computer, which uses appropriate software to monitor its operating parameters.

It is also possible to install additional instruments such as measuring sensors for the abiotic environment, underwater lights for night observations, lasers, infra-red cameras, etc.



The computer communicates via an Ethernet network with the other devices in the system, for transferring images and measurements (ie electrical quality, speed and network status, etc.).

It has a Linux operating system so that it is possible to add applications, change settings remotely and secure access via ssh protocol.

The computer has an electronic circuit designed for voltage and current measurements, both on the power line and on other consumers (wiper, lights, etc.).

The camera, lens and electronic parts are mounted in a watertight housing (camera housing). The housing is made of thermoplastic, with a removable front part made of transparent crystal and an o ring seal.

The ethernet switch and the fibre-to-copper converter are also located in a sealed hub housing.

The removal of all individual parts is by design easy, allowing for on-site maintenance or replacement of parts of the system without having to lift out of the sea the entire installation.

Wet plugs suitable for the marine environment have been fitted, allowing the cables to be connected and disconnected in the water.

The two enclosures were designed entirely for the needs of the project, taking into account parameters such as depth, mounting, oxidation, cathodic protection and resistance to ultraviolet (UV) radiation.



Particular attention was paid to the ability of disconnection - cut-off of the system. So in case a fishing gear gets entangled in one of the cameras (housing), or "catches" a cable branch, then by the tensile force exerted, this particular branch is disconnected from the rest of the overall installation without pulling apart and eventually losing the whole system.

An automatic cleaning function of the crystal has been provisioned in the camera housing that removes marine deposits that develop over time and reduce the effectiveness of the optical system. Thus, a wi+++per system made for the needs of this particular housing was installed, consisting of a sealed servo motor and a cleaning arm with a rubber cleaning material. The cleaning system is fully and autonomously controlled (via image processing algorithms and optical system quality diagnostics) by the camera computer. During the design phase, the practice of 3D-printer manufacturing was followed for all components to ensure full size functionality.




Software application

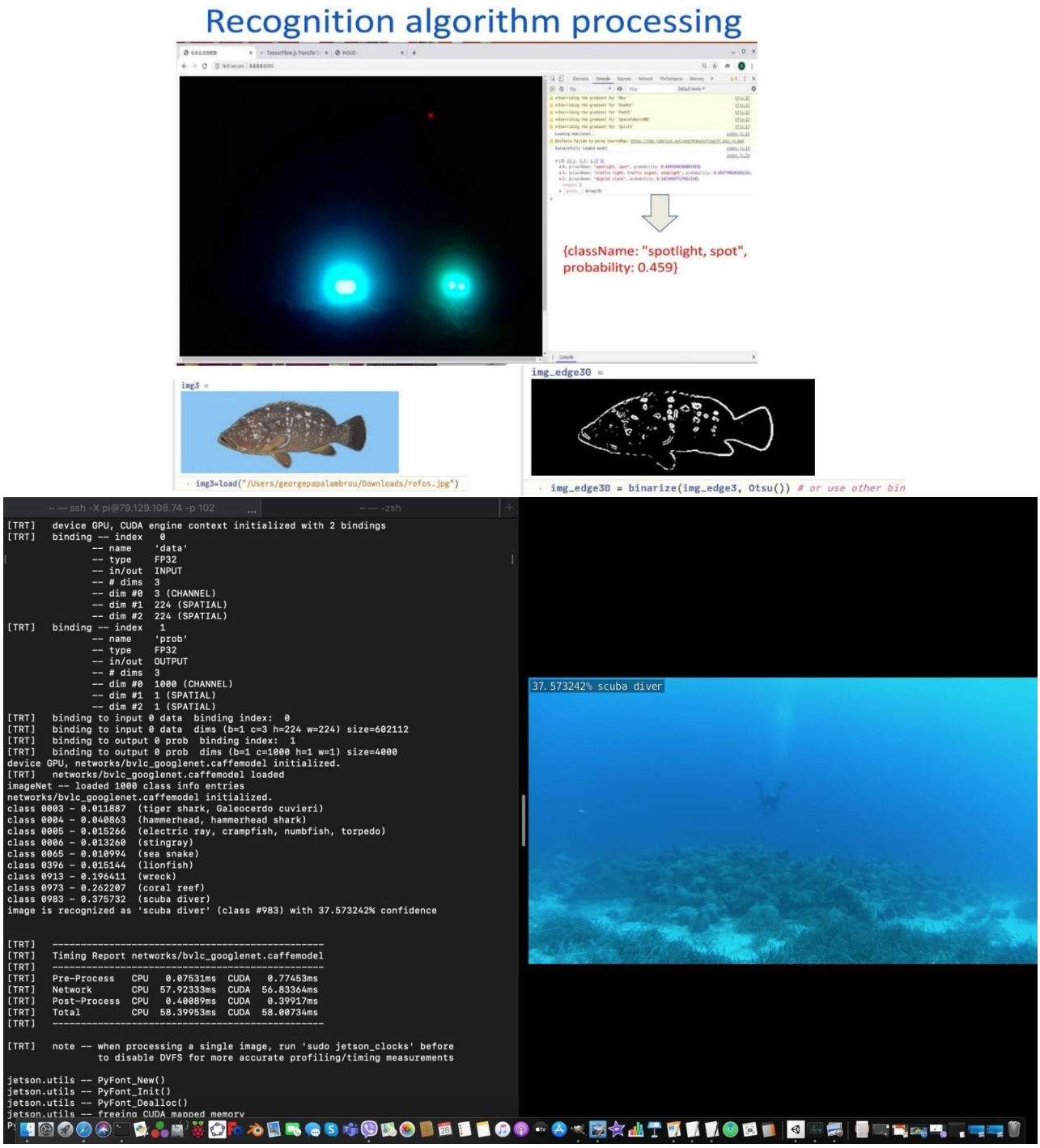
The "NOUS" system has a wealth of automatic monitoring and protection capabilities through machine learning algorithms and image and audio processing. It is thus possible to detect any presence in the area of interest, such as divers, remote-controlled robots-ROVs, as well as the slightest light source in the dark. In particular, any alteration of the area of interest can be identified. In addition, an appropriate algorithm counts and detects the slightest change in the image on the camera housing crystal and, if necessary, immediately activates the wiper.

In all the above cases, an appropriate message is sent to selected recipients to evaluate the change in the area and carry out further investigation.

The machine learning algorithms used allow both the recognition of the object and the determination of its position in the image (object detection). They can also identify and classify their findings into specific categories (classification).

The Artificial Intelligence (AI) system on the "NOUS" uses neural networks that during the "training" phase were adapted to the data of the environment of the wreck monitored in Peristera, the land area of the equipment installation and the marine area on the surface of the wreck.

Different operational scenarios in the wreck area were tested and video and image footage was collected in different phases, such as in calm conditions, with sea turbulence, during daytime and night diving, with use of lighting, ROV passage, different water column turbidities, with creation of debris on camera lenses, the passage of boats and other floating objects.



Perspectives

After the inauguration (August 2020) there has been intense interest from Greek and international stakeholders, both from the diving public that visited the marine museum and from scientists about the potential of "smart" monitoring of marine life which can be continuous and in real time.

The topic was covered by the world's major news agencies and media *1+, *2+, *3+.

After about one year of pilot operation, the system is gradually moving into the second phase of its development, during which it will be enriched with new classes: fish fauna and protected species living in the National Marine Park of Alonissos Northern Sporades (N.M.P.A.N.S.), with the prospect of extending the EEAX Peristera at Stratoni, Halkidiki. In this direction, image processing and classification tests for the fish fauna observed at the wreck site have already started.

In April 2021, Microsoft has chosen to support the biodiversity conservation effort through "NOUS" by providing technical support on AI issues and access to its computing infrastructure in the form of a grant, supporting the proposal "Machine Learning and Real Time Monitoring for the conservation of marine life with emphasis on seahorses".

More information can be found on the NOUS website at https://nous.com.gr.

References

1. L. Papadimas, V. Triantafyllou, Ancient 'Acropolis of the sea' opens to divers, guarded by high tech, Reuters, 30/7/2020, https://www.usnews.com/news/world/articles/2020-07-30/ancient-acropolis-of-the-sea- opens-to-divers-guarded-by-high-tech
2. M. Atmatzidou, Diving into Greece's first underwater museum, National Geographic, 2/12/2020, https://www.nationalgeographic.com/travel/article/diving-into-the-first-underwater-museum-in-greece?cmpid=org=ngp::mc=social::src=facebook::cmp=editorial::add=fb20201202travel-greeceunderwatermuseum::rid=&sf240674775=1&fbclid=IwAR2PjCSz2WoJF0V1pgg1YsWl9ILtjy3M4r916F_rH_IPw0p-KVikgQINNuU
3. Y. Elafros, Science Culture, "Shipwreck surveillance gets Microsoft funding", Kathimerini, 27/4/2021, https://www.ekathimerini.com/culture/1160037/shipwreck-surveillance-gets-microsoft-funding/?fbclid=IwAR27xKef-CL6jDZa8m--j1yBVhBfR0CNOY3tgwG_Fc-5uJ3Q0iV0UOFOtwQ

Underwater Parks of the Northern Black Sea Region and Sustainable Development of Tourism

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Keywords: underwater parks, recreational diving, blue growth, underwater technology, sustainable tourism

Abstract

One of the basic principles of preserving the underwater cultural heritage is the organization of storage and access to it on the spot in such a way as not to harm it. To date, hundreds of underwater archaeological sites have been explored in the Northern Black Sea region, some of which can be used in tourism or are already visited by divers individually or through diving centers.

In Russia and Ukraine, about 250 thousand divers and about a thousand diving centers and clubs are together. The main number of divers in these countries dives into the Black Sea, where they get acquainted with diving and for beginners. This mainly happens in the summer months. The Northern Black Sea region is a place of intensive tourism development. In 2019, 17.5 million people rested in the Krasnodar District, in the Crimea - 6.9 million people. In Odessa, Nikolaev and Kherson regions, about 4.3 million people rested together. About 0.5% (140 thousand people) of this number knew the joy of diving with scuba diving in warm Black Sea water.

The lack of prepared underwater routes until recently significantly reduced the possibilities of scuba diving in the Northern Black Sea region. Over the past 5-6 years, the situation has begun to change. Projects for the creation of underwater parks began to appear. Already, diving centers have organized underwater routes that specialize in attractive underwater landscapes and flooded objects of the First and Second World Wars. Some of them specialize in underwater archeology. The proposed report informs about the current state of underwater parks and underwater routes of the Northern Black Sea region and how the situation with underwater archaeological parks will change in the near future. The ideas proposed as part of the development of the concept of Blue Growth are productively used by the diving industry to promote the territory among tourists.

Sustainable and Resilient Management of Underwater Cultural Heritage (UCH) in Remote Mediterranean Islands: A Methodological Framework

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Keywords: Mediterranean Island Regions, Underwater Cultural Heritage (UCH), Heritageled Local Development, Participatory e-Planning, Social Networks

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Promotion of Accessible Underwater Cultural Heritage Site (AUCHS) on the example of an XVIIIth-century frigate that sank in the Aegean Sea

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Keywords: frigate "St. Theodore", wreck, exhibition, Mediterranean`s corsairs

Abstract

Our team of underwater archaeologists (ANO Underwater Archaeological Society), historians and museologists make a project to promote the frigate "St. Theodore". This frigate where Russian and Greek sailors served. It is possible to create (AUCHS) on its wreck. It sank as a result of a strong leak in the Aegean Sea near the island of Agios Efstratios in 1771. The ship's documents indicate that Russian and Greek sailors were on board and all of them were rescued by Greek corsairs. The location of the wreck suggests that amateur divers can dive here. At the bottom, it is assumed the presence of fragments of a large sailing ship, cast iron cannons and anchors. The island of Agios Efstratios as a significant part of AUCHSs is far enough away from tourist centers and a long excursion is needed to visit this wreck. That's why serious advertising campaign is needed. Our report offers creation of a virtual museum exhibition about the ship "St. Theodore" and about the events in which she participated. Such an exposition will consist of copies of documents from archives, 3D models of ships, video materials about the history of the discovery of the wreck, reconstruction of the death and recreation of its original appearance using augmented reality technologies. In addition, it is possible to broadcast the wreck online using deep-sea video cameras. Such an exposition can be exhibited in museums, travel agencies and online in Internet. As an example of promoting, our team plans to present the exhibition "Corsairs of the Mediterranean Sea", which illustrate the actions of Greek corsairs during the Russian-Turkish war 1768-1774.

An Archaeopark proposal in the Black Sea in the light of underwater research of Ancient Calpe Port

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Keywords: Calpe, Shipwreck, Ancient Port, Underwater Archaeology, Nicomedia

Abstract

Ancient Calpe Port was established on a natural bay in modern Kerpe, located in Kandıra district on the Black Sea coast of Kocaeli (Nicomedia). The name Calpe is mentioned in the ancient writer Xenophon's work Anabasis. The port is a good example of the Ancient Black Sea ports in terms of its period, location, construction technique, and plan. Therefore, it has been an important trade center since ancient times.

Underwater surveys were carried out here by Kocaeli Archaeology Museum Directorate in 2020. As a result of these surveys around the port, wrecks/ruins that have survived to the present day have been identified. Additionally, apart from the intact wooden pieces, many terracotta (amphorae, oinochoe, plates, sherds, etc.) artifacts belonging to these shipwrecks were found. In the following years, excavations will be carried out in this area, the depth of which will vary between 2-8 meters. It is planned to reveal the underwater cultural heritage of the region at accessible depths.

Currently, there are diving centers for tourism purposes in Kerpe. With this project, it is aimed to create sustainable underwater tourism areas. The shipwreck areas would be an exceptional cultural tourism attraction for diving enthusiasts; short diving sessions are planned to be held during scientific excavation works. Moreover, it is among our aims to establish an underwater museum in Kerpe with the data obtained from the excavations and research.

1. Introduction

This study aims to emphasize the importance of transforming the area into an underwater archaeopark and touristic diving point in the context of the findings from the underwater research in the Ancient Calpe Port.

Ancient Calpe Port is located in Kerpe Town of Kandıra District of Kocaeli Province in modern Turkey today. In the literature research, Calpe Port has been frequently mentioned in ancient sources and modern research. The port is a good example of the Ancient Black Sea ports in terms of its period, location, construction technique, and plan. Therefore, it has been an important trade center since ancient times.

Underwater surveys were carried out in Calpe Port by Kocaeli Archaeology Museum Directorate in 2020. As a result of these surveys around the port, wrecks that have survived to the present day have been identified. Additionally, apart from the intact wooden pieces, many terracotta (amphorae, oinochoe, plates, sherds, etc.) artifacts belonging to these shipwrecks were found. In the following years, excavations will be carried out in this area, the depth of which will vary between 2-8 meters. It is planned to reveal the underwater cultural heritage of the region at accessible depths.

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2. Materials and Methods

The port was built in a deep place within the natural bay. The ancient port of Calpe, with its natural bay in the Northwest direction, which is not affected by the strong winds and roughness of the Black Sea, has been the shelter of the ships sailing in the Black Sea for hundreds of years. All findings obtained within the scope of the underwater study were terracotta. Amphorae constitute the majority of the findings obtained from the research (13 of 23 artifacts found). All formal features of the amphorae were compared with similar samples in order to conduct dating and origin analysis. The density of amphorae in the study reflects the traces of commercial activities.

Due to the lack of extensive research on the area, information regarding the region could be reached from ancient sources and texts written by travelers. This research has certified the accuracy of the information obtained about the Ancient Calpe Port. Nevertheless, the data obtained has shown that many more archaeological findings can be reached in possible in-depth research in the area.

3. Results

Kerpe / Calpe was located within the borders of the Bithynia Region in Ancient Age Figure 1. We do not have any information about when the settlement was first established. However, it is thought that Calpe was founded as an emporion and port in the 7th century BC by the colonists of Miletus or Megara in order to expand, protect, and use the maritime trade routes in the Black Sea (Strabo, 55). The mention of "Calpe Port" (κάλπη) in Xenophon's Anabasis indicates that the settlement where the port is located was in use during the Classical Period. Xenophon mentions the use of the port of Calpe around 400 BC. He refers to the crowded villages in the region, the abundant agricultural products, and the wealth of trees that could be used for shipbuilding (Ksenophon, 199).

In his quotations, Polybius states that the kingdoms of the Hellenistic Period in the Aegean and Mediterranean exported raw wood from Kalpe and its surroundings to be used in shipbuilding (Polybius, 88). In the same period, it can be thought that the port became a commercial or military transport center from the Black Sea to the city of Nicomedia or from Nicomedia to the Black Sea (Hannestad, 2007).

The whole kingdom was transferred to Rome around 74 BC by the King of Bithynia, Nicomedes IV, and became a province of Rome. In the following ten years, with the conquest of the western part of the Pontus Kingdom in the East, the province began to be called Bithynia et Pontus (Doğancı, 2003).

The historian Nicomedia Arrianus, a Roman citizen, born in 86 AD and familiar with Greek culture, mentioned that the Port of Kalpe was a sheltered port suitable for the use of large ships with its form and depth (Arslan, 2005, 25). It is estimated that the commercial and military road, starting from Chalcedon and continuing to Trabezos, visited the port, which is named Calpes Portus in ancient sources (Miller, 1916, 638). Around the 13th century, when Calpe and its surroundings were under Byzantium control, the settlement in the Black Sea continued to be at the forefront as Carpi Port (Baldwin, 1985).

The port of Calpe and its surroundings, which developed with its sheltered port from the rough waters of the Black Sea when trade was intense, and its easy access to the central cities by land, can be considered quite far from its ancient state today. The ancient form of the port and its surroundings, which was at the forefront during the colonization of Miletus, Roman, Byzantine, and Ottoman, could not be preserved until today.

Nonetheless, the data obtained from the ruins can give an idea about the characteristics of the port. Today, some of the pier ruins of the harbor are located on land, and some are underwater. Port ruins, most of which are underwater, have a length of approximately 80 meters and a width of 36 meters.

The breakwater is scattered over an area of approximately 2000 square meters in the northeastern part of Calpe Bay. It is estimated that the breakwater was built in the northeast-southwest direction against the waves (Aslan 2014). The remains close to the land have been preserved in-situ with the support of their location on the bedrock. As the slope of the bedrock increases towards the water, the number of blocks used in the breakwater increases as well. According to the in-situ blocks, it is understood that the crate-type wall technique was used in the construction of Calpe Harbor (Højte, 2008). The port of Calpe, which was actively used by the Roman, Byzantine, and Genoese until the Ottoman period, continued its function and existence throughout the ages, and today it only consists of scattered blocks.

In 2020, underwater surveys were conducted at four main dive sites in Calpe Bay. Three of these dives were carried out on the north side of the bay and the other on the southwest side Figure 2. In the first dive site, the presence of exposed amphorae and potsherds, and pieces of wooden ships were observed. Metal Y anchor fragments and amphorae were documented in the second and third dive sites. In the fourth diving area, the remains of the breakwater and potsherds belonging to the Calpe Port were seen Figure 3. In general, we can list the unearthed artifacts in the areas as amphorae and potsherds, ceramic plates, ceramic lids, and jugs.

3.1. Amphorae

3.1.1. Catalog No: 1

The terracotta amphora has a height of 56 cm and has a broken rim and a thin neck. Its body is grooved and cylindrical. In terms of its form, the find was used in the 6th century AD around Sinop and the Black Sea with its carrot-shaped double handle, grooved body, and long neck. This amphora originating from Sinop is called Sinope B/C1 (Tezgör et al., 2003). Sinop B/C1 is a common rim-to-bottom groove-coated sample and exactly matches the sample from the Calpe Figure 4.

3.1.2. Catalog No: 2

A terracotta amphora is 60 cm high and has a conical body that tapers towards the base. The bottom part is pointed; the mouth, neck, and handle parts are broken and missing.

Amphora shows similarities with Proto-Rhodian Type or Chios Type 5 according to Doğer (Doğer, 1991, 86-87) and Chios Type IVc according to Özbay (Özbay, 2019) in terms of form structure. Similarities such as the conical form of the body tapering towards the bottom and the placement of the seating tip at the bottom show that

the amphora resembles both types. However, the fact that the shoulder part forms a hard corner on the note where it meets the body suggests that the amphora looks more like Chios Type IVc. This type emerged as a subgroup of type IV, which developed until the end of the 4th century BC. The island of Chios wine amphora type was produced from the 5th century BC to the 3rd century AD. It has spread over a wide area from Morocco to the Black Sea coast. It is known that the Chios type was widely used, especially in the colonies in the Black Sea Figure 5. 3.1.3. Catalog No: 3

The terracotta amphora is 41 cm high. It has a bulging oval body, and the upper part of the body is broken and missing. The amphora, whose neck, handle, and mouth parts are not visible from the top of the body, resembles the Pamphylia Type IV amphora with its curved and swollen body structure and non-grooved surface. This type, which has been used since the second quarter of the 1st century AD, can be seen in many centers under Roman rule (Grace, 1973). In terms of the figure, it is seen that the Agora of Athens resembles the Group F 95 example. F95 is dated to the 1st century BC (Robinson, 1959, 20) Figure 6.

3.1.4. Catalog No: 4

The amphora is 46 cm high. The upper part of the body is broken and missing. The amphora has a conical form that narrows from the body to the bottom. At the bottom, we see that its form, which narrows down from the body, protrudes outward. This form is a structure that can be associated with the usage of the amphora. Amphora can be evaluated typologically with its conical structure and outwardly curved bottom part, considering the deficient features at hand. With these features, it resembles the form Herakleia Pontike Type 3 Figure 7. This type appeared around the 3rd century BC (Doğer, 1991, 118). According to Dominique Kassap Tezgör, these vessels were used from the beginning of the 4th century BC to the middle of the 3rd century BC (Tezgör et al., 2003, 169).

3.1.5. Catalog No: 5

The terracotta amphora has a height of 37 cm. The upper part of the body, whose entire exterior consists of grooves, is broken and missing. Physically, it resembles the Sinope B amphora type and is dated to around the 7th century AD (Tezgör et al., 2003, 177-178). According to Khalvashi and Inaishvili, this type is called Type D Sinop I. Since the shoulder, mouth, and handle parts are broken and missing, it is necessary to interpret the work using its grooved form and the form of the rest. The amphora shows Sinope B characteristics with its groove density. It has been used extensively in the Black Sea (Tezgör et al., 2003, 177-178; Khalvashi & Inaishvili, 2010, 499) Figure 8.

3.1.6. Catalog No: 6

The terracotta amphora has a height of 28 cm. The work has a rounded protruding lip and an inward narrowing neck structure. It has double handles, which are located between the shoulder and neck. The part from the shoulder to the bottom is broken and missing. It was used in the late and the early 6th century AD until the 8th century AD. It is similar to the Late Roman 13 (LR 13) amphora type. Mouth, neck, and handle structure constitute these similarities. The origin of the LR 13 Amphora goes back to Amathus and Paphos. It has spread from the Eastern Mediterranean to the Black Sea region (Riley, 1975; Briese & Vaag, 2005, 169) Figure 9.

3.1.7. Catalog No: 7

Considering the wine exports made with Chios amphorae in the 5th century BC and 4th centuries BC, it is seen that it spread to the colonies in the Black Sea, as far as Sicily in this period (Doğer, 1991, 16). Developing from Type 4 at the end of the 5th century BC and the beginning of the 4th century BC, such amphorae consist of a

very high neck, angular shoulder, conical body, and a truncated conical handle clearly separated from the body (Doğer, 1991, 86). The find obtained from underwater studies is called Chios type 4 and is dated to 430/420-400 BC. It has a broken and narrow mouth, a thin bracelet lip, a long narrow neck, and long double handles that connect from neck to shoulder; however, the lower part of the neck and handles are broken and missing Figure 10.

3.1.8. Catalog No: 8

The artifact, which has brown tones, has a rim diameter of 10.2 cm and is 24.5 cm long until the broken part. It resembles a Rhodes amphora in form. It is dated to the end of the 3rd century BC and the beginning of the 2nd century BC. Its origin is Rhodes, and its distribution area is the Eastern Mediterranean, Aegean, Russia, France, Spain coasts (Grace, 1963, 323-325). It has a broken and narrow mouth, a thin bracelet lip, a long narrow neck, a slightly convex upper neck part, a downward narrowing neck structure with double handles connecting the neck to the shoulder, and deep grooves on the inside. However, the lower neck and the handles are broken and not present Figure 11.

3.1.9. Catalog No: 9

The piece of terracotta amphora has a height of 11 cm. Most of the find is broken and incomplete. This amphora fragment resembles the Late Roman 1 (LR 1) amphora type, which was used between the 5th and 7th centuries AD, with the outward-turned lip structure, the neck form narrowing from the shoulder to the mouth, and the partial shape of one of the handles (Hill, 2016, 10). It is known that these amphora samples were widely used throughout the Mediterranean (Peacock & Williams, 1986, 186) Figure 12.

3.1.10. Catalog No: 10

The terracotta amphora has a height of 38 cm, and the rim of the flat short-necked work is broken. The neck should have double handles between the shoulders. Grooves can be observed on the body. It has a torpedo form. It shows similarities with the Late Roman 1 (LR1) amphorae produced in the late periods 5th century AD. early and 7th century AD. The torpedo appearance of the amphora, the grooves on the bottom of the handles, and the thick handles reflect the Late Roman 1 features produced in the local production areas of Western Cyprus, Rhodes, and Caria on the southern coasts of Anatolia. This amphora type is known to be seen in North Africa, the Eastern Mediterranean, and the Black Sea (Peacock & Williams, 1986, 186), (Hill, 2016, 10-12) Figure 13.

3.1.11. Catalog No: 11

The upper body is broken. It has grooves on it. It has a thick wall. It resembles Spatheion 3 Type B Amphora in terms of wall and structure. However, there are grooves on this work, the bottom part is shorter, and the upper part is completely broken and absent. It resembles the P66 form found in the Yassıada shipwreck in terms of wall thickness and shape. The example on Yassıada is dated to the end of the 6th century AD and the beginning of the 7th century AD (Bonifay, 2004, 124-129); (Bass et al., 1982, 181-182) Figure 14.

3.1.12. Catalog No: 12

The terracotta amphora has a height of 38 cm. Its spherical-shaped structure has a grooved surface on the body. The handles are ear-shaped, and the neck is short. There are some fractures in the body part of the Byzantine period work. It resembles the Late Roman 5/6 (LR 5/6) amphora type, which was produced from the early 6th century AD to the 7th century AD, with its bag-like form, and smoothness from the mouth, neck, and bottom to the handle. We can show that the work has semicircular ear-shaped handles and that the

grooves expand on the body and tighten towards the bottom as other similar sides (Hill, 2016, 20). It has origins in the Eastern Mediterranean, Egypt, and Palestine. It is known to spread to the Aegean, Cyprus, and Carthage Figure 15.

3.1.13. Catalog No: 13

The amphora has a height of 32 cm. The work has a body form that expands from the shoulder and has a straight muzzle and a short neck. It has a grooved surface starting from the handle level between the shoulder and the body. The bottom of the body part is broken and missing. This type is similar to the Günsenin 4 amphora type with features such as the grooves on the shoulder between the beginning and the end of the handle, the form of the handles, and the mouth starting with the handle combination. This amphora type was produced between the 12th and 14th centuries AD, is known to be a vessel of Black Sea origin, and has spread in the Marmara and Black Seas (Hill, 2016, 40), Figure.

4. Conclusions

The density of amphorae among the finds reflects the traces of commercial activities. The fact that the amphorae belong to different time periods indicates the active use of the port in the historical process, rather than a single shipwreck Figure 17. Four of these amphorae are of Black Sea origin. The remaining eight amphorae are thought to be widely distributed products in the Mediterranean and surrounding regions. According to the studies, the earliest one is dated to the 4th century BC and the latest one to the 14th century AD. The general density is between the 3rd and 7th centuries AD.

Among the amphoras, Late Roman 1 (LR 1), Late Roman 5/6 (LR 5/6), Late Roman 13 (LR 13), Khios IVc, Rhodos, Pamphylia 4, Spatheion 3 Type B are of Mediterranean and Aegean origin. On the other hand, amphorae of Black Sea origin such as Herakleia Pontika 3, Sinope B/C1, Günsenin 4 were obtained.

Apart from the findings documented during the underwater survey, many more potential findings can be unearthed with an underwater excavation that would be carried out in the area. A scientific underwater excavation followed by conservation activities should be initiated in the area for artifacts vulnerable to damage that may result from marine and human factors. In this way, underwater ancient artifacts can be transformed into cultural assets and delivered to society. Thus, cultural assets can be promoted, and as a result, they can be transferred to the future by placing them in the social memory. In order to clarify and support the assumptions made in the examinations, it is of great importance to conduct in-depth research in the field.

Today, the Kerpe town, which is at the forefront of summer tourism, can be turned into an area where archeological and historical tourism can be revived with diving tracks to be established in the area after underwater excavations and research.

Figure 1. Bithiynia Region, Calpe and Surroundings

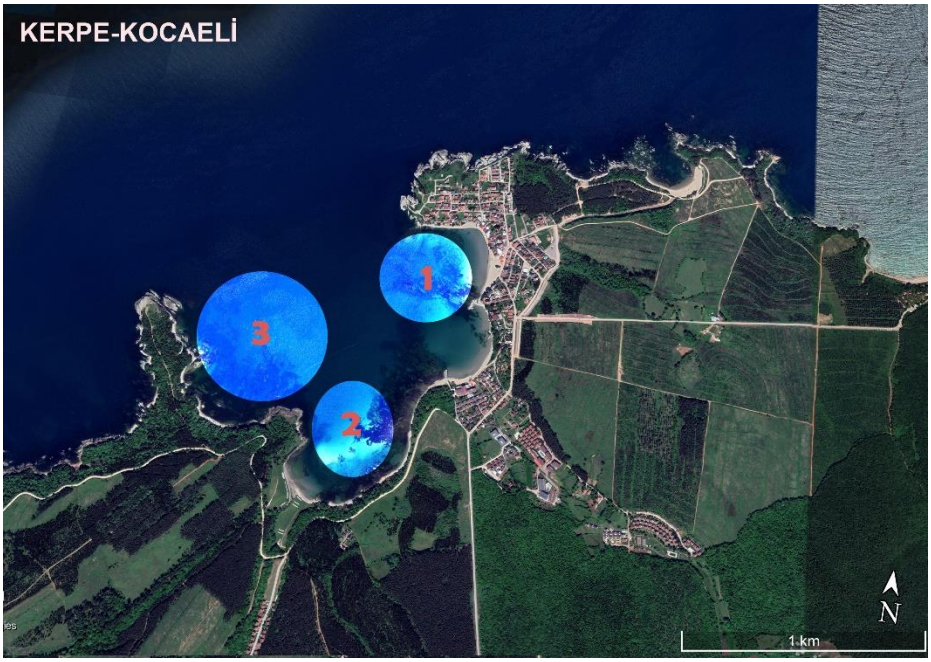

Figure 2. Study Areas of Underwater Research on the Black Sea Coast of Kocaeli in 2020

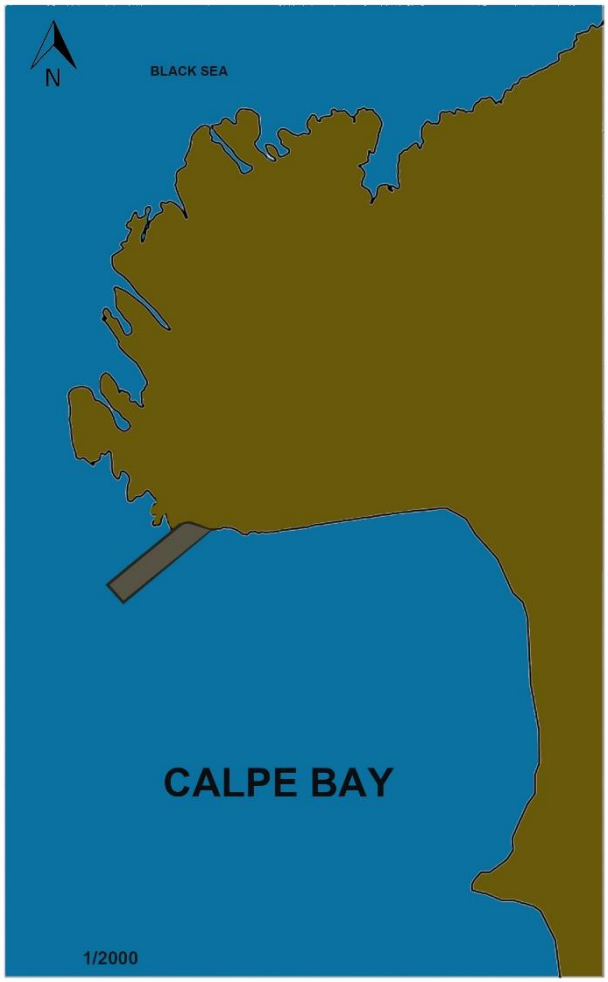

Figure 3. Plan of Calpe Ancient Breakwater and Port.

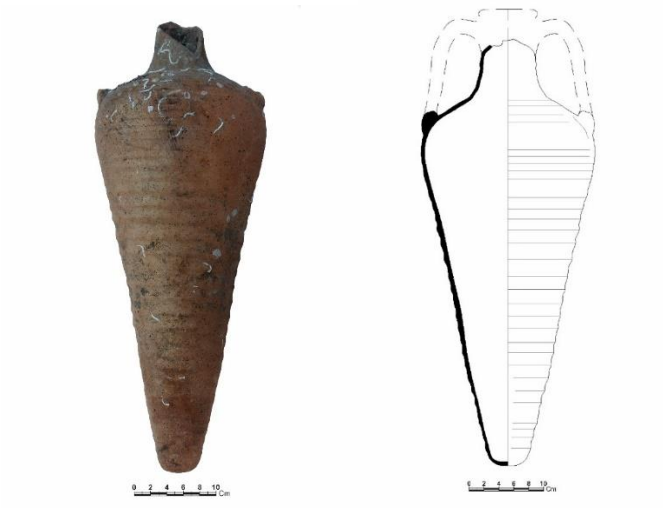

Figure 4. Catalog No: 1 Sinope B/C1

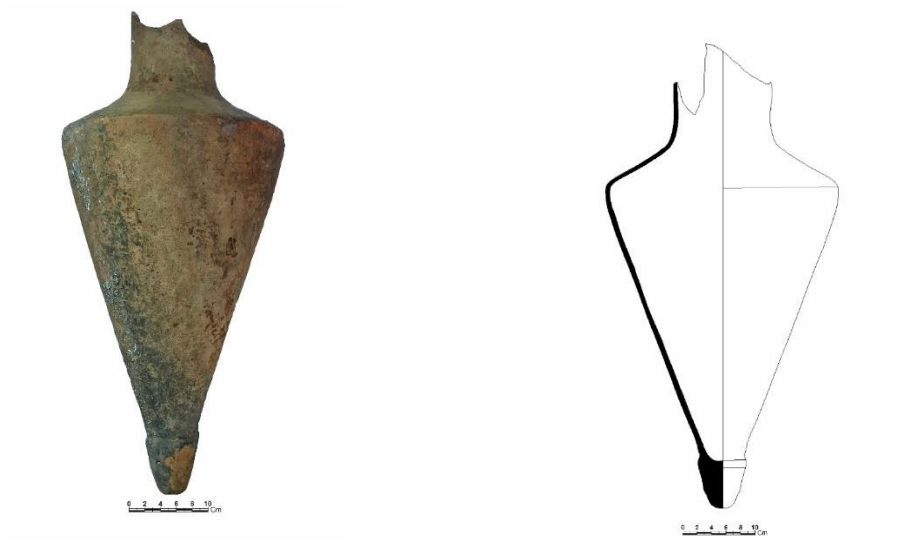

Figure 5. Catalog No: 2 Chios Type IVc

Figure 6. Catalog No: 3, Pamphylia Type Type IV

Figure 7. Catalog No: 4, Herakleia Pontike Type 3

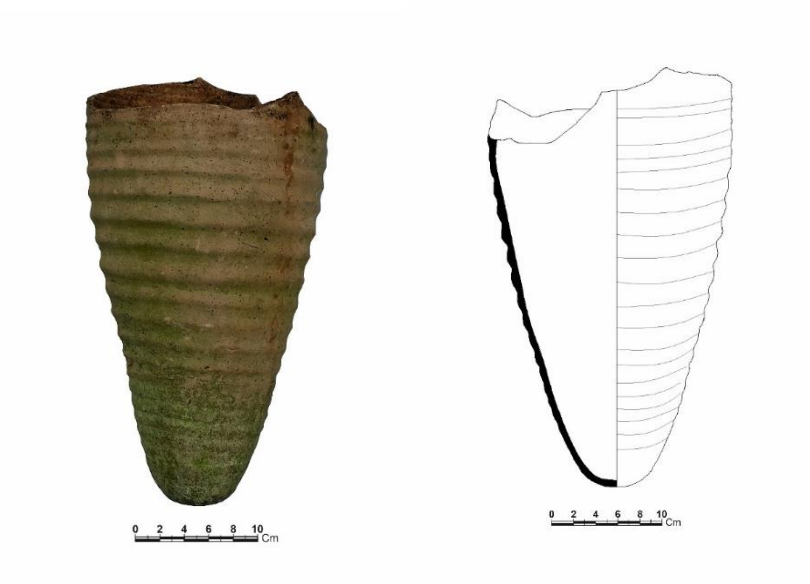

Figure 8. Catalog No: 5, Sinope B

Figure 9. Catalog No: 6, Late Roman 13

Figure 10. Catalog No: 7, Chios Type IV

Figure 11. Catalog No: 8, Rhodes

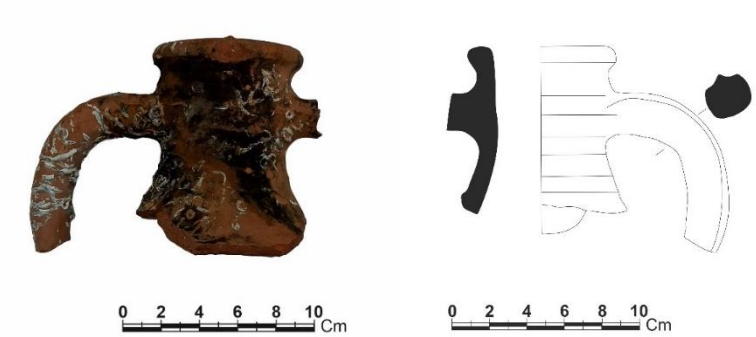

Figure 12. Catalog No: 9, Late Roman 1

Figure 13. Catalog No: 10, Late Roman 1

Figure 14. Catalog No: 11, Spatheion 3 Type B

Figure 15. Catalog No: 12, Late Roman 5/6

Figure 16. Catalog No: 13, Günsenin 4

Figure 17. Some Amphora sherds

References

Ancient

1. Ksenophon, (1974). *Anabasis, onbinlerin dönüşü*. (Trans. to Turkish By T. Gökçöl). Hürriyet Yayınları: İstanbul.
2. Polybius, (1922). *The Histories*. (Trans. W.R. Paton I-VI. Cambridge, Mass). London: The Loeb Classical Library.
3. Strabo, (2005). *Antik anadolu coğrafyası XII-XIV*. (Trans. to Turkish By A. Pekman). İstanbul.

Modern

1. Arslan, M. (2005). *Arrianus'un Karadeniz Seyahati: Arriani Periplus Ponti Euxini (Vol. 1)*. İstanbul: Odin Yayıncılık.
2. Aslan, E. (2014). Bithynia Bölgesi Kalpe Limanı. *OLBA*, 22, 129-153.
3. Baldwin, M. W. (1985). Missions to the East in the Thirteenth and Fourteenth Centuries. *A History of the Crusades*, 5, pp. 452-518.
4. Bass, G. F. & Van Doorninck, F. H. & Bryant, V. M. (1982). *Yassi Ada (No. 1)*. Texas A & M University Press.
5. Bonifay, M. (2004). *Etudes sur la céramique romaine tardive d'Afrique (Vol. 1301)*. Oxford: Archaeopress.
6. Briese, M. B. & Vaag, L. E. (2005). *Trade Relations in the Eastern Mediterranean from the Late Hellenistic Period to Late Antiquity: The Ceramic Evidence*. University Press of Southern Denmark.
7. Doğancı, K. (2003). Bithynia Tarihi – I, Bithynia Krallığı (MÖ 297 – MÖ 74) (Yeni Bir Yüzyılın Eşiğinde İnegöl). *Bursa Defteri*, pp. 74-84.
8. Doğer, E. (1991). *Antik çağda amphoralar*. İzmir: Sergi Yayınevi.
9. Grace, V. R. (1963). Notes on the Amphoras from the Koroni Peninsula. *Hesperia: The Journal of the American School of Classical Studies at Athens*, 32(3), pp. 319-334.
10. Grace, V. (1973). Imports froms Pamphylia. *Bulletin de Correspondance Hellénique*, 1(1), 183-208.
11. Hannestad, L. (2007). Timber as a trade resource of the Black Sea. In The *Black Sea Studies*, 6, pp. 84-99.
12. Hill, T. (2016). *A Guide to Late Roman and Byzantine Amphorae*. University of Arizona.
13. Højte, J. M. (2008). The cities that never were: Failed attempts at colonization in the Black Sea. In *Meetings of cultures in the Black Sea region*, June, 2008, pp. 149-162.

14. Khalvashi, M. & Inaishvili, N. (2010). Sinopean imports on the Black Sea littoral of south-west Georgia. In *Sinope, The Results of Fifteen Years of Research*. Proceedings of the International Symposium, 7-9 May 2009, Ancient Civilizations from Scythia to Siberia 16, pp. 487-509.
15. Miller, K. (1916). *Itineraria romana: römische Reisewege an der Hand der Tabula Peutingeriana*. Stuttgard: Strecker und Schröder.
16. Özbay, F. (2019). Klazomenai fgt (Feride Gül Tarlası) sektöründen ele geçen ithal ticari amphoralar. *Dumlupınar Üniversitesi Sosyal Bilimler Dergisi*, 59, 74-94.
17. Peacock, D. P. S. & Williams. D. F. (1986). *Amphorae and the Roman economy: an introductory guide*. New York: Longman.
18. Riley, J.A. (1975). Pottery from the First Session of Excavation in the Caesarea Hippodrome. *BASOR*, 218, 25-63.
19. Robinson, H. S. (1959). *Pottery of the Roman period: chronology (Vol. 5)*. American School of Classical Studies at Athens.
20. Tezgör, D. K. & Lemaître, S. & Pieri, D. (2003). La collection d'amphores d'Ismaïl Karakan à Sinop. *Anatolia Antiqua*, 11, 169-200.

Exploring modern shipwrecks using digital technologies: the case study of the Christoforos Shipwreck

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Keywords: 3D Modelling, 3D Recording and Mapping, Photogrammetry, Modern Shipwreck, Virtual Reality, Digital Technologies.

Abstract

The paper presents the application of a methodology based on digital technologies for creating the interactive virtual scenario of the underwater site of the Christoforos Shipwreck. The huge wreck lies in the Panormos Bay of the Skopelos island (Greece) at a depth of 45 meters.

In particular, the paper describes the 3D reconstruction of the underwater site carried out by using an advanced underwater photogrammetry scheme capable to provide a high detailed 3D reconstruction of the shipwreck and focus on the development of the virtual scene for its visualization and exploitation.

The resulting Virtual Reality (VR) application recreates the exact ambient conditions inside and outside the water simulating the flora and fauna of the place, the coastline, allowing users to live a recreational and educational experience by virtual diving in the underwater site.

1. Introduction

As reported by UNESCO, approximately 3 million shipwrecks lay across the oceans [1]. Ancient wrecks often provide precious historical information, but also modern shipwrecks are important testimonies of the recent past, witnessing commercial routes, battles, and how human factors can impact the marine environment. In this scenario, 3D digital technologies represent an invaluable set of effective tools for documentation and monitoring purposes, but also to raise awareness to the general public of these important historical and naturalistic assets.

After a brief historical description of the site, this paper will present the workflow used to 3D reconstruct the Christoforos shipwreck through photogrammetric techniques and the optimization performed to render the

model on a virtual scenario in low-cost VR HMD devices. This kind of methodology can represent an effective low-cost business model to promote and valorize modern shipwrecks in diving centres to divers and non-divers tourists.

2. Historical Context

On the 2nd of October 1983, early in the morning, the Christoforos ship with its 15 crew members left the port of Volos for the port of Piraeus. The ship was loaded with 2.600 tons of concrete and had Algeria as the final destination. The weather conditions were good but, during the evening, the wind brought rains and strong North gales. On the 2nd of October 1983, the ship arrived in Panormos, but at about 16.00 the waves broke one of the portholes of the bridge. As a result, the bridge flooded and the angle of the list on the left side increased by 17 degrees while there was an influx of water in the hold. On the 3rd of October 1983, the tries to save the ship became useless and the captain gave the crew the order to leave the ship and board on the Giannakis vessel. Christoforos sank in an upright position at about 05.30, at a depth of 43 meters (Figure 1).

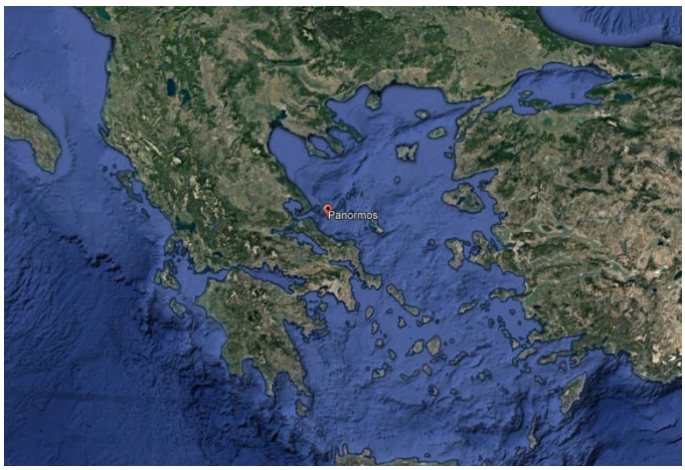

Figure 1. The position of the shipwreck on a map

3.Materials and Methods

3.1. Underwater Survey

Considering the dimensions of the shipwreck, 80 meters long and 11 meters wide, sinking at 45 meters depth, two camera operators, supported by at least one more diver, have worked together to recover all the data necessary to 3D reconstruct the model. To complete the task, the data acquisition has been split into two main chunks: one team worked on the hull of the shipwreck, reconstructing the vertical part, and one team worked on the bridge of the shipwreck. To connect the two acquisitions, a good overlap of the images taken was necessary, also considering the different setup of the cameras available for the teams.

On the first day team n.1, with a horizontal camera position, dived around the upper part of the hull, also capturing elements of the bridge, to have enough overlap with the team n.2 photographs.

The next 3 days, team n.1, with a vertical camera position, dived around the deepest part of the hull, creating strips with an overlap of 70-80%, completing 3 technical decompression dives, to collect the data of the hull and the propeller. Every dive took almost 25 minutes of bottom time and 30 minutes of decompression along the ascent.

Team n.2 was in charge to acquire the bridge using a standard aerial photogrammetric approach. The shipwreck has been divided into 4 parts and the images produced a good amount of overlapping sequence. The work took 4 non-decompression deep dives.

To properly scale and geo-referencing the model, a group of divers has taken 4 GPS points along the shipwreck deck.

3.2. 3D Reconstruction

During the survey days, the 2 teams acquired 4734 pictures. After the image-processing, a Structure-from-motion (SfM) 3D reconstruction was performed using the commercial software Agisoft Metashape Pro [2] and the measurements have been applied to the sparse point cloud resulting in an average scale error of 0.3m along with the whole shipwreck.

Later, a Multi-View Stereo (MVS) algorithm was used by Metashape Pro to produce a dense 3D point cloud. After the meshing and the texturing process, a complete model has been obtained. The giving output is a 68.266.397 million dense point cloud and a mesh of 20.000.000 polygons.

In the end, the model has been cleaned up and corrected from the unwanted surfaces and all the holes were properly closed with Geomagic Wrap[3] and Meshlab[4] software, in preparation for use in a virtual scenario environment (**Figure 22**).

Figure 2. Final render of the Shipwreck

4. Virtual Scenario

Once the survey and 3D reconstruction activities ended with the generation of the textured 3D model of the Christoforos shipwreck site, the 3D model has been adopted as starting point to develop an interactive virtual scenario to be exploited by users.

The HTC Oculus Quest headset has been chosen as the targeted device for the VR app for portability reasons. In order to develop compatible software with this device, the Unity 3D game engine has been used for development.

The creation of the scene also required a reconstruction of the seabed and the coastal surroundings of the shipwreck site, as the user exploration starts above sea level. To realize a high-fidelity representation of the Skopelos' bay, a 3D model has been reconstructed from aerial footage [5].

The exploration of the underwater shipwreck site starts above the water surface in the diving spot. To make a more attractive and engaging experience, the terrestrial environment has been added and constructed in the most realistic way possible. The buoy and the inflatable boat have been added to the virtual scene, as well as the 3D reconstruction of the stretch of coastline that overlooks the diving site.

For the underwater natural environment to be more realistic the graphical effects and physically accurate simulations, such as light rays, refractions, fog, caustics, particles, and bubbles, have been added. The virtual scenario has been also populated with 3D models of the flora and fauna typical of the specific marine ecosystem (**Figure**).

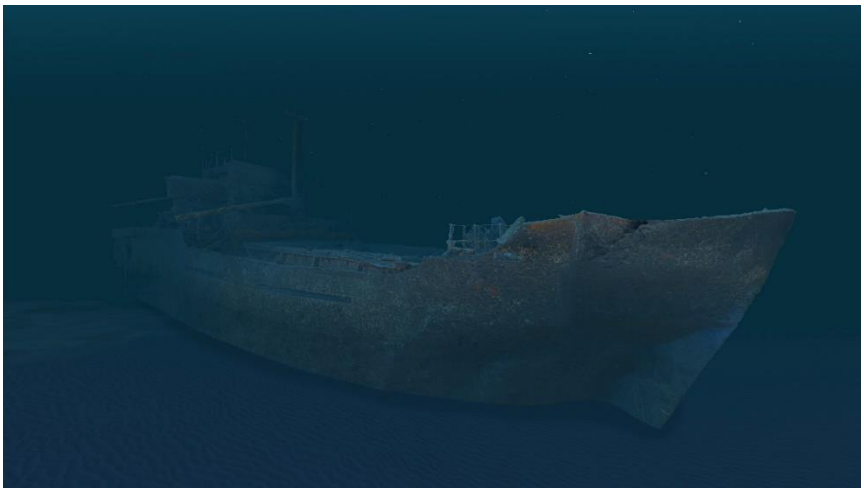

Figure 3. Examples of the rendered light rays coming from the surface. On the left, a shoal of fish moving close to the shipwreck.

5. Conclusions

The paper has presented the application of a methodology that, with the use of advanced photogrammetric techniques in conjunction with game engines developing and VR technologies devices, is used for the creation of a shipwreck 3D model and the surrounding environment. The virtual interactive scenario, optimized for standalone HMD devices, has been created to be used for making the shipwreck more accessible. In fact, VR technologies are perfect for those applications thanks to their capability to allow users to explore a sensible 3D replica of the underwater site, especially in those environments where diving requires particular certifications and procedures. In particular, this engaging representation has enormous potential for the tourism sector to make the shipwrecks, which sank to a depth not accessible even to most of the divers, more approachable and enjoyable for the general public.

References

1. UNESCO. Available online: www.unesco.org/new/en/culture/themes/underwater-cultural-heritage/underwater-cultural-heritage/wrecks/ (accessed on 04 August 2021)
2. Agisoft Metashape Pro. Available online: www.agisoft.com (accessed on 04 August 2021)
3. Geomagic Wrap. Available online: it.3dsystems.com/software/geomagic-wrap (accessed on 04 August 2021)
4. Meshlab. Available online: www.meshlab.net (accessed on 04 August 2021)
5. Gupta, S.K.; Shukla, D.P.; Application of drone for landslide mapping, dimension estimation and its 3D reconstruction, (2018)

Introducing Virtual Interactive Navigation in the submarine environment of Santorini

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Abstract

Until recently, the magnificent world beneath the sea waves could only be reached through conventional ways, such as diving or snorkeling, or via costly methods of Oceanography using submersibles, e.g. ROVs and AUVs. The dynamically advancing fields of Virtual and Augmented Reality create opportunities to a wider community to access the submarine world. Nonetheless, the necessary tools for virtual storytelling are still at an early stage and, thus, VIRTUALDiver aimed at developing a novel interdisciplinary approach, which fuses the current technological developments in VR and AR, with photogrammetry and oceanography to highlight the terrestrial and underwater wealth of Santorini volcano island. VIRTUALDiver's approach provides a successful educational and entertaining cultural product. A detailed and visually accurate mapping of the underwater and terrestrial relief was reconstructed based on significant, multi-temporal, validated information and data, which were collected using state-of-the-art technologies. Multibeam data ensured accurate reconstruction of wide underwater areas, whereas a ROV provided images for detailed reconstructions of specific scenes, such as shipwrecks. Advanced image processing algorithms ameliorated the visual appearance of the photo-textured 3D models. Moreover, multimedia content, such as interviews from experts and locals, was created with green screen photography and 360° video production. Through a set of specially designed and developed tools for multimedia content management in Unity 3D, the design team was able to write narrative scenarios and produce interactive experiences for VR and AR environments without the need of specialized programming knowledge. This paper presents VIRTUALDiver's interdisciplinary approach on developing technologically advanced cultural-touristic applications.

Photogrammetric techniques for digitalization of underwater cultural assets: The case study of the Torre Santa Sabina's Shipwreck

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Keywords: Underwater Photogrammetry, Digital archaeology, Geomatics, Underwater Cultural Heritage Documentation, UCH Enhancement

Abstract

Underwater cultural sites are, for their intrinsic nature, among the most difficult-to-reach heritage. The difficulty of operating in underwater environments derives not only from the reduced stay time of the operator on the site but also to environmental condition that might affect the survey (such as light condition, turbidity of the water, etc.) reducing its overall quality. The possibility offered nowadays by the adoption of digital photogrammetry techniques allows one to virtually reconstruct the surveyed underwater assets to make it accessible also remotely, via visualization and dissemination platforms (online or offline). In order to improve the study of the documented cultural heritage artefacts and sites, it is crucial to adopt the right photogrammetric principles, such as carefully planning the acquisition geometry, opportunely calibrating the camera before the final acquisition, correctly acquire the images with satisfying the optimal overlap and side-lap, using metric scale bars and or Ground Control Points in order to achieve 3D metric and georeferenced products that are geometrically consistent and coherent with the real object of the survey. This paper is related to the photogrammetric survey of the late-imperial era roman shipwreck, located in Baia dei Camerini, Torre Santa Sabina (BR), Italy, in the framework of the project *UnderwaterMuse* (Italia-Croatia 2014-2020 Cooperation Programme).

An integrated topographic and photogrammetric (underwater and UAV) survey has been conducted, and in the present research the last advancements in the underwater photogrammetry data acquisition and processing will be addressed in combination with the UAV achievable products. More in detail a focus on camera calibration and quality assessment of the achieved results will be presented.

Use of cheap surface and submarine automated vessels for research and promote Accessible Underwater Cultural Heritage Site (AUCHS)

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Keywords: USV, ROV, underwater monitoring, opensource, AUCHS

Abstract

The development surface and submarine automated vessels (USV, U-ROV etc.) progressing for more than 30 years, but their cost is too high for use in small scientific projects. Our team developing the system that is comparable in functionality to similar devices, but at cost up to 10 times cheaper than existing commercial solutions. This will allow use those technologies small-budget projects. Parallel with the development specialized companies, opensource solutions are being developed, which are most often used in amateur robotics. Our goal is to build on the basis of opensource solutions a modular system with interchangeable components with the possibility of simultaneous use of a whole fleet of such devices, united into a single network. Using those components, depending on the task, it can be assemble the necessary vessel for solving specific task. It can be Unmanned Surface Vehicle USV, Underwater Remote Operated Vehicle (ROV) or monitoring online-video system for AUCHS.

The report will show the results of the working prototypes of the system:

1. In 2019-2020, in the flooded port area of Preserve "Tauric Chersonese", successful tests were carried out of a prototype of an Unmanned Surface Vehicle (USV) for building a side-scan sonar mosaic and for researching Accessible Underwater Cultural Heritage Sites (AUCHS) in open water conditions.

2. Underwater Remote Operated Vehicle (U-ROV) for building a 3D-model of the bottom.

3. An underwater camera module for online-monitoring the situation under water AUCHS.

Towards an innovative system for the cataloguing of underwater cultural heritage: the case of “Gran Carro” of Bolsena (Viterbo, Italy)

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Keywords: 3D model; BIM (Building Information Modeling); tourist platforms; linked open data; semantic web; digital ecosystem

Abstract

We present an innovative system for the participatory production and return of data and images relating to the underwater cultural heritage, which has been tested and developed by the Central Istitute for Cataloguing ad Documentation and the Archaeological Superintendence of Southern Etruria in a pilot project involving the archaeological area of the Early Iron Age's site named "Gran Carro" of Bolsena (late 10th-9th century BC). The site is unique for its state of conservation among the pile-dwelling settlements in Italy, and it certainly represents one of the most important discoveries that took place at the end of the 1950s. It is currently submerged halfway along the eastern coast of the Bolsena Lake and it is the first protohistoric deposit identified in the inland waters of peninsular Italy. The study of this site has recently become part of the ICCD Digital Library of Italian Culture project with the aim of creating a **3D model** of the archaeological context and developing a **BIM** model to be subsequently uploaded to the INCEPTION platform (University of Ferrara). A **3D model** that can be interrogated, building a new concept of cataloguing for the management, conservation and enhancement of accessible and inaccessible cultural heritage. The INCEPTION platform is in fact equipped with customizable tools aimed at increasing searches, data use, download / upload and accessibility through applications that allow new forms of use by tourists and operators in the cultural heritage sector, by connecting or integrating with existing **tourist platforms**. The data made available through the use of **linked open data** deriving from systematic scientific recognition, documentation and cataloguing activities, including photographs, audio-visuals and sounds recordings, appropriately described and contextualized, are then put in a **semantic relationship** with data from other sources on cultural heritage and tourism, thus favouring the creation of a **digital ecosystem** that can also narrate submerged realities in an innovative way.

The ancient shipwreck of Peristera, Alonissos, as the first accessible underwater cultural heritage site in Greece

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Abstract

In the summer of 2020 the ancient shipwreck of Peristera, a Classical antiquity merchant ship found off the shore of the island of Alonnisos in the Sporades, was made accessible to the public during a trial period. This trial period was part of the Project "Creation of Accessible Maritime Archeological Sites in Alonnisos and the Western Pagasetic" funded by the 2014-2020 Partnership Agreement for the Development Framework ("ESPA"). From the 3rd of August to the 2nd of October 2020 246 divers visited the ancient shipwreck and 66 scheduled dive visits were organized by the diving centres.

The creation of the first accessible underwater archeological site in Peristera was welcomed by both the community of experts and the general public and there many positive comments in the national and international diving community. The trial period helps to assess the facilities of the site, the diving routes but also the experience of the visitors.

ACCESSIBLE UNDERWATER TOURISM: archaeology at your fingertips

GianPaolo Colucci

Underwater Archaeologist - External reference for underwater archaeology of the National Museum and Archaeological Park of Egnazia - Director of the cultural association L'Anfora - Albatros diving Scuba Blind International Disabled dive School Instructor

Abstract

From 8 to 12 September 2020, a specific course was held in Porto Cesareo (LE) for archaeologists who are former diving instructors for accompanying blind divers into the sea. This project, promoted by REGIONE PUGLIA promotion aimed at expanding the tourist offer - has been realized by the association ALBATROS Progetto Paolo Pinto ONLUS Scuba Blind International Disabled dive School, specializes in the social promotion of diving activities for the blind and motor disabled.

The underwater archaeologists who participated in the course learned not only the techniques to accompany blind divers underwater, but also, with the support of special teaching aids in Braille, how to "show" their sites and underwater archaeological finds. Accompanied by specially trained archaeologists, blind divers can dive safely and also visit and appreciate underwater archaeological sites.

This methodology enables the blind diver to explore, observe and recognize not only the marine environment and its species but also the site or archaeological find independently and at any dive site free of the constraints of dedicated routes. The blind diver, accompanied by able-bodied underwater archaeologists, can logistically rely on the diving centers and practice underwater archaeological tourism by integrating with groups of normal divers. Underwater archaeology therefore becomes a cultural and integration vehicle aimed at achieving maximum motor and perceptual autonomy.

Archaeological sites open to visits in the marine environment: the case of the so-called "Terme del Lacus" in Baiae (Italy)

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Abstract

The contribution intends to focus on the recent underwater investigations carried out in Baiae (Na, Italy) at the so-called "Terme del lacus". It is a sumptuous complex of buildings, probably incorporated within the imperial *palatium*, located on the north-eastern sides of the *Baianus lacus* and which has recently been partially made accessible to archaeological underwater tourism. The investigations were carried out by the Parco Archeologico dei Campi Flegrei and by the Istituto Centrale del Restauro with the aim of carrying out an accurate archaeological and architectural study of the submerged evidence and at the same time providing a mapping of the state of decay of the architectural evidence in order to proceed with the definition of the protection actions to be launched in the coming years. The investigation campaign of July 2020 was realized inside a room with a geometric polychrome mosaic floor dated between the Severian and Diocletian periods. An exploratory survey carried out within a lacuna of the tessellated area allowed not only to acquire information on the executive techniques for laying the mosaics in the later phase of the settlement, but also to obtain important data on the phases of occupation of the complex in relation to the negative type of Phlegraean bradism. Parallel to the stratigraphic excavation, the consolidation and restoration of the mosaic was carried out using innovative techniques and tools that are the result of twenty years of experimentation that the Istituto Centrale per il Restauro is carrying out in the Gulf of Pozzuoli in the context of project called "Restoring underwater". An important innovation launched for the entire duration of the diving site was to include the site within the circuit of visits that daily, through the diving centers and under the coordination of the Park Visitor Center, allow divers to immerse themselves on the ruins of the ancient *Baiae*. This initiative, called "Open yard", although now widespread in the terrestrial environment, is still little practiced for underwater archaeological sites. At set times, and without hindering the work in any way, the divers had the opportunity to reach the specially defined site with special guides, observing at a safe distance the activities carried out by archaeologists, restorers and diagnosticians. The success of this initiative has been remarkable and has allowed a considerable increase in the experiential baggage of underwater tourists.

Different approaches for the protection and promotion of ancient and WWII, Accessible Underwater Cultural Heritage Sites (AUCHS). The cases of Fournoi and Leros wreck sites under the ongoing INTERREG V-A Greece- Cyprus2014-2020 project "An.Di.Ka.T."

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Keywords: ancient wrecks, WWII wrecks, Fournoi, Battle of Leros, AUCHS

Abstract

In the context of the promotion and utilization of the rich Underwater Cultural Heritage of our country, the Ephorate of Underwater Antiquities (EUA) participates as a partner in "An.Di.Kat", an INTERREG V-A, Greece-Cyprus 2014-2020 programme, titled "**Diving Routes in Marine Protected Areas of the Eastern Mediterranean - Development of Diving Tourism Network**". Among the main goals for EUA are the "field study - identification, delimitation and mapping of diving routes of environmental and archaeological / historical interest in the areas of Fourni and Leros islands" (D: 4.3.1), a "protocol and instructions for development and operation of a diving network" (D: 6.3.1) and the participation in drawing up an action and business plan (D: 6.3.2) from the results of the field study. The archipelago of Fourni, after the systematic research of the Fournoi Underwater Archaeological Project, during the years 2015 - 2020, emerged as one of the richest archaeological sites in the Mediterranean with an extremely large concentration of ancient, medieval and modern shipwrecks while in the sea area of Leros, a large number of modern shipwrecks related to the famous "Battle of Leros" that took place between the Allies and the Axis powers during World War II are protected monuments. Both cases have been selected due to their large concentration of UCH monuments of indisputable historical/archaeological value for each respective period. Both islands have the capacity to become attractive diving destinations with an abandonment of AUCHS, even though they are not among the famous tourist destinations. In both cases significant historical and archaeological research needs to be carried out prior to protection and promotion proposals. Despite their similarities, the two cases exhibit specific features and significant differences in relation to the approach of their field study as well as the methodology applied for protection and promotion of the sites. With the most important one being the chronological difference of the majority of wrecks found in the respective areas, there are also differences in the scale of the sites, the mass of the materials found, as well as different approaches regarding some ethical issues that arise in the case of Leros, for example in relation to the survivors of these wrecks. This paper aims to focus on these differences.

1. Introduction

In the context of the promotion and utilization of the rich Underwater Cultural Heritage of Greece, the Ephorate of Underwater Antiquities (EUA) participates as partner in “ANDIKAT” project, an INTERREG V-A, Greece-Cyprus 2014-2020 programme, titled "Diving Routes in Marine Protected Areas of the Eastern Mediterranean - Development of Diving Tourism Network”. The programme is co-financed by the Greek state and the European Community. Lead beneficiary of the operation is the Region of South Aegean and other partners include Samos Municipality, Energeiaki AE, Ministry of Agriculture of Cyprus, Cyprus University and Limassol Tourism board.

Main goals of the project is the development of a network of diving routes in eight marine areas in Greece and Cyprus, as a tool for the protection and preservation of the marine natural environment, through a sustainable know-how transmission in terms of management and protection of marine areas, the conservation of the natural heritage, the promotion of the cultural heritage, the awareness of the people for the above, as well as a sustainable development and enrichment of the already existing touristic facilities and the reinforcement of the economy of the regions included in the programme through the promotion and establishment of a new touristic product - the low-impact diving kind of tourism.

The role of the Ephorate of Underwater Antiquities consists in considering the possibility to make the many Underwater Cultural Heritage sites of two relatively remote areas of Greece, accessible to the public: the islands of Fournoi and Leros (Figure 1).

Figure 1. The island of Fournoi and Leros in the Southeast Aegean.

The Ministry of Culture through the Ephorate has three basic targets according to the deliverables of the programme. Chronologically first, field research has to be done, in order for a selection of the appropriate underwater cultural heritage sites to be made, as for both the areas there exists a big concentration of candidate sites. Once selected, the areas or sites proposed as accessible to the public have of course to be protected through the legal processes that Greek and international law imply. Last but not least, a protocol for good practices, based on current legislation and the experience gained from the pilot operation of the site

of Peristera in Alonissos, in combination with the geographical, archaeological and historical characteristics of each area has to be proposed.

Both in Fournoi and Leros, as previously mentioned, numerous Underwater Cultural Heritage sites of either archaeological or historical interest have been identified, but giving access to all of them wouldn't be manageable for the time being. For this reason, the final selection of some of them has been based on some criteria established. The archeological or historical value of each site has been taken into serious consideration, as opening of the UCH to the public has been one of the primary aims of the Ministry. In addition, the state of preservation of both the sites and the artifacts included, as well as the adequacy and the coherence of each site were quite a significant aspect that was examined before a site was proposed. The assurance that several safety requirements, such as medical centers, decompression chambers or heliports can be easily accessed, has been also an important concern, as both regions are quite remote and far from major urban areas. Accessibility to every departure position either by nearby marinas, good roads or other visitor facilities (accommodation, restaurants etc) along with the climatic conditions (mainly of the various winds blowing in the Aegean Sea) present in each area have also been examined. Last but of prime significance, allowances for the fulfillment of the divers of all levels have been made. The recommended trails are separated into three basic diving levels; beginners, experienced and technical divers. Therefore, three depth zones are proposed, one shallow up to 20m for beginners, a second up to 40-45m for experienced divers and a deeper one up to 60m for well trained and technical divers, the number of which has been steadily increasing in recent years.

2. Fournoi Island

The Fournoi archipelago lies several miles to the south of the large eastern Aegean islands of Samos and Ikaria. Composed of 20 islands and islets, the complex is a significant part of the Aegean's navigational landscape. Its position across the passage formed by the island of Samos and Ikaria, on the north-south sailing route in the eastern Aegean, as well as on the west-east axis from mainland Greece to the east Asian coast, result that these islands received during the past a very large load of navigation traffic.

A collaborative survey by the Greek Ephorate of Underwater Antiquities and RPM Nautical Foundation from 2015 to 2018 located 58 shipwrecks, although a considerable area remains to be surveyed. For the complex of Fournoi, four groups of wrecks have been selected in order to be visited: three groups at the east of the island of Fournoi and one group of wrecks at the northwest part of the island of Thymena. As a departure point for the east part group of wrecks the small port of Kamari is proposed, while for the wrecks of Thymena, the divers are proposed to be departing from the main port of Fournoi (Figure 2).

Figure 2. The location of the 58 wrecks around Fournoi and the AREAS A-B-C-D of proposed routes.

Focusing at the east of the island of Fournoi, the area around Kamari cove, three distinguished areas of interest are recommended:

1. AREA A - Aspros Kavos, meaning “White Cape”, because of the white foam that sea droplets form due to strong winds blowing often at this area, justifies the concentration of 6 wrecks discovered.

2. AREA B - Right in front of Kamari cove, there is a small islet called Agios Minas, where three wrecks have been identified. This is the Area B of the routes of Fournoi, at depths of 25 m up to 65 m, suggested for very experienced divers.

3. AREA C - In between the two islands, very close to the shore, right 200m from Kamari, one can dive at an anchorage where 22 anchors of several periods have been located. Access is also possible by swimming directly from the shore. This trail is suggested for experienced divers, as the average depth is about 35 to 60 m.

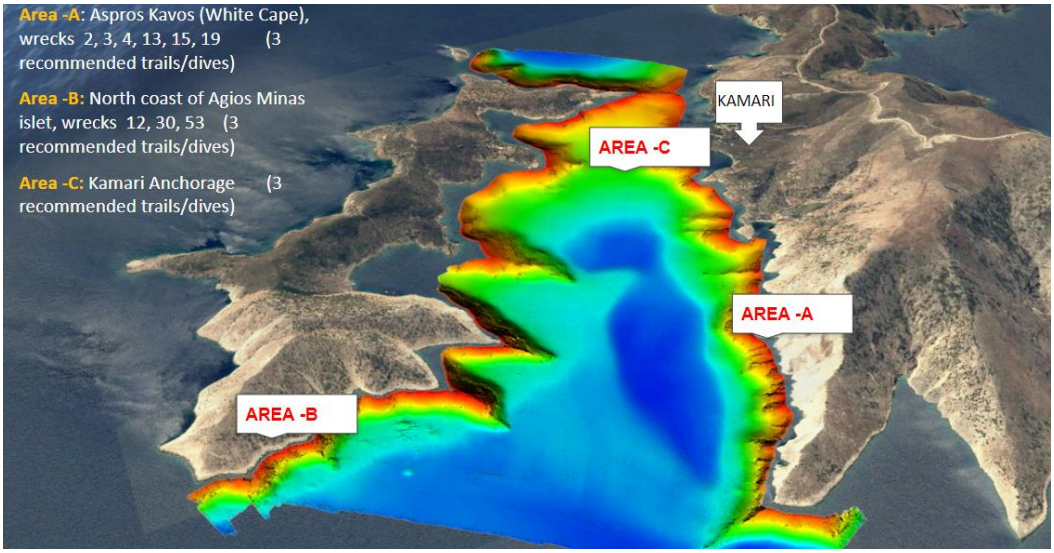

Figure 3. The AREAS A, B, C of Fournoi around Kamari cove.

Presenting in detail all the trails' proposals goes beyond the purpose of this paper; therefore focus will be set on just one of the areas above, AREA A. In this area, two different trails are proposed (Figure 4):

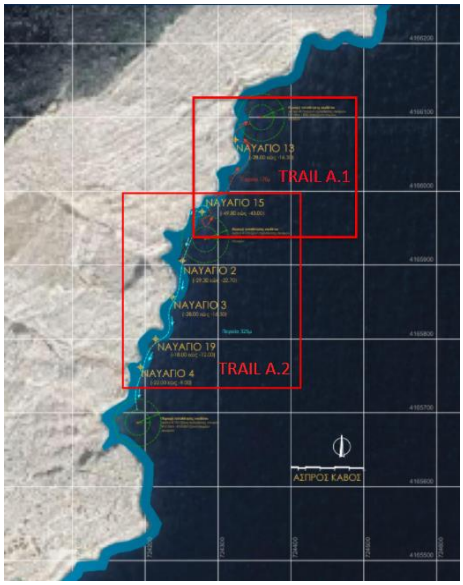

Figure 4. The AREA A with the Trails A.1 & A.2

1. Trail A.1 – At the northernmost point of Aspros Kavos is recommended for experienced divers. The visitor starts the diving trail from south at Shipwreck 15, which is deeper (at 45-50 m) and continues northwards, to Shipwreck 13, which is at a shallower depth (15 m.), saving decompression time. Figure 5 shows a suggested path over the shipwrecks. Depending on the divers' preferences though, the shipwrecks can be visited separately, increasing the number of persons that can dive into the shallower wrecks.

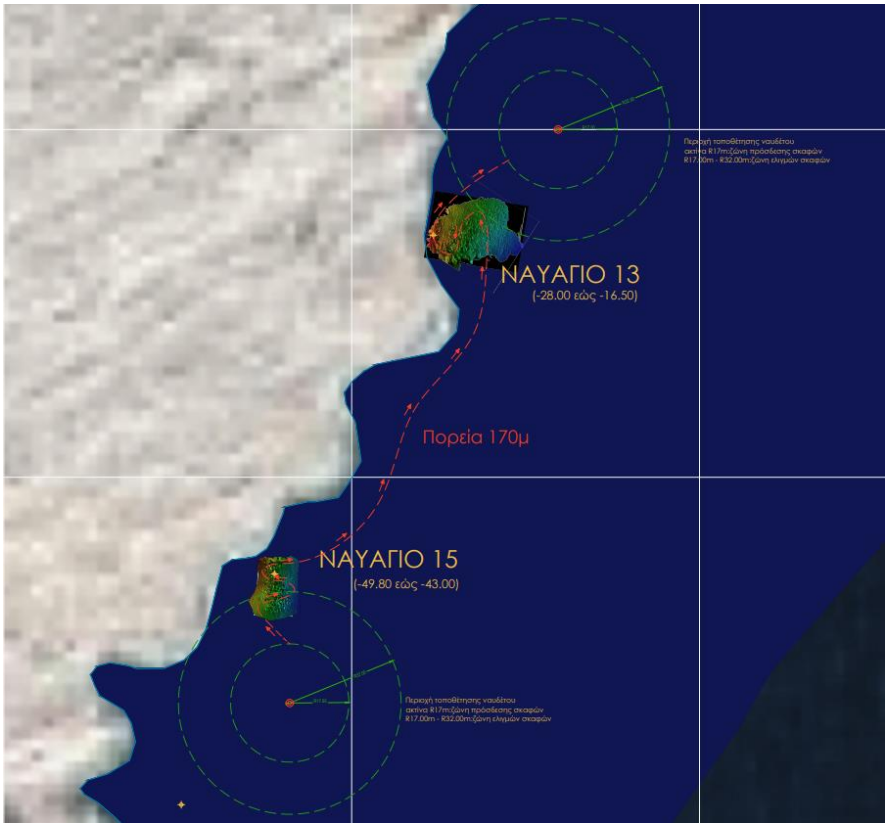

Figure 5. Suggested path of the Trail A.1

2. The Trail A.2, always at the AREA A of Aspros Kavos is also a trail addressed to experienced divers. Divers start from north going south, at an average depth of 45m at Shipwreck 15 -same as before- and move south to Shipwreck 2 at 20-25 m, continuing to Shipwreck 3, the main concentration of which is at relatively the same depth. The course continues further south and upwards, with Shipwreck 19 (at 18 m) and then at Shipwreck 4 (18-10 m). The duration of the dive is estimated at about 40 minutes, while the decompression times are limited due to the continuous ascent till the end of the course. Again here, the several shipwrecks can be separately visited or less experienced divers can skip the deep wreck of 45m and follow a shorter trail with a group of four wrecks.

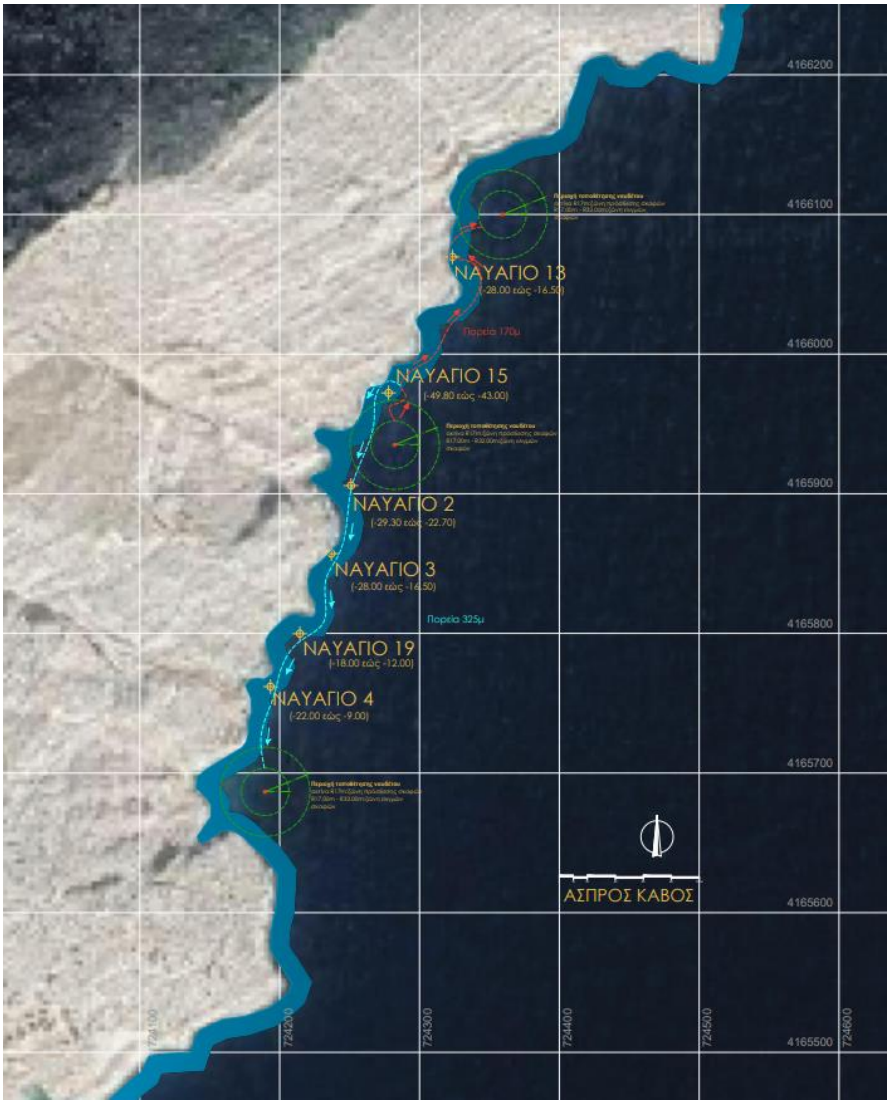

Figure 6. Suggested path of the Trail A.2

With the identification of 58 shipwrecks and much more coastline to search, Fournoi may have one of the largest concentrations of ancient shipwrecks in the world. Choosing among them which can be accessible by the general public is a rather difficult task that demands rumination, attention and pondering on many factors simultaneously.

3. Leros Island

The second region of interest of the project is the island of Leros. The island has a unique modern history, as from 1912 to 1943 was an important Italian naval and aeronautical base, with military installations, artillery, ammunition depots, barracks, command posts, radio center, big fuel warehouses, military hospitals, and even an electric power plant. The old port of Lakki, the deepest natural port of the Mediterranean, was transformed by Mussolini into a new city with modern urban design of rationalist architecture, characteristic of the fascist period (Figure 7).

Figure 7. WWII infrastructures on the island of Leros

Numerous private collections as well as the Beleni's Tower collection with material from the Italian occupation and World War II are exactly the attestation of an era that has sealed the history of the island. During the Second World War, due to its many natural coves that provided safe anchorage to every warship, Leros was the second most bombed island in Greece after Crete. Worth mentioning is the battle of Leros that lasted 52 days, the last victory of the Axis and the last defeat of the Allies, during which the legendary Greek destroyer Queen Olga D15, who had successfully participated in many operations during the war, together with the British destroyer HMS Intrepid (D10) were sunk by German Junkers 88 bombers.

The importance and uniqueness of this island is certainly reflected underwater too. The sea area around the island is the only place where someone can find wrecks of Italian, German, British and Greek military ships and aircrafts together.

As far as the diving trails are concerned, in Leros the situation is a bit different. Wrecks are suggested to be visited separately as they are far from each other in most of the cases. Two groups of wrecks have been distinguished here too though, based exclusively on their location. One group includes wrecks lying at the gulf of Lakki and another wrecks around the north and east part of the island. For the first the port of Lakki will be used as a departure point, for the second, the port of Agia Marina is proposed, as it is situated at the eastern part of the island and closer to the second group of wrecks. A very brief presentation of the two areas will follow.

Figure 8. The suggested AREAS A & B of the island of Leros

1. AREA A – The zone with the largest concentration of shipwrecks on the island is of course the main port. There are four different sites here. First and foremost, the highlight of the island is the very important for the history of the Second World War Greek destroyer Queen Olga. Today lots of her parts are missing as they were taken by the locals during the difficult times after the War. A second wreck is the one of an American landing craft, which arrived probably after the War, as part of the Marshall plan for help. A metal antisubmarine net that, when stretched upon the entrance of the harbor, protected Lakki from the entrance of enemies and when lowered or moved, permitted friendly vessels to enter, along with an Italian vessel that assisted the laying of this net, are two more underwater sites.

Figure 9. Diver at Queen Olga

2. AREA B – It includes five wrecks that can be visited from Agia Marina as a starting point. An Italian barge for another anti submarine metal net that existed for the protection of the gulf of Partheni at north, a German bomber aircraft Henkel 111 at Blefouti bay, a German landing vessel near the islet of Stroggyli, an aircraft of Arado type at the island of Agia Kyriaki and, finally -a deep dive at 50 meters- a Junkers 52 airplane, sank because of fire near Ano Zymi at the east of Leros.

4. Similarities and differences

Both the cases of Fournoi and Leros have been selected by the Ministry of Culture thanks/due to their large concentration of UCH monuments - at least 58 at Fournoi and 9 -or maybe more- in Leros. The value of each region is indisputable for each respective period, in Fournoi from an archeological point of view, in Leros from a historical one. Both islands do not belong to the most famous Greek tourist destinations. Nevertheless, they have the capacity to become attractive diving destinations with an abundance of Underwater Cultural Heritage Sites, in combination with an attractive natural environment, several cultural assets and their social wealth. Promoting them as diving destinations could attract visitors who choose to travel based on the offer of alternative forms of tourism; it could also extend the tourist season, create new infrastructures and jobs and contribute to the improvement of the existing tourism, in the context of a sustainable tourism development in terms of environmental sustainability.

Despite their many similarities, the two cases exhibit specific features and significant differences. Most of them result from their difference in chronology: in Fournoi we deal with archaeological evidence, in Leros on the other hand, with historical proof. The methodology that must be applied in each case is different: in the case of Fournoi we need to follow a strict archaeological process, involving many professions and participants in the research, for several years and -in many cases- without definite results. For the recent wrecks of Leros on the contrary, research in historical archives or even through oral testimonials is enough to get a clear idea of the monument in question - which doesn't mean it is an easy task of course.

There are also differences in terms of the size of the wrecks and the volume of materials found: most of the times only the surface findings of an ancient shipwreck can be seen and further investigation and probably excavation is necessary -and this is the case of some of Fournoi shipwrecks- while in Leros the diver sees the whole wreck in most of the cases, or at least one gets a clear image of the monument one visits. In terms of material, the main finding in Fournoi is not other than amphorae or other ceramic vessels of different origins and chronology, metal/lead/stone anchors, building material and most probably wood in the future, while the WWII wrecks of Leros are made of metal and modern materials. The preservation of the metallic frame of the wrecks of Leros is of course problematic and obviously raises questions about the future of the sites.

Regarding the wrecks found in Leros, it is not of minor significance that the visitor can come across ammunition material and still active sea-mines, which can turn out to be very dangerous in case of undisciplined divers. Furthermore, in Leros, we have run into human bones -remains of the soldiers that have lost their lives during the several battles. Rule number 5 of the UNESCO 2001 Convention calls for carefully considering unnecessary impact, in calling for due respect of human remains and venerated sites. This, in combination with the fact that there can be survivors of those wrecks, is a factor that raises moral questions that must be taken under serious consideration. Anyhow, the Ministry of Culture aims to a “no-touch” approach for the preservation of both the sites in Fournoi and Leros.

Last but not least, since the goal of our efforts is to render these sites accessible by the public, laws and regulations must be enacted. In the case of Fournoi, the process is a bit more complex, as the model followed must be the one recently implemented in Alonissos, Persistera shipwreck, where after a State order that officially recognizes the area as Archaeological Site, particular regulations must be set. In the case of Leros, the wrecks that will be included in our proposal as diving destinations are already nominated as underwater monuments by a Ministerial Decision in 2003, as they have sunk at least 50 years ago. According to a new law voted in May 2020 (4688/2020), the visiting conditions of these shipwrecks are much milder in relation to Underwater Archaeological Sites, as the constant surveillance of the Ephorate is not necessary. Finally, the Ministry of Culture very recently, composed a list of 91 wrecks, out of which, eight are in Leros, giving the diving centers direct accessibility to the sites. A common law among the Ministries of Culture, Defense and Nautical Affairs -that are also responsible- is expected to be enacted soon.

References

1.Thoktaridis, K., Bilalis, A. (2015). Shipwrecks of the Greek ships - Dive into their history (pp.260-299). Athens: Ekaterini Laskarides Foundation Publications.

2.Leros Shipwrecks. viewer.homage.com/hydrovious-diving-center-diving-center/094181200152008378?short&. (Aaccessed on 31 August 2021).

3.Mentoyiannis, V., Mitsotakis, K., Nikolaides, G. (2004). 52 days 1943. Athens: Kastaniotis.

4.Viglaki, M., Koutsouflakis, G., Campbell, P. (2019). Κορσηιτών νήσοι, Αρχαιολογικά ευρήματα και μια προσέγγιση της ιστορίας των Φούρνων Κορσεών (pp. 142-225). Athens: Fournoi Municipality.

The importance of Stakeholders' participation in the management of Accessible Underwater Cultural Heritage Sites (AUCHS) towards local sustainable development of Alonissos

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Keywords: stakeholder management; cultural tourism; Accessible Underwater Cultural Heritage Sites (AUCHS); heritage-led Local Sustainable Development (LSD)

Abstract

Cultural heritage is the fundamental second component of tourism industry together with natural environment since it embodies the course of human history worldwide from antiquity till today. mIn the same time, it has always been a significant competitive advantage, if not the most unique component of the strategy of each place towards its establishment and further flourish as a tourist destination. Museums as entities that preserve and promote this heritage, tent to be more actively involved with their local communities, in the sphere of sustainable cultural tourism. The present paper investigates the complex relationships existing between Accessible Underwater Cultural Heritage Sites (AUCHS) and their stakeholders, in an effort to implement a heritage-led smart insular cultural tourism development strategy for Alonissos and Sporades Islands area in general. In particular primary and secondary research methods are applied for the needs of the paper. Firstly, the responses of local stakeholders to the opening of the underwater museum of Peristera Shipwreck in Alonissos, being the 1st Accessible Underwater Cultural Heritage Site in Greece are analysed via interviews. Followed by a benchmarking of best practices of existing underwater museums management systems, of equal characteristics to the area of Sporades islands, on the basis of local stakeholders' level of participation in them and the related effectiveness and efficiency of this strategic decision on local sustainable development.

Implementing multi-criteria analysis in the selection of AUCHS for the integration of digital technologies into the tourism offering; the case of MeDryDive

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Keywords: Accessible Underwater Cultural Heritage Sites (AUCHS), site selection methodology, multi-criteria analysis, CCI integration, dry dive

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Comparison of economic and tourist factors in the protection of underwater cultural heritage in the Republic of Croatia: a case study on the ancient shipwrecks protected by metal cages and shipwreck from the bay Letavica on the island of Pag

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Keywords: Underwater Cultural Heritage, in situ preservation, active monitoring, economic impact, tourist valorization

Abstract

The Republic of Croatia is a country with a long tradition and experience in the protection of underwater Cultural Heritage. As an example, the practice of physical protection of ancient shipwreck sites is made in the form of placing metal cages and physically protecting the CH sites. As of the end of 2020, 9 sites have been protected by metal cages. Although this practice has proven to be successful, new knowledge and experiences gained through the application of this practice have opened some questions and pointed out the shortcomings of this method of protection. In 2018 new Roman shipwreck in the bay of Letavica on the island of Pag was discovered. After the discovery and preliminary research, it was decided to establish active monitoring using modern technologies. This approach eliminated the use of a metal cage, and open the possibility of archaeological research. Apart from the archeological research, this practice opens the possibility of a diving visit for tourist purposes.

This paper aims to make comparisons of underwater protected sites in Croatia and their economic and tourist valorization. The first group would consist of sites protected by metal cages, while the second group would include the site of Letavica, where protection in the form of active monitoring was applied. Also, this paper aims to present detailed data and make general comparisons on the effectiveness of protection at protected underwater sites, discuss and compare economic aspects and their impacts between the case studies, keeping in mind the above parameters.

Underwater Cultural Heritage Tourism and Alternatives to Diving Tourism

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Keywords: underwater cultural heritage, cultural observatories, in-situ underwater observation, diving tourism

Abstract

Although many efforts have been made, still mass tourism is intense in Greece and is prevailing. The factors that explain the development of this form of tourism are the natural environment, the cultural wealth, the good climate, the kind hospitality and the rich history. This type of tourism has been greatly analysed in previous studies, but nowadays yet another untapped opportunity presents. Promoting sea sand sun tourism with a twist can provide a viable sustainable alternative of undersea, sand sun by combining coastal and heritage tourism. The very recent adoption of a new legal framework concerning recreational diving activities in Greece has generated an increased demand for the development of diving tourism in the country. Underwater archaeological parks that combine diving with dry foot access to cultural heritage can provide a viable yet sustainable economic activity with the potential of regenerating areas and regions that have undergone an economic crisis.

From a policy of restriction to the permission of recreational diving, the process of valorising, representing and managing underwater archaeological heritage in Greece has been a recent development. The emphasis is on capitalizing on culture and heritage while at the same time appealing to a new target market of divers. His paper explores the potential for developing a hybrid alternative to underwater archaeological exploration combining both diving and dry foot access. The paper aims to promote underwater cultural heritage as an additional asset for the Greek tourism market. Innovative ways of observation and interaction with the underwater cultural heritage of Greece can include land observatories and simulated diving experiences and create a framework for experiencing in-situ underwater cultural heritage while offering the required protective framework.

DIVE IN BLUE GROWTH

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MeDryDive

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