

# Project Summary

## STACHEM

### Science and Technology for Archaeology and Cultural Heritage in the Eastern Mediterranean

Grant Agreement number: FP7-228130

#### *1. INTRODUCTION*

The Eastern Mediterranean region, including Greece, Asia Minor, Cyprus and the Levant, is probably one of the richest areas of the world as far as archaeological heritage is concerned, and undoubtedly one of the most investigated. It lies at the heart of the Fertile Crescent that saw the emergence of the first human civilizations, and at the crossroads of the trade routes linking those early civilizations. Because of the sheer number and diversity of early human settlements in the area, and probably also because of its relative proximity to Western Europe, the region (spanning from Egypt to Turkey and Greece) has attracted more archaeological expeditions than any other area in the world, and yielded an extraordinary variety of finds spanning all aspects of human activity, from jewelry to ceramics, textiles, monuments, shipwrecks and entire cities. The analysis of these finds has played a key role in documenting the emergence of civilizations, and their passing existence over the last ten millennia or so.

However, due to the scarcity of scientific and technological resources in the region, these analyses have occurred to a large extent in research institutions far removed from the origin of the artifacts, mostly in Western Europe and North America. With the increasing awareness of the value of its own cultural heritage, the public authorities in the region are also increasingly reluctant to send such artifacts away for analysis. Similarly, the documentation in digital form of the cultural heritage of the region, which is immensely rich and diverse, lags significantly behind that performed in the more developed areas of the world. Moreover, scientific analysis of finds and documentation, preservation and communication services lack a regional strategy. There are excellent research centers in the region (some of which are members of the STACHEM partnership) and certain elements of advanced research infrastructure, but coordination and policies are indeed lacking. This has several adverse effects, such as duplication of efforts, lack of interoperability at the data level, and in general missed opportunities for collaboration among research institutions. In addition there is, as mentioned above, a clear shortage of scientific and technical resources, such as laboratories of applied chemistry and physics for archaeology, multimedia communication centers, digital libraries, etc., so that analyses and data processing very often have to be carried out far away from the region.

There is therefore a pressing need to make technical resources available for archaeology in the immediate proximity of the excavations themselves, and to properly document the cultural heritage of this key region. In this context, the Cyprus Institute (CyI) has launched the Science and Technology for Archaeology Research Center (STARC), which is designed to become a significant scientific and technological resource for the regional archaeology and cultural heritage communities. It is important to ensure that, from its earliest design and planning

phase, STARC is adapted to the needs and demands of these communities, and that its development is integrated in European and regional strategies for the build-up of research infrastructures in the relevant fields. CyI/STARC has therefore joined other regional players and a few European leaders drawn from relevant fields to initiate a coordinated effort for the build-up of the necessary research infrastructure and the pooling and coordination of the associated resources.

The goal of the STACHEM project was to contribute to a regional strategic plan for research infrastructures devoted to archaeological sciences and digital heritage in the Eastern Mediterranean, and simultaneously to support and complement the design and planning process of STARC, ensuring that it is embedded in the said strategy, closely adapted to the regional needs and integrated in the Euro-Mediterranean environment of archaeological sciences and digital heritage. The STACHEM project has been focusing on the following areas:

- natural and materials science approaches to the study of archaeological remains and sites
- technologies and infrastructure for underwater archaeology
- applications of information and communication technology to cultural heritage

Since these areas are future areas of activity of STARC, an additional motivation for the project is that the said strategy and framework will also favour the development of the regional and European dimensions of STARC.

### *The Science and Technology for Archaeology Research Center*

The primary mission of STARC is to become a center of excellence in the technologies that are useful to the work of archaeologists in the field as well as to the museums and collections that document and preserve their work. It will be active in the applications to archaeology and cultural heritage of modern technologies including materials sciences and biological analysis, marine and underwater exploration techniques, and information technology relevant to the field of digital cultural heritage. The ambition of STARC is to become a major resource for the region, by developing and applying cutting edge techniques and instruments that are of direct value to practicing archaeologists, by providing technical expertise unique in the Eastern Mediterranean, by training young people to become archaeological scientists and technologists, by collaborating with teams in the field on projects of common interest and by becoming one of the major voices of the region in the rapidly developing area of the preservation of cultural heritage in digital form. The application of advanced materials science, chemistry and biological techniques to the study of archaeological artifacts is a crucial issue for example in mapping trade routes in the Eastern Mediterranean and the Middle East, where it is well known that Cyprus played a central role both as a producer of raw materials (copper in particular) and as a trading center. Underwater exploration aims, between others, to allow a comprehensive and detailed mapping of submerged archaeological remains (primarily shipwrecks) in the Eastern Mediterranean. It is of particular importance to ensure that STARC truly serves the needs of the region and thus becomes an efficient instrument for the implementation of the European neighborhood policy.

It should be noted that although CyI had defined the general outline of the research and educational agenda of STARC, the detailed actions that the Center will engage will be dictated to a very large extent by the requirements of the regional community. This was one of the motivations behind the STACHEM project, which set out to collect and evaluate these needs and requirements and ultimately to distil a regional strategic plan and provide input for STARC's design and the planning of its development. The lack of such a regional research policy concerning the infrastructure for archaeological research to which STARC could have aligned its plans has been a motivation to undertake the work described here. However, the input that the project will provide for the elaboration of a Euro- Mediterranean strategy in the relevant scientific fields (i.e., archaeological sciences, underwater archaeology and digital heritage) will benefit not only the development of STARC but also the design, planning and optimal management of other research infrastructures in these fields.

## *2. OBJECTIVES*

As mentioned above, the two major objectives of the STACHEM Project were to contribute to the regional coordination of policies and pooling of resources in the fields of archaeological sciences and digital heritage, and in parallel to make sure that from its earliest phase STARC is optimally integrated into the Eastern Mediterranean archaeology and cultural heritage communities, and develops strong ties with European institutions active in archaeological sciences and digital heritage. It is clear that these two main objectives have mutual synergies; indeed there are two principal components in the development of STARC or of any similar research center: (1) the planning and implementation of the infrastructure and (2) the development of the research and educational portfolios, which can be optimally realized only if they are adapted to the regional context and to the requirements of the Eastern Mediterranean archaeology and cultural heritage communities and if maximal complementarities and synergies are sought with existing efforts in the European archaeological sciences and digital heritage environment. These objectives have been realized by associated actions that ultimately benefit the entire regional communities in the fields of archaeology and cultural heritage.

Furthermore, it should be noted here, that since the STACHEM project - beyond providing important input for the development of STARC - will also benefit the design, planning and optimal management of other research infrastructures, The STACHEM activities and outcome are generally useful to other research teams or organizations in the region, and particularly to future newly formed research teams and to those located in remote areas.

The main components of the STACHEM project have been:

- The assessment of the science and technology requirements of the regional archaeology and cultural heritage communities
- Coordination of the existing and future infrastructures, and of other technological resources in the fields of archaeological sciences, marine investigations and digital heritage, on a European and regional scale, aiming at future cooperation, complementarity and pooling of resources

- The incubation and preparation of research and educational programs, in collaboration between the consortium partners and with other players that will be identified through the networking process
- The creation, through an adequate regional networking process, of a regional users community that have sustainable links both with STARC and with the research cluster that has been created through the STACHEM project
- The preparation of a training program aimed at archaeologists and cultural heritage specialists in the Eastern Mediterranean

In order to achieve the above STACHEM has adopted a bottom-up approach, so as to achieve a response to specific needs of the scientific community in order to coordinate the development and networking of existing infrastructures (notably of STARC) and to strengthen the development of a EU policy in the relevant field. The STACHEM partnership, as outlined below, together with the involved stakeholders and other institutions aggregating around the project idea, have mobilised a substantial amount of resources and expertise, thus achieving a critical mass.

### *STACHEM Partnership*

The project's objectives have been achieved by the action of a consortium coordinated by CyI that has grouped European leaders and regional players, with a strong complementarity of expertise in the thematic areas mentioned above:

(1) Archaeological sciences:

- Archaeological Research Unit, University of Cyprus, Cyprus [UCY-ARU]
- Centre de la Recherche Scientifique – Centre de Recherche et de Restauration des Musees de France, France [CNRS-LC2RMF]
- Cultural and Educational Technology Institute, Research Center Athena, Greece [CETI]
- University of Athens, Department of Archaeology, Greece [UoA]
- The Weizmann Institute – The Kimmel Center, Israel [Weizmann])

(2) Marine related technologies:

- UCY-ARU
- CNRS-LC2RMF
- Institute of Nautical Archaeology at the Texas A&M University, USA/Turkey [INA])

(3) Digital heritage:

- The Cyprus Institute, Cyprus [CyI];
- CNRS-LC2RMF
- Ministero per i Beni e la Attività Culturali – Ministry for Cultural Heritage and Activities, Italy [MIBAC]
- Weizmann

### *3. ACTIVITIES AND OUTCOMES*

The STACHEM partnership has contributed to the elaboration of a strategic plan for research infrastructures in the fields of archaeological sciences and Digital Heritage, and to the incubation of a regional research cluster in which STARC and the other partner institutions will be fully integrated. In parallel has ensured that the

STARC infrastructure and its research and educational portfolio are shaped in such a way as to provide maximal service to the scientific and technological needs related to archaeology and Cultural Heritage in the region and in Europe.

Within the STACHEM project opportunities for synergies and coordination have been explored, and needs and requirements in the region assessed. The latter include suggestions for joint trans-national activities. In order to do so, STACHEM has built-up a community of users, and held periodic workshops for continuous monitoring and update. In addition to its benefits on the European and regional scales, the project is anticipated to have an impact at the national levels for the medium and long-term strategy of the institutions involved in the project and their partners. Further, the STACHEM project has produced significant input for STARC's design and planning of its development, and more generally for the archaeology and cultural heritage communities in the region, by its contributions to progress towards a regional strategic plan.

At the same time, the co-operation between first-class research institutions such as those present in the STACHEM partnership - and others with which links have been established through the STACHEM project – have succeeded in the formation of a regional research-intensive cluster with European and international outreach.

Specifically, the project activities and outcomes may be summarized as follows:

	Activity type			WP and outcome
Scientific domain	Inventory of existing infrastructures in the region, identification of needs	Coordination of the use of the existing infrastructures	Definition of a coordinated research and educational programme	
Archaeological Science and Technologies (S&T)	Report on needs and existing infrastructures for S&T	Coordination on S&T	Research and Educational program on S&T	WP2 – D8
Underwater archaeology (UW)	Report on needs and existing infrastructures for UW	Coordination on UW	Research and Educational program on UW	WP3 – D9
Digital Heritage (DH)	Report on needs and existing infrastructures for DH	Coordination on DH	Research and Educational program on DH	WP4 – D10
Overall (resulting from integration of the above)	Report on needs and existing infrastructures: the demand	Coordination plan: optimizing current response	Research and Educational programmes: improving future response	WP2 – WP6 White paper (not a formal deliverable)
International workshop and	Disseminating strategic policy			WP5-WP6

other dissemination				
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In the following the main activities and outcomes are summarized, according to the structure of the STACHEM project, corresponding to workpackages. These are:

- Archaeological sciences (WP2)
- Underwater Archaeology (WP3)
- Digital Heritage (WP4)
- Dissemination and networking (WP5 and WP6)

### *3.1 WORKPACKAGE 2: ARCHAEOLOGICAL SCIENCES*

Within WP2 on “Coordination of infrastructures, research and education in materials science and archaeometry”, the infrastructures required for the study of archaeological artefacts, remains and sites in the Eastern Mediterranean, and of the associated scientific and technological resources in the region were surveyed. The workpackage focused on the assessments of needs, coordination of infrastructures and preparation of collaborative programs within the domain of physical, chemical and biological analyses of archaeological remains.

#### *Inventory of existing infrastructures in the region, identification of needs*

The preparation of a list of active regional research centers and a profile database of these institutions has been achieved using internet resources, publications and journals as well direct information obtained from research networks. Data on 9 countries in the Eastern Mediterranean region (Cyprus, Egypt, Greece, Israel, Jordan, Lebanon, Malta, Syria, Turkey) and 4 countries related to these countries in partnerships (France, Italy, United Kingdom, United States) are included. Within the Eastern Mediterranean region, 98 institutions and 202 contacts have been registered (Figure 1). Institutions considered include: Research Centers, Universities or educational institutions, Ministries, Museums, Collections, Foreign institutions, Private companies, International organizations. In total, 17 Research Centres, 23 Universities or Educational institutions, 27 Museums-collection management and museum laboratories, 18 Foreign institutions, 2 Private companies with services for Cultural Heritage, 5 International organisations, 4 Museums Conservation and Restoration Workshop and 2 Non profit associations have been recorded (Figure 2)

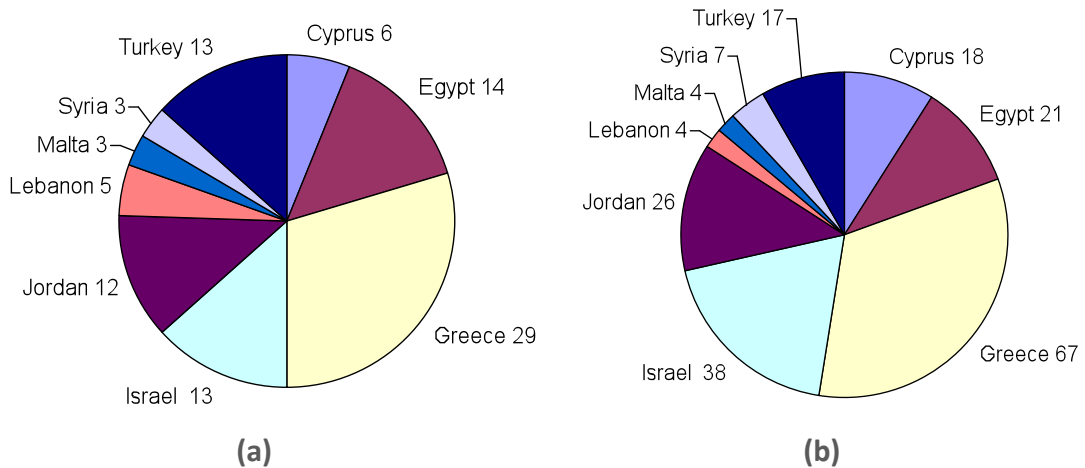


Figure 1 Number of institutions (a) and contacts (b) per country, in the Eastern Mediterranean region, for the STACHEM WP2 survey.

In order to survey the infrastructures in the countries of the Eastern Mediterranean region, a list of areas and sub-fields of the activities, the materials and the equipments available has been compiled (Table 1).

Table 1 Type of information referred to in the database and their number of entries, for the 9 countries in the Eastern Mediterranean region.

Database reference tables	Number of entries
Institution (Name, type of institution, institutional and legal status, address, website, brief description)	98
Contact (Title, Full name, institution, function, phone, fax, email)	202
Activity (Materials study, Bioarchaeology, Paleoenvironment and climate, Geoarchaeology, Dating, Archaeological prospection, Underwater Archaeology, Archaeological excavation, Statistical and Computational methods, Data management and processing, Documentation/Archives, Conservation, Restoration, Reproduction of ancient techniques, Digitization, Research and Education)	50
Equipment (Current laboratory equipment and Non-destructive testing, Photography/ Imaging, Digitisation & Image Archiving, Radiography, Microscopy, Chemical element analysis, Chromatography and Mass spectrometry, Ion-Beam analysis, Structural analysis, Surface analysis, Colorimetry, Dating, Archaeological prospection, Mechanical and thermal properties of materials, Environmental and weathering tests, Biological equipment, Large instruments)	177
Material and reference collections (Ceramic, Glass, Metal, Painting, Textile, Paper, Photography, Wood, Biological composite, materials, Organic material, Inorganic materials)	45
Collaborative programs (national, binational, european, international)	4

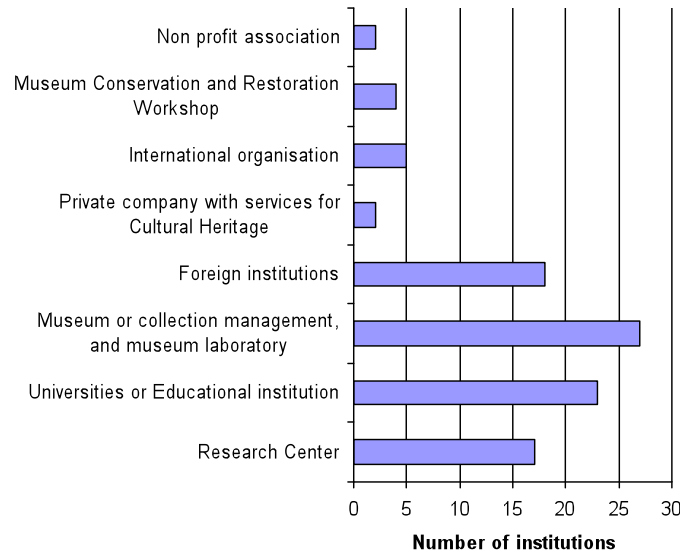


Figure 2 Distribution of the type of institutions registered in 9 countries in the Eastern Mediterranean region for the STACHEM WP2 survey.

To complete and update the database, a format questionnaire has sent to the contact persons for review and correction, followed by the integration and incorporation of changes into the database. The questionnaire which aims to improve the knowledge on the existing infrastructures and evaluating the needs of the region, is organized in 3 main sections:

- 1) Institution or company (e.g., general information, contact persons, legal status, staff qualification, partnerships)
- 2) Expectations and Needs for the future (e.g., wishes for equipment available for trans-national access, reference collections available for studies) (Table 2)
- 3) State of art of the institution (e.g., activities, materials, equipments)

The number of institutions contacted has been progressively enlarged not least thanks to the networking conducted within the various meetings and workshops organized within the STACHEM project. The database is constantly updated and improved.

Table 2 Questions asked in the questionnaire to evaluate the needs of the institutions

Needs in	Questions
<b>Collaborations</b>	<ul style="list-style-type: none"> <li>- Who would you like to collaborate with in the Eastern Mediterranean region?</li> <li>- How would you like to exchange with other collaborators?</li> </ul>
<b>Activities</b>	<ul style="list-style-type: none"> <li>- How would you extend and enrich your activities within the Eastern Mediterranean region?</li> <li>- Which activities would you like to improve or develop in your institution?</li> </ul>
<b>Materials</b>	<ul style="list-style-type: none"> <li>- Which type of materials would you like to study thanks to a trans-national access?</li> <li>- Which reference collections available in YOUR institution could be</li> </ul>



	studied thanks to a trans-national access?
<b>Equipments</b>	<ul style="list-style-type: none"> <li>- Which equipments NOT available in your institution would you like to use thanks to a trans-national access?</li> <li>- Which equipments available in your institution could be used thanks to a trans-national access?</li> <li>- Which equipments are lacking in your institution to improve your work?</li> </ul>

About 80 questionnaires have been sent and 28 have been answered in the countries of the Eastern Mediterranean region. All the data have been integrated into the STACHEM-WP2 survey database. This database now allows retrieving information such as which activities, equipments, materials studied and reference collections are available in a specific institution. On the other hand, one can know which institutions in the Eastern Mediterranean region can provide a specific equipment, work in a special field of research, or have a particular reference collection.

*Coordination of the use of the existing infrastructures, targeted planning new ones at STARC and elsewhere in the region*

The database which integrated data from the answered questionnaires served as the basis to prepare a draft report on an overall description of the Eastern Mediterranean region organized by areas, sub-fields of archaeometry, and available instrumentation and technology; with focus on advances, problems and potential in the coordination and use of existing and planned infrastructures.

*Overall description for the EM region*

Among the 50 listed activities, 6 areas regrouping 11 sub-fields of activities are mainly practised by the institutions recorded. The main areas in which the institutions are involved are research and education, characterization and technological studies, and conservation and restoration (Figure 3). Also documentation and archives, geoarchaeology as well as archaeological excavations are represented activities in the region.

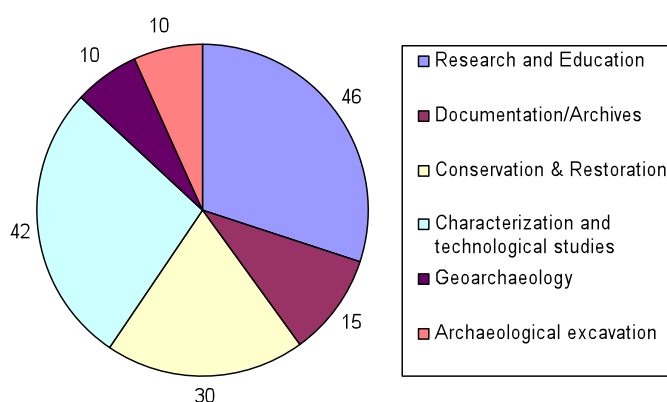


Figure 3 Main activities in archaeometry in the EM region. The numbers indicate the number of institutions involved in the respective activities.

Greece appears to be the country in the region with the highest numbers of institutions and of activities related to Cultural Heritage. In the more eastern part of the Mediterranean region, Israel, Egypt, Turkey and Jordan are the countries with a number of institutions involved in archaeometry. This may hint towards a lack of existing infrastructures in Cyprus and Lebanon. The new centre STARC will therefore have a key role at a national level in the field of natural and material sciences for archaeology and cultural heritage.

Regarding the relative distribution of the main fields of activities mentioned above within the countries that have the highest number of institutions involved in archaeometry, strengths and weaknesses become apparent (Figure 4):

- Greece seems to have real assets in characterization and technological studies as well as in research and education in the field of natural and material sciences and training. Geoarchaeology is also well developed in this country. These activities could be extended to the other countries of the region thanks to networking and trans-national activities and training.
- While archaeological excavations appear to be an important activity for institutions in Israel, Jordan and Turkey, material studies seem less developed in these countries. It is interesting to note that Jordan has a very strong involvement of research and educational institutions in the field of Cultural Heritage. However, it seems that, in this country, there is a lack of documentation and archiving activity and conservation and restoration are still poorly developed, apparently due to a lack of funding in the field and a lack of specialized training.
- Egyptian institutions have strong activities in documentation and archiving as well as in conservation and restoration. However, it seems that there is a lack in characterization studies and archaeological excavation. Indeed, both activities are often lead by foreign countries of Western Europe.

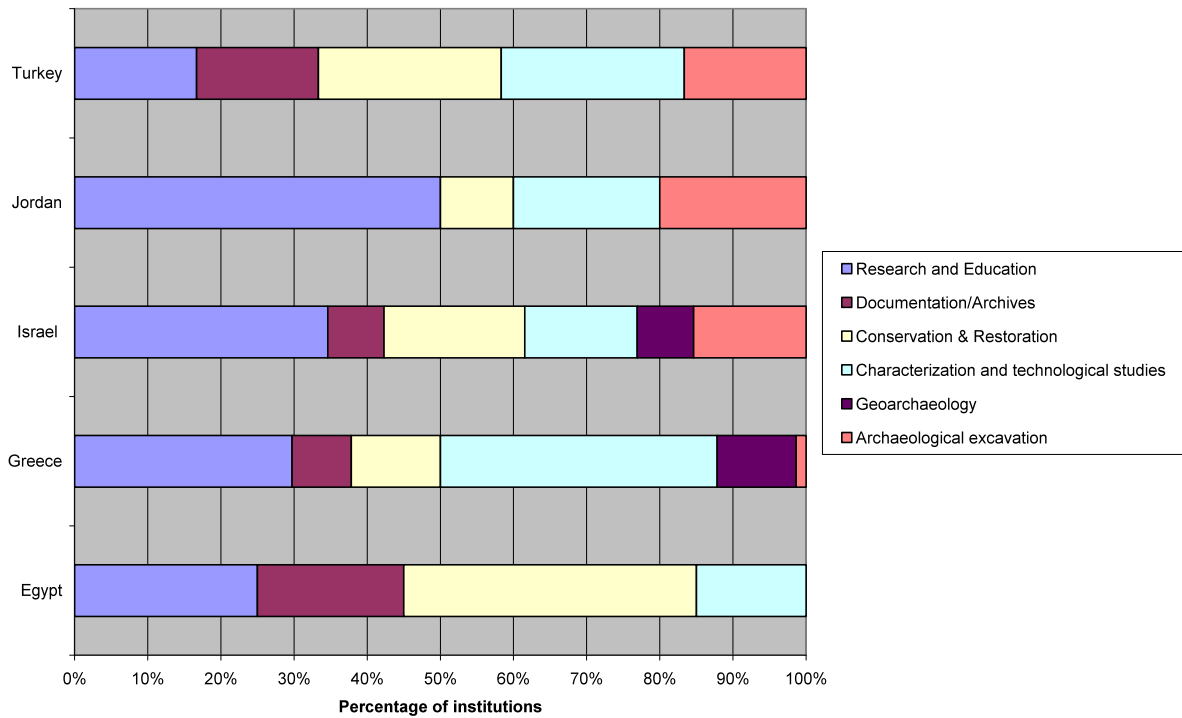


Figure 4 Relative distribution of the main fields of activities within the countries of the EM that have the highest number of institutions.

According to our survey, Greece has the highest number of equipments dedicated (or which can be used) to the study of archaeological artifacts, but also Turkey and Israel are countries with important equipped infrastructures. Egypt, Jordan, Cyprus, Malta and Lebanon are countries where it seems that there could be a lack of equipment for archaeometry (Figure 5). Thus, the new instrumentation planned to be bought in STARC will be very useful for the local community but also for neighboring countries like Egypt, Jordan and Lebanon.

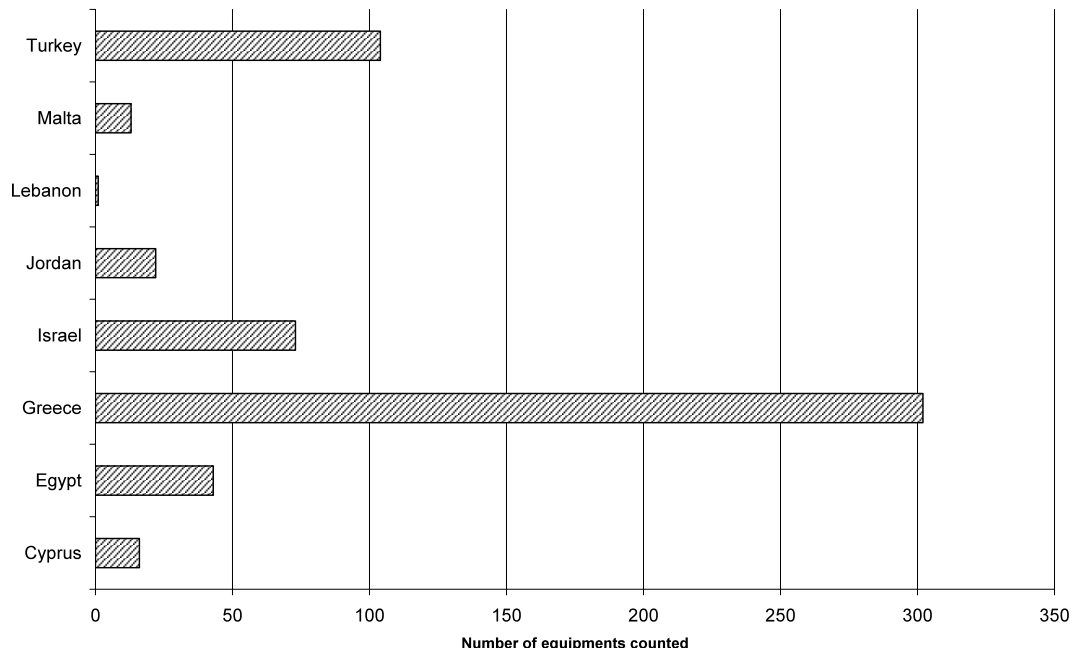


Figure 5 Number of equipment counted in the institutions within the different countries of the EM.

When looking at the distribution of the main types of equipment in the institutions and in the main active countries according to the STACHEM WP2 survey (Figure 6), the following can be observed: (a) laboratory, microscopy, archaeological prospection and photography and imaging equipments are the most represented in the region. (b) Structural and chemical analyses, chromatography and mass spectrometry and dating are less present in the region and are indeed lacking in some countries. For example in Egypt, if equipment for structural analyses is well developed, it seems that there is no available equipment for chromatography or mass spectrometry or for dating of cultural heritage artefacts. (c) There appears to be a lack in equipment for radiography, mechanical and thermal properties, environmental and weathering tests and ion beam analyses. These features can be explained by the fact that radiography and ion beam equipments are rather expensive and cannot be afforded by small institutions. On the other side, mechanical and thermal properties as well as environmental and weathering tests equipments, even if they are much less expensive, are not the types of investment preferred by the laboratories.

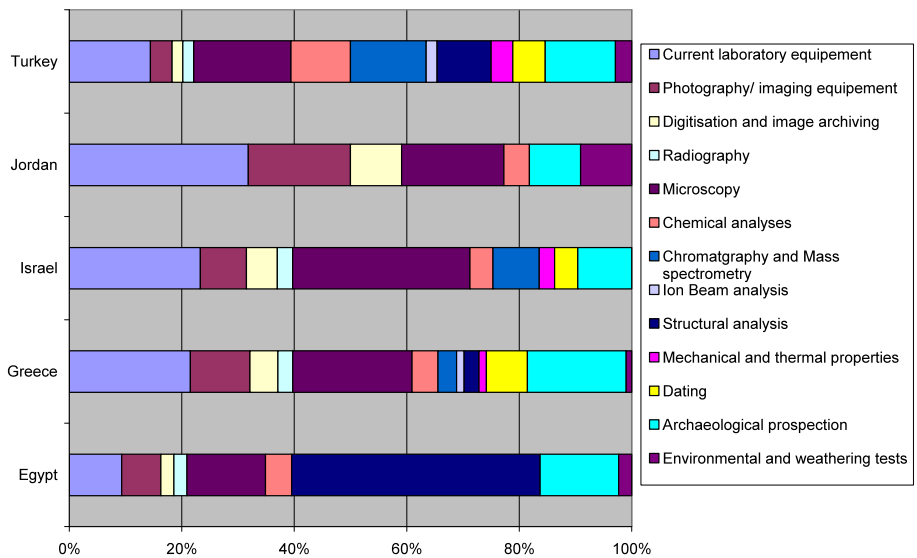


Figure 6 Distribution of the main types of equipments a) in the institutions b) in the main active countries according to the STACHEM WP2 survey in the EM region.

The survey of the existing infrastructures in the Eastern Mediterranean region allows us to give a first overall description of the region organized by areas, sub-fields of archaeometry, and available instrumentation and technology. It shows there is a great potential for Greece to play the role of the driving country in the field of archaeometry in the region, in term of transfer of knowledge and technology. Israel and Turkey are also well equipped and have research and educational institutions involved in the study of cultural heritage artefacts. Because of the less well developed or indeed lack of existing infrastructures in Cyprus, Egypt, Jordan and Lebanon, the new centre STARC will play a key role not only at a national level but also at an international level by providing equipment and expertise much needed in the region. Furthermore, some shortages of instrumentation in the larger region have been identified, and it is anticipated that new instrumentation available at STARC will give rise to collaborations with various partners of the Eastern Mediterranean, in the framework of the networks currently established through STACHEM activities.

### *Current and potential needs in the Eastern Mediterranean region*

Although this part of the questionnaire was mainly answered by the Greek community, the answers obtained allow us to obtain an idea about the needs in the Eastern Mediterranean region. To the questions “Who would you like to collaborate with in the Eastern Mediterranean region?” and “How would you like to exchange with other collaborators?” nearly all the answered questionnaires were positive to the total of the choices proposed to them. However, we have noticed that a small preference would go to the collaborations with research centers, universities and educational institutions. Concerning the exchange with the collaborators, a preference would go to International multidisciplinary workshops. Furthermore, this survey has

shown that the activities the targeted community is interested in developing is mostly **measurements / analyses on archaeological artefacts** (Figure 7). The main type of materials the researchers would like to study are, in order of preference, **ceramics, stones, metal, glass and pigments** (Figure 8). Similarly, the reference collections available in the institutions are mainly **ceramics, stones, metal, glass and marble**. In terms of equipment needs, all the institutions answered they would like to have access to fixed and portable equipment in the region.

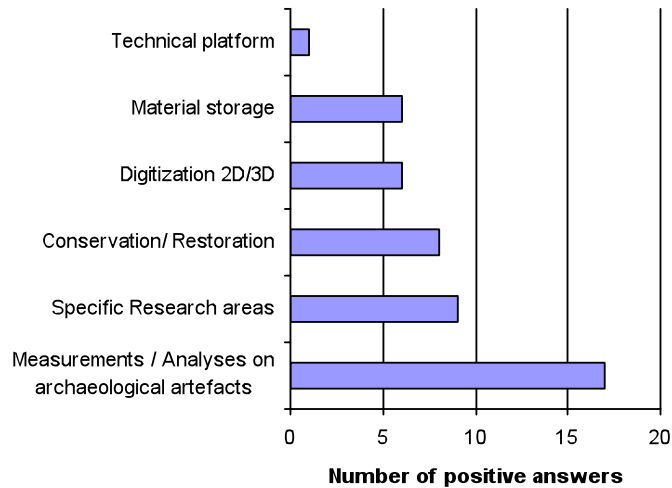


Figure 7 Distribution of the activities the researchers interviewed would like to develop in 9 countries in the Eastern Mediterranean region for the STACHEM WP2 survey.

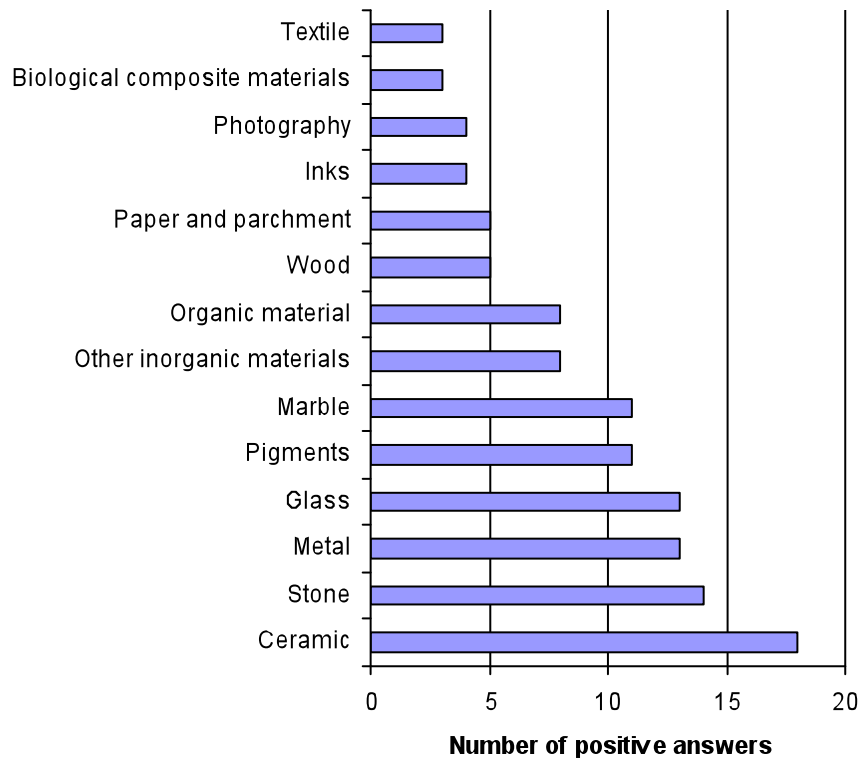


Figure 8 Distribution of the materials the researchers interviewed would like to study in 9 countries in the Eastern Mediterranean region for the STACHEM WP2 survey.

### *Planning of new infrastructures*

Buying a SEM-EDX apparatus (scanning electron microscope adapted to archaeological research, i.e. large sample chamber, capability to work under environmental conditions) with all the necessary materials (Precision Crosscut saw, Automatic Polisher and a Carbon Evaporation device), appears as an important improvement of equipment at STARC. The SEM with coupled EDS unit will allow full characterisation of a variety of archaeological materials. Complementary portable and fixed instrumentation has been planned within STARC partly thanks to the STARLab project and includes instrumentation for chemical and physical analyses, instrumentation for geophysics and surveying and instrumentation for 2D and 3D digital data acquisition.

### *Definition of a coordinated research and educational programme to take maximal advantage of the existing and new infrastructures*

The research and educational programs suggested aim at establishing the CyI-STARC as an expert for the study of Archaeological and Cultural Heritage artefacts in the Eastern Mediterranean region, by creating high-level competences within the CyI-STARC. It will give the opportunity to create steady collaborations, and to develop new collaborative research projects within the area of applications of materials and natural science to archaeology.

### *Definition of coordinated research programs*

The Eastern Mediterranean region and especially Cyprus is very rich in terms of its archaeology and cultural heritage. One of the research projects objectives are to conduct pilot studies of archaeological artefacts in the EM countries to arrive at a thorough understanding of the functional, social and decorative use of materials and technologies. This is key also to understanding the transfer of technological knowledge. The aim is to develop an appropriate strategy for artefact investigation based on a combination of 2D and 3D imagery, physico-chemical analyses, archaeological prospection and creation of an implemented database of reference collections. This can also be applied, for example, to the study of human remains, or to conservation issues. Furthermore, the use of portable and non-destructive instrumentation will allow not only to gain time and to multiply the number of analysed areas, but also to investigate in situ large scale artefacts which cannot be moved or which are in a bad conservation state. To complement these techniques, analyses will be performed on micro-sampling in the stationary laboratory and in partner laboratories. Indeed, sampling gives information often inaccessible to classical methods.

In such projects, every aspect will be considered: the archaeological or historical context as well as the multi-scale analyses of the morphology, the structure and of the composition. The determination of the state of conservation of the artefacts as well as the identification of the materials used will be obtained using a multi-analytical

approach. Depending on the context, these analyses will be made on site or via micro-sampling. Such a large panel of techniques is necessary to enrich the knowledge on various types of materials (technology, provenance and chronology of a production, weathering mechanisms, etc). Information on the previous interventions and consolidations will also be brought to light thanks to the analyses of adhesives and external products. These projects will focus on different types of materials, for example, ceramics, metal, glass or pigments. They need to be carried out by multi-disciplinary teams, joining archaeologists, scientists, conservators and curators. The STACHEM network helped to create and foster exchanges between institutions in the EM region. All the partners and many users have expressed their wish to collaborate and to strengthen links between the different countries and the various actors of the community. PhD students with joint supervisions in the different fields and countries could be hosted in the concerned institutions. Exchanges between researchers could be enhanced by trans-national activities.

### *Definition of coordinated educational programs*

One area that received a considerable amount of interest and attention in the various events organized within the STACHEM project was the training aspect. Great interest was expressed in developing better systems for educating undergraduates in natural and material sciences applied to archaeology and cultural heritage (including both field schools and classroom learning), and increasing the number of qualified and interested people in the field. Summer schools could be organised with experts coming from Eastern as well as the Western Mediterranean region and beyond. We would suggest schools be of a duration of 3 to 7 days and contain theoretical courses as well as practical tutorials with training on portable or fixed instrumentation. Discussions on good practises would also take place. Attendance could be both students and scientists and archaeologists wishing to improve their knowledge in the field.

### *Final remarks on WP2*

The STACHEM project WP2 on “Coordination of infrastructures, research and education in materials science and archaeometry”, has achieved an inventory of the existing infrastructures in the Eastern Mediterranean region as well as of the identification of needs. The preparation of a profile database provides the groundwork and has enabled, together with the organization of two small regional workshops coordination of the use of the existing infrastructures and has assembled the researchers around discussions dealing with targeting planning new infrastructures in STARC and elsewhere in the region, thus allowing the proposition of coordinated research and educational programs to take maximal advantage of the existing and new infrastructures.

The above is therefore a first step to an enhanced networking of the infrastructures of the Eastern Mediterranean region and thereby to the building of a community of users with joint trans-national activities. Now, the objective is to create a permanent



interoperability among the participating infrastructures, establishing cooperation and exchange of knowledge with other infrastructures active in this field, with the aim of structuring a common Eastern Mediterranean Research Area. We would propose therefore, that a future project might be structured along the following three activities: networking, access to infrastructures and joint trans-national activities. The participating institutions would all operate in cooperative interdisciplinary programmes with curators, conservators/restorers, librarians, archaeologists, art-historians..., and therefore would represent, in their own countries, an important model for the overall community concerned with study and conservation-restoration of the cultural heritage.

### 3.2 WORKPACKAGE 3: UNDERWATER ARCHAEOLOGY

#### *Underwater Archaeology in the Eastern Mediterranean*

If archaeology is the scientific study of the human past through its physical remains, underwater archaeology occupies a special place in the investigation of the means by which people communicate, things move, and culture is transmitted. This includes not only ships and harbors, but whole submerged landscapes of prehistory and history, investigated not merely by scuba diving and remotely operated vehicles, but through the allied work of ceramicists, social historians, epigraphers, paleobotanists, zooarchaeologists, chemists, geologists, oceanographers, conservators, ethnographers and naval architects, to name just a few. Nor does this include only the discovery and excavation of sites, but rather their curation and preservation as well as the comprehensive inventory and data-sharing that facilitates both dissemination of science and education at all levels. Thus, with collaboration today more essential than ever, the integration of underwater archaeology as part of STACHEM offers an opportunity to build and improve on the cooperative nature and infrastructure for underwater archaeology. A regional approach, moreover, makes sense for studying a shared maritime heritage that is a direct manifestation of the interconnectivity that linked peoples and cultures around the eastern Mediterranean, as Plato put it, like “frogs round the pond.”

The discovery of obsidian from the island and Melos in Franchthi Cave on the Greek mainland indicates that people have been utilizing water craft for transport and resource gathering in the eastern Mediterranean since at least the 10<sup>th</sup> millennium BCE. Indeed, the colonization of the region’s many islands, including Cyprus and Crete by 6000 BCE, would not have been possible without the construction and use of ships and boats.

The early projects of the 1960s mark the beginning of 50 years of scientific underwater archaeological work. Widely regarded as one of the most important archaeological discoveries of the last century, the Uluburun shipwreck (excavated between 1984 and 1994) has demonstrated the wealth and quality of information that can be found as a result of the scientific applications of modern advancements in underwater archaeology. In the past 50 years, major underwater surveys and

excavations throughout the eastern Mediterranean have been conducted, in all spanning more than four millennia of human history. During the past few years, well over a dozen large underwater excavations have been undertaken, along with many more surveys. The pace of investigation continues to rise. As such, any broad collaborative initiative of this type might start with an inventory of resources—material and human—available for work within the region, as well as a comprehensive inventory of publicly accessible information. In this way, we can most effectively capitalize on the strengths and identify the most promising avenues for development.

One of the most prominent challenges for a regional collaboration initiative lies in the means for investigating and protecting sites outside the more thoroughly explored shallow near-shore waters. Over the past two decades, research beyond diving depths has grown and developed through partnerships between archaeologists, marine scientists, engineers, and a variety of specialists. The refinement and increasing availability of remote sensing and other equipment—from sonar, magnetometers, sub-bottom profilers to ROVs and AUVs—now facilitates survey for shipwrecks at all depths in the Mediterranean.

Despite significant financial and logistical requirements, the pace of this type of work continues to grow and what should be immediately apparent that it is absolutely crucial role of well-defined collaboration and mutually beneficial research agendas on the part of government ministries, academic institutions, scientific and non-profit organizations.

### *The Purpose of Work Package 3: Underwater Archaeology*

The STACHEM Work Package 3 (WP3), centered on underwater archaeology, focuses on the infrastructures required to conduct underwater archaeological fieldwork (and associated activities) throughout the eastern Mediterranean. It also encompasses the unique technological and other scientific requirements demanded by such activity, including access to appropriate equipment, specialized training, and conservation of waterlogged materials. The purpose of WP3 is to establish a connection between competence centers active in underwater archaeological work, to form meaningful collaborative relationships between organizations to better utilize resources and knowledge in the region. This was done through gathering and sharing information on current activities and capabilities, with the intention of public distribution of the gathered information among interested institutions to better foster resource sharing and long-term collaboration.

The two primary tasks were:

- Collection of infrastructure information on relevant institutions, individuals, and projects active in underwater archaeology in the eastern Mediterranean.
- The compilation of this data into an easily disseminated format, in particular a database.

The information that WP3 gathered was focused in 3 major areas:

- Contact information and current partnerships.
- Underwater equipment, activities, and capacities.

- Expectations and future needs.

The STACHEM WP3 takes an unprecedented approach to assessing and better using the resources available for underwater archaeology in the eastern Mediterranean. The resulting database holds centralized and standardized infrastructure information on dozens of relevant institutions, and thus provides a valuable new resource for the archaeological community working in the eastern Mediterranean. The following summarizes these goals, the methods employed to meet them, and results.

**Competence Centers.** Generally, a competence center for the present purpose is a specialized organizational structure - public or private - with specific competencies and skills. As to the competence centers associated with underwater archaeology, it is not possible to give formal criteria for defining them. The competence centers that participated in the WP3 were diverse and ranged from large publically funded research institutions and universities to small privately funded research centers. Geographically, they are quite disperse, and united only in that they all conduct or provide key support to underwater archaeological work in the eastern Mediterranean.

#### *Methodology adopted for the survey*

Despite underwater archaeology being a somewhat smaller and more recently developed field than certain others within the discipline, information of interest to the STACHEM Project was found to be remarkably dispersed throughout different areas and media. Because of this, the focus and detail of available data was found to be very inconsistent. This initial information gathering was carried out utilizing primarily freely available (generally web-based and published) sources, as well as through established contacts with persons and groups in the study region. Many of the organizations of interest have a web-presence, and all applicable information was collected as available in this format. Emphasis was placed on collecting details of contact information, relevant logistics and facilities (including conservation and storage), and recent (since 2000) work by academic and non-profit institutions established in the area, as well as government ministries involved in the protection and management of this type of heritage. The goal was to establish a current inventory of resources available for conducting underwater archaeology in the region. This inventory was intended to serve as a basis by which to evaluate the status of the region as a whole, as well as smaller-scale distributions of resources that could be shared and accessed by institutions operating or based in the same local area.

Since the relative quantity and comprehensiveness of the data available in this easily-accessible format on different institutions and organizations varies considerably, the resultant database was only intermittently filled, and so a more direct and complementary approach was needed to complete the data collection. In response to this concern, a survey was created to send out to institutions and organizations in the study area. Institutions were selected on the basis that they have conducted or been actively engaged in the logistical or scientific support of recent (within the last 10 years) underwater archaeological work in the eastern Mediterranean. This meant that many of the organizations on the list were actually located in the eastern

Mediterranean, though this was not a requirement. Many foreign institutions conduct work in eastern Mediterranean waters and therefore became organizations of interest for the goals of WP3. The survey was modeled after others undertaken by STACHEM partners for data acquisition related to parallel work packages. The survey was distributed to more than 50 relevant institutions. The database was consequently modified to better accommodate the detailed data collected by the survey.

### *Geographical Coverage*

The concept of an eastern Mediterranean region is not entirely clearly defined. Underwater archaeological work is clearly confined to submerged sites, and in the case of the STACHEM Project, this means sites in the eastern Mediterranean Sea (including the southern Adriatic and Aegean Seas) as well as the Nile Delta. Therefore, the survey was limited to organizations that conduct underwater archaeological work in the coastal waters of the following countries:

- Italy
- Slovenia
- Croatia
- Bosnia and Herzegovina
- Montenegro
- Albania
- Greece
- Turkey
- Cyprus
- Syria
- Lebanon
- Israel
- Egypt
- Libya
- Malta

### *The Structure of the Survey*

The survey was organized in three parts:

- Institution or Company Information
- State of Your Institutions (Areas of Specialization)
- Expectations and Future needs

The bulk of the survey focused on collecting information on underwater archaeological activities, equipment, and capacities, with the goal of establishing a comprehensive survey of existing infrastructures. This was sub-divided into three sections:

- Underwater Prospection
  - Activities include: Diving/snorkel survey (non-intrusive and with artifact collection), remote sensing (within and beyond diving depths), geophysical/geochemical/magnetic prospection, sea floor/bathymetric mapping, photogrammetry, and satellite/aerial imagery.

- Equipment includes: SCUBA equipment, underwater camera, dive compressors, GPS, GIS, sidescan and multibeam sonar, metal detector, magnetometer, sub-bottom profiler, recompression chamber, research vessel, auxiliary vessel, ROV, AUV, and submersible.
- Underwater Excavation
  - Activities include: Diving excavation, remote excavation (within and beyond diving depths), site mapping by hand, photogrammetric site mapping, automated/remote site mapping, and on-site conservation.
  - Equipment includes: Largely the same as the equipment for underwater prospecting, but also includes air lift, water dredge, generator, aquameter, Total Station, electronic distance meter, tools for artifact cleaning and on-site conservation, and artifact storage.
- Non-Fieldwork
  - Activities include: Resource management/protection, database management/GIS, digitization and image archiving, materials conservation/conservation research, materials analysis/dating, and student training.

This is the largest and most detailed section of the survey. Collecting data on equipment and activities by active organizations is essential to assessing the infrastructure for conducting and supporting underwater archaeological research. While the survey is not exhaustive in its assessment of all possible equipment and activities, it evaluates the most significant infrastructure elements necessary to carry out most underwater archaeology. The focus is primarily on field work, as this is often the most resource intensive and limiting aspect of the discipline.

### Expectations and Future Needs

The third and final section of the survey was focused on the expectations and needs of the surveyed organizations. Detailed information was collected on desired collaborations. Broadly, the questions asked:

- With whom would you like to collaborate in the eastern Mediterranean?
- What format would you prefer for exchange among collaborators?
- Which type of materials would you like to study thanks to trans-national access?

The final three questions asked:

- What equipment NOT available in your institution would you like to use through trans-national access?
- What equipment available in your institution could be used through trans-national access?
- What equipment are you lacking to improve your work?

The three sections (contact and organizational information, current activities and equipment, and expectations and future needs) all collected information necessary to assess the current state of the infrastructure and gauge desire and willingness for trans-national collaboration. The goal was to fill the more important gaps in the current knowledge and potential regional collaborations through this survey, and through the new opportunities for networking provided by within the framework of

the regional workshop series in underwater archaeology. This allows the work package to raise the data quality to a uniformly high standard across the various diverse areas mentioned above and focuses of underwater archaeology in the eastern Mediterranean. Among the most crucial lacunae still in need of attention are a near total lack of representation from Syria, Lebanon, and Jordan. This certainly is at least in part indicative of a dearth of underwater archaeological fieldwork in these states, especially compared to those states in which this type of work has a particularly long history (Greece, Turkey, Israel, etc.). Various STACHEM project work packages' inclusion of heads of relevant antiquities departments in these countries, however, promises to make some progress on fostering connections and perhaps too an interest in developing this aspect of the local cultural heritage sector, perhaps as part of a regionally based collaborative initiative building on the STACHEM project's network.

## *The results*

### *The Competence Centers*

The list of centers included in the survey and inventory of WP3 was largely compiled from the contacts of the STACHEM and INA networks. Additional centers were located through internet searches and the recommendation of in-network institutions. In total, 22 completed surveys were returned. While this rate of return is less than had been hoped, it has provided very complete, detailed and uniquely useful information on the range of organizations that have completed the survey. The results pertaining to underwater archaeological infrastructure are listed below, accompanied by a discussion of the apparent trends and significance. Each graph represents the number of positive responses (out of 22) by organizations.

### Underwater Prospection

This section of the survey is concerned with the activities and equipment involved in underwater prospection aimed at the discovery and investigation of underwater cultural heritage. Typically, this phase of a project precedes larger-scale investigations such as excavation. Prospection, also called surveying, allows archaeologists to locate and identify sites of interest. Through visual or instrumental inspection accompanied by recording in situ or diagnostic artifact removal, an approximate date and possibly region of origin may be determined. Other significant features may be determined through survey, including approximate cargo size and type (in the case of shipwrecks), the extent of a site (useful in planning excavations), and assessing the logistical requirements for carrying out a full or partial excavation. Prospection provides a key tool for underwater cultural heritage management, helping resource managers develop and implement plans for long-term preservation. The graph below displays the responses when asked about certain activities related to underwater prospection.

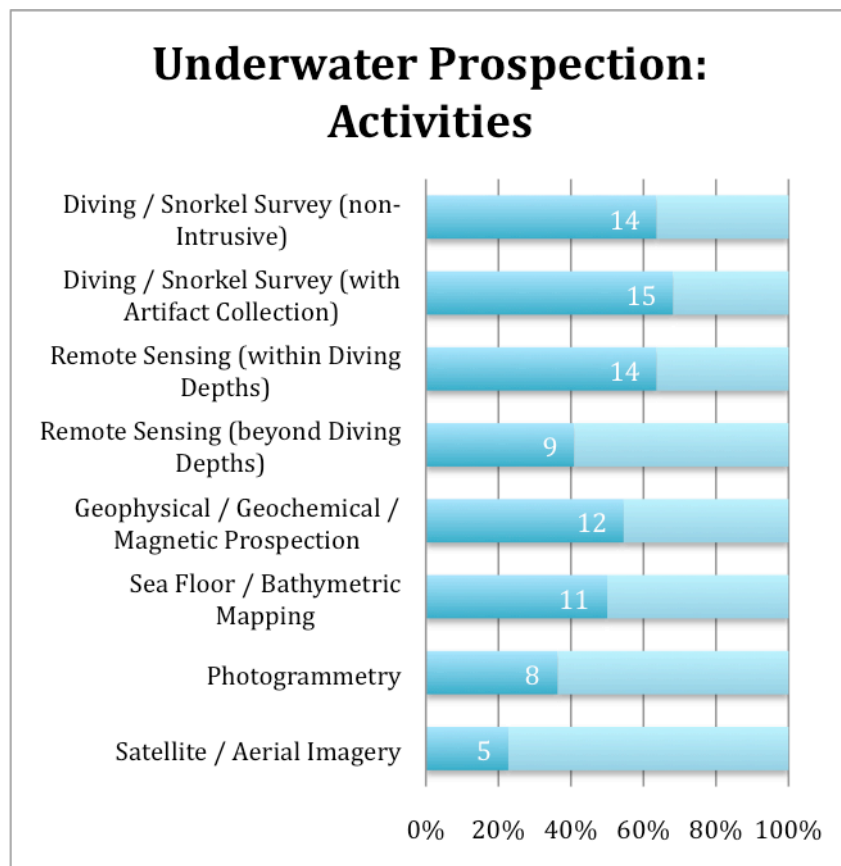


Figure 9 Graph of responses in Underwater Prospection: Activities

Underwater prospection: activities: While a large number of the respondents indicated they were active in diving/snorkel survey and in remote sensing, deepwater survey, including sea floor bathymetric mapping, shows lower numbers of positive responses, possibly reflecting a lack of expensive equipment to undertake such work or an intentional avoidance because of the complications with excavating remains at great depths. Photogrammetry, a technique being used with increased frequency in underwater archaeology, requires specialized and costly imaging equipment and it is therefore unsurprising that a lower number of organizations would use such methods. The same holds true with satellite/aerial imagery, which in addition to being expensive is only starting to be employed in limited applications for underwater work.

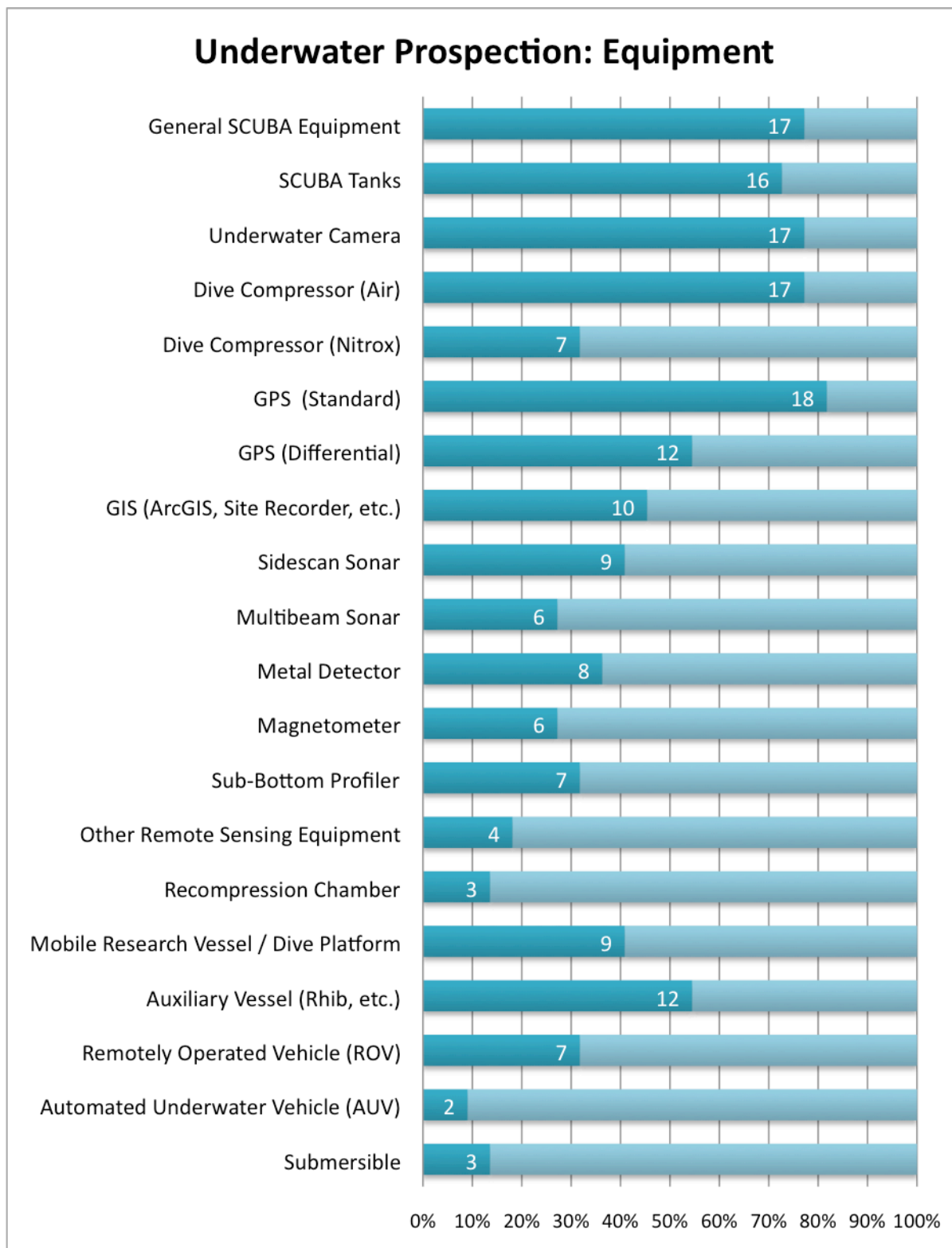


Figure 10 Graph of responses in Underwater Prospection: Equipment

A high number of respondents have indicated that they are equipped to carry out basic diving surveys and excavations. Remote sensing equipment (such as sidescan sonar, multibeam sonar, underwater metal detector, a magnetometer, a sub-bottom profiler) is among the most expensive in this category, and many organizations choose to



partner with larger organizations that already possess the capabilities (this often includes non-archaeological organizations, as remote sensing has many applications in oceanography, geology, and other fields) rather than purchase it on their own. Large equipment (e.g., own recompression chamber, own manned submersible) is somewhat poorly represented among respondents. However, an encouraging number of organizations reported having their own mobile research vessel or dive platform. The same holds true for a small auxiliary vessel, which can prove most useful in supporting near-shore diving operations and conducting shallow water remote sensing and diving surveys. Almost one third reported having their own ROV, while only a couple of organisations reported having their own AUV. Much like remote sensing equipment, these large and expensive resources are often shared among institutions, and are not specific to archeological organizations. The economic situation of several smaller organizations likely prevents them from owning and maintaining their own research vessel. Substantial benefit could be gained through partnerships with organizations possessing their own vessels and those smaller organizations that do not.

Overall, the results of this section of the survey indicate that an infrastructure is in place in many areas to support the most basic underwater archaeological operations. The widespread presence of SCUBA equipment and GPS enable organizations to carry out underwater surveys within safe diving depths, which is crucial in locating potential sites for study or excavation. Supporting equipment, including remote sensing capabilities and ROVs/AUVs are less widely represented, likely a product of their purchase and operational costs. Increasing the presence of these technologies, as well as their sharing across institutions will increase the efficiency and coverage of underwater prospection, which will result in increased ability to locate, investigate and protect underwater cultural heritage.

### Underwater Excavation

This section of the survey collected information on activities and equipment integral to underwater excavation. This is the phase of a project typically follows survey and in situ documentation. Excavation is the process of methodically dismantling a site while recording the spatial positions and context of individual artifacts, removing to the surface part or all of the artifacts or features associated with a submerged site. Excavations demand careful documentation of the three-dimensional position and relationship of artifacts within the site before removal. Although it is possible to learn much from the non-intrusive observation of a submerged site without removing artifacts, considerably more and different insights can be gained when artifacts can be analyzed in a laboratory. Additionally, excavation allows archaeologists to discover artifacts or features buried beneath natural deposition of sediments, other overburden and surface artifacts. Depending on the size and location of a submerged site, excavation can be expensive and may require an undetermined amount of time to complete. Underwater excavations require an extensive support structure and a wide range of personnel (both divers and surface support crew) to successfully complete. Primarily for this reason, far more sites are located and surveyed than excavated. Typically, archaeologists select only the most diagnostic, well preserved, or otherwise most significant sites to excavate in full.

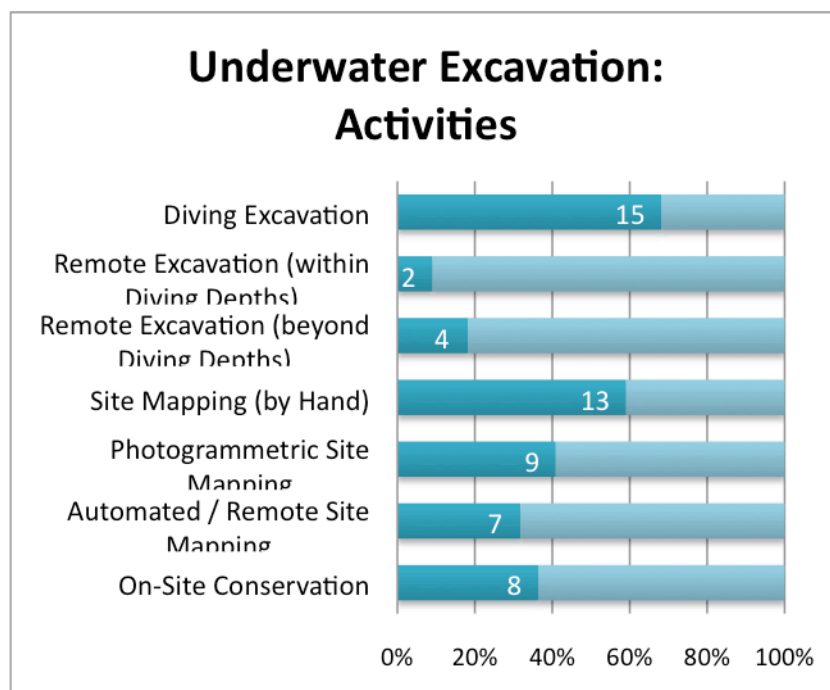


Figure 11 Graph of responses in Underwater Prospection: Activities

Among respondents, the majority indicated they were active in underwater excavation within diving depths. A fundamental part of underwater excavation is site mapping. Often archaeologists employ more than one method of site mapping, including mapping by hand, photogrammetry, and remote sensing methods. Of those surveyed, more than half indicated they employed site mapping by hand (the least resource-intensive but most time-intensive method of mapping), 40.9% indicated they employed photogrammetric site mapping (a more resource-intensive method) and only 31.8% employed automated or remote site mapping techniques (the most resource-intensive method). Few organizations reported participating in remote excavations. This type of remote excavation, conducted using ROVs, is notably expensive and generally only attempted by organizations that possess the necessary equipment to do so and only in circumstances where the cultural heritage is either of particular historical interest or threatened with destruction.

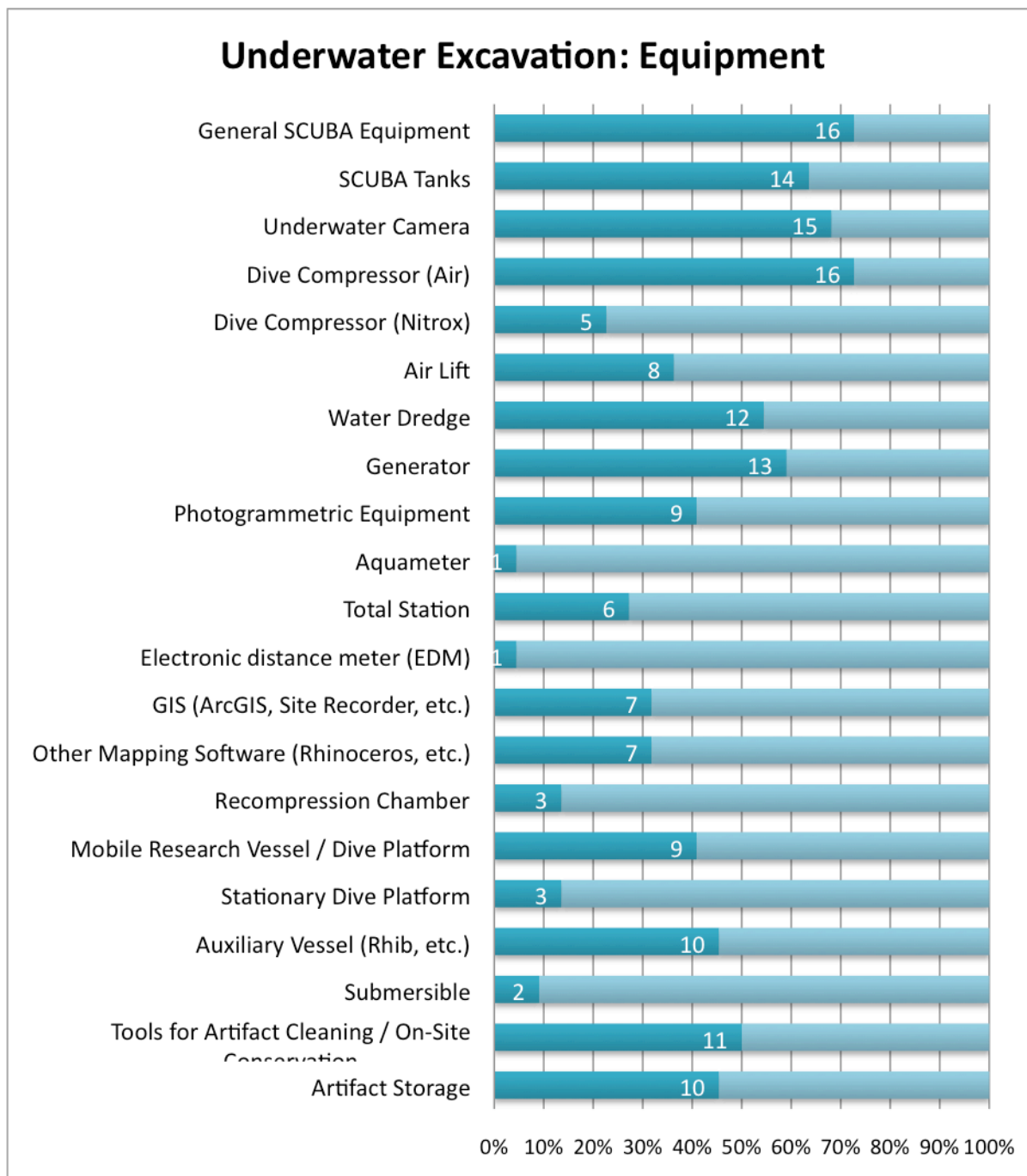


Figure 12 Graph of responses in Underwater Excavation: Equipment

Much of the equipment necessary to conduct and underwater excavation is the same as that required for underwater prospection and similar numbers were reported by the surveyed organizations.

Equipment for the *documentation of a site*, beyond mapping by hand, include photogrammetric equipment, aquameter, a total station for mapping very shallow, generally near-shore sites, and an electronic distance meter. Software required to effectively use and interpret the information gained from this measurement equipment includes GIS software or other types of mapping software suitable for archaeological use. The somewhat poor showing in this section of the survey highlights one key area for resource sharing and collaboration. The importance of accurately mapping and

managing the data from a site before and during excavation is recognized as fundamental to later attempts at interpreting the site's remains. Although tried-and-true methods of mapping by hand are still widely employed, they can be time-consuming and subject to human error. The electronic methods of mapping, using the equipment discussed in this section of the survey, increase both the efficiency and accuracy of mapping an underwater site. Furthermore, by using mapping software such as GIS, maps can be created that contain significantly more levels of data than a map created by hand and help facilitate data transfer across a shared platform within the greater archaeological community.

Other unique requirements for underwater excavation include tools for *artifact cleaning and on-site conservation measures*, which half of those surveyed reported having on hand. Similarly, proper storage of excavated materials is a growing necessity, and nearly half of those surveyed reported having such capacities. Material removed from submerged sites must be specially treated in order to keep it from alteration and disintegrate and it is therefore of paramount importance that an excavation team be properly trained and prepared to handle the on-site conservation requirements of an underwater operation. The statistics reported in this section of the survey are therefore significant, as they show that significantly more organizations possess the basic capacities for and are active in underwater excavation than are prepared to manage the intricate demands of care for artifacts in the field.

Overall, many organizations possess the basic equipment to send divers to the bottom, create site maps by hand, and raise artifacts. Far fewer are equipped to map sites using digital means, and only some have the necessary larger support surface systems to expedite and properly conduct larger-scale underwater excavations. Additionally, around half of those surveyed report having the necessary tools to clean and conserve artifacts in the field, an essential step to maintaining the archaeological integrity of the artifacts. This area, regarding the equipment necessary to conduct underwater excavations, is certainly one area in which greater resource sharing could have widespread benefits for the underwater archaeological community in the eastern Mediterranean.

### Non-Fieldwork

Non-fieldwork activities are as essential to underwater archaeology as those in the field. It is through non-fieldwork activities that interpretation and analysis is carried out, findings are disseminated in scientific and popular formats, training at all levels is accomplished, and excavated materials are conserved for long-term storage and display. The areas of non-fieldwork activity investigated in this survey are not exhaustive, and are largely general in their scope, but they do cover the most significant aspects of this type of work and give a general impression of the state of the art in the eastern Mediterranean region.

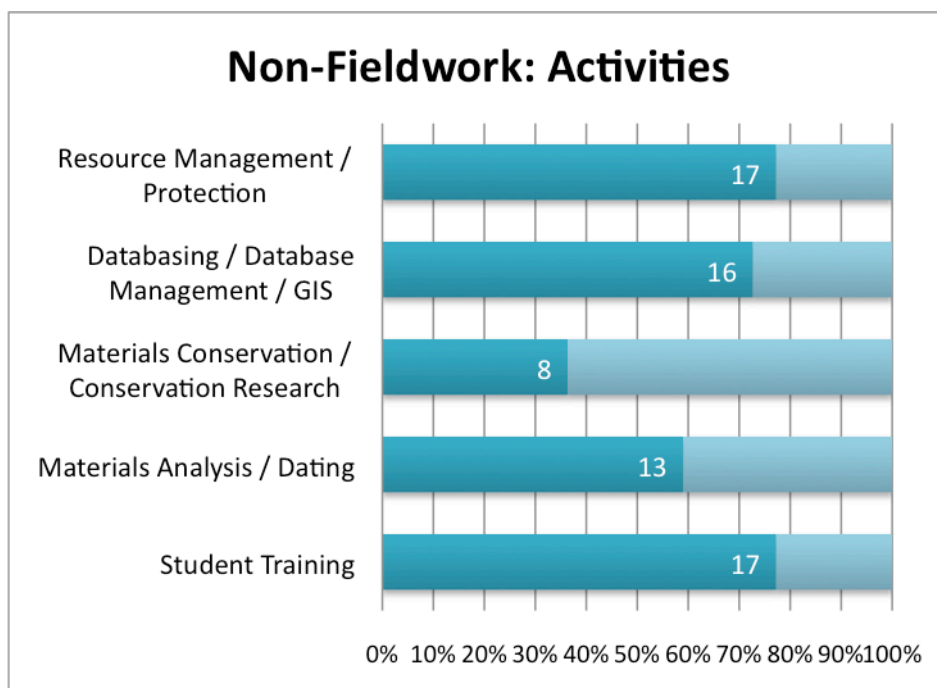


Figure 13 Graph of responses in Non-Fieldwork: Activities

A high number of respondents indicated they are active in resource management and protection. This is an area of growing interest and activity, particularly following the ICOMOS 1996 Charter and the UNESCO 2001 Convention, and the subsequent adoption of their scientific standards and principles by various countries throughout the eastern Mediterranean region. On an annual basis, ever more organizations are taking it upon themselves to not only locate, survey, and excavate underwater sites, but also to take steps to protect them from human and environmental hazards. A similarly high number of respondents indicated they are active in databasing, database management, and GIS. These are crucial new areas of activity in the increasingly digital and collaborative field of archaeology. The creation of databases of archaeological information, including GIS maps, is one significant way in which this data can be easily organized and shared, maximizing its impact on both the scientific and management levels.

The conservation of archaeological materials is a primary concern for any artifacts recovered from a site, whether on land or underwater. Materials recovered from submerged, particularly marine, sites require special facilities and care to be properly stabilized and conserved for both current and future research and public education and enjoyment. Methods are continually being developed to overcome the challenges of caring for waterlogged materials, and many of the processes require specialized training and equipment. Over one third of those surveyed reported activity in materials conservation or conservation research. Because of the level of specialization needed to properly handle archaeological material recovered from submerged sites, typically a small number of laboratories will process material for a large number of research organizations. The statistics on conservation reported in this survey reflect this tendency. In the eastern Mediterranean, a small number of specialized laboratories conserve the materials excavated from a wide range of sites by a large number of institutions and projects. While this is not an inherently

unsustainable or negative situation, it does result in a backlog of work, which in turn may have detrimental impacts on artifacts if proper storage practices are not observed. The equipment required to conserve waterlogged material is specialized, though not always particularly expensive even if considerable allotments of space may be necessary. It does, however, require careful training to use effectively and to ensure conservators understand the requirements of handling such fragile material.

Nearly three fifths of reporting institutions state they are active in materials analysis and dating. Depending on the type of analysis or the method of dating used, these practices may require specialized equipment or specially trained personnel. Typically, this kind of materials analysis goes beyond the historic or archaeological interpretation, and focuses on more technical details of composition, place of origin, etc.

Over three quarters of respondents indicated they are involved with student training. This particularly high response underscores the growing need to train new archaeologists in order to advance and expand the field. Training can take several different forms, including formal degree-granting programs, field schools, workshops, or internships. The large number of organizations participating in education ensures that a reasonably well-developed infrastructure exists to support those interested in training in underwater archaeology.

In summary, the majority of organizations surveyed are active in one or more aspect of non-fieldwork activities. The statistics for this essential complement to archaeological fieldwork show that a solid base for future developments exists among institutions active in the region. Improvements in materials conservation can certainly be made through collaborations in training, sharing methods and equipment, and creating a more widely distributed network of conservation laboratories. Furthermore, new collaborative initiatives could offer a wider range of training opportunities at all levels from undergraduate through post-graduate as well as non-professional and advanced technical training for professionals already active in the field.

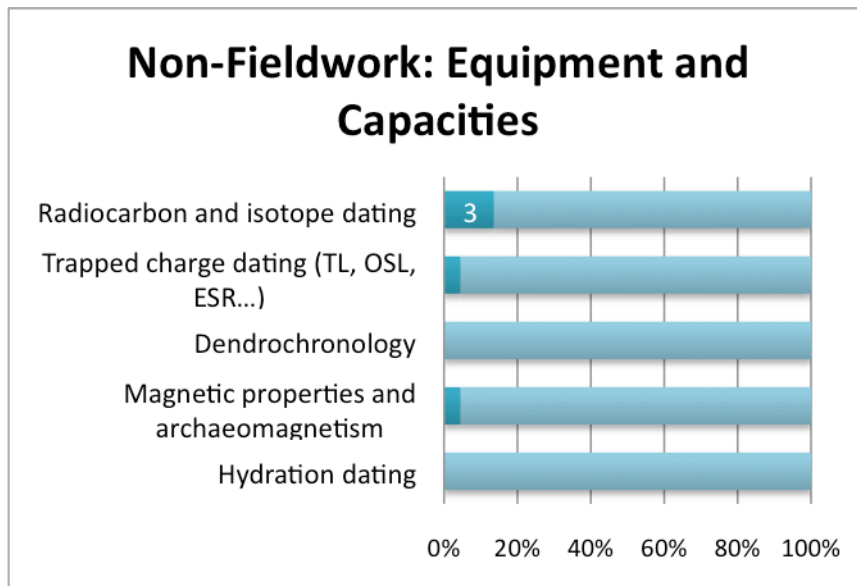


Figure 14 Graph of responses in Non-Fieldwork: Equipment and Capacities

This section of the survey examines in greater detail some of the dating and analysis methods commonly used in underwater archaeology. While the previous section examined the status of materials dating and analysis generally, the survey sought information on some more specific capacities. A low 13.6% of respondents indicated they are active in radiocarbon or isotope dating, one of the most common methods for establishing an approximate date of manufacture for ancient materials. A very low 4.5% of those surveyed indicated they had the capacities for trapped charge dating, and the same percentage reported the capacity for analyzing magnetic properties and archaeomagnetism. None of the surveys indicated they possessed the capacities for dendrochronology and hydration dating. The particularly poor showing in this section of the survey is likely a result of the interdisciplinary nature of such procedures. Often, archaeologists will contract with non-archaeological laboratories for the types of analysis mentioned in this section of the survey. The ability of a research organization to conduct its own analyses, however, increases the efficiency and ease with which these types of important data can be gathered. Although it would likely require a large amount of money to provide eastern Mediterranean underwater archaeological research institutions with their own laboratories and equipment, networking with other laboratories both within the region and worldwide will increase the ability of institutions to conduct the highest quality research possible. A useful model here might be the widespread application of dendrochronology in underwater archaeology, where only a handful of laboratories both in and outside the region actually perform the analysis for dozens of institutions and projects throughout the eastern Mediterranean.

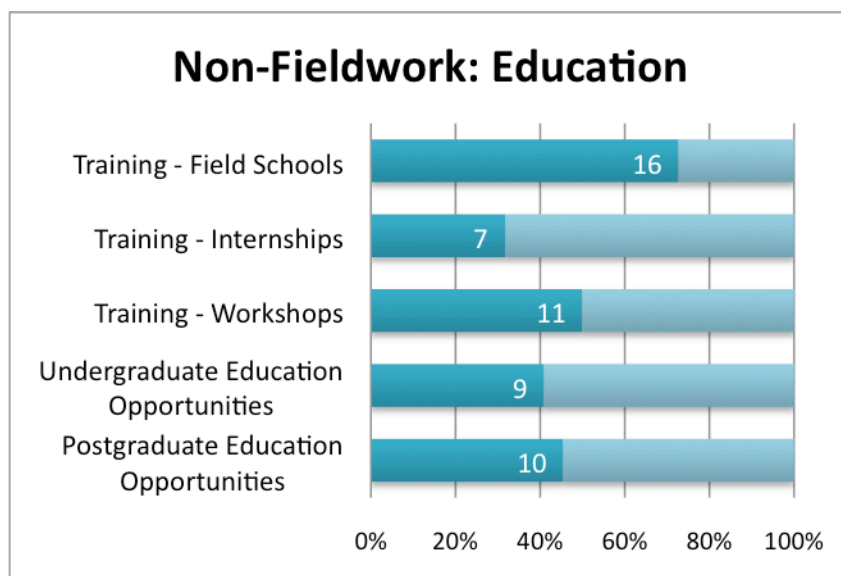


Figure 15 Graph of responses in Non-Fieldwork: Education

As previously stated, education is an integral part of successfully improving the underwater archaeological infrastructure in the eastern Mediterranean. A very high percentage, 72.7%, of respondents indicated they are active in hosting field schools. These field schools often provide university credit and are fundamental parts of both undergraduate and graduate educations in archaeology. They train students in the basic methods of conducting underwater archaeological fieldwork. Although it is possible to learn many of the principles and techniques in the classroom, hand-on experience in the field is often the best way to learn. If organizations are conducting fieldwork, it is often possible to incorporate a field school component into the work, while still advancing the survey or excavation. The high number of institutions offering field schools in encouraging and provide solid evidence for one particularly thriving sector of the underwater archaeological infrastructure that might yet benefit from new collaboration.

Internships are another training opportunity for new archaeologists. Rather than the fieldwork training field schools provide, internships are usually based in laboratories or research centers. Just under one third, or 31.8%, of reporting institutions state they actively offer some form of internship. Experience gained from these internships can include conservation training, analytical and technical methods training, and information management. The low number of organizations offering internships may be due to the limited number of institutions conducting conservation or technical work. Related to internships are workshops, which 50% of respondents reported as hosting or actively participating in. Workshops may be designed to incorporate both new and experienced archaeologists, and emphasize peer-training and collaboration. Workshops in underwater archaeology may focus on particular topics or remain broad in scope and have more general aims. Workshops hold great potential for establishing collaboration in the region, and will be revisited in a later section of the survey, discussed below.



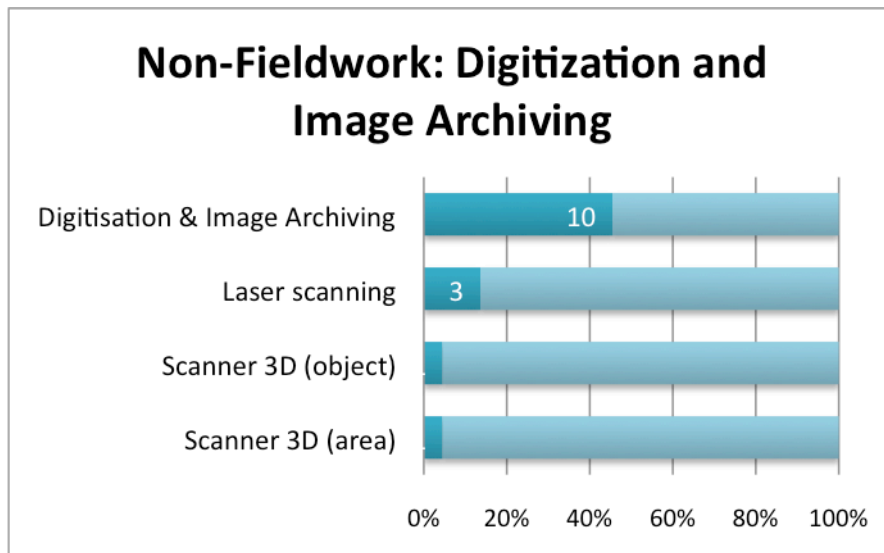


Figure 16 Graph of responses in Non-Fieldwork: Digitization and Image Archiving

The final aspect of non-fieldwork examined by the survey addresses digitization and image archiving. Under half, or 45.5%, of respondents indicated they were active in general digitization and image archiving, while only 13.6% have the capacity for laser scanning, and only 4.5% were active in both object and area 3D scanning. Digitization and image archiving is a relatively new but increasingly important aspect of underwater archaeological research and is rapidly becoming common practice. Digitization of artifacts and features enables researchers to access and analyze them in unique and informative ways. It also enables easy dissemination and sharing of archaeological information, which is instrumental to a thriving academic dialog. Image archiving not only preserves images for future generations of researchers, but also creates an easily distributable and accessible database of images. Increasing the number of organizations active in this aspect as it relates to finds and sites underwater will no doubt contribute significantly to improving the academic community both in the eastern Mediterranean and beyond.

In summary, the results of the non-fieldwork activities section of the survey indicate several areas for improvement. Field training is already relatively widespread, and is the most encouraging area of the reported statistics along with resource management and training. Databasing is another area that shows a particularly well developed infrastructure and expertise, but requires interfacing with digitization and image archiving to be the most effective. Improvement is needed in nearly all other areas to establish a firm and competent infrastructure to support underwater archaeological work.

#### Expectations and Future Needs

The third and final section of the survey investigates the desire and preference for regional collaboration. The response in this section was remarkable, and the results are indeed encouraging for launching any regionally based collaboration initiative. Below, the response statistics are presented and discussed. The preferences indicated in this section of the survey will inform the decisions made by the STACHEM Project

regarding recommendations for improving the infrastructure required to conduct underwater archaeological work in the eastern Mediterranean.

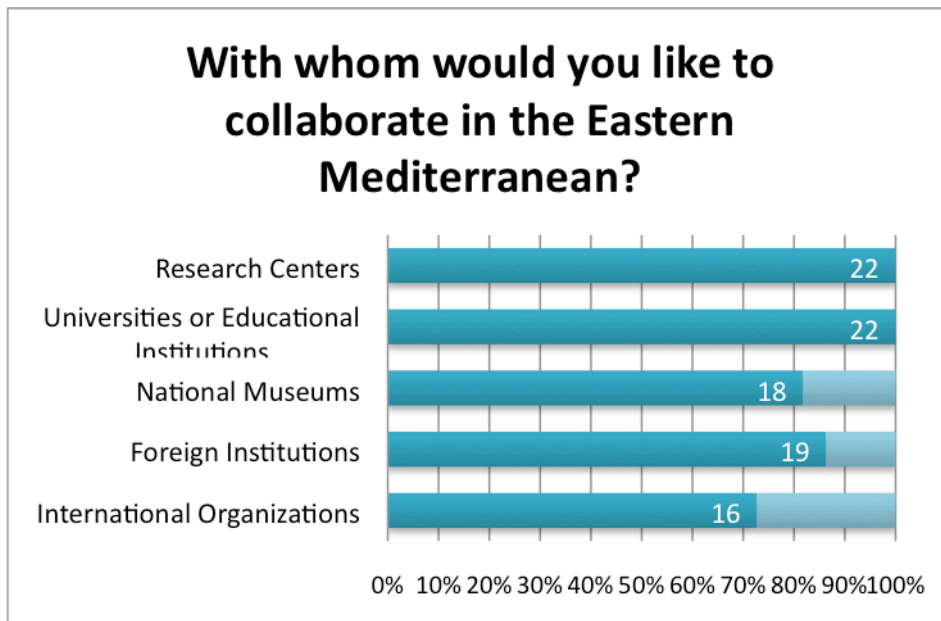


Figure 17 Graph of responses in Expectations and Future Needs: Desired Collaborations

In this first section, 100% of respondents indicated they would like to collaborate with research centers or universities. Slightly less, 86.4% indicated they would like to collaborate with foreign institutions, 81.8% with national museums, and 72.7% with international organizations. Thus, the overwhelming majority of those surveyed indicated the desire for collaboration in the region. While certainly some collaborative relationships do already exist in the region, all of those surveyed indicated a willingness to participate and become part of the larger collaborative communities. The responses lean slightly more toward research centers and universities, which at present typically have the largest and best established infrastructures for conducting underwater archaeological work. This section of the survey gauged the desire for collaboration, while the following sections gathered more detail on the types and focus of potential regional collaborative efforts.

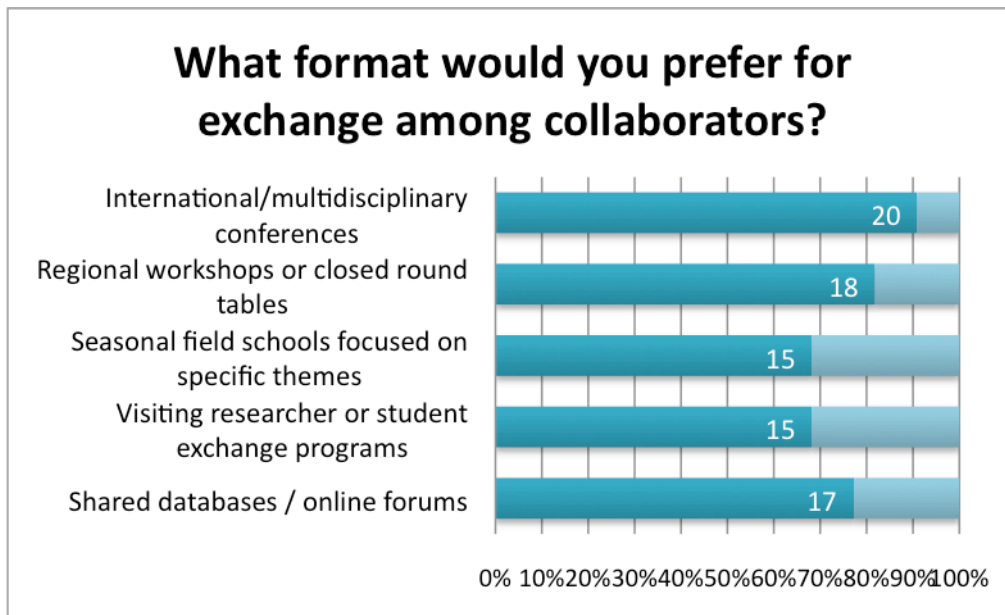


Figure 18 Graph of responses in Expectations and Future Needs: Preferred Format

The preferred format for exchange among collaborators appears largely to be international and multidisciplinary conferences, indicated by 90.9% of respondents. Second to this, are regional workshops of closed round tables, preferred by 81.8% of respondents. Shared databases and online forums also received interest, with 77.3% of respondents indicating interest in this format. Over two thirds, or 68.2%, showed interest in both focused seasonal field schools and exchange programs. The results of this section show a desire to improve the functioning and capabilities of organizations through formal collaborative means. Field schools and exchange programs scored the lowest, perhaps because of the logistical cost of running such programs. Many of the smaller organizations may not have the resources or personnel to devote to exchange or field school programs, and may account for their slightly lower scoring. Shared databases and online forums received a great deal of interest, which is very much in line with the goals of STACHEM Work Package 3. Organizations seem willing to collaborate either at a distance (through online means) or in structured meetings (conferences and workshops).

## Which types of materials would you like to study thanks to trans-national access?

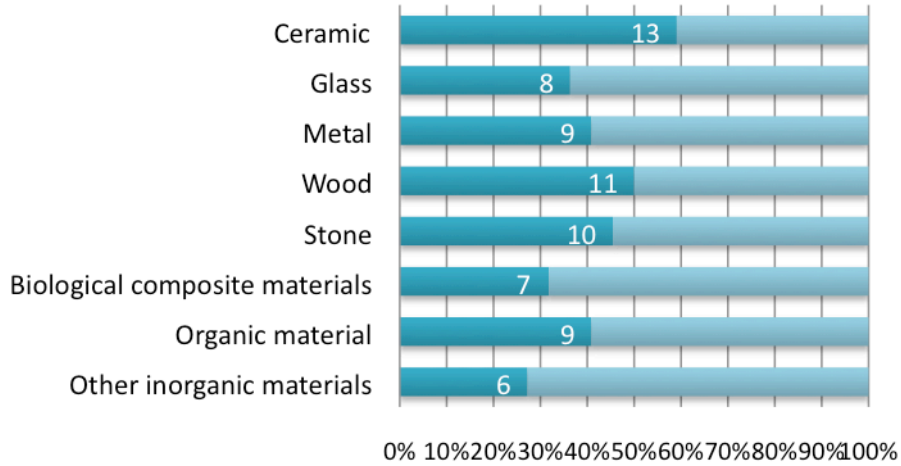


Figure 19 Graph of responses in Expectations and Future Needs: Materials

Looking more closely at the types of capacities that organizations would like to develop, this section investigates the specific materials for which institutions would like greater access to analysis capacities. Ceramics were reported highest, with 59.1% of respondents indicating interest. Over one third, 36.4%, of respondents indicated the desire to access glass, 50% wood, 40.9% metal, 45.5% stone, 31.8% biological composites, 40.9% organic material, and 27.3% other inorganic materials. Not surprisingly, the responses in this section do generally approximate in preferential order the most common types of material recovered from underwater sites. Ceramics, wood, and stone artifacts are often the largest, most numerous or significant items excavated. Glass, metal, and organic materials tend to be less well-preserved, rarer, and smaller in quantity among submerged sites, although these too should not be discounted in importance.

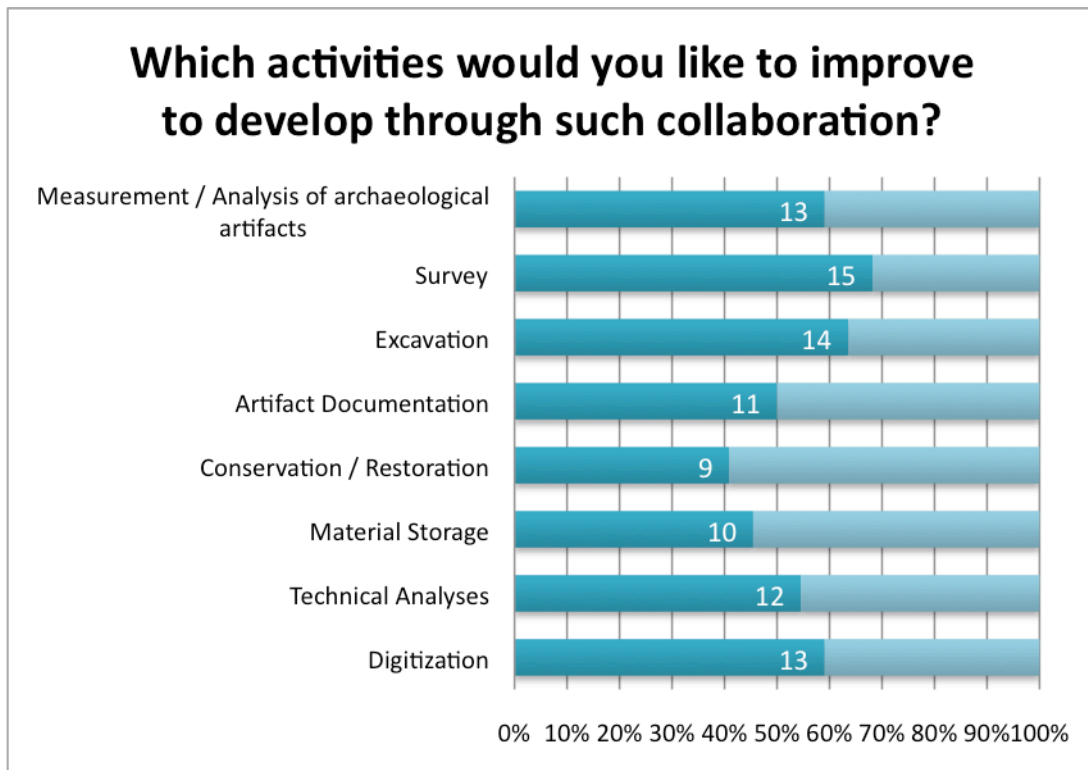


Figure 20 Graph of responses in Expectations and Future Needs: Activities

This section directly measured the desired areas of operational improvement among institutions. Nearly three fifths, 59.1%, of organizations reported the desire to improve measurement and artifact analysis techniques, while 68.2% expressed desire to improve survey methods, and 63.6% excavation techniques. Half, or 50%, showed desire to improve on artifact documentation, 40.9% on conservation and restoration, 45.5% on material storage, 54.5% on technical analysis, and 59.1% on digitization. None of the results in this section are remarkably high, but they do show a strong desire to improve on techniques and methods used in underwater archaeology. Perhaps the most significant aspect of this section is the response regarding conservation and restoration. The low percentage in this area may be a reflection of the current situation of archaeological conservation in the eastern Mediterranean, where a few centers handle the conservation demands for an entire region. Conservation facilities are expensive and require specially trained personnel and years to develop, and may be perceived as outside of the budgets and capabilities of many smaller institutions.

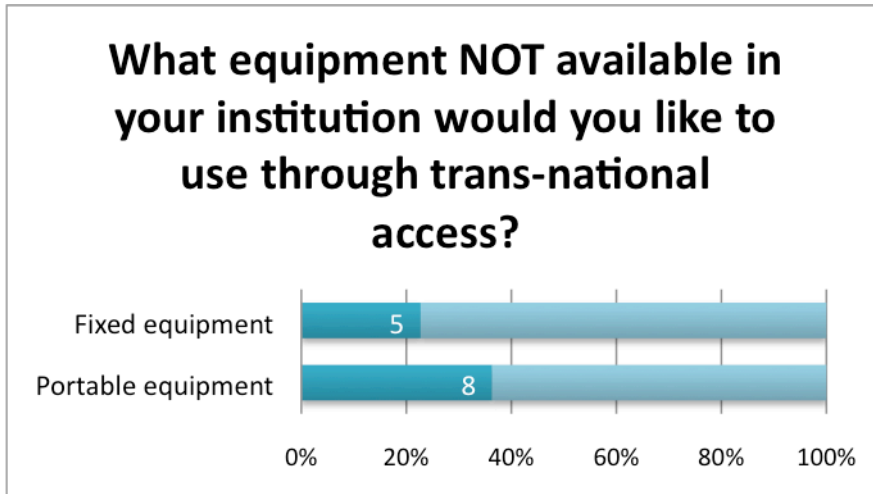


Figure 21 Graph of responses in Expectations and Future Needs: Non-available Equipment

The concluding three sections gauged generally the willingness and desire both to access and to share equipment within the region. The first of these questions asked what types of equipment to which the organization would like access. Under one quarter, 22.7%, responded they would like access to fixed equipment, and 36.4% indicated they would like access to portable equipment. This is a surprisingly low amount of interest given the high degree of desire for collaboration reported above. Reasons for this may be similar to the relatively low desire reported above for collaborative field schools and internship programs: namely logistical and personnel restraints. This may also be reflective of the feeling that many institutions very quickly built and so already have a sufficient equipment infrastructure for their own purposes, and therefore simply do not perceive a need to access the equipment of other organizations. It is expected that once new collaborative relationships are formed, and institutions receive training in the areas reported above, the numbers of institutions desiring access to equipment, both fixed and portable, will grow.

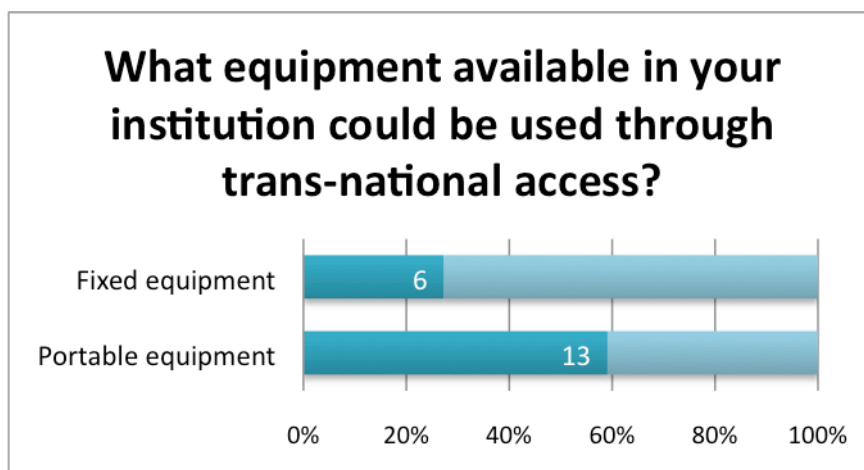


Figure 22 Graph of responses in Expectations and Future Needs: Available Equipment

This section recorded the desire of institutions to share their own equipment with other regional organizations. Just over one quarter, or 27.3%, reported they were willing to share fixed equipment and 59.1% were willing to share portable equipment. These statistics are more or less in line with those reported in the previous section. A

very small number of organizations are willing to share fixed equipment and little more than half are willing to share portable equipment. The higher interest in sharing portable equipment is perhaps telling, and points to the potential viability of creating a new portable infrastructure designed for sharing across political boundaries within the eastern Mediterranean region. Even so, among the reasons for a showing that is perhaps lower than anticipated may be that the majority of institutions equipment sees regular intensive use by the owning organization, and therefore would simply not be available for use by others. As with the previous section, it is likely that as collaboration begins, these numbers will increase reflecting a greater willingness to share available resources as more resources become generally available in the region.

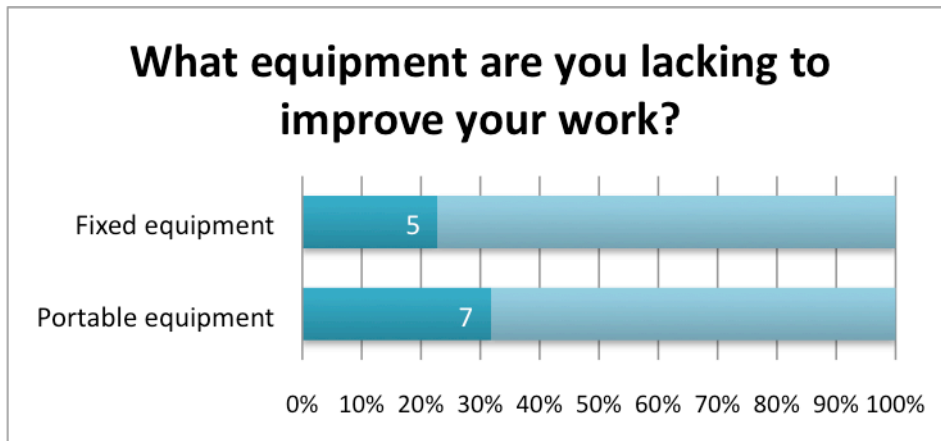


Figure 23 Graph of responses in Expectations and Future Needs: Lacking Equipment

This concluding section asked the general state of equipment as it relates to an institutions desire for improvement. Under one quarter indicated they lacked fixed equipment, and 31.8% indicated they lacked portable equipment. When these three final questions are interpreted together, it gives impression that by and large, organizations active in underwater archaeology in the eastern Mediterranean are sufficient in their current equipment needs. This is almost certainly not the case, as earlier sections of the survey have indicated. More likely, the operational and logistical challenges of sharing equipment, in particular across political boundaries, have discouraged resource sharing throughout the region. In opening lines of dialogue and creating collaborative forums, the resources that do exist in the region may begin to be used to their fuller potential through joint training efforts and equipment sharing.

In summary, the results of the survey show a general and basic infrastructure for carrying out underwater archaeological operations. Many institutions possess the equipment and capabilities necessary for basic survey and excavation fieldwork operations. Few, however, possess the equipment and capabilities for more advanced methods applicable to survey and excavation. A wealth of resources exist in the region, though are accessible by a minority of organizations. All of the responding institutions indicate a desire for collaboration and networking, though many lack the necessary means to do so and the environment for such resource sharing may not at present be facilitating maximal use of either already existent or potentially developable new resources. The work of WP3 in underwater archaeology and its

associated survey has revealed this strong desire and some of the preferred methods for establishing a network of collaboration and resource sharing.

## *Conclusion*

### *General Comments*

The STACHEM Work Package 3 has aim at a thorough assessment of various key aspects of infrastructure for underwater archaeology in the eastern Mediterranean. The raw data was gathered through a variety of publically available sources and an extensive survey that detailed the capacities, interests and preferences for organizations active in the field. The results of this survey and all other available information have been compiled and reorganized into a database so that other questions and inquiries might be made in the future. Additionally, the two regional workshops devoted to WP3, brought about the first stages of new collaboration and information sharing, and thus represent important first steps toward improving the infrastructure necessary to carry out thorough scientific underwater archaeological work with a long-term regionally coordinated strategy.

Generally, the assessment of this information gathering suggests a solid and relatively widespread infrastructure already in place to carry out the most basic diving operations in many of the countries around the eastern Mediterranean. A few larger research centers possess the bulk of the large and more technically demanding and expensive infrastructure, including the region's very few dedicated research vessels and well-equipped specialized conservation laboratories, as well as the higher-end remote sensing equipment and peripherals like ROVs and AUVs. As a result, activities related to basic diving survey and excavation is generally high and widespread. This solid foundation of active, motivated and competent organizations is firmly established, creating a fertile environment in which to grow new collaborative relationships and resource sharing opportunities.

Basic non-fieldwork activities supporting underwater archaeology, including resource management and protection, databasing, and student training (particularly field schools) are similarly rather widespread within the eastern Mediterranean. The infrastructure for more technical analyses of materials and conservation of waterlogged artifacts, however, remains comparatively lacking, as do digitization and image archiving initiatives, which are thus areas of significant opportunity for improvement through additional input from the different collaborative networks that are part of the overall STACHEM Project, like the work package in digital heritage.

A desire for open collaboration in the region is clearly quite pronounced. Most organizations have expressed a preference for formats such as international conferences or workshops that might help participants forge more specific collaborative relationships and pursue individual transnational opportunities. Information sharing and, in general, a free flow of open communication rank as some of the most appealing forms of collaboration, and such endeavors are notably straightforward, inexpensive and sustainable relative to the highly beneficial and long-term positive relationships and concrete outcomes that might be achieved in this



way. A high percentage of active institutions expressed the desire to improve on their current activities through international collaboration and sharing programs.

One of the most striking observations from the survey and other information gathering concerns the uneven activity and expertise in underwater archaeology. Within the eastern Mediterranean region, Syria and Lebanon are notably absent from the discussions and lists above, and unfortunately no active organizations could be located at present for inclusion in these results. This is not to say that no work has been done in either country, but rather that the infrastructure is not so firmly in place in these general regions to support sustained underwater archaeological investigations. On the other hand, while archaeology underwater is relatively new to certain government ministries and even in the academic sector for some eastern Mediterranean countries like Cyprus and Egypt, its rapid development over the past few years here is ensuring a future of productive investigation and successful management of submerged sites. This trend may in the future be universal within the study region, particularly if aided through more specialized and directed transnational collaboration initiatives to follow the STACHEM Project and capitalize specifically on the increasingly developed expertise within this regional community.

Overall, Work Package 3 has shown that the necessary equipment and personnel do already exist in sufficient numbers within the eastern Mediterranean to conduct advanced and fruitful underwater archaeological work in some countries, and support collaborations in many areas across boundaries drawing on the region's expertise. Many resources, however, are under-utilized for these collaborations as a result of their wide dispersal and lack of a regionally focused and coordinated research strategy. A minority of organizations possess the majority of the technology and resources, without all the proper channels and agreements being in place that might allow smaller institutions more ready access to such equipment and training opportunities. Willingness and desire on the part of both the larger organizations as well as the smaller ones, though, indicate that there is much clear room for improvement and that the creation of a purposeful and open network of resources and knowledge might help foster these goals and help diffuse underwater archaeology capacities and expertise in a productive way to all corners of the eastern Mediterranean.

### *Suggestions for Improving Underwater Archaeology Infrastructures in the Eastern Mediterranean*

The following represent five broad suggestions for improving the regional infrastructure for conducting collaborative underwater archaeology based on the results of the survey and the completion of the goals of the STACHEM Project's Work Package 3. These suggestions factor in both the areas of improvement identified in the activities and equipment section of the survey, as well as the preferences for collaboration. The implementation of these suggestions may be significantly facilitated by the database of contacts, institutions, infrastructures and equipment compiled as part of the project.

### *Training Initiatives*

One of the most direct ways to benefit the existing infrastructure is through regionally based training initiatives aimed at different complementary student and professional levels. Such joint initiatives might take several forms, but all will function to increase communication, data and equipment sharing, general competence and more specialized expertise in investigating and managing underwater cultural heritage. Among the initiatives of the most urgency suggested are:

*a) Regional student field schools*

Despite the number of competence centers in the region, there appears still to be a lack of appropriate student training opportunities. While advanced postgraduate students in particular have traditionally played key roles in a number of underwater archaeological projects, it is imperative that opportunities be in place to introduce undergraduate students to the subject in a controlled and manageable environment where they can develop fundamental skills. Field schools have long offered opportunities around the world, but in the eastern Mediterranean there have not always been projects at suitable depths and with suitable support equipment and staff to ensure the best results and an overall positive training experience. A regional approach would draw on the depth of experience in many parts of the eastern Mediterranean to bring students together across boundaries to work together and build skills on a project at the appropriate setting. Such an arrangement would require some basic funding for student travel and subsistence, but would draw on the available infrastructure and benefit to an already existing underwater project. It would ensure that some opportunity for students within the region on an annual basis, perhaps moving occasionally to a new setting and project, while producing basically trained student archaeologists to continue work at a more challenging range of sites and settings.

*b) Jointly sponsored advanced training programs*

These may be organized by subject, according to the areas which demand the greatest attention. Archaeological work in deeper water, basic conservation of waterlogged materials, advanced photogrammetric and remote or automated mapping, and perhaps even the digitization of archaeological materials, which rank among the areas of greatest opportunity for joint training programs as identified in the results of the survey. Such programs could be hosted by organizations firmly competent in the area of interest, with additional support drawn from personnel at other organizations. As opposed to the more permanent annual basic student field school, these would be organized on an ad hoc basis as need and interest arise, and as opportunities present themselves for networking and linking to other funded collaborative transnational projects and initiatives. Again, a multinational approach to hosting these regional training programs will benefit the spread of competence and maximize the impact of relatively few specialized experts in a given area.

*c) Specialized regional seminars on underwater archaeology technology*

Differing from the above training programs that focus largely on methods, these seminars would seek to train established archaeologists and students alike in the

newest technologies of the field, which are slowly becoming more available to organizations and more commonplace on a range of projects. The specific focuses would of course depend on the particular technologies as new opportunities arise, but some potential areas of interest include remote sensing equipment (applicable to both shallow water and deep-water work), three-dimensional mapping software, ROVs (and potentially also AUVs), and even digitization equipment (including 3D scanning).

Other less obvious topics also merit pursuit in this venue and would make valuable subjects for such regional or even international seminars. First and foremost is the topic of technologies for in situ preservation, which garnered much interest in discussions at the WP3 regional workshops and has come to the forefront with the recent implementation of the UNESCO 2001 Convention and its Annex Rules preferring in situ preservation. Another crucial avenue to pursue with focused regional seminars might be innovative technologies for publishing in underwater archaeology so as to reach the widest audience possible.

Such seminars might be hosted either in the location of the particular equipment, or else in the field on a particular project if portability makes this possible. Higher competence in these and other technologies in the region will lead to a higher overall quality of work. Although not all organizations in the region may have access to the technologies that training seminars might focus on, it is important for active archaeologists to have a better basic awareness of the state of the field and the newest available methods and solutions. Furthermore, these seminars would facilitate sharing of new opportunities for the maximal utilization of such specialized equipment and facilities for employment on projects around the eastern Mediterranean.

#### *International Conference on Science and Technology in Underwater Archaeology*

One outcome particularly supported by discussion in both the regional workshops and surveys involves using the STACHEM platform to launch in Cyprus a regionally based, but internationally inclusive, conference on science and technology in underwater archaeology. The particularly transnational nature of underwater archaeology in general, especially the more technologically demanding focuses like deep-water survey and the more timely demands of science for in situ preservation, means that the overall project's goals of knowledge and infrastructure sharing might benefit from added expertise and collaborative partners from the wider EU community and beyond. Using the example of deep-water archaeology, in the past decade, deep-water surveys have been undertaken in collaboration with the Greek Ministry of Culture by American, Canadian, Norwegian, in addition to Egyptian and Greek-based teams. While these groups do not all constitute the STACHEM project's primary focus, their continuing archaeological presence in the eastern Mediterranean seems sufficient to justify their inclusion in some limited aspect in at least the collective database, as well as of course the international conference in late April. Such a regional and international collaborative event might be a highly productive avenue to explore by the Cyprus Institute, INA, and the Archaeological Research Unit of the University of Cyprus, perhaps in concert with our local regional workshop hosts (the Hellenic Center for Marine Research and the Recanati Institute for

Maritime Studies) as a distinct international conference following the conclusion of the STACHEM project.

### *Access to Equipment*

Much of the survey and the work of Work Package 3 focused on the availability and use of equipment in the field. Within the eastern Mediterranean there already exists a substantial quantity of equipment, but also a great disparity in its distribution and access, generally as a result of lacking expertise and the prohibitive cost of purchasing or supporting and maintaining the technology and personnel needed to carry out underwater archaeological work. Some regional partnerships do exist for equipment sharing, but certainly a more developed system for sharing the available resources would be to the overall benefit. As indicated previously, the organizations surveyed indicated a ready willingness to collaborate. Portable equipment—in particular aimed at survey but also for excavation—was the category both most sought and most available for sharing, as opposed to more specialized fixed equipment.

Thus, the STACHEM WP3 database of organizations and information provides a crucial first step toward facilitating this network. Even so, the complications and expense of moving equipment readily from country to country was a recurring theme in discussions, creating a need for a group capable of facilitating such sharing as crucial as the clearinghouse of information and equipment itself. The establishment of funds earmarked toward moving equipment on the one hand, and students or experts on the other hand, would allow this network to maximize its impact and effectiveness without unnecessary duplication of expensive equipment.

### *Mobile Survey Kit*

The development of a new and specifically mobile setup including the basic range of survey (or excavation) gear offers another possibility and a dedicated alternative for providing on site equipment to as many projects as possible around the eastern Mediterranean. Such a 'Mobile Survey Kit', for example, would consist of all the necessary equipment (outlined below) to carry out a basic underwater survey at limited diving depths. The package would be designed around supporting diving survey rather than combined survey and excavation, since broad surveys often are necessarily highly mobile to cover much ground in a matter of days and weeks, whereas excavations remain more stationary, taking upwards of several months. The equipment contained in this system would be integrated into a shipping container, allowing for fast, easy and relatively inexpensive transport and deployment in the field. The mobile nature of this package would ensure that survey could take place around the eastern Mediterranean year round, and off-season down-time many organizations experience outside the summer when placing their equipment in storage for a significant part of the year. This model has been successfully employed in the operations of both RPM Nautical Foundation and the Leon Recanati Institute for Maritime Studies. Both organizations have found significant benefits from the ability to ship a self-contained survey operation to archaeologists in the field.

The Mobile Survey Kit would contain, at the minimum, the following:

- SCUBA gear. This consists of wetsuits, buoyancy control devices, regulators (1<sup>st</sup> and 2<sup>nd</sup> stage with octopus and pressure/depth gauge), dive tanks (compressed air), masks, and fins for a suitable number of people to be determined. This is the most basic amount of gear necessary to support diving survey within safe diving limits and would enable organizations to conduct underwater work even if they lack any of the necessary gear to do so.
- Compressor. The presence of a gas-powered air compressor would allow the survey team to fill SCUBA tanks on site, a crucial capability that would allow a team to operate self-sufficiently and conduct sustained survey operations outside major areas where dive shops are typically located.
- Generator. A low-power generator would provide power to a range of equipment such as laptops, cameras, etc.
- RHIB (Rigid-hulled inflatable boat). Accessibility to survey sites is essential for efficient diving operations. The inclusion of a RHIB in the equipment package would ensure high mobility and constant access to sites, as well as provide a useful safety precaution. These boats are typically 4-9 m long, lightweight, durable and highly buoyant, with a shallow draft and requiring minimal maintenance. They are capable of supporting small diving operations as well as limited remote sensing in coastal waters.
- Sidescan sonar. The addition of a sidescan sonar unit, while not absolutely necessary, might significantly augment diving survey operations, allowing a team to cover larger areas efficiently without exhaustive diving.
- Underwater still cameras and video camera. High-quality digital cameras with solid underwater housings are integral to enabling a team to record visually its finds, and also assist in the creation of site maps and photomosaics.
- Laptops with ArcGIS, Site Recorder and Adobe Photoshop, along with other relevant mapping software as necessary. Used in combination with the digital camera, sidescan sonar, and the observations and measurement of divers, the laptops would be all-weather and ‘ruggedized’, allowing them to work in all conditions. The ability to compute on site would allow teams to create detailed maps of their survey areas and individual sites, which are essential to the documentation, management and interpretation of archaeological remains underwater.

Such a Mobile Survey Kit has the potential to increase substantially the overall underwater archaeological activity in the eastern Mediterranean with minimal and targeted acquisition of new infrastructure. Not only would it allow already established organizations opportunities that would otherwise not be available, and integrate effectively with field school suggested previously. It would also provide a basic startup kit to support the efforts of new archaeologists striving to establish underwater archaeology in areas lacking an infrastructure, helping them determine more carefully their needs for eventual acquisition of equipment as possible.

### *Guidelines for Good Practice in Eastern Mediterranean Underwater Archaeology*

One area that merits attention but could not be effectively investigated in the present project is the standards for good practice in underwater archaeology, an avenue of discussion that would complement well the other discussions of best practice put forth by the complementary work packages within the STACHEM Project. While general

principles have been circulated by organizations such as ICOMOS, in its 1996 Charter, and UNESCO, in its 2001 Convention, the different experiences of individual organizations ranging from academic archaeologists to policymakers and heritage managers merit further discussion. In particular as it pertains to the STACHEM Project, the specific role of new applications of science and technology for underwater cultural heritage preservation would be a welcome area for discussion and debate on best practices, perhaps as part of the above proposed International Conference on Science and Technology in Underwater Archaeology. Such best practices are a growing concern in light of new pressures not only from the well-known threats of treasure hunting in deep seas, but also from the rapid development along coastlines and expansion of the diving industry throughout the eastern Mediterranean, a particularly complex scenario which merits further exploration in an international venue of experts.

### *3.3 WORKPACKAGE 4: DIGITAL HERITAGE*

The STACHEM work package 4 Digital Heritage focused on the infrastructures required for the digitization of archaeological remains ranging from small objects to entire cities, in multiple types of representations (images, video, 3D). It also encompasses the infrastructure required to store securely, represent and distribute the digitized material. Its purpose is to establish a connection between competence centres dealing with digitisation with services to support and inform cultural organisations embarking on this field.

It has been organised into 3 main tasks:

- inventory of existing infrastructures for the digitization of archaeological and cultural heritage artefacts in the Eastern Mediterranean, and identification of needs;
- coordination of the use of the existing digitization and storage infrastructures and recommendations for the development of infrastructures and an appropriate research agenda at STARC and elsewhere in the region;
- definition of a coordinated research programme to optimize the digital preservation and access to the archaeological heritage of the Eastern Mediterranean.

The information that WP4 is gathering concerns the following areas:

- Digitization (2D and 3D data acquisition – including scanning, image-based modelling - and processing);
- Digital Documentation of Archaeological Heritage (data Management and information systems; cultural thesauri; ontologies; standardization);
- Computer Visualization Techniques for Research and Communication in Archaeology (3D Modelling; Digital Reconstructions; Virtual and Augmented Reality);
- Virtual Museums and Sites;
- Digital Libraries.

The proposed guidelines take into account weaknesses and strengths of institutes of the Eastern Mediterranean area that day by day carry out research in the field of digital heritage, and suggest possible recommendations to overcome the gaps and maximise the efforts. For this reasons the chosen approach to the topic takes into account not only the single research activities but also a more comprehensive policy context that can support them in reaching new publics and funding opportunities.

The information and communication technologies (ICT) have largely contributed to the opening of new scenarios in various fields of the research sector, including archaeology. The steadily growing bond between ICT and archaeology involves a wide range of applications from the spatial ones to those related to the data management. Despite the potential of technologies for archaeology, its penetration in the discipline is not as massive as might be expected and suffers the lack of standard approaches.

The present document represents a small contribution to the analysis of such changes; its aim is to analyse the potential of some competence centres in ICT applied to archaeology around the Mediterranean basin. This document will drive these centres towards making ever more effective use of the available resources.

The role of the following is to:

- identify gaps and strengths of the research in the digital heritage field in the Mediterranean basin;
- make this information apparent and available to the stakeholders (partners and final users);
- promote a research culture by identifying areas of research interest and opportunities for future collaborations.

### *Methodology of the information retrieval*

#### Background

These guidelines have been developed on the basis of:

- the MINERVA experience on the field carried out in Europe;
- the survey on competence centres and good practices in digitisation;
- suggestions from the STACHEM thematic workshops;
- electronic comments with partners and experts.

The networking activities carried out in the framework of workpackage 4 ‘Digital heritage’ were based on the multiannual experience that the Italian Ministry capitalised with the management of the MINERVA projects and renewed and adapted to the STACHEM specific requirements.

#### Stakeholders

The institutions and the experts that were involved into the activities of WP4 were selected on the basis of the different criteria that included the STACHEM consortium, whose member come mainly from the academic sector, the MINERVA network, that covers the ministerial area and the cultural institutions (museums, archives, libraries),

and finally Internet, since the Web is considered as an important complementary source for retrieving useful information and discovering institutions not yet involved through the personal and professional channels. All the information has been elaborated thanks to the cooperation of all these experts which are at the same time the addressees – the stakeholders - of the general trends outlined below.

#### Geographical coverage

The concept of Eastern Mediterranean region is quite broad and undefined. The approach that was followed in the framework of WP4 was that one to investigate the digitisation state of the art in the countries that:

- were listed among the STACHEM partners;
- are neighbours of the country coordinator (Cyprus) which is also the hub of the region.

At the end, the countries investigated were the following ones:

- Cyprus
- Egypt
- Greece
- Jordan
- Israel
- Italy
- Lebanon
- Malta
- Syria
- Turkey

#### *Background information: the survey*

The STACHEM WP4 survey for building the 'Inventory of existing infrastructures for the digitization of archaeological and cultural heritage artefacts in the Eastern Mediterranean' was carried out with the aim of gathering a first core of information and setting up the experts' network. This research enjoyed of the experience that the Italian Ministry had obtained in the framework of the MINERVA EU project.

The survey was made up of two parts<sup>1</sup>:

1. Competence Centre - Form I
2. Good Practice - Form II

The form I – Competence Centre was intended to be used to investigate the status of the cultural institutions and their activities on the digitisation and management of archaeological resources; by the other hand, form II – Good Practice was used by the single competence centres to introduce examples of activities in the field of digitisation of the archaeological heritage they are working on.

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<sup>1</sup> Details on the form can be found at the following URLs:

Form I - Competence Centre, [http://www.surveymonkey.com/s.aspx?sm=dAiqtMu18TPYYmpEPg5fIQ\\_3d\\_3d](http://www.surveymonkey.com/s.aspx?sm=dAiqtMu18TPYYmpEPg5fIQ_3d_3d)

Form II - Good Practice, [http://www.surveymonkey.com/s.aspx?sm=Fywx8BY8D9cNxBSjk0hL3w\\_3d\\_3d](http://www.surveymonkey.com/s.aspx?sm=Fywx8BY8D9cNxBSjk0hL3w_3d_3d)



A short analysis of the inventory of existing infrastructures for the digitization of archaeological and cultural heritage artefacts in the Eastern Mediterranean, and identification of needs will be illustrated hereafter. The results outlined a clearer picture of the state of the art of digitisation of archaeological heritage in Eastern Mediterranean – including strengths and gaps. 38 institutions participated in the survey:

<u>Country</u>	<u>Number of competence centers</u>
Malta	1
Syria	1
Cyprus	2
Egypt	2
Lebanon	2
Jordan	3
Turkey	3
Israel	6
Greece	8
Italy	10

The large majority of these Competence Centres are of national level (67.9 %); only few ones operate locally (7.1 %). The academic and research sectors are the most covered (51.6% and 35.5% each). The public sector is the most represented (78.1%). All of them contributed to the creation of a network of experts that participated to the following steps of the work, i.e. the regional workshops.

A considerable part of the information that contributed to the elaboration of this document was also gathered during the two STACHEM workshops relating to WP4.

### *Human and infrastructural frameworks for ICT applications in cultural heritage: references*

#### *Introduction*

The European policy framework plays a fundamental role in putting into practice the results of the research area in future ICT and applications for purposes that are specific to the cultural heritage sector. In fact STACHEM was funded by the programme FP7 - Infrastructures of the European commission that naturally refers to it and to the policy that inspired it, the Lisbon Strategy<sup>2</sup>, an action and development plan for the European Union between 2000 and 2010.

The Research Infrastructures part of the FP7 Capacities Programme supports an innovative way of conducting scientific research by the creation of a new environment for academic research in which virtual communities share, federate and exploit the collective power of European scientific facilities.

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<sup>2</sup> [http://www.europarl.europa.eu/summits/lis1\\_en.htm](http://www.europarl.europa.eu/summits/lis1_en.htm)

The objective is to strengthen European capacities and performance of specific research infrastructures, and increase user communities' involvement in opportunities offered by research infrastructures and their commitment. Support will be provided through networking activities' to foster a culture of co-operation between the participants in the projects and scientific communities benefiting from the research infrastructure. They could include joint management and pooling of distributed resources, development of common standards, protocols and interoperability, foresight studies for new instrumentation, methods and technologies and the promotion of clustering and concentration actions amongst related projects.

The actions carried out in the framework of the STACHEM work package 4 were inspired by the results in term of recommendations and guidelines that emerged from such European frameworks but also from (in)formal networks of experts as well as past and ongoing projects. In fact, beyond the policy infrastructures for digitisation and research infrastructures (and subsequent funding lines) that the European Union set up during the recent years, there are many initiatives in terms of projects and networks that were taken into account as point of reference for the WP4 activities and that – in case of future developments – can be considered for a wider interaction.

The complete database on competence centers compiling their answers has been made available on the website of the Ministry's Osservatorio per i Beni e le Attività Culturali -OTEBAC (Observatory for cultural heritage and activities).

#### Investigation areas

- 1) **acquisition and harvesting** (2D objects; 3D management of data; Multimedia platforms; Other)
- 2) **documentation and management** (Data Management and Information Systems; Cultural thesauri; Ontologies; Standardisation)
- 3) **visualisation** (2D Graphical User Interface; 3D Modelling; Digital reconstructions; Virtual and augmented reality; Other)
- 4) **access to digital resources** (Websites; Virtual exhibitions; Digital libraries; Portals; Other)
- 5) **outstanding research and specific interests** (Short and long-term preservation; IPR; Multilingualism; Social Networks; Other)
- 6) **specialisation area** (Movable archaeological objects; Immovable archaeological objects; Restoration; Other)

#### *Lessons learnt*

#### *Strengths and gaps*

Generally speaking, the countries who participated in the survey demonstrated to have a sufficient competence in the different fields of the digitisation of archaeological and cultural heritage.

Some of them (Cyprus, Egypt, Greece, Israel, Italy, and Turkey) have competence in most of the fields, while other ones (Jordan, Malta, and Lebanon) seem to show some gaps. No feedback at all was received from Syria.

As regards area 1 **acquisitions and harvesting** the main competence is in the following fields:

- 2D acquisition
- 3D scanning of objects
- 3D Studio Max, Cinema 4D
- Data set alignment and registration Reflectance capture
- Digital and High-resolution photogrammetry
- Field station for acquisition data in archaeological contexts
- Laser scan
- Multimedia in museums
- Photogrammetry
- Shape capture
- Stereoscopic imaging
- Video and audio digitization
- Volume computation

As regards area 2 **documentation and management** the main competence is in the following fields:

- DBMS and integrated systems
- Applications for the management of visitor data for museum collections
- Applications for the storage and processing of archaeological data
- Applications for the management of cultural tangible and intangible heritage
- Ontologies compatible with CIDOC CRM
- Metadata: Dublin Core, Spectrum, CDWA, Marc 21, EAD
- GIS databases
- SQL databases

As regards area 3 **visualisation** the main competence is in the following fields:

- 2D graphical user interfaces (GIMP, CD-DVDROM titles, info-kiosks, PDA, 2D vector and raster drawings, digital ortophotos, ASP, JAVA, HTML, ArcGis 9.3)
- 3D Modelling (Meshlab, wireframe, surface, rendered models, comparative analysis, VRML, textured modelling, Rapidform, MENSİ)
- Digital reconstructions (Blender, 3D animations, virtual reconstructions, photorealistic walkthroughs, 3D reconstructions of buildings, monuments, urban and territorial contexts, objects)
- Virtual and augmented reality (Blender, Quick Time VR, VRML and X3d deployment)

As regards area 4 **access to digital resources** the main competence is in the following fields:

- Websites (cultural websites, educational websites, institutional websites)
- Digital libraries
- Portals
- Usability evaluation
- WebGis interfaces and GPS positioning systems
- Design
- Virtual exhibitions

As regards area 5 **outstanding research and specific interests** the main competence is in the following fields:

- Digitisation of sound
- Watermarking
- Digital restoration
- Integrated service for preventive archaeology
- Geo-referenced 3d digital surveys
- Studies of weathering and making plans for conservation
- Field studies for salvage archaeology

However, some weaknesses in the approach to digitisation were highlighted. As a consequence, this implies the absence of specific devoted infrastructures.

- Generally speaking, there is a **poor attention to the accessibility of the research information and data** once it is produced; the implementation of digital libraries and repositories based on open standards and interoperability is not a priority for most of the competence centres.
- **Low level of standardisation.** This topic can be referred to various aspects of the digitisation process; it means the use of **in-house metadata** for the information description (and this means low level of interoperability), the high **use of proprietary software and technologies** against the open source ones, lack of application of **cultural thesauri** for the standardisation of the language.
- Implementing **short and long term preservation** strategies is not commonly acknowledged among the selected competence centres since only 11 positive feedback were collected; furthermore, there is confusion about this expression since a few institutions answered about preservation of physical artefacts and not digital objects.
- A poor attention is paid to **multilingualism**. Languages other than mother tongue are used both for web sites and software platforms (for instance, WEBGIS applications for the management of archaeological data that have a Multilingual User Interface in Italian and English. English is always used as second language.
- The selected competence centres showed a low interest on **IPR issues** related to the management of physical and digital archaeological artefacts.
- Only few institutions deal with **restoration** and **conservation** (only 10 positive feedbacks upon 38. However, when this happens, sophisticated tools are used.

- **No networking** of centres and researchers; sometimes research carried out separately by different departments of the same institution.

### *Recommendations*

The following recommendations takes into account the outcomes of the STACHEM WP4 activities but also the action lines set up by the EPOCH Research Agenda.

#### Recommendation 1. Improve training

The information gathered stressed the need of improving training both at academic and vocational levels. Digitisation of archaeological artefacts seems to be an activity which is additional to research and, consequently, learnt from direct field experience and not a topic of university studies. This may lead to creation of lacunae in the professional skills, with particular regards to the use of standards.

Professional researcher profiles who can match both humanities and ICT backgrounds are warmly welcomed.

#### Recommendation 2. Foster standardisation for the interoperability

“Standardisation is the process of developing and agreeing upon technical standards. A standard is a document that establishes uniform engineering or technical specifications, criteria, methods, processes, or practices<sup>3</sup>”. This short but effective definition of standardisation given by Wikipedia is the clear picture of what is often missing in the digitisation of cultural heritage.

The low level of standardisation of the digitisation processes that was verified during the survey is mainly concerned to the use of common languages for structuring the information than on technical aspects and this may block the circulation and comparison of research data among different institutes.

By the way, the rapid development of digital library and semantic standards that helps structuring the information and support interoperability should be fostered and become subject of academic curricula.

#### Recommendation 3. Encourage networking of programmes and experts

People-networking is not diffused by researchers and experts of the Mediterranean basin. Of course, academic exchanges and conference are common practices like all over the world but specific networks devoted to digitisation like MINERVA and SEEDI could be places where the ideas move but, mainly, new projects born and funding opportunities can be found.

Promoting such kind of network by the countries of in the Mediterranean region could also improve the definition of even more specific EU programmes<sup>4</sup>.

#### Recommendations 4. Promote dissemination of data and information by a wider public

The research outcomes are not frequently disseminated outside the boundaries of the academic world. However, it is not uncommon that the main research activities – in

<sup>3</sup> <http://en.wikipedia.org/wiki/Standardization>

<sup>4</sup> Specific Euro-Mediterranean partnerships already exist but not for the cooperation in the digital heritage field ([http://ec.europa.eu/external\\_relations/euromed/index\\_en.htm](http://ec.europa.eu/external_relations/euromed/index_en.htm)).

particular the archaeological ones – concerns sites and artefacts that are world's common heritage (see for instance the Good Practices related to the via Appia project, Hierapolis in Phrygia or Petra).

A larger attention to the online communication of the efforts undertaken could raise the profile of the promoting institutions and awareness by the wide public.

#### *3.4 DISSEMINATION AND NETWORKING ACTIVITIES WITHIN THE STACHEM PROJECT*

Successful dissemination activities were a key factor for success and impact of the project, and dissemination activities have indeed been extremely successful, both in terms of participation (number and caliber of delegates in STACHEM events) as well as in the creation of a network of users and providers of infrastructures relevant to archaeological research in the region, as set out in the project description. Strong ties have been established in the various events, between institutions as well as between individuals. These provide a solid foundation from which to proceed in the future, through the creation of a network from which STARC and all other institutions will be able to access expertise and infrastructure and create collaborative efforts, both regarding research and education.

While the International Conference, held from April 26<sup>th</sup> to 28<sup>th</sup> 2010 in Nicosia, Cyprus, has been the most publicly visible event related to the dissemination and outreach activities, the groundwork for networking the regional infrastructures has been laid in smaller workshops, thematic in nature, destined to support the aims of work packages 2, 3 and 4. A total of six small workshops, two for each thematic area, have been organized in different locations in the region, outside Cyprus (workshops on infrastructures for natural and material science applications to archaeology in Xanthi, Greece (8<sup>th</sup> May 2009) and in Amman, Jordan (8<sup>th</sup> and 9<sup>th</sup> November 2010); workshops on infrastructures for underwater archaeology in Athens, Greece (1<sup>st</sup> of December 2009) and in Haifa, Israel (24<sup>th</sup> and 25<sup>th</sup> of February 2010); workshops on infrastructures for digitization of cultural heritage in Paestum, Italy (20<sup>th</sup> of November 2009) and Florence, Italy (22<sup>nd</sup> April 2010). Each workshop has brought together providers and users of infrastructures from different countries in the region. The primary goal of these workshops has been to foster the exchanges of ideas, interactions and common plans among the participants, and thus to start structuring each of the thematic areas. The results of the discussions held during the workshops has provided essential input for work packages 2, 3 and 4.

In addition these smaller thematic workshops, an initial users meeting has been held in Cyprus at the beginning of the project, with circa 70 participants from Cyprus and other countries of the region. This included the invited participation researchers from the region (excluding Cyprus) that have an interest in archaeological sciences, underwater archaeology or digital heritage. The prospective users and collaborators delivered short presentations, followed by a round table to discuss the perceived and potential needs of the regional scientific community. The initial users meeting has played an important role through the early creation of contacts between regional researchers and institutions, from which an expanded network of contacts has then gradually been formed.

An important component has been the search for and exploit of synergies with other EC-funded initiatives in related fields. In this regard, the joint STACHEM-

LinkSCEEM workshop held in Amman, Jordan on the 9<sup>th</sup> of November, as well as the 2<sup>nd</sup> STACHEM regional workshop on infrastructures for digitization in cultural heritage, which was organized as a STACHEM-ATHENA joint workshop should be mentioned.

#### *4. IMPACT OF THE RESEARCH*

As is apparent from the activities and tasks described above, the outcomes of the STACHEM project will not only contribute to the design and shaping of a specific infrastructure, namely that provided by STARC, but also to its optimal integration in the European landscape, and will help to create a background framework and strategy for future projects in the fields of archaeological sciences and digital heritage. It will thus contribute to the objectives of the European policy for research infrastructures, through the assessment of needs and demands in the Eastern Mediterranean region, the preparation of sharing and coordination of resources, and that of future collaborative research. Through its contribution to a regional strategic plan for research infrastructures, and the benefit it will bring in parallel to the regional dimension of STARC, the project's outcome will favour future regional collaboration and synergies with EU-funded Mediterranean programs. This contributes to EU objectives in the fields of international scientific collaboration and neighbourhood policy in the Mediterranean and the Middle-East.

In addition, the activities that have been suggested within the STACHEM project, related to the access and training of users, will contribute to the build-up of sustainable approaches to the needs of research communities, through the provision of resources and training, and the preparation of adequate peer review processes for regional projects requesting the use of scientific and technological resources in the fields of archaeology and cultural heritage.

*Target groups such as policy makers or civil society for whom the research could be relevant*

Target groups for whom the research carried out within the framework of the STACHEM project is or could be relevant, include for example:

- users' and providers' communities (e.g., archaeologists, archaeological scientists, museums, research and educational institutions [e.g., national research institutes, universities....]), please note that while the STACHEM activities and outcome are generally useful to other research teams or organizations in the region, they are particularly so to future newly formed research teams and to those located in remote areas
- governments and governmental institutions (national authorities overseeing antiquities, museums, tourism...)
- policy makers, both on national and international levels