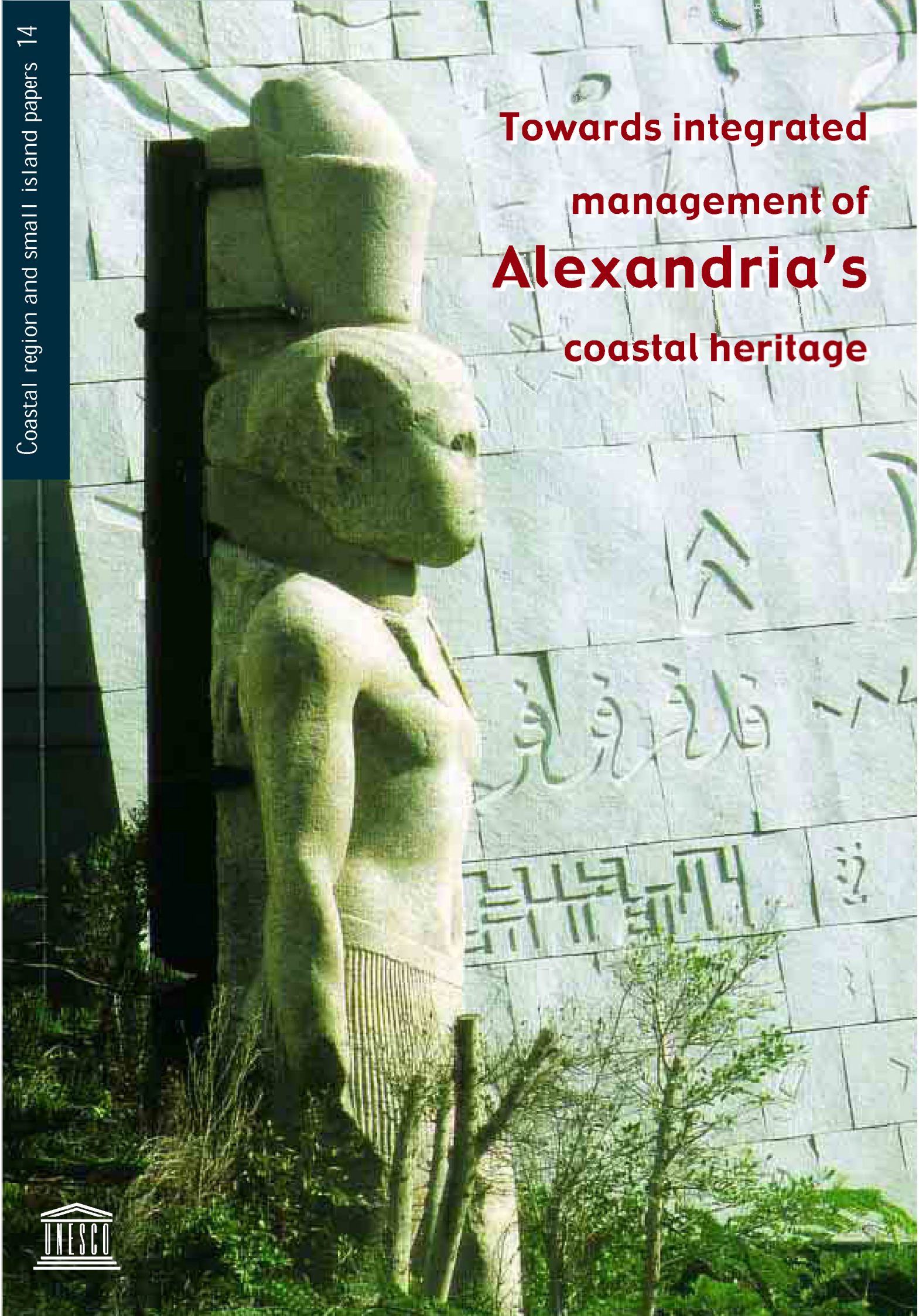
Coastal region and small island papers 14

Towards integrated management of Alexandria's coastal heritage



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Qait Bey Fort
Pharos Island
Western Harbour
Eastern Harbour
Cape Lochias
El-Silsilah
Al Raml Station
Bibliotheca Alexandrina
Roman Theatre at Kom El-Dekkah
Mahmoudia Canal
Alexandria
The Cornish
Scale 1:800
Map drawn by M. Turner

Coastal region and small island papers 14

Towards integrated management of Alexandria's coastal heritage

by
Selim Morcos, Nils Tongring, Youssef Halim,
Mostafa El-Abbadi and Hassan Awad

a joint endeavour of the

University of Alexandria, Supreme Council of Antiquities (Egypt)
Governorate of Alexandria and UNESCO

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4930 Castello,
30122 Venice, Italy.
fax: +39 041 5289995
e-mail: roste@unesco.org

The Chairman,
Department of Oceanography (AUDO),
Faculty of Science,
Alexandria University,
Alexandria 21511, Egypt.
fax: +20 3 391 1794
e-mail: audo_alex@yahoo.com

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Coastal Regions and Small Islands (CSI) platform
UNESCO, 1 rue Miollis
75732 Paris Cedex 15, France
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Cover: Colossal statue of Ptolemy (13 m long) salvaged between 1995 and 1996, exhibited in front of the Bibliotheca Alexandrina. Photo: S. Morcos.

Title page: 18th century engraving of the Pharos of Alexandria by Fischer von Erlach.
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Foreword

The world's archaeological patrimony is vulnerable to damage and decay and especially so at coastal and underwater sites. Natural forces such as storms, currents and wave-action may result in coastal erosion that undermines or buries structures and artefacts. Global climate change and a rise in sea level are likely to exacerbate this. Increasing coastal populations threaten archaeological sites, directly by encroachment of housing and other buildings, and indirectly through pollution and poorly planned coastal protection measures.

Alexandria has three important archaeological sites in close proximity to one another, one on land and two in shallow water. The 15th century Qait Bey Citadel stands at the entrance to the Eastern Harbour, the remains of Alexandria's ancient lighthouse, the Pharos, lies just offshore from the Citadel and the ruins of Ptolemaic Royal Quarters are in the Eastern Harbour.

Preservation of all three sites requires an integrated and interdisciplinary approach. In 1997 the University of Alexandria, the Supreme Council of Antiquities, and other Egyptian institutions, together with the United Nations Educational, Scientific and Cultural Organization launched an initiative to preserve these sites and eventually open them to the public and scholars as a museum.

With this in mind, an international workshop on Submarine Archaeology and Coastal Management was held in Alexandria in April 1997, bringing together a wide variety of specialists from Egypt, other Mediterranean countries and further afield. This publication describes the outcome of the workshop and the various follow-up activities in a context which broadens both literally and figuratively what is known of Alexandria's past. The activities are in the nature of a slowly growing initiative, which as it gathers momentum, will progress towards effective management and a balanced solution for Alexandria and its archaeological heritage.

Special thanks are given to Selim Morcos, Nils Tongring, Youssef Halim, Mostafa El-Abbadi, Hassan Awad and Harry Tzalas who contributed to this publication, to Claire Blackburn and Gillian Cambers for editing the text, and to the many others who contributed to the activities.

Dirk G. Troost,
Chief CSI

Profiles of the contributors

Selim Morcos is an oceanographer credited for his published works on the Suez Canal and the Red Sea. He was a member of the International Indian Ocean Expedition in 1962. Author of the first book in Arabic on submarine archaeology 'The Sunken Civilization, 1965', he lectured and wrote widely to promote the submarine archaeological discoveries off Alexandria pioneered by Kamel Abul-Saadat. From Alexandria University, he moved to Paris to join UNESCO in 1973. Due to his efforts, UNESCO supported the mission of Honor Frost to Alexandria in 1968, as well as the international workshop on Submarine Archaeology and Coastal Management in 1997 and its follow-up. Prof. Morcos received the medal of the French Government for submarine archaeology in 1997. An avid scholar of maritime and oceanographic discoveries, he is currently Chairman of the Editorial Panel of the Sixth International Congress on the History of Oceanography.

Nils Tongring, a mathematician at the Graduate Center of the City University of New York, was associated with Woods Hole Oceanographic Institution (WHOI) for over ten years. In 1994, in collaboration with American and Egyptian scientists, including Selim Morcos of UNESCO and the late James Broadus of WHOI, he began a comprehensive study of the coastal area of Alexandria, particularly the submerged ancient harbour of Pharos discovered by Jondet below the present Western Harbour. The reliability of this early work is the most important archaeological issue in the study of the Alexandrian littoral; this can be resolved by the advanced technology available today.

Youssef Halim is Professor of Biological Oceanography since 1973, and former Vice Dean for Graduate Studies and Research (1976–1982) of the Faculty of Science, Alexandria University. Professor Halim obtained a Dr ès sciences naturelles from La Sorbonne in Paris in 1956. His broad specialization is on the Ecology of the marine environment, with a focus on the monitoring and management of the coastal and estuarine environments. His scientific publications in this field and his broad school of M.Sc. and PhD. graduates, particularly while co-ordinating the UNESCO/UNDP/Alexandria University Project on Aquatic Environmental Pollution (1980–1986) won him UNEP's Global 500 Award in 1997.

Mostafa El-Abbadi is a historian known for his scholarly works on the Greek and Roman times and the interaction between the successive Pharaonic, Hellenistic and Arab cultures. He is credited for his contribution in promoting the revival of the ancient library of Alexandria, embraced by Alexandria University in 1974 and UNESCO in 1986. A recipient of the Cavafy Award for classical Greek studies (1997) and of the National Award of Merit in the Social Sciences (1998), Dr. El-Abbadi is President of the Archaeological Society of Alexandria (founded in 1893). He is a member of the Supreme Council of Antiquities (SCA), and Chairman of the Consultative Committee on Preservation and Development of Submerged Archaeological Sites and the Qait Bey Citadel in Alexandria.

Hassan El-Banna Awad is a marine scientist who focused on the study of oil pollution in the Red Sea, in Saudi Arabia (1987) and in Egypt (1997). His interest in submarine archaeology led him to study the water quality and pollution control over the submerged sites in the Eastern Harbour. Prof. Awad was the Rapporteur of the international workshop on submarine archaeology. He is currently Chairman of the Department of Oceanography, University of Alexandria and Rapporteur of the Consultative Committee on submerged archaeological sites in Alexandria.

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Executive summary

Alexandria lies on the Mediterranean coast at the western edge of the Nile Delta. It was founded in 331 BC and over the next three centuries became a centre of trade and scholarship. Three major archaeological sites from different eras remain: the 15th century Qait Bey Citadel, the submerged remains of Ptolemaic Royal Quarters and underwater ruins of the ancient lighthouse, the Pharos.

An international workshop on Submarine Archaeology and Coastal Management (known as 'SARCOM') was held in Alexandria in April 1997, organized by the University of Alexandria, the Supreme Council of Antiquities and the United Nations Educational, Scientific and Cultural Organization. The workshop followed a series of recent archaeological discoveries in Alexandria's Eastern Harbour and a controversial project designed to protect the Qait Bey Citadel, which had inadvertently placed large concrete blocks over part of the ancient Pharos Lighthouse site. The aim of the workshop was to find a way of preserving Alexandria's past while allowing the modern city to develop. Workshop sessions covered a wide range of topics ranging from Alexandria's historical background to remote sensing to pollution. The workshop declaration included ways in which the Citadel might be stabilized without endangering the nearby Pharos site, and how Alexandria's archaeological sites might be made into an on-land and underwater museum.

The ideas and recommendations resulting from the workshop have been followed-up by further studies into the protection of the Qait Bey Citadel, the feasibility of establishing an underwater archaeological museum, and ways to control the marine pollution and manage wastewater in the Eastern Harbour. A second workshop was held in 1999. The Supreme Council of Antiquities appointed a Consultative Committee for Planning and Follow-up, which in turn created a task team that led these activities.

Proposed future activities include the establishment of a university chair in submarine archaeology and integrated coastal management, inscription of Alexandria's archaeological sites on the World Heritage List, and the preparation of a comprehensive project document. The need for an integrated coastal management programme which will provide for sustainable modern development as well as preserving the archaeological patrimony is of utmost importance.

1

Introduction

Recent archaeological discoveries in and around the ancient harbour of Alexandria have revived interest in the city's heritage. At the same time, the rapid urban and coastal development of modern Alexandria raises many important coastal management issues which need addressing in order to ensure the harmonious development of human activities while protecting the submerged remains of the ancient city.

The city was built on a limestone ridge which separates the Mediterranean Sea from Lake Mariout. In the last 120 years, Alexandria has increased twenty-five fold in size and now covers all the land between the lake and the sea. Its winter population is about four million people, rising to five million in the summer. It is Egypt's principle seaport and an important industrial centre, providing 40% of the country's industrial output.

Geological factors have played an important role in the history and prehistory of Alexandria. Relative sea level changes, resulting from subsidence and global sea level rise, have also played a significant role. Submerged Roman and Greek ruins in the Eastern Harbour and Abu Qir Bay, dating from 500 BC are now submerged 2–5.5 m below the surface of the sea. In addition, major earthquakes have impacted Alexandria during historic times, resulting in the complete destruction of the Pharos Lighthouse. The importance of Alexandria's relation with the sea has long been clear from ancient written sources and lately there has been a revival of interest in exploring the archaeological traces of this history. The physical remains of Alexandria's heritage, already threatened by the forces of nature, are now also threatened by intensive man-made development.

Since the 15th century, the Qait Bey Citadel has guarded the outer arm of Alexandria's Eastern Harbour. It is now a landmark of national significance. In the early 1990s the Supreme Council of Antiquities, which is responsible for the Citadel, became concerned about erosion at its north-eastern perimeter and decided in 1991 to entrust the Coastal Protection Authority with taking the necessary protective measures to protect the Citadel from further wave damage.

Work began on the project in 1993 and some 180 concrete blocks, each weighing several tons, were placed about 30 m offshore from the Citadel. A team of divers engaged in shooting a film noticed that the concrete blocks were coming to rest on partly buried ruins. Dumping of the concrete blocks was stopped. The ruins, hidden under the waves and covered in sediment, were those of Alexandria's ancient lighthouse, the Pharos, one of the seven wonders of the ancient world. Ironically, Alexandria's 15th century Citadel was being protected at the expense of the vestiges of its 3rd century BC Ptolemaic Pharos, the building that had once stood in its place.

Recognizing the need to take a comprehensive approach, which would include integrated urban management, the impact of the city's sewage effluent on the archaeological site, and the unique historical heritage, the University of Alexandria, the Supreme Council of Antiquities (SCA) and the United Nations Educational, Scientific and Cultural Organization (UNESCO) jointly organized an international workshop on Submarine Archaeology and Coastal Management in April 1997. During this workshop, historians told Alexandria's story from its foundation in 331 BC through to today. Archaeologists gave insights into the challenges and techniques being introduced in the rapidly developing discipline of underwater archaeology. Geologists and oceanographers explained how coastal processes such as currents, sedimentation and waves affect coastal archaeological sites. The threat to Alexandria's underwater heritage caused by the city's acidic

wastewater, as well as the need for legislation specific to underwater sites, was discussed.

Some of the papers presented in the workshop on Submarine Archaeology and Coastal Management have already been published (Mostafa *et al*, 2000). This present publication contains the discussions and outcome of the international workshop as well as a description of several follow-up activities. Chapter 2 describes the history of Alexandria, while the summaries of the papers presented at the international workshop, as well as the recommendations and declaration resulting therefrom, are included in Chapter 3. Taken as a whole, they give a picture of the current state of the city of Alexandria and its archaeological sites and go some way to showing how the modern city might learn to live in harmony with its past. It is clear that Alexandria is in need of an integrated management strategy that will allow it to grow and modernize while preserving and making use of its archaeological and cultural heritage. Chapter 4 describes the follow-up activities undertaken since the 1997 workshop. These include a decree establishing a consultative committee, consultations and round table discussions, further investigations and a second workshop. The need for integrated coastal management and future stages for the initiative are discussed in Chapter 5.

2

Alexandria's place in history

Ancient Alexandria

The site of Alexandria and its coastal environs appear to have possessed some significance even before Alexander the Great founded the city. Greek literary tradition dating back to Homer recognizes the island of Pharos as a landing stage for international navigation, and there is some evidence of Pharonic port facilities to the northwest of the island. Rhakotis, on the mainland, was one of several hamlets that guarded the Egyptian coastline from possible sea-borne incursions during the Pharonic period.

However, it was with the founding of Alexandria in 331 BC that the site steps into the full light of history. A causeway known as the Heptastadion, was constructed to link the mainland to the island of Pharos, thus creating two remarkable harbours: Portus Magnus to the east and Eunostus to the west. Within the innermost corner of the Eastern Harbour, close to the Heptastadion, a structure known as the Kibotos was built, and functioned as a lock connecting the sea with Lake Mariout to the south. The lake was in turn connected to the River Nile by canals, thus providing a link for maritime shipping to the inland waterways of Egypt and greatly increasing the possibilities for transport and commerce.

Due to its unique geographical position and man-made facilities, Alexandria flourished around the Eastern Harbour, where the lighthouse stood on Pharos to the west of the entrance, and the Royal Quarter spread over Cape Lochias and El-Silsilah (Al-Silsila) to the east (Figure 1).

Perhaps the most picturesque description of the Eastern Harbour is one left by Strabo, a geographer of the first century BC. 'On entering the great port, the island and lighthouse of Pharos lie to the right while on the left are seen a cluster of rocks and Cape Lochias, on whose summit a palace stands. As the ship approaches the shore, the palaces behind Cape Lochias astonish one because of the number

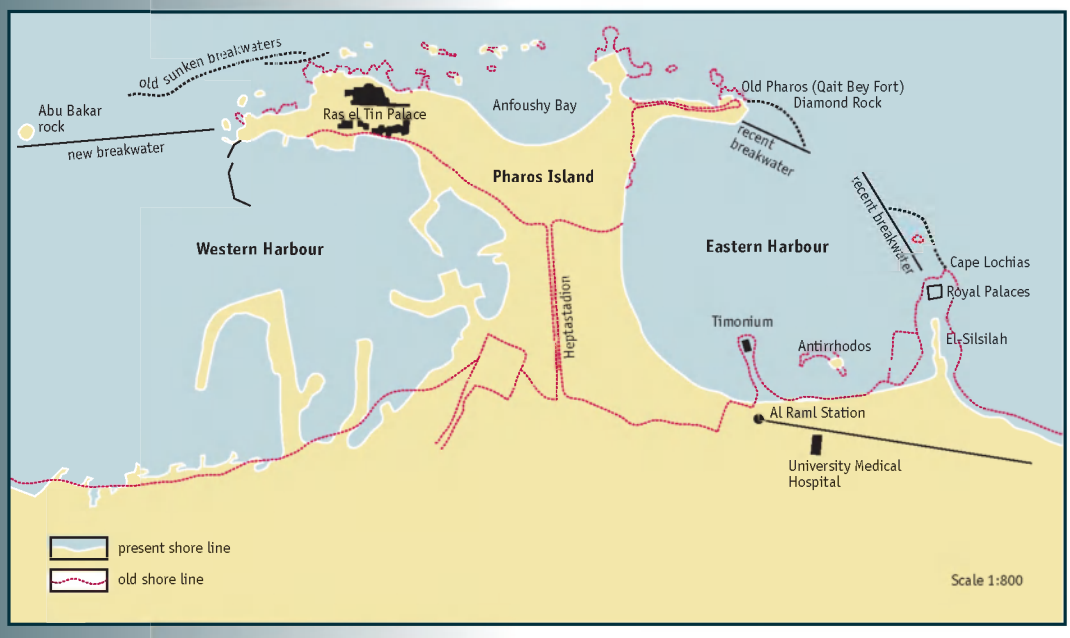


Figure 1. Positions of harbour installations of ancient Alexandria, superimposed on a chart of the present-day city *(redrawn by M. Turner after Morcos, 2000)*.

of dwellings they contain, the variety of constructions, and the extent of their gardens ...' (Strabo, The Geography, Vol XVII).

From the time of its foundation by Alexander the Great in 331 BC, and continuing for almost one thousand years thereafter, Alexandria experienced uninterrupted growth and prosperity. It flourished and grew rich and productive and became, in Strabo's words, 'the greatest emporium in the inhabited world' (El-Abbadi, 2000). Within decades of its foundation, it had become the major commercial centre of the ancient Mediterranean, and for more than three hundred years it remained the richest and most prosperous city of antiquity. Its eventful history has left Alexandria with a variety of archaeological remains, many of which are now submerged (Morcos, 1985).

The Pharos and the Qait Bey Citadel

The Pharos, the beacon of old Alexandria and one of the seven wonders of the ancient world, was built in the third century BC under Ptolemy I and Ptolemy II. A structure rising to a height of about 120 m (Figure 2), it cast a bright light that could be seen for 30 nautical miles. Strabo described it as being constructed of white marble. The task of constructing a building of such a height on such a narrow base has baffled archaeologists and engineers. The importance and grandeur of the building secured for the Pharos a position of pre-eminence in the annals of civil engineering (Hague and Christie, 1975). Al-Masudi left a reliable eyewitness account of the lighthouse as he saw it in 944, before a violent earthquake brought down the top part of the tower in 955. A series of earthquakes from the 10th to the 14th century completed the destruction. Its remains lie underwater near the entrance to Alexandria's Eastern Harbour. The Qait Bey Citadel, built by Mameluk Sultan Ashraf Qait Bey towards the end of the 15th century, stands on the site of the former lighthouse. The re-use of the site was first suggested by Thiersch in 1909 (Figure 3).

Alexandrian archaeologists have been aware for a long time that a significant part of the ancient city is underwater, the result of local tectonic changes and global sea-level rise. Ruins dating from 500 BC are submerged 2–5.5 m below the surface of the sea. Some of the submerged monuments remained very obvious. Late in the nineteenth century, two magnificent obelisks (1500 BC), one lying and the other standing were facing the Eastern Harbour only 120 m from the shore. Of the two Cleopatra's Needles that once adorned the entrance to the Cesarium temple, one now stands on the Thames embankment in London. The other was offered by Khedive Ismael in 1879 to the USA to be erected in New York's Central Park (Figure 4). Gorring (1882), who transported the obelisk, noted that several other columns could be seen standing under the water

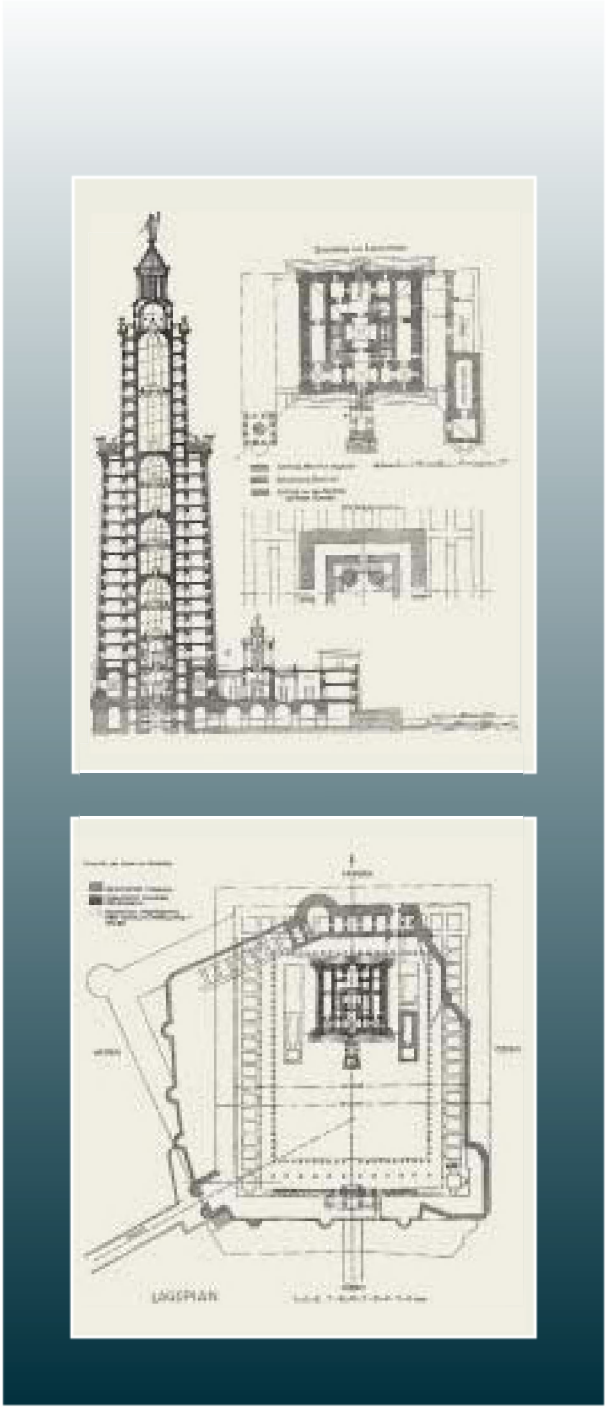


Figure 2. Reconstruction of the ancient Pharos Lighthouse *(Thiersch, 1909)*.

Figure 3. Ground floor plan of the Qait Bey Citadel superimposed on the reconstruction of the ancient Pharos Lighthouse *(Thiersch, 1909)*.

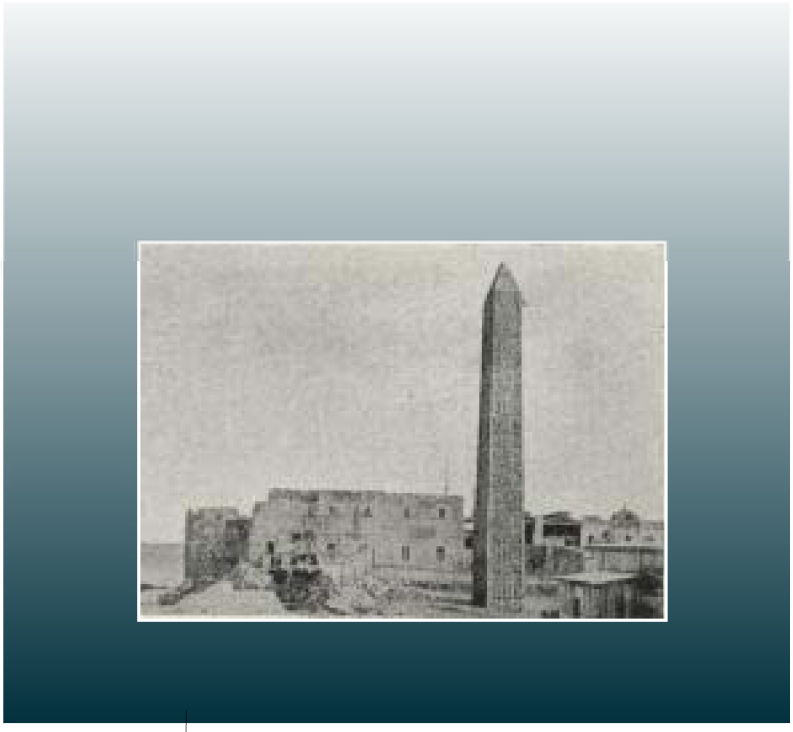


Figure 4. Cleopatra's Needle facing the Eastern Harbour, in 19th century Alexandria, before its transport to New York in 1879 *(after Breccia, 1914)*.

on a clear day. Breccia (1914) maintained that the outline of Antirhodos Island and several monuments could be seen on a clear day under the waters of the Eastern Harbour. The coastal waters of Alexandria were a tourist attraction at the end of the 19th century. A one-day boat trip conducted by Abbé Suard allowed tourists to view many submerged structures and statues. The highlight of the excursion as it appeared in 'Alexandrie ancienne et nouvelle' (Suard, 1899) was a visit to the Pharos site, where divers equipped with ropes and harpoons attempted to lift pieces of marble and stone for the tourists.

In 1961, Kamel Abul-Saadat discovered a statue of Isis (Figure 6, p. 21, and Figure 7, p. 24) and other Pharaonic artefacts in Alexandria's Eastern Harbour. He identified another 18 items scattered on the sea floor between the Qait Bey Citadel and Diamond Rock, a distance of 130 m (Morcos, 1965; Frost, 1975).

The submerged archaeological sites then remained relatively undisturbed until coastal erosion at the base of the citadel caused concern for its stability. In 1993, approximately 180 concrete blocks, of 7–20 tons each, were placed 30 m offshore from the most eroded section of the Citadel's base, to create a submerged breakwater. Unfortunately the blocks were placed directly on top of antiquities found along the margins of the submerged Pharos site. The resulting furore in the national and international press ended further dumping of blocks until a more thorough engineering and archaeological survey could be carried out, and an integrated solution found to give optimum protection to all aspects of the site.

The coastal erosion threatening the Qait Bey Citadel and the controversy surrounding its protection led the Supreme Council of Antiquities to request the Centre d'Études Alexandrines of France's Centre National de la Recherche Scientifique to study the area around the Citadel. A privately-funded Franco-Egyptian mission consisting of 30 divers and led by Prof. Jean-Yves Empereur was launched. The mission started its work in the autumn of 1995. Its aim was the full documentation of the whole site as well as the restoration of a number of important pieces. Since then the mission has continued its work for a number of seasons and located and recorded many archaeological pieces, mainly architectural elements, such as building blocks, columns and capitals, most of which are made of Aswan granite. Thirty-four pieces have been salvaged, restored and are now displayed in the archaeological gardens of Kom El-Dekkah in Alexandria.

The description of the 2,500 pieces scattered over an area of 2.5 hectares attests to an extraordinarily rich underwater archaeological site. Hundreds of columns of Pharaonic and Greek style, mostly in pink granite from Aswan but some in marble, ranging from small nodules to huge granite shafts 2.4 m in diameter, have been documented. Twenty-eight sphinxes bear the insignia of well-known Pharaohs from the 19th to the 6th century BC. There were four obelisks: three Pharaonic (end of 14th century BC), and one Ptolemaic from a much later period (early 3rd century BC). All these elements help to build-up a picture of the Pharos (Empereur, 1995, 1996a, 1996b, 1998, 2000).

The many interesting artefacts raised by Jean-Yves Empereur and his team since October 1995, the work of Franck Goddio's group on mapping the Eastern Harbour since 1996 (La Riche, 1996; Goddio and Darwish, 1998; Goddio *et al*, 1998; Foreman, 1999; Goddio, 2000;) and the threats posed to these sites by erosion, pollution and misdirected sea defence efforts, focused the world's attention on Alexandria in the late 1990s.

3

International Workshop on Submarine Archaeology and Coastal Management

Background to the workshop

In May 1994, the Marine Policy Center of the Woods Hole Oceanographic Institution organized a one-day meeting on 'Alexandria, the Land-Sea Relationship, Marine Archaeology, and Coastal Development'. The meeting convened by the late James M. Broadus and Nils Tongring, brought together a number of archaeologists and marine scientists, including three from Egypt (Farouk El-Baz, Makram Gerges and Selim Morcos). The effects on Alexandria of relative sea-level rise, changes in the Nile Delta and rapid urban and coastal development were among the questions addressed. The participants emphasized the importance of interdisciplinary research and the need for integrated coastal management. They suggested a workshop in Alexandria to discuss specific problems, which also relate to other parts of the Mediterranean, and coastal regions elsewhere.

The discussions and conclusions of the May 1994 meeting were described in a memorandum, drafted in Arabic and addressed to the Archaeological Society of Alexandria in July 1994 by Prof. Selim Morcos. The findings were further discussed at a round table held at the conclusion of a symposium on 'Europe and Egypt, Co-operation in Archaeology' (Alexandria, 7–8 December 1994), and were the main subjects discussed at the annual scientific meeting of the Archaeological Society of Alexandria, 3–4 April 1996.

Parallel to these activities was a welcome development in UNESCO. Late in 1995, the Organization's General Conference approved the establishment of an interdisciplinary initiative on 'Environment and Development in Coastal Regions and in Small Islands' (CSI). In November 1995, a meeting of UNESCO staff members from the Sectors for Natural Sciences and for Culture discussed a proposal by Selim Morcos to support an interdisciplinary workshop on the underwater historical sites of Alexandria and its coastal environment. This was followed, one year later, by a briefing to a meeting of UNESCO staff members, in November 1996, on the progress made in convening the workshop. It was decided that UNESCO co-sponsor the proposed workshop through the joint effort of CSI, Divisions of Cultural Heritage and Geology, in co-operation with the UNESCO Office in Cairo.

The idea of convening a broad-scale international scientific meeting to consider Alexandria's underwater heritage was supported by scholars both within Egypt and in institutions abroad. The University of Alexandria designated a Steering Committee composed of Hassan Awad, Mostapha El-Abbadi and Youssef Halim, who took the necessary steps to bring this dream to fruition.

The international workshop on Submarine Archaeology and Coastal Management was convened in Alexandria, 7–11 April 1997. The event was organized in response to the widespread interest expressed by the scientific and cultural communities in Egypt and abroad, and benefited from the moral and material support of several governmental and non-governmental organizations.

The workshop came at an opportune time as the need for an interdisciplinary approach to resolve the conflicting needs in the coastal area became apparent. This workshop was one of the first international meetings to examine the relationship between submarine archaeology and coastal development. The workshop took place as a result of (i) the convergence of the interests of both the University of Alexandria and the international scientific community, (ii) the favourable response of UNESCO, and (iii) the successful field work in and around the Eastern Harbour carried out by scientists supported by the Supreme Council of Antiquities, as well as several national and international institutions and other sources. The workshop was

organized by the University of Alexandria, the Supreme Council of Antiquities and UNESCO. Annex 1 contains the names of the individuals involved in the workshop organizing committee.

The workshop was supported by:

- Archaeology Department, University of Alexandria
- Oceanography Department, University of Alexandria
- Archaeological Society of Alexandria
- Institut Français d'Archéologie Orientale, Cairo
- Centre d'Études Alexandrines of the French Centre National de la Recherche Scientifique, Alexandria
- Institut Européen d'Archéologie Sous-Marine and its mission in Alexandria
- Woods Hole Oceanographic Institution, USA
- Egyptian Environmental Affairs Agency
- Ministry of Tourism
- French General Consulate, Alexandria
- Italian Embassy, Cairo
- Alexandria Businessmen's Association

Objectives

The objectives of the workshop were as follows:

- To review previous studies and evaluate the progress made in surveying the sunken harbours and the submerged archaeological sites of Alexandria, and the surrounding area.
- To exchange experiences with the international community concerning modern technologies in submarine archaeological research, detection and survey.
- To assess past and present morphodynamic shoreline changes in Alexandria, and changes due to sea-level rise and land subsidence, and to make predictions for the next century.
- To analyse the stresses on the coastal environment and on the submerged archaeological remains caused by intense urban development and land-based activities, including pollution, erosion and sediment accretion.
- To recommend a global strategy for the Qait Bey/Pharos area, integrating sustainable development of coastal areas with the protection of the submerged archaeological sites.

Workshop organization

Opening session

The opening ceremony for the workshop was held in the Alexandria Conference Centre on 7 April 1997. Professor Essam Salem, then President of the University of Alexandria, welcomed the participants and emphasized that the University, by virtue of its geographic position, gives high priority to disciplines related to marine sciences and Mediterranean studies. Dr Ali Hassan, then Secretary-General of the Supreme Council of Antiquities, referred to the ongoing underwater archaeological activities in and around the Eastern Harbour and the threat posed to these sites by ill-conceived shoreline protection measures, such as in El-Silsilah. Mr Adnan Shihab-El Din, then Director of the UNESCO Regional Office in Cairo, discussed the Organization's programmes in relation to the issues under consideration. He referred particularly to a UNESCO initiative, the 'Environment and Development in Coastal Regions and in Small Islands' platform. He also made mention of the Cultural Heritage Division, which has a long tradition of co-operation with the authorities and scholars of antiquities in Egypt, and is hosting negotiations on a new convention for the protection of underwater cultural heritage. The then Governor of Alexandria, Councillor El-Sayed El-Gawsaky, assured the participants of the endeavours of the Governorate of Alexandria to plan the development of the coastal zone of Alexandria in a scientific and environmentally sound manner.

More than 250 personalities including staff members from the Alexandria Governorate, the Ministry of the Interior, the Ministry of Tourism, the Egyptian Navy, the Egyptian Environmental Affairs Agency and the Alexandria Businessmen's Association attended the opening session. Diplomatic representatives from embassies and consulates in Cairo and Alexandria attended the opening session and some of the working sessions of the workshop. About 70 media personnel from TV, radio and the press, from Egypt and abroad, covered the meeting. Some 100 experts and participants from Egypt and abroad took part in the working sessions of the workshop (Annex 2).

Figure 5. Honor Frost and Kamel Abul-Saadat on the Pharos site, during the field work of a UNESCO mission in October 1968. *Source: H. Frost*

Workshop sessions

Eleven workshop sessions over four days were devoted to scientific presentations and discussions (see Annex 3 for the contents of each session). The scientific presentations covered a wide range of topics on the following major themes:

- Alexandria's historical background
- underwater archaeology along the Alexandrian coast and around the Mediterranean Basin
- remote sensing and archaeology
- conservation and management techniques for underwater artefacts
- legislation
- pollution and erosion
- integrated management of coastal development and heritage.

The scientific presentations are summarized in this report as well as some of the discussions. Full-length versions of many of the papers have been published in 'Underwater archaeology and coastal management. Focus on Alexandria' (Mostafa *et al*, 2000).

Working groups

During the second phase of the workshop, participants formed two working groups to discuss the stability of the Qait Bey Citadel and the long-term management of underwater archaeological sites. The conclusions of the two groups formed the basis for the final recommendations of the workshop. Annex 4 lists the persons involved in the working groups.

Field trips

Two field trips offered the participants an insight into the marine-related archaeological sites of Alexandria. The first was a visit to the Roman Theatre at Kom El-Dekkah to examine the recently recovered archaeological artefacts from the Pharos site. They also visited the Maritime Museum to see the treatment and conservation laboratory, the statue of Isis, and other artefacts discovered by Kamel Abul-Saadat and raised by the Navy in 1962. On the second trip, the participants travelled to two archaeological sites near Alexandria, Marea and Marina.

Exhibition

The Italian exhibition 'Diving in the Past, La Marmotta Case Study' was inaugurated and lasted for the duration of the workshop. This was arranged by the organizers of the workshop, the Italian Cultural Centre in Egypt and the Italian National Museum for Prehistory and Ethnography 'Luigi Pigorini' in Rome. The exhibition focused on the systematic annual research excavations, conducted since 1992 in the submerged village of Marmotta, Lake Bracciano, central Italy. Here, in the summer of 1994, a great wooden canoe carved from a single tree-trunk was discovered and salvaged, and is currently being restored. The purpose of the exhibition was to explain to the public how research institutes operate and help to protect underwater remains.

Awards

During a reception, hosted in the General Consulate of France in Alexandria on 8 April 1997, His Excellency J. P. Castella, French Consul General, awarded Government medals inscribed with their names and the words 'Archéologie Sous-Marine', to three pioneers of submarine archaeology in Alexandria:

- Ms Honor Frost, U.K.
- Prof. Selim Morcos, Egypt
- Mr Kamel Abul-Saadat, Egypt (posthumously), accepted by his brother Mr Ezat M. Sadeq.

Highlights of the workshop discussions

The focus of the workshop discussions was on the recent work of the Empereur and Goddio teams and the problem of the Citadel. The participants showed considerable interest in the early archaeological discoveries of Kamel Abul-Saadat in the Eastern Harbour around Qait Bey and El-Silsilah – Cape Lochias, particularly the raising of an impressive statue of a woman, ostensibly Isis or a Ptolemaic Queen (Figure 6; and Figure 7, p. 24). The more recent success of Jean-Yves Empereur and his Franco-Egyptian team of archaeologists and divers in mapping the thousands of fragments lying off the Qait Bey Citadel, and the recovery of some of the more interesting pieces, were also discussed. Most of the finds are probably from the Pharos itself and the surrounding site. The male colossus, which was salvaged in separate pieces, in October 1995 and April 1996, attracted considerable attention.

A Franco-Egyptian group under the leadership of Franck Goddio conducted a series of dives in the Eastern Harbour and made an outline of the Ancient Harbour. In his preliminary account, Goddio referenced his outline by means of a geographic information system, accurate to 50 cm. Apart from some slides of amphora and other objects that were lifted to the surface, cleaned, photographed, and replaced, and a schematic map, no details have yet been released. The most striking difference from the Strabo description is that the Antirhodos Island is now placed to the west of the Timonium peninsula. A considerable number of amphorae were found unbroken, which suggested to one questioner that they marked a wreck, not the shore. Another advised caution in identifying docks, pointing out that hundreds of years of oceanic processes may distort the evidence. There was a discussion as to whether Roman and Greek work could be distinguished based on the colour of the mortar. The finds were unquestionably jumbled columns from different periods, and this could provide verification of the story of medieval defenders who, fearing an invasion from the sea, dumped any moveable object they could find into the harbour.

The discoveries have had many consequences for the Egyptian Antiquities Services of the Supreme Council of Antiquities and for the future of archaeology in Alexandria. For example, a new museum on the history of Alexandria is planned and the Supreme Council of Antiquities has become more aware of the growing significance of Egypt's Greco-Roman past.

To understand the tectonic changes that have occurred in the area, coring and sediment analysis must be carried out. It is becoming increasingly evident that a multidisciplinary approach, involving archaeologists, geologists, oceanographers, art historians and Egyptologists, is necessary to investigate the complex development, decline, and disappearance of the ancient city of Alexandria.

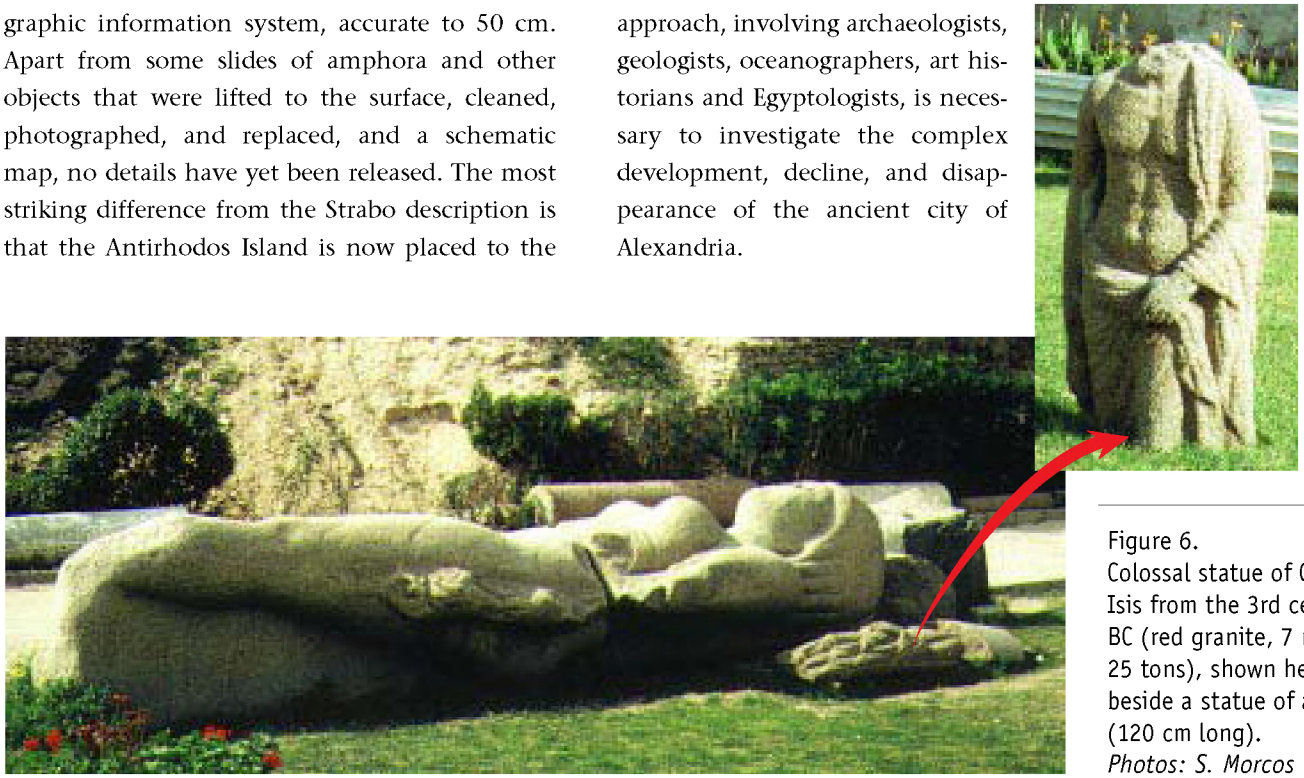


Figure 6.
Colossal statue of Goddess Isis from the 3rd century BC (red granite, 7 m long, 25 tons), shown here beside a statue of a man (120 cm long).
Photos: S. Morcos

The immediate problem of the erosion of the Qait Bey Citadel's foundation was raised. The preliminary modelling, as described in the meeting, was inconclusive. The study of more elaborate models is underway, but some *ad hoc* measures to halt the damage may have to be taken before the theoretical analysis is completed.

Another concern discussed was the continuing flow of untreated, municipal and industrial wastewater into the Mediterranean Sea at Alexandria, both inside and outside the Eastern Harbour. This is estimated to be about 300,000 cubic metres per day, representing one third of the city's wastewater. The remaining two-thirds, of which half receives primary treatment, are released into Lake Mariout from where it flows out through the El Mex pumping station to El Mex Bay, west of Alexandria. Plans are being made to divert all of the city's wastewater to the treatment plants and Lake Mariout, thus stopping the input of untreated wastewater into the Eastern Harbour. The control of this problem will determine future levels of sustainable multi-purpose use of Alexandria's coastal area. Unfortunately, the business community, though invited, was not represented at the workshop, nor were the users of the Eastern Harbour, such as fishermen, boat builders and boat owners. It is noteworthy, however, that the Alexandria Businessmen's Association co-sponsored the workshop.

A suggestion was made to create an underwater archaeological park in the Eastern Harbour. However, it was not clear how this would be implemented. Preserving the offshore area may become increasingly difficult, as has been the case with land sites, e.g. the new Alexandria Library and Conference Centre and the nearby hospital have been constructed in important historical areas, even though only limited archaeological exploration had been undertaken. One extreme view might be to drain the entire Eastern Harbour. Perhaps more practically, a concern for the Greco-Roman city may at least reduce any further loss and slowly add to the finds already made, making the modern city an increasingly important tourist destination. The publicity given to the recent recovery efforts demonstrates the great worldwide interest in the Ptolemaic city.

Summaries of the workshop presentations

(For a list of the presentations, see Annex 3)

Session I

Ancient Alexandria and the Mediterranean world

LOTFY A. YEHIA, ARCHAEOLOGY DEPARTMENT, FACULTY OF ARTS, ALEXANDRIA UNIVERSITY, ALEXANDRIA, EGYPT

Links between the site of Alexandria and other points along the Mediterranean shore started long before the foundation of the city. Evidence from literary, historical and archaeological sources, points to military encounters and commercial contacts involving Pharos and Rhacotis.

During Ptolemaic and Roman times, Alexandria gradually claimed precedence over other Mediterranean cities in various fields. Its lighthouse and two active ports made it the 'Greatest Emporium in the World', while the Mouseion or the School of Alexandria, together with its famous library, gave it the lead in specialized learning in medicine and astronomy, and allowed for an exchange of scholars.

In matters of religion and religious thought, Alexandria also played a prominent role. The Egyptian cults of Isis and Serapis spread from Alexandria to the Asian and European shores of the Mediterranean. Christian Alexandrian scholars defended their new creed against Roman pantheism within the Mediterranean basin and exchanged ideas with visiting fellow Christians.

The greatest emporium in the inhabited world

MOSTAFA EL-ABBADI, ARCHAEOLOGY DEPARTMENT, FACULTY OF ARTS, ALEXANDRIA UNIVERSITY, ALEXANDRIA, EGYPT

Alexander conceived his new city, Alexandria, as an emporium or trading centre. His finance minister in Egypt, the notorious Cleomenes, controlled an international trade monopoly in grain from Alexandria.

Under strict Ptolemaic economic policy, efficient financial regulations were formulated.

Ptolemy II Philadelphus ordered the exchange of foreign gold and silver for new Ptolemaic coins as a condition for trading in Alexandria and throughout the rest of Egypt. A papyrus from the middle of the 2nd century BC mentions the formation of a multi-national company engaged in trade with lands in east Africa. The banker for this contract was a Roman citizen. From the middle of the 2nd century BC, Roman financiers played an increasing role in the Alexandrian money market. Backed by Roman capital and interest, in 118–116 BC Alexandrian sailors discovered the use of the monsoon winds for navigation within the Indian Ocean. Thus, for the first time, the return journey from Egypt to India was made possible in less than one year. As a result, Alexandrian foreign trade multiplied many-fold.

Augustus Caesar conquered Egypt in 30 BC. Alexandrian businessmen took full advantage of the so-called *pax Romana*, which meant among other things, trade by both land and sea. With perfect harbours and easy means of communication, Alexandria maintained close, direct contacts with world markets during the ensuing three centuries. It flourished and grew rich and productive and became, in Strabo's words, 'the greatest emporium in the inhabited world'.

Alexandria's urbanization plan and eco-tourism

MOHSEN ZAHRAN, PRESIDENT, NATIONAL AUTHORITY FOR THE LIBRARY OF ALEXANDRIA AND URBAN ADVISOR TO THE GOVERNORATE OF ALEXANDRIA

In 1983 a comprehensive development plan for the city of Alexandria was agreed upon by all parties concerned. Expansion of the city would be towards the desert, there would be a network of roads throughout the city, and transport would be expanded to encourage decentralization.

Alexandria faces many problems including urban migration, sewage disposal, tourist village expansion. In order to solve these problems, there is a need for the:

- implementation of a coastal management programme
- preparation of guidelines and an effective coastal management plan, which will include urban waterfront revitalization
- rediscovery of waterfronts and conservation of natural heritage.

While there is conflict between the conservation of natural resources and economic development, the identification, rehabilitation and preservation of historic sites must remain a priority. A database of these sites should be compiled. Community participation is also needed in the development and implementation of the coastal management plan.

Coastal resources: The need for a management system

IBTEHAL Y. EL-BASTAWISSI, ARCHITECTURE DEPARTMENT, FACULTY OF ENGINEERING, ALEXANDRIA UNIVERSITY, ALEXANDRIA, EGYPT

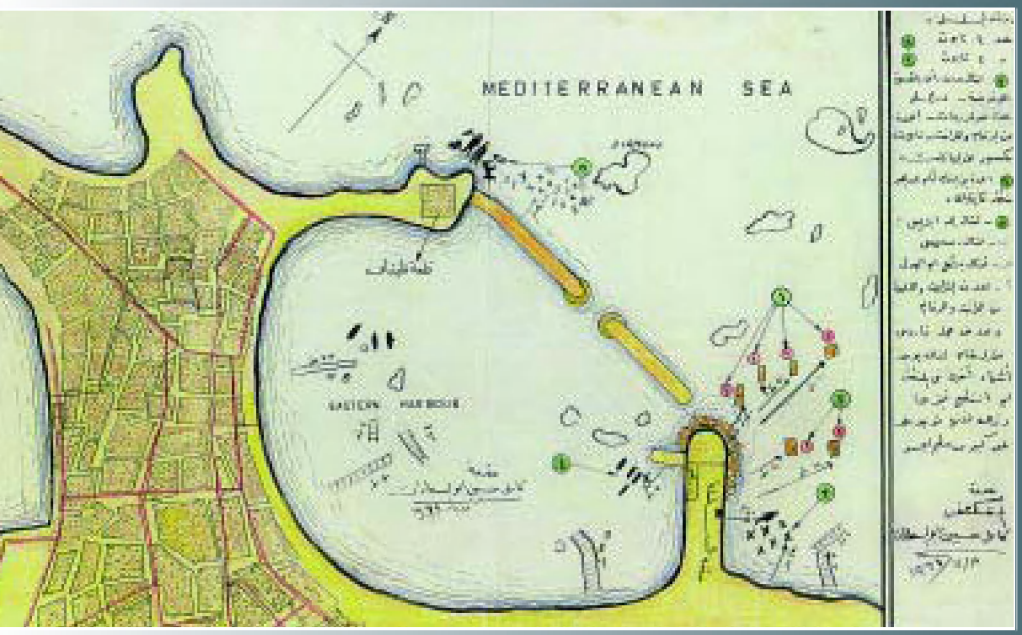
Coastal resources are concentrated in a narrow band where the continent meets the sea; however, they are used by a population scattered across the continental landmass. The pressure on these scarce coastal resources has grown with increases in population, wealth, mobility, and leisure time. The presentation examined man's interaction with the coastal zone and discussed how a coastal management programme might be conceived and implemented. The principles and guidelines for coastal zone management plans were also explored. Waterfront revitalization was discussed with reference to Alexandria.

Session II

Preservation of submerged monuments and development needs

NICOLAS GRIMAL, THEN DIRECTOR, INSTITUT FRANÇAIS D'ARCHÉOLOGIE ORIENTALE, CAIRO

Questions on how to preserve underwater monuments were discussed. These included what to preserve, the technology to preserve underwater monuments, and how to interpret underwater discoveries. There is a need for a database includ-



Legend in Arabic:

Area of Silsila. 1. Four sarcophages; 2. Two sarcophages; 3. Statue without head, in a Greek dress, stairs with 3 steps, columns in marble and granite, broken sarcophage made of basalt; 4. Columns of marble in front of the Tiro Club (hunting/shooting club).
Area of Qait Bey. 5a. Statue of the Goddess Isis; 5b. Statue of Ramses; 5c. Statue in the form of a sphynx; 5d. A number of sarcophages and columns in granite and marble, and a number of stones in marble from Pharos. 'There are also other objects in the area which I could not identify, since they are present at a great depth from the sea surface'.
Presented by the discoverer, Kamel Abul-Saadat, 7/11/1961

(Comment by S. Morcos: The date provided by Abul-Saadat coïncides with the period during which his discoveries were made. This map was actually drawn at a later date.)

Figure 7. Drawing by Kamel Abul-Saadat, showing the positions of his discoveries in the Eastern Harbour and around the Qait Bey Citadel *(Morcos, 2000)*.

ing submarine monuments, environmental parameters and development plans. Any emergency interventions, such as are needed in Alexandria, must take into account existing development plans.

Early discoveries of submarine archaeological sites in Alexandria

SELIM MORCOS, FORMERLY UNIVERSITY OF ALEXANDRIA AND UNESCO, PARIS

While early archaeologists of Alexandria were aware that a significant part of the ancient city existed under the sea, no serious attempt was made to explore the underwater heritage. This was largely because of the primitive tools available for underwater exploration prior to World War 2, and the large amount of rich, unexplored heritage on land. The task was left to chance and to some pioneers driven by scientific curiosity and enthusiasm.

In 1859, Larousse found that the old Canopic branch of the Nile extended some 8 km along the bottom of Abu Qir Bay. In the early 1930s, a pilot reported to Prince Omar Toussoun that, while flying over the bay, he saw vast remains below the water. Guided by local fishermen and aided by divers, Toussoun was able to locate several large structures and to salvage a statue, the head of Alexander the Great now on display in the Greco-Roman Museum. In 1965, Kamel Abul-Saadat located the position of ships from the French Fleet which had been sunk during the Battle of the Nile. He later (1983–4) helped Jacques Dumas and his 'Bonaparte' expedition to study and salvage part of the fleet.

Gaston Jondet, the Chief Engineer of the Department of Ports and Lighthouses, discovered the Old Port of Pharos in 1910. He described the colossal breakwaters and structures submerged at depths of about 8 m below the surface. This discovery came as a great surprise due to the lack of solid historical evidence of the existence of such structures.

In 1961, Abul-Saadat discovered a huge statue of Isis and other artefacts in the Eastern Harbour. He captured the imagination of the public by uncovering the underwater remains of the jewel of Alexandria – the Eastern Harbour with its famous lighthouse on the site of Qait Bey Fort, on Pharos Island to the west, and El-Silsilah (Cape Lochias) with its royal palaces to the east.

The three main underwater archaeological sites of Alexandria, the ancient harbour in Ras-el-Tin, the Eastern Harbour and Abu Qir Bay, are of great significance, not only to the city, but also to

human knowledge of history, geography, geology, oceanography and climatology. For example, Abu Qir Bay covers the mouth of the Canopic branch of the Nile, which was one of the oldest natural harbours in the history of mankind, as well as several human settlements which flourished before the foundation of Alexandria and existed alongside it.

Omar Toussoun and Gaston Jondet presented and published theories and interpretations of their discoveries in the Archaeological Society of Alexandria. Unfortunately, Kamel Abul-Saadat had neither the means nor the facility to do this. This modest but proud archaeologist was often frustrated by the lack of recognition he received. The author helped Abul-Saadat compile a list of objects he had discovered in the Eastern Harbour, make accurate drawings of them, and prepare one or two maps of their locations based on his visual observations (Figure 7). However, Kamel Abul-Saadat did not live long enough to fulfil his dreams and see his own work published.

Recuperating an Alexandrian pioneer in submarine archaeology: Kamel Abul-Saadat

HALA HALIM, CULTURAL EDITOR,
AL-AHRAM WEEKLY, EGYPT

The underwater archaeological work done by the Alexandrian diver Kamel Hussein Abul-Saadat (1934–1984) was, in many respects, singular. His investigations of submerged sites were a self-motivated, self-financed, single-handed endeavour. His work, though amateur, is all the more significant, since it took place at a time when the authorities had not the equipment, the expertise or even the interest to investigate underwater archaeology. A biographical sketch of Abul-Saadat provides an understanding of the socio-cultural and political background of the period 1960 to 1980. Most of the sites he discovered and explored have since been scientifically surveyed and/or excavated. As to the details of his finds, his maps and sketches, it was covered in-depth by Prof. Morcos who knew Abul-Saadat and worked with him.

Session III

The two ports of Alexandria as shown on plans and maps from the 14th century to the time of Mohamed Ali

HARRY E. TZALAS, PRESIDENT, HELLENIC INSTITUTE FOR THE PRESERVATION OF NAUTICAL TRADITION, ATHENS, GREECE[1]

Alexandria, during medieval and post-medieval times, suffered a gradual decline, reaching its nadir during the Ottoman period. The old town, enclosed within its Islamic fortifications, was nearly abandoned and became a mound of ruins. A new conurbation was formed on the strip of land reclaimed by the Nile deposition on both sides of the Heptastadion. This was the nucleus for modern Alexandria that developed during the first half of the 19th century.

The ancient ports, of the 'Megas Limin' (eastern port) and the 'Eunostos' (western port), which originally intercommunicated through openings in the Heptastadion dike, became two distinct harbours. The western port, more spacious and deeper, was reserved exclusively for Islamic vessels, while other ships were allocated anchorage in the eastern port, the entrance of which was better controlled by the batteries of the Qait Bey fortress.

Notwithstanding the loss of their initial importance after the opening of the new trade route to India via the Cape of Good Hope, the ports of Alexandria remained in use and their commercial activities, although reduced, continued. This is contrary to events at other ancient ports that became silted-up or were submerged, e.g. the ports of Cornish, Kencrhal and Lechaion, which were abandoned centuries ago.

A number of plans and maps drawn during the second half of the 15th century, along with travellers' accounts, attest to the situation up to the 19th century. At this time, after opening the western port to all vessels, Mohamed Ali built new

[1] See Annex 1 for brief account by H. Tzalas of a programme developed by two Greek Institutes and Patras University, in co-operation with Egyptian counterparts. This activity was initiated subsequent to SARCOM '97; the impetus for it was provided, at least in part, by the Workshop experience.

facilities making Alexandria one of the leading commercial centres of the Mediterranean. There are over 50 maps and plans from the mid-14th century to the mid-19th century showing the harbours of Alexandria. Most of these early maps are far from accurate and contain artists' distortions and exaggerations. Some maps are copies made by people who had never set foot in Alexandria. In spite of their inaccuracies, these maps and plans, supplemented by the narratives of travellers, are precious documents that deserve close investigation and can contribute to a better understanding of the mediaeval and post-mediaeval topography of Alexandria. Such documents can be of great help to field and underwater archaeologists in researching the history of the 'Eunostos' and the 'Megas Limin', perhaps the most prestigious of all ancient Mediterranean ports.

The author presented and commented on an unpublished map of Alexandria, showing its ports, which was drawn in the year 1603 by a spy working for the Reign of the Two Sicilies. This important and unique document shows, for the first time, a plan of Alexandria not subject to the usual artistic distortions and fantasies. It is a depiction by a person solely concerned with drawing an accurate map meant to be used for an attack on the city. The maps and plans also provide marine archaeologists with interesting representations of a variety of merchant and war vessels from the Islamic and Christian worlds.

Nelson Island project: Research into archaeology and geology

PAOLO GALLO, PROFESSOR OF EGYPTOLOGY, UNIVERSITY OF TURIN, AND DIRECTOR OF ARCHAEOLOGICAL MISSION AT NELSON ISLAND, UNIVERSITY OF PISA, ITALY

A research programme has been established at the University of Pisa to study the Greco-Roman site of Nelson Island which is now half-submerged. It is very important to study and preserve this ancient site which is threatened by the sea. The programme has two goals, firstly to study and understand the site from historical and archaeological viewpoints, and secondly to evaluate the changes in the coastline of Abu Qir Bay since the Greco-Roman period to the present era.

The proposed programme for 1997–8 will start with a topographical survey of the island and conduct an underwater survey. The underwater archaeological ruins will help to show sea-level variation through the ages and contribute to an understanding of the geological setting of the whole Abu Qir Bay in the context of the north African coast.

The coastal sites of Central Lazio: A problem of preservation

ANNALISA ZARATTINI, SOPRINTENDENZA ARCHEOLOGICA DEL LAZIO, ROME, ITALY

A surveying programme, encompassing the partially submerged coastal sites of Lazio, seeks to identify and preserve those sites of archaeological and cultural interest. A preliminary phase of this project involved the reconstruction of ancient geomorphological features in relation to historical topographic research.

The area chosen for study lies between Cape d'Anzio, Torre Astura, Gaela, Sperlonga and the Pontine Islands. Large centres of population like Anzio, Circei and Terraeina were linked along the via Severiana by a series of coastal villages. The period under study extends from the end of the 2nd century and the beginning of the 1st century BC to the present day. These sites provide evidence of intense urbanization almost always connected with the breeding and preparation of fish, an industry typical of the Roman world.

Inauguration of the Italian exhibition: 'Diving into the past – la Marmotta' case study

MARIO MINEO, SOPRINTENDENZA SPECIALE AL MUSEO NAZIONALE PREISTORICO ETNOGRÁFICO 'LUIGI PIGORINI', ROME, ITALY

The exhibition 'Diving into the past', displayed at this workshop, was organized by the Italian Cultural Centre for the Arab Republic of Egypt and the Italian National Museum for Prehistory and Ethnography 'Luigi Pigorini', Rome. The exhibition illustrates the art of explaining the results of underwater excavations to the public.

The first settlements at Marmotta date back to the early Neolithic period. The appearance in Italy of the first communities with an economy based mainly on agriculture and animal husbandry has been attributed either to an act of colonization carried out by small groups of people coming from distant lands, or to the slower process of 'cultural improvement' of local Mesolithic groups. Systematic annual research excavations have been carried out since 1992 in the submerged village of Marmotta, Lake Bracciano, central Italy, by the Soprintendenza Speciale al Museo Nazionale Preistorico Etnográfico 'Luigi Pigorini' (National Museum for Prehistory and Ethnography). In the summer of 1994, a great wooden canoe carved from a single trunk was discovered and salvaged, and is currently being restored.

The exhibition 'Diving into the past' is currently on show at the 'Luigi Pigorini' Museum in Rome, where it accompanies restoration work likely to last several more years on the single-piece wooden canoe. The purpose of the exhibition is to show the public the various ways in which research institutes study and protect the cultural underwater heritage. The exhibition at the workshop consisted of the original display accompanied by a life-size drawing of the wooden canoe, since it was not possible to transport the canoe to Egypt.

Session IV

Developing 'wise practices' in coastal management: A cross-sectoral approach

Douglas Nakashima, Programme Specialist, Environment and Development in Coastal Regions and in Small Islands, UNESCO

Coastal areas are complex human and natural environments. Many of the most diverse and productive of the earth's ecosystems occur in this belt where land meets sea. Some 60% of the world's population lives within 60 km of the coastline; and through a combination of population growth, migration and urbanization factors this figure will likely rise to 75% by the year 2020. Moreover, more than two thirds of the world's megacities are located on the coast. It is widely acknowledged that interdisciplinary and cross-sectoral co-operation is the only way to find enduring solutions to these challenging and inherently complex problems.

In response to this need for integration, UNESCO launched, in January 1996, an initiative called 'Environment and Development in Coastal Regions and in Small Islands'. The principle objective of this endeavour is to help UNESCO Member States towards the achievement of environmentally sound, socially equitable and culturally appropriate development of coastal regions. On the basis of lessons learned from various field project activities, as well as integrated coastal management initiatives elsewhere, UNESCO has set for itself the task of elaborating a set of guiding principles and practical methods: wise practices for sustainable coastal development.

Through the collaboration of experts in several relevant disciplines, and decision-makers from the responsible bodies, this workshop can assist in finding integrated solutions for coastal erosion problems affecting Alexandria's coastal heritage. The wise practices developed in this process may contribute in the long term to the fully integrated management of Alexandria's coastal region.

Remote-sensing applications to underwater archaeological exploration along the coast of Alexandria

Farouk El-Baz, Director, Centre for Remote Sensing, Boston University, USA

The northern coastline of the Nile delta has undergone numerous changes throughout recorded history. The subsidence of the coastal area and the submergence of many archaeological sites were due to natural processes. However, other changes occurred due to human activities, most notably since the construction of the High Dam at Aswan. The formation of Lake Nasser has held back the sediment, and thus inhibited the growth of the northern boundary of the Nile delta. As the eastward-moving Mediterranean currents began to erode the promontories at the mouths of the two branches of the Nile River, this process released sediment to the beaches, establishing a new balance. The resulting

changes must be monitored and understood prior to undertaking a programme of underwater archaeological exploration along the Alexandrian coastline.

Satellite images provide an exceptionally useful tool to monitor such short-term changes. Landsat Thematic Mapper images obtained annually between 1984 and 1993 were recently used to characterize minor changes along the coastline of Alexandria. Results of these analyses may be of significance in understanding the process of burial of archaeological sites.

Once the coastal zone environment is understood and a mechanism for monitoring both natural and man-made changes is established, remote-sensing equipment can be employed to help uncover hidden archaeological sites and artefacts. The instruments that have the greatest promise include:

- Side-scanning sonar: this emits sound waves by an electro-acoustic transducer. Objects buried on the bottom generate specific 'echoes' that help define the range, bearing and the nature of the targets.
- Magnetometers: these detect differences in the magnetic field of subsurface features and the surrounding soil. Small localized features, such as metal objects, are easily detectable. The proton magnetometer is most often used in archaeological investigations, because of its ability to detect very small variations in magnetic fields.
- Electromagnetic sounders: these produce magnetism by an electric current. Highly sensitive electromagnetic equipment is presently being tested by the Space Research Institute in Russia, which may be adaptable to archaeological investigations off the coast of Alexandria.
- Sub-bottom profilers: these can produce detailed profiles of the bottom topography, which may help to indicate the location of buried sites.
- Video and other imaging apparatus: these can be used in submersible craft, manned or unmanned, to provide high-resolution images of features on the sea bottom.

A combination of these methods would be required to fully understand the nature of the coastal area off the shore of Alexandria and its submerged archaeological features. A multidisciplinary team of investigators is required to ensure that such a programme would satisfy the exploration goals without harming the coastal environment. In addition, the coastline of Alexandria should be protected from further urban development until the archaeological survey is completed.

Coastal processes and proposed protection work along the Alexandria coastline

ALFY M. FANOS AND OMRAN E. FRIHY,
INSTITUTE OF COASTAL RESEARCH, ALEXANDRIA, EGYPT

This paper discusses coastal changes, sand movement caused by waves and currents, and methods of shore protection, both in general and as they relate to Alexandria's beaches. A brief summary of the studies required before executing any protection work is also included.

The city of Alexandria has a coastline 31 km long that extends from Abu Qir to El-Dikheila. The coast is generally undulating and interrupted by rocky headlands that form small embayments and pocket beaches ranging from 0.3 to 1.6 km long. The rocky part of the shoreline, with no beaches, is about 18 km long with an almost vertical concrete wall protecting the Corniche. The original sandy beaches are characterized by relatively steep slopes of 1:30 and a sediment size ranging in diameter from 1.6 to 0.13 mm. Beach sediments are derived from local rocky limestone islets extending about 300 m into the sea and aligned more or less parallel to the shoreline. These islets give natural protection to Alexandrian beaches against winter storms.

Most of Alexandria's beaches are eroding. There is evidence of sand loss and some beaches have disappeared completely; only a few beaches are generally stable. The erosion rate is about 20 cm/year, based on comparison of aerial photographs between 1955 and 1983.

Waves, currents, sea-level variations and wind are the main forces causing sediment movement along Alexandria's coastline. Usually about 14 winter storms per year attack the coast with maximum wind speeds of 35 knots. These storms and their surges cause significant coastal erosion, and result in overtopping and flooding of the Corniche and adjacent buildings. The wave action removes sand from underneath the concrete blocks that front most of the Corniche. This phenomenon is threatening the stability of the Corniche road, causing subsidence of the asphalt at Gleem and in some other localities near the Eastern Harbour. The Qait Bey Fort is also suffering from a similar process; parts of its floor near the sea have subsided and many cracks have appeared damaging the building. Similar erosion is likely to adversely impact submerged archaeological artefacts.

Between 1987 and 1994, artificial beach nourishment projects, with and without concrete jetties, were implemented at Abu Qir, Stanley, El Asafra, Mandara and El Shatby beaches. Every year, 20-ton blocks are dumped into the water to protect the Corniche wall from wave action. Similar blocks were placed in front of Qait Bey Fort to protect it, but they damaged other submerged archaeological monuments. The project was stopped.

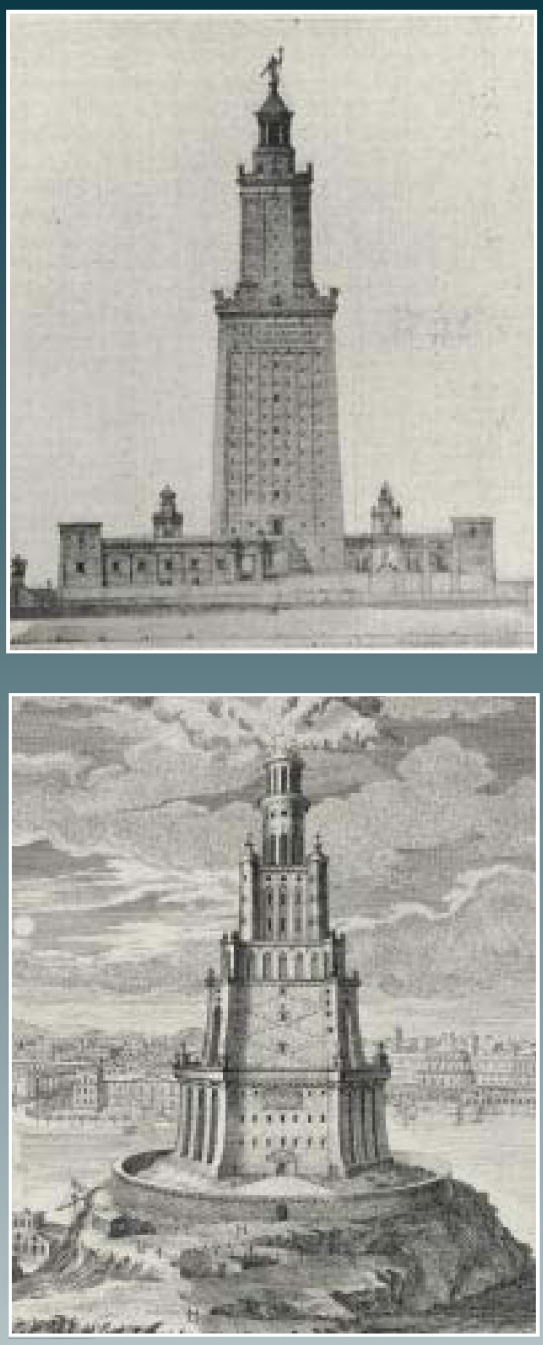


Figure 8.
Two interpretations of the Pharos Lighthouse: above, reconstruction by a scientist, in the early 20th century, as a three-storey building *(Thiersch, 1909)*; and below, an 18th century engraving of a five-storey building as imagined by artist J. B. Fischer von Erlach *(© Historical Picture Archive/CORBIS)*

Session V

From Byblos to Pharos: Some archaeological considerations

HONOR FROST, FELLOW OF THE SOCIETY OF ANTIQUITIES, LONDON, UK

Two aspects of lighthouses were discussed: firstly how changes in sea-level affect ancient harbour installations, including lighthouses; and secondly, the function of lighthouses, namely to mark a port for ships far out to sea so that they can identify it. The traces of two early lighthouses on the Levant coast were described. Although the Pharos of Alexandria was famed as being the largest lighthouse of antiquity, it was not the first.

Recent excavation of submerged archaeological sites of Qait Bey region

JEAN-YVES EMPEREUR, CENTRE D'ÉTUDES ALEXANDRINES, CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE, ALEXANDRIA, EGYPT

The results of a four-year underwater survey by a Franco-Egyptian team of divers and archaeologists were described. The site is the sea floor off the Qait Bey Citadel at the eastern end of the ancient island of the Pharos. The work was undertaken at the request of the Supreme Council of Antiquities, to evaluate the situation with regard to the protection of the foundation of the Qait Bey Citadel, and to explore and preserve the submerged archaeological site. This continued Kamel Abul-Saadat's archaeological work which was carried out in 1961. Some 2,500 pieces of stonework of archaeological interest, scattered over 2.5 hectares, have been uncovered. These include columns, bases, capitals, sphinxes, statues and some immense blocks of granite, and were probably part of the great Pharos Lighthouse.

Protection of the Pharos excavation in Alexandria, some preliminary results on wave agitation and sedimentological problems

DENIS AELBRECHT, J.-M. MENON AND ÉRIC PELTIER, LABORATOIRE NATIONAL D'HYDRAULIQUE – ÉLECTRICITÉ DE FRANCE

Archaeologists working in Alexandria expressed the wish to move a submerged concrete wall which covers part of the Pharos archaeological site, in order to carry out the excavation. The Électricité de France Foundation and the Laboratoire National d'Hydraulique have been asked to study the impact of such a measure. The wall, if altered, must still protect Qait Bey Fort from wave action, allow the Pharos excavation to continue, and protect the archaeological site from water movement and sedimentation. Also under consideration is the creation of a submarine museum, which could be visited by divers or people using glass-bottomed boats.

Wave computations for an area 500 by 400 m around the excavation site have been carried out with the use of ATRIUMS software. This software was developed by the Laboratoire National d'Hydraulique. It takes into account bottom refraction, diffraction, reflection against obstacles (dikes, seawalls, breakwaters), surf-breaking and bottom friction, and may be run in monochromatic wave mode as well as in random wave mode. Results are given in terms of significant wave heights, wave orbital velocities, wave incidence and breaking rate. The analysis of the offshore wave climate at Alexandria showed that the prevailing waves come from the west-northwest, northwest and northeast. Computations were run on these prevailing wave directions for three potential configurations of the displaced wall: (i) without any protecting wall; (ii) with an emergent breakwater located roughly in a southwest-northeast direction in front of the excavations; and (iii) with a submerged breakwater in the same location.

Results can be used to assess the wave-driven longshore current responsible for suspended material transport. During a recent visit to the site, information on sediment conditions was collected. It seems that the risk of potential sedimentation by sand or mud should be considered carefully. The risk is increased by a nearby urban water outlet.

Tentative results from simulations were discussed during the workshop. General trends on the impact of the breakwater can be surmised, but further study is needed on sediment characteristics.

The preliminary conclusions need more precise quantification. A further integrated study should include: (i) the comprehensive analysis of available data; (ii) the acquisition of new relevant data; (iii) refined local numerical modelling of wave-driven currents, sand transport and pollutant circulation. Such computations would test configurations for the projected breakwater. The study might also include physical modelling for optimization of the selected configuration. Part of such an integrated study has already been undertaken at the Laboratoire National d'Hydraulique, within a European marine science and technology research project, in order to numerically estimate sediment deposition behind a detached breakwater under the action of frontal waves. Results from this study were presented to illustrate the methodology involved, which might be applied to the Alexandrian site.

Session VI

Underwater archaeological survey of Alexandria's Eastern Harbour

FRANCK GODDIO, INSTITUT EUROPÉEN D'ARCHÉOLOGIE SOUS-MARINE, FRANCE

A detailed underwater survey of the Eastern Harbour of Alexandria was carried out in 1996. The ancient shoreline with its harbours and dock works (covered by surprisingly little sediment) were located and mapped at a number of scales, with an error of less than 50 cm using a global positioning system. Separate maps of the two main archaeological sites were made at a scale of 1:100. The position of all the artefacts found was carefully determined.

Northern coast and submerged cities of Egypt

IBRAHIM A. DARWISH AND AHMED ABDEL-FATTAH, SUPREME COUNCIL OF ANTIQUITIES, ALEXANDRIA, EGYPT

Over the last few years, the field of underwater archaeology has witnessed great activity and marvellous discoveries. One site particularly rich in underwater antiquities is Abu Qir Bay. It has indigenous architectural remains and exogenous artefacts such as sunken ships. Also important is the Eastern Harbour site, where an accurate, detailed map defining the royal harbours and palaces has been made by Mr Franck Goddio.

A Franco-Egyptian mission led by Prof. Jean-Yves Empereur surveyed the submerged site of the Pharos to the east of Qait Bey Citadel. Thirty-six of the approximately 2,000 pieces found at this site were saved and exhibited to the public. In 1914, Gaston Jondet found the ancient harbour, part of which had been built out of large stone blocks without mortar. Several classical sources (particularly from the 4th century AD) refer to the fact that the north-western coast was rich in archaeological sites and harbours and that there was continuous change in the number and importance of these harbours. Surveys have been carried out at various sites on this coast including Shaabtenam-El Bohairat, Ras Kanaes and Ras Hoala.

In concluding this survey of underwater archaeology, reference should be made to the many problems facing submerged sites. Foremost among these are tourist villages, drainage, corrosion, diving clubs and fishermen. Egypt has a lot to offer in the field of underwater antiquities and there are surely sites which still await discovery.

Session VII

Proposed survey of Alexandria harbours by a sonar sub-bottom profiler

NILS TONGRING AND NEAL W. DRISCOLL, MARINE POLICY CENTER, WOODS HOLE OCEANOGRAPHIC INSTITUTE, MASSACHUSETTS, USA

The advance of sonar technology and computer display in the last decade has made detailed three-dimensional imaging and mapping of offshore features and structures possible. This technology has been used to display the buried part of the Ptolemaic palace precinct and the pre-Alexandrian structures in the Western Harbour, first observed by Jondet. A sonar sub-bottom profiler, developed at Woods Hole, is now able to resolve sediment layers 5 cm thick, to depths of 30 m. It can detect structures buried in ocean silt and sand, and so, by means of acoustic imaging, a virtual walk through the structures of the ancient shoreline is now possible.

Protection of shipwrecks: the experience of the Spanish National Maritime Archaeological Museum, Cartagena

IVÁN NEGUERUELA, NATIONAL ARCHAEOLOGICAL MUSEUM, CARTAGENA, SPAIN

The construction of a marina at Mazarron, Spain, in the years 1979–81, caused coastal changes in the Playa de la Isla. The primary, visible effect has been the disappearance of the entire beach. Tons of sand have been transported to other areas of the shore.

As a consequence, in the following eight years, the remains of two 7th century BC Phoenician vessels were discovered on the sea floor. In

addition, about 8,000 pottery shards, of which about 70% are Phoenician, were found. The ships were built using the 'mortise and tenon' technique. Ship number 1 has been excavated and removed from Mazarron to the laboratories of the National Museum in Cartagena. Ship number 2 remains on the sea bottom.

A protection system was developed to avoid human or natural damage to ship number 2. This included passive protection, a combination of traditional tunnels with the design of a metallic modular strong box, and active protection, through close official co-operation with the Spanish sea-police. To date, we are still developing the system in collaboration with sport divers and amateur clubs.

Some remarks on the harbours of Sabratha, Libya – a case study

NICOLA BONACASA, ISTITUTO DI ARCHEOLOGIA,
FACOLTÀ DI LETTERE, PALERMO UNIVERSITY, ITALY

Sabratha Harbour was a natural outlet to the Mediterranean Sea. In fact, it was a Tripolitanian emporium, as was Oea (Tripoli) and Leptis Magna. To the north of the Forum and the Seaward Baths, one can see that the harbour is in part submerged and damaged due to its position on the reef. To the north and to the west of the Seaward Baths, one can discern the ruins of docks and a breakwater, whereas to the east of the 'tonnara' are perhaps the foundations of a lighthouse. The hypothesis that the harbour once extended toward the eastern end of the bay, near the Temple of Isis, is highly unlikely.

Sabratha Harbour, aside from being one of the main outlets from the Sahara Desert, was on one of the main routes to Rome on the African Mediterranean coast. Slaves, ivory and exotic animals were the valuable goods transported along this route. The symbol of the famous statue Sabrathensium, an elephant, is represented in the 'Piazzale delle Corporazioni', at Ostia.

Session VIII

National legislation and submarine archaeological sites

MOHAMED A. EL-GINDY,
(FORMER) ATTORNEY GENERAL OF EGYPT

There are three sections of Egyptian legislation, which deal with matters related to submarine archaeological sites: Protection of the Environment, Protection of Archaeological Sites, and Protectorates and Natural Reserves in Egypt.
The major points covered in this legislation are:

- Protection of non-living resources and structures of society, archaeological remains
- Environmental activities and assessment should be authorized by the Egyptian Environmental Affairs Agency
- Protectorates and Natural Reserves in Egypt.

To ensure full protection, underwater archaeological sites should be specifically mentioned in the legislation. Furthermore, any underwater archaeological park should come under the jurisdiction of the Supreme Council of Antiquities.

Principles for the protection of underwater cultural heritage

LYNDEL PROTT, CULTURAL HERITAGE DIVISION,
UNESCO

UNESCO and other bodies have been interested in the protection of underwater cultural heritage for a long time and have undertaken a number of initiatives. This paper reviewed the major recommendations of the Organization and of various other agencies, as well some of the relevant activities and international principles involved. The main recommendations and conventions discussed were:

- Recommendation on international principles applicable to archaeological excavations (1956)
- UNESCO Convention on the means of prohibiting and preventing the illicit import, export and transfer of ownership of cultural property (1970)

- UNESCO Convention concerning the protection of the world cultural and natural heritage (1972). This deals with national jurisdiction; general legislation on the protection of cultural heritage; and specific legislation covering protected areas, marine reserves, sea/land sites and restricted areas.

Other instruments under discussion are:

- Buenos Aires draft convention on the protection of underwater heritage (International Law Association)
- Sofia Charter on the protection and management of underwater cultural heritage (1996) (International Council on Monuments and Sites)

Other areas requiring consideration include setting priorities, seeking and proposing imaginative protective solutions, and recommendations on management for continuing the process.

Human impacts on Alexandria's coastal environment

YOUSSEF HALIM, OCEANOGRAPHY DEPARTMENT, FACULTY OF SCIENCE, ALEXANDRIA UNIVERSITY, AND FATMA ABOU SHOUK, ENVIRONMENT DEPARTMENT, ALEXANDRIA GOVERNORATE, EGYPT

Alexandria's environmental problems have grown in severity as its population and associated urban and industrial development have increased since the beginning of the 20th century. Alexandria interfaces with the sea along approximately 100 km of coastline. The adjacent marine environment is impacted by the daily disposal of large volumes of untreated municipal wastewater from several point sources. Of even greater concern are the ill-conceived and ill-informed coastal engineering works which have contributed, in some cases, to the irretrievable loss of submerged archaeological sites. A broad framework for an action plan and a management policy was outlined.

Session IX

Variability of currents and hydrography in the coastal zone of Alexandria

AHMED EL-GINDY, OCEANOGRAPHY DEPARTMENT, FACULTY OF SCIENCE, ALEXANDRIA UNIVERSITY

Data on currents and hydrography in the coastal area of Alexandria are important for biological and chemical marine studies, sediment transport, sewage disposal, and economic activities including fisheries. The protection and management of the coastal region, and in particular of archaeological sites of historic and tourism importance, requires data on environmental conditions. This paper presented the results of surveys on current patterns and variations, and hydrography, carried out in 1976, 1978 and 1985–1986. Proposals to develop a temporal and spatial database to help manage archaeological sites were presented.

Environmental issues associated with submarine archaeology along the Alexandria coast

OSSAMA M.T. ABOUL DAHAB, OCEANOGRAPHY DEPARTMENT, FACULTY OF SCIENCE, ALEXANDRIA UNIVERSITY

This presentation described the current environmental status of Alexandria's coastal archaeological sites. It reviewed the environmental issues associated with searching, locating, excavating and dating artefacts of ancient civilizations in Alexandria's coastal belt. Protection of coastal archaeological resources through the formulation of an integrated coastal zone management plan and the development of legislation was discussed.

Session X

Preservation of wooden artefacts from underwater archaeological sites: the Neolithic wooden canoe from the Bracciano Lake, Central Italy

MARIA A. FUGAZZOLA, SOPRINTENDENZA SPECIALE AL MUSEO NAZIONALE PREISTORICO ETNOGRÁFICO 'LUIGI PIGORINI', ROME, ITALY

The submerged settlement of 'La Marmotta' (Anguillara Sabazia, Roma) in Lake Bracciano is a biological archive of exceptional importance. It represents the oldest Neolithic lake settlement in all of Europe (sixth millennium BC) and has produced a considerable amount of data. The archaeological surfaces of damp sites offer a rich source of paleo-environmental, biological and cultural data.

The excellent state of preservation of organic remains buried in submerged settlements permits detailed reconstruction of the way of life of ancient human communities, the surrounding natural habitat, and the relationship between man and the environment.

All organic and non-organic remains, such as wood, bone, horn, pottery, seeds, etc. when immersed in water for an extended period of time, undergo chemical, physical and biological degradation. This often results in profound structural changes depending on the nature of the artefact, the length of time the object has been in the water, the surrounding environmental conditions such as pH, pollution and the nature of the sediment. It is particularly important for organic remains to undergo protective treatment immediately on removal from the water. The artefacts may be subjected to further treatment for disinfection, restoration and conservation. The treatment of a large, one-piece oak canoe, found in the village under 8 m of water was described to illustrate the restoration procedures.

Conservation of mixed archaeological materials: Saadana Islands Shipwreck

EMAD KHALIL, DEPUTY DIRECTOR, INSTITUTE OF NAUTICAL ARCHAEOLOGY, EGYPT, AND HOWARD WELLMAN, THEN DIRECTOR OF CONSERVATION, INSTITUTE OF NAUTICAL ARCHAEOLOGY, EGYPT

The Institute of Nautical Archaeology is the preeminent American organization conducting research into nautical archaeology worldwide, and providing training for nautical archaeologists in the United States. Since the Institute of Nautical Archaeology-Egypt (INA-Egypt) established its permanent base in Alexandria in 1994, to explore Egypt's nautical heritage, it has conducted four major projects and intends to continue its work.

As the Institute's main interest is the exploration and excavation of ancient shipwrecks, its initial project in 1994 was the first-ever archaeological underwater survey of the Egyptian Red Sea coast from Al-Quseir north to Ras Mohamed. Twenty-six areas were visited along the coast, with more than 134 hours of diving, and several archaeological sites were located. During this survey the Saadana Island Shipwreck was located.

The Saadana Island Shipwreck is a 50 m long, 18th century, porcelain carrier of unknown nationality, located 20 km north of Port Safaga, and lying in 30–42 m of water at the foot of a fringing reef. This ongoing excavation was the second major project for INA–Egypt. During two excavation seasons, summer 1995 and 1996, over 3,000 dives were logged, excavating parts of the ship's stern and midship section. Nearly 1,300 porcelain, earthenware, copper, glass and organic artefacts were recorded, raised and transported to the Alexandria Conservation Laboratory for Submerged Antiquities. As the methods used to build this ship are unknown, the ship itself is an artefact of extreme importance in the understanding of the Arabian Sea maritime trade of this period. The third and final season of excavation is planned for summer 1997.

The third project was the first shipwreck survey of the Egyptian Mediterranean coast west of Alexandria. The survey took place in March 1996, investigating 16 sites including six ancient har-

bours, along the 150 km coastline between Sidi Abd Al-Rahman and Ras Hawala. Material evidence for seafaring, discovered during the survey, dates from the 4th century BC to the 7th century AD. The experience gained from this survey has given knowledge of where and how ships are likely to have sunk along the northwest coast, and how to find them. With this knowledge and experience, INA–Egypt's second northwest survey was planned for September 1997.

Marine archaeology involves surveys, excavations and the collection of artefacts. The latter, especially from marine sites, require conservation. With that in mind, in October 1994, INA-Egypt submitted a plan to the Supreme Council of Antiquities to convert five outbuildings at the National Maritime Museum in Alexandria into a complex for conserving antiquities from INA–Egypt projects. Permission was granted to begin renovation in April 1995. The first task was to build two tanks for artefact storage and desalination. The five buildings, completed in November 1996, have become the Alexandria Conservation Laboratory for Submerged Antiquities, and include laboratory space, store rooms, mechanical space and rooms for photographic and written documentation and research. Artefacts from Saadana Island and the surveys are currently being conserved by INA–Egypt staff and conservators from the Supreme Council of Antiquities.

These four projects, involving survey, excavation and conservation, lay the pattern for INA–Egypt's future contribution to research into Egypt's nautical heritage. The intention is to continue surveys and excavations, developing the Alexandria Conservation Laboratory, to create a lasting legacy of archaeological research and illuminate a little-known aspect of Egypt's long history.

Implications of climatic changes and sea-level variations on Alexandria

OMRAN E. FRIHY AND ALFY M. FANOS, INSTITUTE OF COASTAL RESEARCH, ALEXANDRIA, EGYPT

The presentation was based on a study to evaluate expected climate change and sea-level rise and their impact on the Alexandrian region and its archaeological sites. This evaluation is based on the integration of the expected rise in sea-level, geomorphic land-use analysis, and an assessment of the socio-economic impact on the low-lying areas of Alexandria. Low-lying coastal zones are highly vulnerable to even minor changes in sea-level, particularly when sediment supply is limited. Moreover, predicted global warming may accelerate sea-level rise.

Relative sea-level rise, which includes the effect of land subsidence or uplift based on tide gauge records at Alexandria, indicates a range of 2–2.9 mm/year. A short time series of annual tide gauge data indicates uplift of the Alexandrian area by 0.7 mm/year.

Few studies have been published regarding the impact of sea-level rise on Alexandria. Various sea-level scenarios plotted on land-use maps indicate that sea-level rise will have social and economic effects on Alexandria. None of the studies applied predictive models, such as the Brunn Rule, to predict beach profile changes resulting from a rise in the water level. Nor did they assess the negative consequences on inland and submerged archaeological sites. It is expected that the main consequences of occasional, cyclical higher sea-levels, especially in low-lying coastal archaeological sites such as El-Shatby and Roushdy, will be sea flooding and disruption of groundwater flow. Seawater penetration of these sites will affect the archaeological monuments. Regarding the submerged archaeological remains in Abu Qir Bay and the Eastern Harbour, sea-level rise would be expected to change offshore bottom profiles, and influence coastal processes and the morphology of the coastline. No studies have been made to evaluate the effect of seasonal climate variations on Alexandria. Storm surges in association with the local sea-level rise are signif-

icant in changing the morphology of the sea bottom. These changes would facilitate the removal of sand from beneath submerged archaeological remains and thus accelerate the processes of sinking and burying them.

Session XI

Data management in underwater archaeology
VICENZO SOMMELLA, ES S.R.L. PROGETTI E SISTEMI, ROME, ITALY

The ultimate goal of archaeology is to obtain knowledge about the past, and to make this information available to other scholars and the general public. Beyond making fascinating archaeological finds, the archaeologist must also manage a vast amount of data and transform this data into meaningful interpretations of the past using new technology. In underwater archaeology, data management is even more important than in other research situations because the excavation phase of research is normally short and it is essential to collect data as quickly as possible. In addition, due to the nature of the area excavated, it is not possible for the public to visit these sites, so archaeologists must utilize various forms of media to disseminate the results obtained.

Modern development and ancient maritime sites in the Tyrrhenian Sea
ENRICO FELICI, ASSOCIAZIONE ITALIANA ARCHEOLOGI SUBACQUEI, ROME, ITALY

Ancient monuments located in the coastal zone can indicate past environmental changes, and thus contribute important information to coastal management. Such is the case for maritime installations that were constructed for residential or utilitarian use. Often these structures, particularly harbours, are susceptible to considerable damage from unwise modern exploitation of the coastline. This has been the case on the Italian coast of the Tyrrhenian Sea where there is a concentration of Roman ports. It was recently calculated that nearly 80% of ancient Mediterranean harbours have been lost due to human activity.

In the same boat and learning the ropes: an Alexandria/Boston comparison
VICTOR T. MASTONE, MASSACHUSETTS BOARD OF UNDERWATER ARCHAEOLOGICAL RESOURCES, BOSTON, USA

The management of submerged cultural resources involves a diverse set of problems, competing interests and difficult decisions. While archaeologists agree there should be no difference in treatment between terrestrial and submerged cultural resources, this is not usually the perception held by other parties who have an interest in these resources. Problems arise as to the appropriate identification, evaluation and protection of these resources. Frameworks must be developed which recognize and accommodate a wide range of appropriate uses for these non-renewable resources. These might include recreational, economic, environmental and heritage uses.

While some solutions are readily found in traditional archaeological management regimes, the diverse and competing interests in submerged cultural resources make many treatments unfeasible. There is a strong need for cross-disciplinary understanding and collaboration among archaeologists, resource managers, marine scientists, engineers, other interested parties and stockholders to ensure the appropriate management of these resources. By drawing on experiences in the development of Boston Harbour and Massachusetts coastal waters, which parallel Alexandria, this paper attempted to address these divergent interests and describe initiatives to promote and protect the underwater heritage.

Workshop results and closure

Recommendations

Based on the deliberations of the working groups and the plenary group, the following recommendations were adopted.

The International Workshop on Submarine Archaeology and Coastal Management, Alexandria, 7–11 April 1997,

Recognizing the necessity for a strategic framework for future management of underwater and onshore cultural heritage and the need for urgent action to protect and preserve the Qait Bey/ Pharos area,

Recommends to the national authorities including:

- Supreme Council of Antiquities, Ministry of Culture,
- Egyptian Environmental Affairs Agency,
- Coastal Protection Authority and Institute of Coastal Research, Ministry of Public Works and Water Resources,
- Ports and Lighthouses Authority, Ministry of Transport,
- Egyptian Navy,
- Ministry of Tourism,
- University of Alexandria,
- Governorate of Alexandria,

that:

a) Qait Bey/Pharos area pilot project

1. An assessment should be made of the present condition of the Qait Bey Citadel and the erosion threat. A request to UNESCO should be considered, soliciting its assistance in identifying and dispatching competent international experts in engineering and coastal processes. Any suggested intervention should take into consideration the need to protect and preserve the integrity of both the submerged lighthouse site and the Citadel.

2. Concurrently, a targeted programme to collect, analyse and interpret key environmental data should be implemented immediately in order to quickly identify (4–6 months) temporary remedial action. This work should stabilize the erosion threatening the Citadel, without compromising the integrity of the underwater archaeological site, until such time as a lasting solution can be found.

3. No further remedial action, including the placement of more cement blocks, should take place until the assessment of the Citadel proposed in paragraph 1, and the study on temporary remedial action proposed in paragraph 2, are completed. Appropriate agencies and experts should be consulted before any counter measures are undertaken.

4. Competent archaeological experts should be requested to complete, as far as is possible, the survey and mapping of the underwater archaeological site of the lighthouse.

5. The data collection programme (see paragraph 2) should be extended and, if necessary, expanded to provide the environmental information required to identify and implement a long-term and lasting solution which will, to the greatest extent possible, maintain the integrity of both the Qait Bey Citadel and the Pharos Lighthouse.

6. An *ad hoc* Task Force, possibly co-ordinated by UNESCO, should be established; it should include specialists from relevant decision-making bodies such as the Egyptian Environmental Affairs Agency, the Supreme Council of Antiquities, the Coastal Protection Authority, the Ministry of Transport (marine transport), the Institute of Coastal Research, the University of Alexandria, the Governorate of Alexandria, along with experts in submarine archaeology and coastal processes. This inter-sectoral Task Force will be responsible for setting an overall strategy for implementing and monitoring this pilot project.

b) Long-term management plan

1. A strategic framework should be drafted for the conservation and integrated management of Alexandria's coastal heritage, both cultural and natural. It should be incorporated into the Egyptian Environmental Affairs Agency's coastal management plan.

2. The placement of concrete blocks inside or outside the Eastern Harbour and any increased use or activity in the Eastern Harbour and Qait Bey area should be stopped until the survey recommended in paragraphs a) 2 and a) 3 above has been completed. Urgent action should be taken to stop the discharge of wastewater into the Eastern Harbour.

3. A survey of the archaeological sites, the geomorphological and hydrodynamic processes, the environmental conditions and state of pollution of the coast of Greater Alexandria should be conducted. The experts and agencies involved should liaise with the Department of Underwater Archaeology of the Supreme Council of Antiquities.

4. The Qait Bey and Pharos sites should continue to be monitored after the initial surveys are complete.

5. On the basis of the surveys, see paragraphs a) 2, a) 3, a) 4, b) 3 and b) 4 above, work priorities should be listed so that critical problems can be faced in a timely manner.

6. Existing laws should be studied to ensure that the special problems of the underwater archaeological sites of Alexandria are appropriately dealt with and in particular:

- The Supreme Council of Antiquities be included as one of the responsible agencies concerned with the protection of the water environment (Law No. 4 on the Environment, Art. 1.38);
- The possibility of establishing a special legal status for the underwater archaeological sites of Alexandria should be studied, as well as the possibility of their inscription on the World Heritage List.

7. The potential economic value of the archaeological sites of Alexandria for tourists and visitors should be studied, e.g. development of museums and archaeological parks on land and underwater.

8. A small group should be established to follow up the recommendations of this workshop, to prepare project proposals and investigate funding possibilities.

Addendum

The workshop further recognizes the importance of the following issues:

- The University of Alexandria should consider developing specialized courses for graduate and undergraduate students in submarine archaeology and related disciplines; it should also consider open education for the public at large.
- The need to make the public, and in particular, young people, aware of the value and significance of their natural and cultural coastal heritage.
- Participants attending this workshop expressed the wish to convene an international conference on Underwater Archaeology and Coastal Management.

Alexandria Declaration

Prof. Hassan El-Banna Awad, the rapporteur, made the following declaration on behalf of the participants of the workshop, during the closing session on the 10 April 1997.

The significance of Alexandria in history has made the threat to its land and marine archaeological sites a matter of urgent concern to Egypt and the world.

Recommendations dealing with the erosion under the Qait Bey Fortress and long-term preservation and management of the cultural assets of Alexandria have been made by the scientific community attending the International Workshop on Submarine Archaeology and Coastal Management. With the co-operation of the world community, we believe that Egypt will be able to succeed in the stated goals of preserving the cultural heritage of the City of Alexandria as part of the heritage of all humanity.

Closure

The workshop was closed with addresses by Prof. Mostafa Hassan Mostafa, Vice-President for Graduate Studies and Research of the University of Alexandria, and Prof. Fathy Abu Aianah, Vice-President for Student Affairs of the University of Alexandria.

4

Follow-up activities

There is an urgent need to secure the integrity of the Eastern Harbour area and to ensure its future, for it is both the boundary and the heart of the old city of Alexandria, giving the downtown area its unique character. It links the city to its past, to a time when the Eastern Harbour, the Pharos and the library were the centre of Mediterranean trade, travel and scholarship. Currently, the Eastern Harbour is the centre for a small commercial fishing fleet with facilities for docking, maintenance and shipbuilding, as well as marinas and recreational centres. The old library of Alexandria was rebuilt as the 'Bibliotheca Alexandrina' and inaugurated in 2002, following an international campaign by UNESCO for its revival.

Over-population, rapid development, inadequate planning and pollution threaten the archaeological sites, the continued commercial use of the harbour and its potential development as a tourist attraction. Any proposed intervention should take into consideration the need to protect and preserve the integrity of all the archaeological sites, including the submerged lighthouse, the citadel, the submerged royal quarter and the El-Silsilah (Figure 9) .

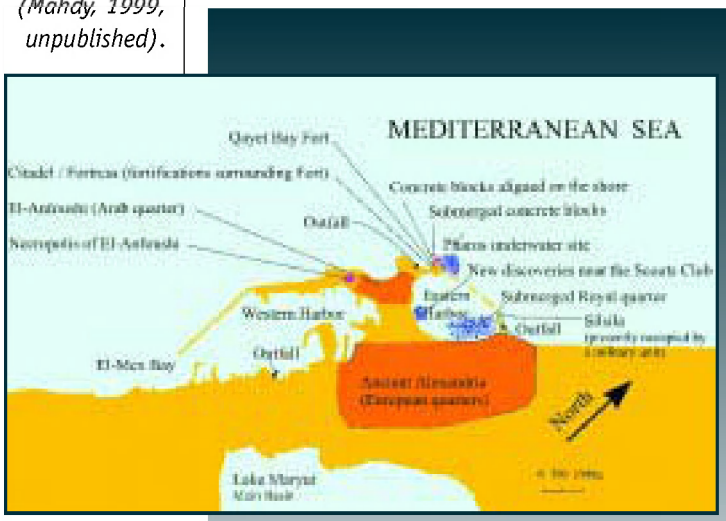


Figure 9. Schematic map of Alexandria showing important sites to be considered within the context of coastal management *(Mahdy, 1999, unpublished)*.

Following the 1997 international workshop, several actions were taken to implement some of the recommendations. These are summarized in Table 1 and will be discussed in this chapter. These actions included feasibility studies on and expert investigations into various aspects of the site, a further workshop and several round table discussions.

Structural assessment of the Qait Bey Citadel

One of the principle recommendations of the International Workshop on Submarine Archaeology and Coastal Management was that an assessment should be made of the structural condition and vulnerability of the Qait Bey Citadel. In response to the Supreme Council of Antiquities' request for technical assistance, an assessment of wave damage and human impact at the Qait Bey Citadel and Pharos Lighthouse sites was conducted with assistance from UNESCO in September 1997. The assessment team consisted of Dr Ing. Denis Aelbrecht, France, Dr Ing. Bertrand Latteux, France, Prof. Eng. Giorgio Croci, Italy, and Prof. Burghard Flemming, Germany.

In the context of this investigation (Aelbrecht *et al*, 1997a, 1997b, unpublished; Aelbrecht *et al*, 2000), the citadel site has been divided into three areas: (i) the Qait Bey Fort itself, comprising a square fortified building measuring about 30 m x 30 m; (ii) the Fortress, which completely encloses the Qait Bey Fort and is, for the most part, encircled by a continuous wall; and (iii) a concrete platform lining the citadel along its eastern and north-eastern sides (Figure 10, p. 42). Figure 11 (p. 43) shows photographs of the Qait Bey Fort before and after restoration work.

Table 1. Summary of the follow-up to the International Workshop on Submarine Archaeology and Coastal Management, 1997–1999

6–12 September 1997	Structural assessment of the Qait Bey Citadel
12–17 September 1998	Feasibility study on the establishment of an underwater archaeological museum, and management of the Qait Bey Citadel site and the Eastern Harbour.
16 September 1998	Round table discussion on the proposed underwater archaeological museum and the management of the Qait Bey Citadel site and the Eastern Harbour.
22 September 1998	Decree forming the Consultative Committee for Planning and Follow-up for the protection and development of the submerged sites and the Qait Bey Citadel.
27 October 1998	First meeting of the Consultative Committee for Planning and Follow-up.
9 December 1998	First meeting of the task team formed by the Consultative Committee for Planning and Follow-up.
13–14 December 1998	Round table discussion on the pilot project for establishing an underwater archaeological museum and managing the Qait Bey Citadel site and the Eastern Harbour.
30 January – 8 February 1999	Investigation into marine pollution and urban water management in the Eastern Harbour.
20–21 November 1999	Workshop on the status of the pilot project for sustainable development of the underwater archaeological sites around the Qait Bey Citadel and in the Eastern Harbour. Adoption of a work plan.

The principle findings of the structural assessment may be summarized as follows:

- A close inspection of the citadel site revealed that neither the Qait Bey Fort nor the surrounding fortress was threatened by wave action at the time of the mission.
- There are cavities below the platform lining the citadel.
- The platform lining the citadel along its eastern and north-eastern perimeter shows serious local structural damage.
- Some adjoining sections of the concrete platform are undercut without, however, showing structural damage at present.
- Other sections of the concrete platform and parapet walls show minor damage from wave overtopping.
- The concrete blocks that form a submerged breakwater 30 m seaward of the citadel provide no useful protection.

Following the assessment, recommendations were made for future action, both short-term and longer term. In the short-term, immediate action was recommended as follows:

- An endoscopic inspection and analysis of the foundations of the platform should be carried out. A fine-grained concrete mass should be

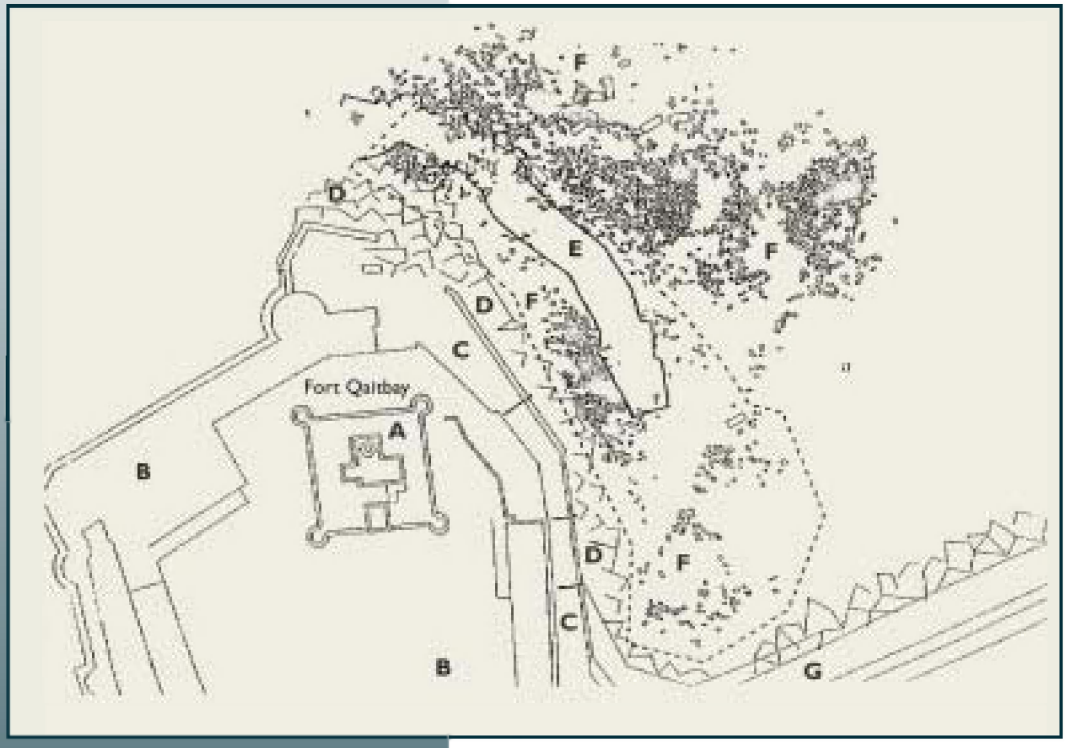


Figure 10.
Diagram, based on an underwater photograph, showing position of concrete blocks resting on part of the Pharos site.
(From final report by Mission 1)
(A): The Qayet Bay Fort.
(B): The fortress, which completely encloses the fort.
(C): The concrete platform which lines the fortress along eastern & north-eastern sides.
(D): A breakwater consisting of large concrete blocks.
(E): 180 large concrete blocks (dropped in 1993).
(F): Pharos underwater archaeological site.
(G): Modern breakwater of the Eastern Harbor.

injected under pressure into the cavities below the platform. Once this is completed, the platform should be cleared of all loose rubble and a reinforced concrete slab should be poured over the existing platform.

- An underwater inspection of the entire base of the citadel should be carried out and a map prepared showing the extent of erosion.
- The concrete platform lining the citadel along its eastern and north-eastern perimeter is damaged and requires urgent attention. Adjoining sections although not damaged also need to be shored-up. Failure of the platform would leave the inner perimeter wall of the fortress vulnerable to wave undercutting.
- Minor damage from wave overtopping should be repaired in the course of routine maintenance work.
- Some superfluous concrete structures above the elevation of the platform should be removed for aesthetic reasons.
- The 180 concrete blocks placed as part of the planned but never completed protective revetment around the Citadel, and which covered the Pharos Lighthouse underwater site, should be removed.

In the longer-term, the following strategies were recommended:

- The interests of all three sites in and around the Eastern Harbour, comprising the citadel, the Pharos Lighthouse and the Royal Quarter, might be best served by uniting them to form

a single entity. This might take the form of a cultural theme park, part open-air and open-water museum, and part marine archaeological reserve.

- The wastewater problem should be assessed as part of an integrated urban water system for Alexandria. (UNESCO's International Hydrological Programme may be able to contribute).
- A task force with representatives from all the interest groups should be set up.
- A scientific data collection programme should be started as soon as possible, involving Egyptian and foreign scientists, and local postgraduate students wherever possible, focusing on the following:
  - A detailed bibliographical study of the construction, damage and restoration events at the citadel,
  - Data collection on meteorology, oceanography, geology and coastal evolution of the area,
  - Modelling of (i) wave propagation from offshore to the coast and wave agitation in the area sheltered by potential structures, (ii) general offshore oceanic circulation and wave-driven forces in the surf zone, and (iii) long-term morphological seabed changes.

Feasibility study on the establishment of an underwater archaeological museum and management of the Qait Bey Citadel site and the Eastern Harbour

The idea of making Alexandria's Eastern Harbour and the area around the Qait Bet Citadel into an underwater museum was first proposed by Selim Morcos (1965). He suggested that: 'visitors could observe the remains of the Pharos and other structures, instead of raising them and stocking them in museums ... especially if they are of colossal size, spread over a large area and forming an integral ensemble with the archaeological site'. Further studies and discoveries since that time, Honor Frost in 1969 (Frost, 1975), Jean-Yves Empereur and his team since 1995 (Empereur, 2000), and Franck Goddio's team since 1996 (Goddio, 2000), have made convincing arguments for an underwater museum.

The International Workshop on Submarine Archaeology and Coastal Management recommended that a long term management plan should be put in place which would include a study of the potential economic value of the archaeological sites of Alexandria for tourists and visitors, e.g. the development of museums and archaeological parks (on land or underwater).

As a follow up to this recommendation, an international team of experts visited the site from 12–17 September 1998, to (i) examine the feasibility of establishing an underwater museum on the site of the ancient Alexandria Lighthouse in the locality of the Qait Bey Citadel; (ii) propose a strategy for establishing such a museum, if feasible, or if not feasible, to propose alternatives; (iii) make suggestions for the management of tourist access to the site and for site interpretation; (iv) make suggestions for the museum display to the public; and (v) make preliminary cost estimations for implementation. The team, supported by UNESCO, comprised Mr Oguz Alpozen, Director,

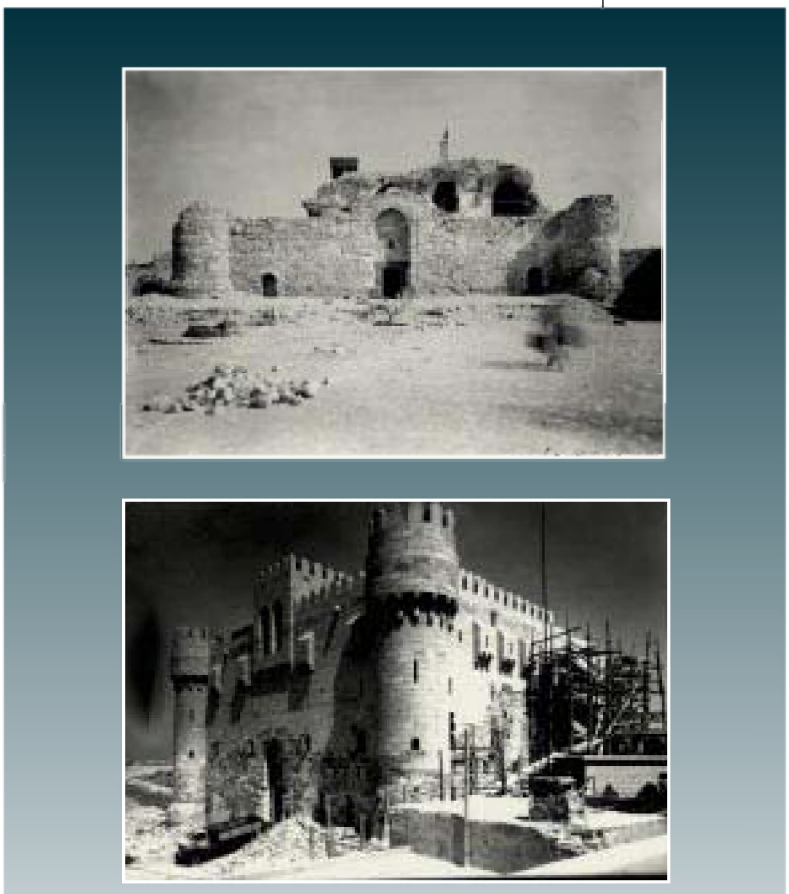


Figure 11. Qait Bey Fort before and after restoration in the 1930s. *Source: Supreme Council of Antiquities, Information Centre*

Bodrum Museum of Underwater Archaeology, Turkey, and Mr Graeme Henderson, Director, Western Australian Maritime Museum, Australia.

The principle findings of the team (Alpozen and Henderson, 1998, unpublished) may be summarized as follows:

- The Pharos Lighthouse is unique and of global importance; its archaeological remains must be preserved and made accessible to the widest international community.
- The establishment of an underwater museum on the Alexandria Lighthouse site is eminently feasible for the following reasons: the significance of the site; its international reputation; the shallow water depth of the site; its proximity to shore and associated underwater remains – the Royal Palaces in the Eastern Harbour; the proximity to a large building, the Qait Bey Citadel, suitable for housing museum support facilities and interpretation material; the lack of competing underwater museums around the world and the growing visitor interest in living museums, or museums that encourage active visitor involvement.
- Successful visitor attractions increase tourist numbers and bring substantial economic benefits.
- The project cannot succeed unless the sewage problem is first addressed.

Figure 12. The Qait Bey Fort and Citadel is presently a popular tourist attraction. *Photo: D. Nakashima*

- The Qait Bey Fort and Citadel should be established and developed as the above-water support and interpretation facility for the underwater museum, and as the repository for material excavated from other submerged cultural sites near Alexandria. Monumental objects removed in recent times from the Alexandria Lighthouse underwater site should be returned to the site after analysis and appropriate preservation is completed. The site is already very popular with Alexandrians and visiting tourists. If it is suitably developed, it will enhance foreign tourism in Alexandria (Figure 12).
- No more artefacts should be removed from the site.
- The Royal Palace site in the Eastern Harbour may prove a suitable extension to the underwater museum.

Following the study, recommendations were made for future action, both short-term and longer term. Short-term recommended actions were as follows:

- Elimination of pollution, which is a serious health risk and aesthetic barrier to the underwater site. It is not feasible to have tourists visit the site when it is polluted with sewage, so visitation and international advertising should be delayed until the sewage problem is completely resolved. The Qait Bey sewage outfall is only a few hundred metres from the Pharos site. Northerly winds drive polluted water towards the Pharos. One solution would be to provide a primary treatment plant and divert the flow to an inland lake.
- Clean-up the Eastern Harbour and Pharos sites, remove the layers of sediment that cover the archaeological remains.
- Nomination of a museum director by the Supreme Council of Antiquities; the director would have overall authority for the fort/citadel and underwater museum.
- Collect and analyse wave, current and water-clarity data with a view to determining the number of diving days per annum and improving diving conditions.
- Nomination of the Pharos site to the World Heritage List.

- Replacing the concrete blocks with a submerged wave-breaker system. The concrete blocks recently dropped in the antiquities area are, according to engineering advice, causing ongoing deterioration to the Citadel and should be replaced with a more effective and non-intrusive seabed wave-breaker system outside the perimeter of the antiquities.
- Restoration of the fort/citadel.

In the longer-term, three stages are recommended:

- During Stage 1, above-water facilities will need to be developed or enhanced, specifically: (i) offices for museum staff; (ii) entrance, approaches and Citadel grounds; (iii) orientation centre; (iv) new exhibits including the history of Alexandria from the 3rd century BC to 1182 (Pharaonic, Greek, Roman and Islamic times); (v) expanded retail outlet for souvenirs, books; (vi) conservation laboratory; and (vii) headquarters for the Institute of Nautical Archaeology.
- During Stage 2, underwater facilities need to be made available, in particular: (i) a building for equipment hire; (ii) a changing area for divers; (iii) dive site entrance-departure zone; (iv) underwater site interpretation; and (v) glass-bottomed boats for non-divers.
- During Stage 3, the underwater museum would benefit by inclusion of the Royal Palace, especially since the Royal Quarters are extensive and well preserved.

Preliminary cost estimates for the land and underwater facilities described in stages 1 and 2 above, amounted to 2.5 million US dollars.

Planning activities and formation of a Consultative Committee for Planning and Follow-up

One of the recommendations of the International Workshop on Submarine Archaeology and Coastal Management was to establish a small group to follow up the recommendations of the workshop.

In September 1998, approximately 30 representatives and experts from the Supreme Council of Antiquities, the Alexandria Governorate, Alexandria University, the Institute of Coastal Research, the Ministry of Tourism and UNESCO attended a round-table discussion. Following a presentation by two of the experts involved in the feasibility study on the underwater museum, it was agreed that the underwater archaeological objects, the Qait Bey Citadel and the Eastern Harbour have the potential to form an integrated archaeological museum with the citadel being the main platform for display and facilities.

As regards the other recommendations, progress was made on the raising of the 180 concrete blocks from the submerged archaeological site. Ten were raised in 1996 to search for the missing legs and feet of the colossal statue of Ptolemy (Figure 13), 45 blocks were raised in February 1998, and finally the remaining blocks in January 2001. Thus the archaeological field is now completely available for exploration and integration into the proposed underwater museum.

Figure 13. Colossal statue of Ptolemy (13 m long) salvaged in separate pieces, the trunk in 1995, the head and arms in 1996; shown at an exhibition 'La Gloire d'Alexandrie' at the Petit Palais in Paris, in 1998. *Photo: S. Marcos*

The Supreme Council of Antiquities arranged for the damaged sections of the platform under the Qait Bey Citadel and the cavities under the bedrock to be inspected by divers and documented photographically in 1999. The platform has been firmly consolidated by extending a thick concrete revetment over it. However, further stabilizing work is needed.

On 22 September 1998, a decree was passed by Dr G. Gaballah, Secretary General of the Supreme Council of Antiquities forming the Consultative Committee for Planning and Follow-up of the Project for the protection and development of the submerged sites and Qait Bey Citadel. At its first meeting in October 1998, the Committee formed a technical task team to review the available data

and information relevant to the project and to recommend future action. Particular attention was given to the citadel and its safety and five of the eleven nominated task team members were directly or indirectly concerned with this issue (Annex 5).

In addition to the task team, the UNESCO Cairo Office commissioned Prof. S. Sharaf El Din to review the oceanography of Alexandria's coastal zone (Sharaf El Din, undated, unpublished). In their respective reports, the task team members brought to light a mass of information related to both natural and anthropogenic processes likely to impact the citadel and the marine environment in the areas of concern. The task team members identified areas of uncertainty and made specific recommendations to acquire the necessary data. The ten reports of the task team were collected in three volumes and deposited at UNESCO and at the Supreme Council of Antiquities.

In a second round-table discussion in December 1998, it was agreed to implement the recommendations of the expert mission of September 1997, regarding the stability of the citadel. This included an endoscopic inspection and analysis of cavities below the concrete platform, using a miniature waterproof TV camera lowered on a fibre optic cable, and taking the necessary measures to stabilize the concrete platform.

Marine pollution and urban water management in the Eastern Harbour were also discussed during the second round-table discussion. Dr Nariman Mostafa Soheil, from the Alexandria General Organization for Sanitary Drainage, said that the Qait Bey and El-Silsilah outfalls will not be closed until 2003, and that the Western Treatment Plant, which will provide for secondary treatment of sewage that currently drains into Lake Mariout and from there into the sea at El Mex west of Alexandria, will not be operational before 2010. The round-table participants strongly recommended that efforts should be made to stop the disposal of untreated sewage in the sea before these dates.

Marine pollution and urban water management in the Eastern Harbour

Alexandria's environmental problems have grown in severity as its population and associated urban and industrial development have increased since the beginning of the 20th century (Halim and Abou Shouk, 2000). Marine pollution in the Eastern Harbour and around the Qait Bey Citadel is caused by the discharge of urban wastewater. The Qait Bey outfall, the main source, is located a few hundred metres west of the Pharos. A smaller one, the El-Silsilah outfall, is located on the eastern side of this peninsula. Both outfalls are outside the Eastern Harbour, but there is intermittent flow into the Harbour from another outfall. Serious deterioration in the water quality in the Eastern Harbour began about 40 years ago when these outfalls first came into operation.

The state of pollution in the Eastern Harbour is widely recognized as the biggest obstacle facing the development of the area as a whole, and particularly the development of an underwater archaeological museum. It is not reasonable to have tourists visit the site or for divers to explore the underwater treasures as long as the discharge of urban wastewater continues to pose a health risk. The northerly winds transport polluted water from the Qait Bey outfall to the Pharos site, which is only a few hundred metres away. In addition, sediment layers, which have accumulated over the last 40 years since urban wastewater has been discharged into the waters around the Eastern Harbour, cover the archaeological sites.

Putting an end to this situation constitutes a financial burden and technological challenge for the city of Alexandria. The most obvious solution is to change the urban water system. However, even if the discharge of domestic wastewater into the area is stopped, much will remain to be done if the water body and sea bed are to recover.

Late in 1998, Prof. Abdelwahab M. Amer of Cairo University's Faculty of Engineering made a technical assessment of Alexandria's water supply and sanitation systems (Amer, 1998, unpublished). This was followed in January/February

1999 by an assessment of the management structure of Alexandria's water system by Dr Alfonsus Nelen (Nelen and Amer, 1999, unpublished).

The principle findings of these assessments may be summarized as follows:

- The city of Alexandria is served by seven water treatment plants. Five take their raw water from the Mahmoudia canal. The other two, that serve western parts of the city and areas to the south and along the north coast, draw their water from the heavily polluted Noubaria canal, resulting in drinking water that does not always comply with water quality standards.
- 80–90% of Alexandria's housing stock has sanitation, most commonly with a septic tank. Sludge from the tanks is disposed of in drainage canals or sometimes even irrigation canals.
- Alexandria's groundwater is becoming increasingly polluted as a consequence of the infiltration of polluted surface water into the aquifers. The salinity of the groundwater is likely to increase due to the intrusion of seawater.
- Lake Mariout is currently used mainly for fishing and water retention. It receives agricultural run-off, untreated and primary-treated sewage and industrial wastewater. The lake is heavily polluted and suffers from several problems including the loss of fish stock, contamination of fish with chemicals and parasites.
- More than 50 million cubic metres of untreated sewage and industrial waste-water are discharged annually into the Mediterranean from Alexandria. To the west of Alexandria, about 2,190 million cubic metres of wastewater per year drain into the sea from the Omum Drain and from Lake Mariout. Abu Qir Bay, east of Alexandria, receives some 730 million cubic metres of wastewater every year from industries located near Kafr El-Dawar and from the local Tabia industries. These wastewaters contain pollutants from textile, dye, pulp, paper and fertilizer industries.
- There are many national and local organizations involved both directly and indirectly in the management of Alexandria's urban water system. The roles and responsibilities of these organizations are not clearly defined. No institutional framework exists to encourage and maintain the necessary communication between the various parties involved.
- Responsibility for environmental protection is widely dispersed among a large number of ministries and institutions. The Egyptian Environmental Affairs Agency is supposed to act as the Inter-ministerial Policy Council for environmental issues.

No organization in Alexandria can provide a comprehensive picture of environmental issues or an assessment of the current physical water system, thus there is no clear definition of the problem and each organization functions in a piecemeal manner. As a consequence, the limited financial and human resources are not used efficiently. The following recommendations were made:

- Integrated water management is necessary to achieve sustainable solutions to water-related problems.
- Integrated planning involving all relevant parties on a local/regional level is preferable to planning at a national level, as proposed by the National Organization for Potable Water and Sanitary Drainage.
- Capacity building, strengthening of the existing institutions and improvement of communication are more important than developing a new technical master plan.
- A multi-sectoral approach including socio-economic aspects is required to improve public awareness and to achieve the necessary public participation.
- Special recommendations for the Alexandria General Organization for Sanitary Drainage include: (i) close the Qait Bey and El-Silsilah outfalls; (ii) expand the Western Treatment Plant, strengthen its management system and activate its industrial wastewater department; (iii) develop a fair and equitable tariff system that allows the Alexandria General Organization for Sanitary Drainage to recover the cost of conveying and treating industrial wastes.

Following this assessment, and during a workshop in November 1999 on the Status of the Pilot Project for Sustainable Development of Submarine Archaeological Sites at the Qait Bey Citadel and the Eastern Harbour, a presentation on water quality and pollution control indicated an improvement in the environmental quality in the Eastern Harbour over the past five years (Annex 6). This followed the partial blocking of wastewater discharges into the Eastern Harbour in 1993. The closure of the Qait Bey and El-Silsilah outfalls in 2003 should improve things further, although a pristine waterfront cannot be expected until all the wastewater that drains from Lake Mariout is thoroughly treated.

Even when all wastewater discharge in the area around the Eastern Harbour is stopped, it will be some time before the area is suitable for diving. The pollutants deposited over the past years will remain in the marine environment, although they may be redistributed. Their predicted lifespan is critical to the underwater museum. A project on the 'State of marine pollution and socio-economic problems related to the success of the underwater archaeological museum project in the Eastern Harbour,' was approved within UNESCO's Participation Programme 2000–2001. This project, which is being carried out by the Department of Oceanography, has the objective of modelling the pollutant remobilization process based on field observations and analysis. Once this information is available, a suitable time to open the underwater museum can be determined.

However, the pollutant remobilization rate also depends on the dynamics of the bay, as was pointed out by Prof. Frihy during the 1999 workshop. Hydrodynamic forces continuously erode the sediments of the Eastern Harbour along its north–south axis. About 70% of the eroded material escapes from the harbour to be deposited offshore. This process will undoubtedly accelerate the recovery of the Eastern Harbour.

Although it has been repeatedly stated that elimination of pollution and assurance of water clarity and safety are preconditions for allowing diving by tourists, limited permission was recently given for diving on the Pharos site outside the Eastern Harbour (not inside the harbour where pollution is more pronounced). Four tourist companies wished to run tours of the site and diving was permitted from October 2001. It is hoped that any disappointment with the present imperfect water conditions will not compromise future plans for the underwater park.

Workshop on sustainable development of submarine archaeological sites at the Qait Bey Citadel and the Eastern Harbour

A workshop was convened on 20–21 November 1999 at the Department of Oceanography, Faculty of Science, Alexandria University to assess the status of the pilot project for sustainable development of submarine archaeological sites at the Qait Bey Citadel and the Eastern Harbour (Anon, 1999, unpublished). This workshop was a follow-up activity of the 1997 international workshop and the 1998 round-table discussions, and was organized by the Supreme Council of Antiquities, Alexandria University and the UNESCO Cairo Office. More than 40 participants attended from the organizing institutions, the Alexandria Governorate, other national institutions and non-governmental organizations; several international experts were also invited. The workshop had three objectives: (i) to review the output of the task team; (ii) to discuss and approve a work plan; (iii) to evaluate the progress made and recommend future action.

Before the technical session, introductory reviews were made by Dr Gaballah and members of the Consultative Committee on Planning and Follow-up. The need to act immediately to protect the foundation of the citadel was emphasized, as well as the need for the sustainable management of the coastal zone of Alexandria's old city.

Ten reports from the task team were presented and discussed (El-Abbadi and Halim, 1999, unpublished). They dealt with archaeological, socio-economic, meteorological, hydrodynamic, geomorphodynamic, seismic and water quality

aspects, and with projected improvements in Alexandria's sewage system. The highlights of these reports are contained in Annex 6 and the workshop recommendations are listed below.

The workshop:

- Recommends that maximum use be made of all the information collected on the socio-economic and biophysical characteristics of the Qait Bey sites when designing the proposed underwater archaeological museum; and that all information, including remote sensing data, should be integrated into a geographical information system.
- Would welcome the inclusion of the Alexandria project to develop an integrated sustainable development strategy in the UNESCO programme for 2000–2001.
- Notes with satisfaction that the sewage outfall in the Qait Bey area will be closed in the near future and welcomes plans for the on-land reuse of treated wastewater for woodland areas south-west of Alexandria.
- Considering that Lake Mariout is a significant archaeological and historical area which constituted the link between Alexandria and the rest of Egypt in antiquity and the Middle Ages, strongly appeals to the authorities to implement current plans to divert all wastewater away from the lake; it also urges the authorities to put an immediate end to all reclamation and landfill work within the lake area.
- Recognizes the steps already taken in removing a number of concrete blocks off the Pharos site and urges the total removal of all blocks. (The blocks were all removed by 2001).
- Strongly urges the Governorate of Alexandria and the Supreme Council of Antiquities to abide by Law 4/1994 for the environment by carrying out a complete environmental impact assessment prior to the authorization of any project or extension likely to affect the environment, archaeological sites or the community in the Alexandria coastal area.
- Urges the Supreme Council of Antiquities to carry out a survey and scan of the foundations and bedrock of the Qait Bey as a preliminary step toward on-site remedial and protective measures for the Citadel.
- Recognizes the need for a detailed map with descriptions of all the archaeological objects offshore from the Qait Bey site, as a preliminary step toward the proposed underwater museum.
- Calls for cleaning up certain archaeological structures, removing fouling growth and accumulated sediments and considering means of *in situ* restoration as a necessary step for the proposed underwater museum in the Eastern Harbour.
- Recommends the publication of a brochure on the project, for potential donors and authorities, to be financed jointly by the Supreme Council of Antiquities and UNESCO.
- Urges the Supreme Council of Antiquities to follow up on the earlier recommendation to approach UNESCO in order to register the Qait Bey Citadel and Eastern Harbour as a protected archaeological site on the World Heritage List.
- Recommends a draft project document, with cost estimates, be prepared.
- Recommends that Alexandria University consider the possibility and desirability of establishing a UNESCO Chair on Sustainable Coastal Development in order to reinforce the ongoing activities in Alexandria.
- Urges the Supreme Council of Antiquities, Alexandria University and UNESCO to follow up on the earlier recommendation to convene a Second International Conference on Underwater Archaeological and Coastal Management.

A work plan drafted by the Consultative Committee on Planning and Follow-up was discussed and approved at the workshop. The main long-term objectives of the plan are: (i) the establishment of the underwater museum, (ii) the preparation and implementation of an integrated management policy and (iii) enhancement of tourism. The immediate objectives of the plan are to:

- Secure the safety and integrity of the cultural heritage sites both on land and underwater, by stabilizing the fort, continuing the exploration and the recording of the submerged archaeological artefacts, removing the concrete blocks and closing the wastewater outfalls.

- Establish a digital database for the environmental, archaeological, socio-economic and urban data.
- Nominate the site to the World Heritage List.
- Prepare a project document.

The work plan included short-, medium- and longer-term actions. In the short-term (one year):

- A sociological survey of the local population should be conducted, followed by an assessment of the socio-economic impact of the proposed project.
- The foundations and bedrock of the Qait Bey Citadel should be scanned, and the offshore area should be subjected to a seismic scan, in order to recommend on-site remedial measures.

In the medium-term (two years):

- A detailed interpretive map of the offshore site and the Eastern Harbour should be prepared.
- An accurate bathymetric map should be prepared showing the offshore site and the Eastern Harbour.

In the longer-term (two+ years):

- A digital database of all the bio-geophysical data should be developed as the basis for modelling the sites. This should include meteorological, oceanographic (physical and chemical), sedimentological, water quality and primary productivity data. In many cases this monitoring should be continued indefinitely.

Bibliotheca Alexandrina and other developments

Inaugurated in October 2002, the Bibliotheca Alexandrina has become a major landmark of the Eastern Harbour, and represents a significant endeavour towards the revival of the cultural heritage embodied in the old Library of Alexandria. Together with the Eastern Harbour, they form an ensemble which reinforces the approach towards an integrated management of Alexandria's coastal heritage.

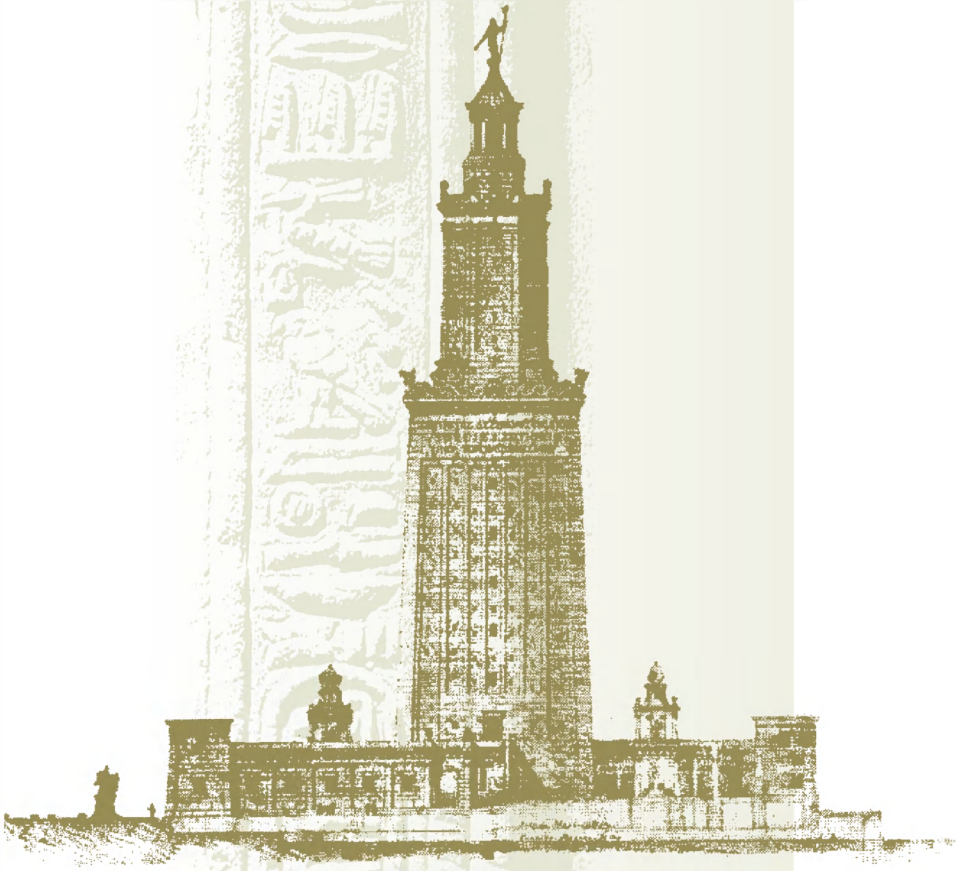
The Bibliotheca stands opposite to El-Silsilah, the small peninsula on the eastern side of the Easter Harbour. One of the most exciting developments is the revival of hopes that this area will soon be accessible for archaeological research. El-Silsilah, once known as Cape Lochias, is where the Royal Palaces stood during Ptolemaic times. As a result of an appeal by the Archaeological Society of Alexandria, it was agreed that this site, which is presently occupied by a military unit, will be accessible for archaeological research by the Supreme Council of Antiquities. The site is of potential interest to the Bibliotheca Alexandrina and plans for the underwater museum.

On the other hand, the activities related to the exploration of the underwater archaeological sites continue to make progress on several fronts. Research papers, popular books and TV films have been produced since the 1997 workshop. Archaeological investigations have continued, along with laboratory conservation efforts to preserve metal and other underwater archaeological objects. Progress was reported during the 1999 workshop (Darwish *et al*, 1999, unpublished).

The Egyptian team of the Department of Underwater Archaeology of the Supreme Council of Antiquities has become more involved in the joint exploration missions working in Alexandrian waters, and is actively pursuing its own independent programme. Empereur and his team have continued their efforts in documenting the Pharos site. Each of the over 2000 objects found have been given an entry card with all the available information and key words in a geographical information system. Detailed maps of the site have been produced. Using geophysical and archaeological data, the Goddio group is completing a new map of the Eastern Harbour showing the contours of the sunken land and port structures. The layout plan of the Royal Quarter, its monuments, harbours and shipyards on Cape Lochias attest to the majestic setting of the Portus Magnus in its glorious past. The Greek mission led by Harry Tzalas concluded in 2003 its tenth survey in the waters east of El-Silsilah and have found numerous architectural elements in the submerged site of Cape Lochias, including the upper part of a broken stele.

5

Concluding remarks



The need for integrated coastal management

The coastal and submerged archaeological sites of Alexandria are of worldwide significance and they represent an important tourism resource for the country. However, they are threatened by the continued disposal of urban wastewater into the sea and coastline alterations. There is an urgent need for an integrated coastal management programme to both protect and develop the on-land and submerged sites. Essential components of such a programme include legal provisions for all underwater sites, co-operation between the decision-makers who sometimes have conflicts of interest, and the implementation of wise practices which must encompass human and cultural dimensions.

In order to establish the legal status of underwater archaeological sites, amendments have to be made to Law No 4, 1994, for Protection of the Environment. The Supreme Council of Antiquities should be mandated at the same level as other agencies to protect the underwater archaeological sites and their environment.

Several agencies are involved with the coastal zone; these include the Governorate of Alexandria, the Alexandria General Organization for Sanitary Drainage, the Coastal Protection Agency, the Egyptian Environmental Affairs Agency, the Supreme Council of Antiquities, the Egyptian Navy and the Ministry of Tourism. There is little communication and co-ordination between them.

A mechanism for mutual understanding and co-ordination between policy and decision-makers on the one hand, and scientists and archaeologists on the other, is called for. A permanent inter-sectoral planning and management board can provide this link. This board would be mandated, among other things, to assess the environmental impact including the archaeological risk, of any proposed governmental or private development project. The guiding concept is that the protection of coastal zone resources is an integral part of the development priorities of the country.

Once the underwater archaeological museum has been developed, and the area has been cleared of polluting sediments and the city's wastewater is properly treated, Alexandria will become a centre of cultural tourism. However, ill-managed, tourism can cause the deterioration of its own assets and of the environment. If properly integrated with the environment, however, tourism can become a powerful force for sustainability. Two prerequisites for the integration of tourism with the environment are partnerships amongst stakeholders, and awareness among all concerned of the benefits of sustainability. Raising awareness among the local population, the stakeholders, the tourists and the public authorities requires on-going training, targeted information and dialogue. Representatives of the tourism servicing sector, the public authorities and environmental specialists and advocates need to meet regularly in an inter-sectoral framework to manage, plan and make decisions.

In order to ensure that cultural tourism can continue in the foreseeable future without damaging the quality of the environment, its cumulative impacts, as well as the impacts of other anthropogenic activities have to be monitored on a continuous basis.

Alexandria's Eastern Harbour is a commercial and recreational centre for the local population. It is a fishing port with facilities for maintaining and building boats; it is also a marina and has recreational centres on its shores. As such it provides a livelihood and entertainment for the local population. The needs of this community will

have to be considered within any integrated management plan. The human dimension is an especially important component of sustainable development, since reluctance of the local population to accept new developments can produce negative feedback, diminishing tourist satisfaction and lowering productivity.

The next stage

The developments realized in the years following the 1997 international workshop are the result of fruitful co-operation between the Supreme Council of Antiquities and UNESCO. They represent slow but undeniable progress towards the sustainable development of the underwater archaeological sites at Qait Bey and the Eastern Harbour, although much remains to be done.

Man-made threats to the archaeological sites are of greater concern than the threats caused by natural processes. The Alexandrian archaeological sites have not yet been inscribed on the World Heritage List. In the continued absence of national and international legal status, the sites will always remain vulnerable to hasty and ill-advised decisions.

The international workshop recommended that the University of Alexandria organize special courses at graduate and undergraduate levels in submarine archaeology and sustainable coastal zone management. The November 1999 workshop also recommended that the university consider the possibility and desirability of establishing a UNESCO chair to promote studies and research in underwater archaeology and sustainable coastal zone management. These suggestions need to be followed-up.

A major constraint at this stage is the absence of a comprehensive project document, which would justify the project, formulate its immediate and long-term objectives and bring to light its cultural and socio-economic returns.

6

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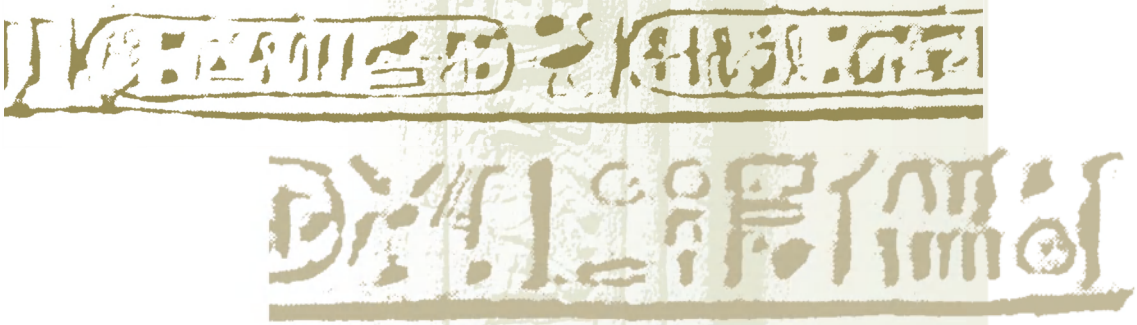

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Annexes

Annex 1

Workshop organizing committee

Prof. Essam Salem *(Chairman)*
President, Alexandria University

Prof. Ali Hassan
Secretary General,
Supreme Council of Antiquities

Prof. Mostafa Hassan *(Vice chairman)*
Vice-President, Alexandria University

Prof. Hassan Awad *(Rapporteur)*
Professor of Marine Pollution

Prof. Mohamed Abd Ella
Vice-President, Alexandria University

Prof. Fathy Abu Aianah
Vice-President, Alexandria University

Prof. Mohamed Mahgoub
Dean, Faculty of Arts,
Alexandria University

Prof. Salem Salem (Late)
Dean, Faculty of Science,
Alexandria University

Prof. Ahmed El-Toukhi
Vice-Dean, Faculty of Science,
Alexandria University

Prof. Mostafa El-Abbadi
Professor, Greco Roman Studies,
Alexandria University

Prof. Youssef Halim
Professor, Biological Oceanography,
Alexandria University

Prof. Hany Helal
Regional Office, UNESCO, Cairo

Dr Ahmed Khadr
Lecturer, Geological Oceanography,
Alexandria University

Mr Walid Nazmy Younes
Assistant Lecturer, Chemical Oceanography,
Alexandria University

Ms Dalia Khalil
Regional Office, UNESCO, Cairo

Annex 2

List of participants in the international workshop

(Ch: Chairperson, S: Speaker)

Ms Fatma Abou Shouk
Environment Department
Alexandria Governorate
60 Horria Street
Alexandria, Egypt
tel: (20-3) 301 1080
fax: (20-3) 302 4477

Dr Denis Aelbrecht (S)
Electricité de France – Pôle Industrie
Division de Recherche et Développement
Laboratoire Nationale d'Hydraulique
et Environnement
6, quai Watier
78401 Chatou Cedex, France
tel: (33-1) 30 87 74 12
fax: (33-1) 30 87 80 86
e-mail: denis.aelbrecht@edf.fr

Prof. André Bernand (Ch)
(Université de Lille III)
4, villa Lourcine
Paris 75014, France
tel: (33-1) 53 80 10 83

Prof. Nicola Bonacasa (S)
Instituto di Archeologia
Facoltà di Lettere
Università di Palermo
Viale delle Scienze
90128 Palermo, Italy
fax: (39-091) 656 0268 / 642 1494

Dr Luca Bondioli
Kenesset Debbana, 4
Attarine, Alexandria, Egypt
tel: (20-3) 482 8227
fax: (20-3) 493 8106

Ms Angeles Pérez Bonet
Museo National de Arqueología Marítima
Apartado de Correos 72
30280 Cartagena, Spain
tel: (34-968) 50 84 15
fax: (34-968) 52 96 92

Prof. Farouk El-Baz (S)
Director, Center for Remote Sensing
Boston University
725 Commonwealth Avenue
Boston, MA 02215-1401, USA
fax: (1-617) 353 3200
e-mail: farouk@bu.edu

Councillor El-Sayed El-Gawsaky
Then: Governor of Alexandria
tel: (20-3) 392 5800/801/808/809
fax: (20-3) 394 7192

Mr Mohamed A. El-Gindy
Formerly: Attorney General of Egypt
8 Adham Street, San Stefano
Alexandria, Egypt
tel/fax: (20-3) 582 0211

Prof. Jean-Yves Empereur (S)
Directeur, Centre d'Études Alexandrines
Centre National de la Recherche Scientifique
50, rue Soliman Yousri
21131 Alexandria, Egypt
fax: (20-3) 390 6962
e-mail: jye@cea.com.eg

Dr Christine Fabre
Service Recherche DEA
Conseil Général des Bouches du Rhône
52, Av. Saint Just
13256 Marseille cedex 20, France
tel: (33-4) 91 21 22 83
fax: (33-4) 91 21 22 98

Prof. Alfy M. Fanos (S)
Institute of Coastal Research
15 El-Pharana Street, El-Shallalat
21514 Alexandria, Egypt
tel: (20-3) 394 4115/6
fax: (20-3) 421 8436

Prof. Enrico Felici (S)
Associazione Italiana Archeologi Subacquei
Via Tripolitania 195, pal. F
00199 Rome, Italy
tel/fax: (39-06) 8620 8038

Prof. Omran E. Frihy (S)
Institute of Coastal Research
15 El-Pharana Street, El-Shallalat
21514 Alexandria, Egypt
tel: (20-3) 394 4115/6
fax: (20-3) 421 8436

Ms Honor Frost (S)
31 Welbeck St.
London W1M 7PG, UK
tel: (44-20) 7935 5856
fax: (44-20) 7935 3971

Dr Maria Antonietta Fugazzola (S)
Soprintendente
Soprintendenza Speciale al Museo Nazionale
Preistorico Etnografico 'Luigi Pigorini'
P. Le Marconi, 14
00144 Rome, Italy
fax: (39-06) 5495 2310

Dr Paolo Gallo (S)
Università degli Studi di Pisa (Egyptology)
via Galvani
156126 Pisa, Italy

Prof. Piro Gianofrotta
Università degli Studi della Tuscia
Facoltà di Conservazione dei Beni Culturali
Ravenna, Italy
fax: (39-0761) 357182

Prof. Gherardo Gnoli
President
Italian Institute for Africa and the Orient
Via Merulana, 248
00185 Rome, Italy
fax: (39-06) 487 3138

Mr Franck Goddio (S)
Directeur
Institut Européen d'Archéologie Sous-marine
41-43, rue de Cronstadt
75015 Paris, France
tel: (33-1) 45 49 18 03
fax: (33-1) 41 21 31 17

Prof. Nicolas Grimal (Ch, S)
Then: Directeur,
Institut Français d'Archéologie Orientale
37, rue El-Cheikh Ali Youssef
BP 11652, Qasr El-Ayni
11441 Cairo, Egypt
fax: (20-2) 354 4635
Currently: Professeur,
Collège de France, Paris
Private address:
14, rue Saint-Guillaume
75007 Paris, France
fax: (33-1) 42 22 47 61

Ms Hala Halim (S)
Then: Cultural Editor,
Al-Ahram Weekly
97 Abdel Salam Aref Street
Glym, Alexandria, Egypt
e-mail: halahalim@hotmail.com
Currently:
University of California at Los Angeles
Department of Comparative Literature
212 Royce Hall, Box 951536
Los Angeles, CA 90095-1536, USA

Mr Emad Khalil (S)
Deputy Director
Institute of Nautical Archaeology
42 Office Building
Moustafa Kamel, Roshdy
Alexandria, Egypt
tel: (20-3) 487 5737/615
fax: (20-3) 487 3088

Mr Victor Mastone (Ch, S)
Board of Underwater Archaeological Resources
Executive Office of Environmental Affairs
251 Causeway Street, Suite 900
Boston, MA 02114-2119, USA
tel: (1-617) 626 1141
fax: (1-617) 626 1240
e-mail: Victor.Mastone@state.ma.us

Dr Michèle Miele
Scientific Attaché, Italian Embassy
24 Galal St.
Boulak, Cairo, Egypt
tel: (20-2) 578 3295
fax: (20-2) 578 3296

Dr Mario Mineo (S)
Soprintendenza Speciale al Museo Nazionale
Preistorico Etnografico 'Luigi Pigorini'
P. Le Marconi, 14
00144 Rome, Italy
fax: (39-06) 5495 2310

Prof. Selim A. Morcos (Ch, S)
UNESCO Consultant
28204 Kenton Lane
Santa Clarita, CA 91350, USA
tel/fax: (1-661) 296 1034
e-mail: selimmorx@aol.com

Mr Iván Negueruela (S)
Director, Museo Nacional de Arqueología
Marítima y Centro Nacional de Investigaciones
Arqueológicas Submarinas
Ministerio de Educación y Cultura
Dique de Navidad, Apdo. de Correos 72
30280 Cartagena, Spain
fax: (34-968) 52 96 92

Dr Eric Peltier
Electricité de France
Cabinet du Pôle Industrie
22-30 avenue de Wagram
75382 Paris Cedex 08, France
tel: (33-1) 40 42 12 73
e-mail: eric.peltier@edf.fr

Dr Enzo Petrassi (S)
ERMA
Via Alvise Cadamosto, 14
Rome, Italy
fax: (39-06) 574 7412

Dr Gérard Pieroni
INSERM
18, Av. Mozart
13009 Marseille, France
tel: (33-4) 91 74 23 00
fax: (33-4) 91 75 15 62

Dr Patrice Pomey (Ch)
Director of Research
Centre National de la Recherche Scientifique
13691 Aix-En-Provence, France
fax: (33-4) 42 64 46 61

Dr Angeliki Simossi (S)
Department of Underwater Antiquities
Hellenic Institute for the Preservation
of Nautical Tradition
30 Kallisperi Street
11742 Athens, Greece
fax: (30-1) 956 4388

Dr Vincenzo Sommella (S)
ES s.r.l. – Progetti e Sistemi,
Via Zoe Fontana, 220
Tecnocittà ed. B1
00131 Rome, Italy
fax: (39-06) 419 1713
e-mail: v.sommella@es-it.com

Prof. Nils Tongring (Ch, S)
Marine Policy Center
Woods Hole Oceanographic Institution
Woods Hole, MA 02543-1138, USA
fax: (1-508) 457 2184
e-mail: ntongring@whoi.edu

Mr Harry E. Tzalas (Ch, S)
President, Hellenic Institute for the
Preservation of Nautical Tradition
94 Skra, Kallithea
Athens 17673, Greece
fax: (30-1) 956 4388
tel: (30-1) 951 4291
e-mail: hmarine@hol.gr

Mr Howard Wellman (S)
Then: Institute of Nautical Archaeology
PO Box 432, El-Ibrahimia,
Alexandria, Egypt
Currently: Lead Conservator
Maryland Archaeological Conservation
Laboratory
Jefferson Patterson Park & Museum
10515 Mackall Road
St Leonard, MD 20685, USA
fax: (1-410) 586 3643
e-mail: wellman@dhcd.state.md.us

Dr Michel Wuttmann (S)
Responsable du Laboratoire de Restoration
Institut Français d'Archéologie Oriental
BP 11562, Qasr El-Ayni
11441 Cairo, Egypt
tel: (20-2) 794 8245/3719
fax: (20-2) 354 4635

Dr Annalisa Zarattini (S)
Soprintendenza Archeologica per il Lazio
Via Pompeo Magno, 2
00192 Rome, Italy
fax: (39-06) 321 4447

ALEXANDRIA UNIVERSITY
Staff Members

Faculty of Science
Oceanography Department
Eastern Harbour Building
Alexandria 21511, Egypt
tel: (20-3) 484 3171/2
fax: (20-3) 491 1794

Prof. Abdallah Mohamed Abdallah
Prof. Hassan Awad (Ch), *Rapporteur*
Mr Medhat Abdel Barr
Ms Amani Abdel Hamid
Prof. Ossama Aboul Dahab (S)
Prof. Manal Atta
Prof. Mohamed Dorgham
Prof. Fahmy Eid
Ms Yousreiah El Faham
Prof. Ahmed El-Gindy (S)
Prof. Fatma El Nady
Prof. Osman El Rayes
Prof. Mohamed El Sabarouty
Prof. Abdel-Fattah M. El-Sayed
Prof. Altaf Ezzat
Prof. Saiedah Hafez
Prof. Youssef Halim (Ch, S.)
Prof. Abdel Ghani Khalil
Dr Ahmed Khadr, *Secretariat*
Ms Hanan Metwally
Ms Omneya Mohamed
Prof. Sayed H. Sharaf EI-Din (Ch)
Mr Sayed Shabara
Mr Walid Nazmy Younes, *Secretariat*

Faculty of Science
Moharam Bey Building
Alexandria 21511, Egypt
tel: (20-3) 392 2918/9
fax: (20-3) 491 1794

Geology Department
Prof. Abdel Al Abou El Ella
Prof. Mohamed El Dahhar
Prof. Kamal Esmaiel
Prof. Hanafy Holail
Prof. Sobhy Osman
Dr Mohamed Abdel Aziz

Zoology Department
Prof. Mohamed El Moufty
Prof. Nabila El Sayed
Prof. Ismaiel Sadek
Biochemistry Department
Prof. Kamal Kandil
Prof. Ahmed El Sharaky

Faculty of Arts
Archaeology Department
Alexandria, El-Chatby, Egypt
tel: (20-3) 487 5737/6/5
fax: (20-3) 487 3088
Dr Mohamed Abboudi
Dr Fadia Abou Bakr
Dr Amal Abo El Ella
Dr Doha Arafa
Prof. Mostafa El-Abbadi (Ch, S)
Prof. Fawy El Fakharany (Ch, S)
Dr Souzan El Kalzah
Dr Magda El Nouaiemy
Dr Fouad El Sharkawy
Dr Hussain El Sheikh (S)
Dr Wegdan El Sherif
Dr Mona Hagag
Prof. Aziza Saied
Dr Fekreiah Saleh
Dr Baheia Shaheen
Prof. Sami Shnouda
Prof. Lotfy Yehia (Ch, S)
Dr Sohair Zaky

Faculty of Engineering
Alexandria, El-Chatby, Egypt
tel: (20-3) 597 5556 / 592 5550
fax: (20-3) 592 1853
Prof. Ibtehal El-Bastawissi (S)
Prof. Mohsen Zahran (S)

Faculty of Tourism and Hotels
Alexandria, Sauter, Egypt
tel: (20-3) 484 3123
fax: (20-3) 487 8401
Dr Moustafa Abdel Hafez
Prof. Mona Barakat
Dr Gihan El Sawy
Dr Mariem Mannaa

SUPREME COUNCIL OF ANTIQUITIES

54, Fakhry Abdel Noor St.
Abbassia, Cairo, Egypt
tel: (20-2) 341 5645
fax: (20-2) 340 7239
Mr Ahmed Abdel-Fattah (S)
Ms Mansourah Awad

Department of Underwater Archaeology (DUA)
Greco Roman Museum
5, Museum St.
Alexandria, Egypt
tel: (20-3) 522 6242
fax: (20-3) 573 9575
Mr Ibrahim Darwish (S)
Ms Omayma Dorgham
Mr Moustafa El Desouky
Mr Mohamed El Sayed
Mr Mohamed Moustafa
Mr Sameh Ramsis
Ms Dorreiah Saied

ACADEMY OF SCIENTIFIC RESEARCH AND TECHNOLOGY

National Institute of Oceanography
and Fisheries
Qait Bey, El Anfoushi, Alexandria, Egypt
tel: (20-3) 556 5429
fax: (20-3) 550 6042
Prof. Hosny Emara
Prof. Sanaa' Hanafy
Ms Eman El-Wazan
Dr Elham Wasef
Ms Nabiha Youssef

UNESCO SECRETARIAT

Dr Hany Helal
Then: UNESCO Cairo Office
8 Abdel Rahman Fahmy St.
Garden City, Cairo 11511, Egypt
Currently: Cultural and Scientific Counsellor
Ambassade d'Égypte
56, avenue d'Iéna
75116 Paris, France
tel: (33-1) 56 89 50 31 / 53 67 88 30
fax: (33-1) 40 70 08 31
e-mail: hhelal@hotmail.com

Ms Ines El-Ibrachi
National Professional Officer
UNESCO Cairo Office
8 Abdel Rahman Fahmy St.
Garden City, Cairo 11511, Egypt
tel: (20-2) 794 3036/5599
fax: (20-2) 794 5296
e-mail: i.el-ibrachi@memo.unesco.org

Ms Dalia Khalil
UNESCO Cairo Office
8 Abdel Rahman Fahmy St.
Garden City, Cairo 11511, Egypt
tel: (20-2) 794 3036/5599
fax: (20-2) 794 5296
e-mail: dalia@mail.unesco.org.eg

Dr Douglas Nakashima (Ch, S)
Programme Specialist, SC/CSI
UNESCO
1, rue Miollis
75732 Paris Cedex 15, France
tel: (33-1) 45 68 39 93
fax: (33-1) 45 68 58 08
e-mail: d.nakashima@unesco.org

Dr Lyndel V. Prott (Ch, S)
Then: Director, International Standards Section
Cultural Heritage Division
UNESCO
1, rue Miollis
75732 Paris cedex 15, France
Currently:
Box 8049
Toowoomba Mail Centre
Toowoomba, QLD 4352, Australia
e-mail: lvprott@bigpond.com.au

Mr Adnan Shihab El-Din
Then: Director, UNESCO Cairo Office
8 Abdel Rahman Fahmy St.
Garden City, Cairo 11511, Egypt
tel: (20-2) 794 3036/5599
fax: (20-2) 794 5296

Annex 3

List of presentations in the international workshop

Session I

- Ancient Alexandria and the Mediterranean world
  Lotfy A. Yehia
- The greatest emporium in the inhabited world
  Mostafa El-Abbadi
- Alexandria's urbanization plan and eco-tourism
  Mohsen Zahran
- Coastal resources: The need for a management system
  Ibtehal Y. El-Bastawissi

Session II

- Preservation of submerged monuments and development needs
  Nicolas Grimal
- Early discoveries of submarine archaeological sites in Alexandria
  Selim Morcos
- Recuperating an Alexandrian pioneer in submarine archaeology: Kamel Abul-Saadat
  Hala Halim

Session III

- The two ports of Alexandria as shown on plans and maps from the 14th century to the time of Mohamed Ali
  Harry E. Tzalas
- Nelson Island project: Research into archaeology and geology
  Paolo Gallo
- The coastal sites of Central Lazio: A problem of preservation
  Annalisa Zarattini
- Inauguration of the Italian exhibition: 'Diving into the past, la Marmotta' case study
  Mario Mineo

Session IV

- Developing 'wise practices' in coastal management: A cross-sectoral approach
  Douglas Nakashima
- Remote-sensing applications to underwater archaeological exploration along the coast of Alexandria
  Farouk El-Baz
- Coastal processes and proposed protection work along the Alexandria coastline
  Alfy M. Fanos and Omran E. Frihy

Session V

- From Byblos to Pharos: Some archaeological considerations
  Honor Frost
- Recent excavation of submerged archaeological sites of Qait Bey region
  Jean-Yves Empereur
- Protection of the Pharos excavation in Alexandria, some preliminary results on wave agitation and sedimentological problems
  Denis Aelbrecht and Éric Peltier

Session VI

- Underwater archaeological survey of Alexandria's Eastern Harbour
  Franck Goddio
- Northern coast and submerged cities of Egypt
  Ibrahim A. Darwish and Ahmed Abdel-Fattah

Session VII

- Sub-bottom profiling of the Alexandria harbour
  Nils Tongring
- Protection of shipwrecks: the experience of the Spanish National Maritime Archaeological Museum, Cartagena
  Iván Negueruela
- Some remarks on the harbours of Sabratha, Libya – a case study
  Nicola Bonacasa

Session VIII

- National legislation and submarine archaeological sites
  Mohamed El-Gindy
- Principles for the protection of underwater cultural heritage
  Lyndel Prott
- Human impacts on Alexandria's coastal environment
  Youssef Halim and Fatma Abou Shouk

Session IX

- Variability of currents and hydrography in the coastal zone of Alexandria
  Ahmed El-Gindy
- Environmental issues associated with submarine archaeology along the Alexandria coast
  Ossama M.T. Aboul Dahab

Session X

- Preservation of wooden artefacts from underwater archaeological sites: the neolithic wooden canoe from the Bracciano Lake, Central Italy
  Maria. A. Fugazzola
- Conservation of mixed archaeological materials, Saadana Islands Shipwreck
  Emad Khalil and Howard Wellman
- Implications of climatic changes and sea-level variations on Alexandria
  Omran E. Frihy and Alfy M. Fanos

Session XI

- Data management in underwater archaeology
  Vicenzo Sommella
- Modern development and ancient maritime sites in the Tyrrhenian Sea
  Enrico Felici
- In the same boat and learning the ropes: an Alexandria/Boston comparison
  Victor T. Mastone

Annex 4

Working group composition during the international workshop

Working Group I:
Stability of the Qait Bey Citadel

V. Mastone *(Chairman)*
D. Aelbrecht
I. Darwish
A. El-Gindy
J.-Y. Empereur
A. Fanos
M. Fathy
H. Frost
Y. Halim
I. Ibrachi
S. Morcos
D. Nakashima
H. Shehata

Working Group II:
Long-term management of underwater archaeological sites

M. El-Abbadi *(Chairman)*
A. Abdel-Fattah
F. Abou Shouk
H. Awad
M. El-Gindy
E. Felici
O. Frihy
F. Goddio
H. Helal
S. Mikhail
I. Negueruela
P. Pomey
L. Prott
N. Tongring

Annex 5

List of task team members formed by the Consultative Committee for Planning and Follow-up

Name and Institution	Tasks *Collect and review information on:*
Mr Mohamed Abdel Aziz SCA, Director General, Islamic and Coptic Antiquities	The Eastern Harbour and Qait Bey Citadel, history of reconstruction and restoration works
Mr Ibrahim Darwish SCA, Director, Dept. of Underwater Archaeology (DUA)	Mapping and history of underwater archaeological sites along the coast of Alexandria
Prof. Mayssah El-Nayal Prof. of Psychology, Faculty of Arts, Alexandria University	Socio-economic aspects of the underwater museum/park project
Prof. Ahmed El-Gindy Dept. of Oceanography, Faculty of Science, Alexandria University	Hydrodynamics, waves, currents, tides and winds
Prof. Omran Frihy Institute of Coastal Research	Coastal dynamics and geomorphology
Prof. Mahmoud Khamis El-Sayed Dept. of Oceanography, Faculty of Science, Alexandria University	Geological aspects, sediment, transport, bottom topography
Prof. Mourad Bacily National Institute of Oceanography and Fisheries	Seismic and geophysical processes
Dr Nariman Mostafa Soheil Alexandria Waste-Water Treatment Plants	The sewage system in Alexandria
Prof. Mohamed Dorgham Dept. of Oceanography, Faculty of Science, Alexandria University	Primary productivity and rate of fouling of submerged surfaces
Ms Fatma Abou Shouk Alexandria Governorate, Dept. of Environment	Urban Plans for Alexandria and the environmental status of archaeological sites
Prof. Hassan E. Awad Dept of Oceanography, Faculty of Science, Alexandria University	Water quality and pollution control

Annex 6

SUMMARY OF PRESENTATIONS

Workshop on the Status of the Pilot Project for Sustainable Development of Submarine Archaeological Sites at the Qait Bey Citadel and the Eastern Harbour 20–21 November, 1999

1. *Qait Bey Citadel*

M. ABDEL AZIZ

The history of the Citadel's restoration was reviewed. The current needs to secure the rock on which it stands, and to restore the Citadel aesthetically, were highlighted (Abdel Aziz, undated, unpublished).

2. *Underwater archaeology in Alexandria*

I. DARWISH

Gaston Jondet, a pioneer of underwater archaeology, discovered the breakwaters of a pre-Alexandrian harbour to the north and west of the Ras el Tin promontory. The Centre d'Études Alexandrines, in co-operation with the Department of Underwater Archaeology of the Supreme Council of Antiquities, rediscovered the submarine site to the east of Qait Bey and carried out a detailed survey. More than 3,000 artefacts were located, including sphinxes, columns, obelisks and granite blocks of more than 70 tons. The Institut Européen d'Archéologie Sous-marine, in co-operation with the Department of Underwater Antiquities, established an accurate map of the submerged royal buildings and royal harbours in the Eastern Harbour and recorded more than a thousand artefacts on the harbour bed (Darwish, 1998a, 1998b, and Darwish *et al*, 1999, unpublished reports).

3. *Socio-economic aspects of the underwater museum project*

M. EL-NAYAL

A study funded by the UNESCO Cairo Office (El-Nayal, 1999, unpublished) was based on the responses of 170 people from the Qait Bey area: 103 fishermen, 60 workers and 7 small-scale business owners. The respondents came from a wide range of educational levels, from illiterate to university-educated individuals, although the average educational level was very low since most of the fishermen were illiterate.

There are about 500 fishing boats in operation everyday in the Qait Bey area. Generally, the fishermen are very dependent on the weather. They cannot fish from January to June because of rough seas. Since fishing is banned during the breeding season in July and August, the fishing season is only four months long, from September to December. There is no alternative work for the fishermen during the off-season. So the fishermen's income is low and they are often in debt.

The development of an underwater museum in the Qait Bey area will have some positive impacts on the economy by creating new jobs in tourism and other related activities: underwater tours, handicraft industries, hotels and restaurants. On the other hand, the project will also have some negative impacts, for example the disappearance of some traditional economic activities and cultural changes due to the influence of tourism.

A programme for the social improvement of the local population, especially the fishermen, was recommended, and would include:

- education, including training in modern fishing methods, introducing the principles of modern economy, establishing a special school for young fishermen;
- encouraging and assisting the fishermen to form co-operatives which would facilitate the purchase of fishing equipment and access to financial credit;

- paying particular attention to the social welfare of the fishermen and their families.

4. *Meteorological and hydrodynamic processes*
A. EL-GINDY

The widely dispersed data in the literature on the oceanographic forces that affect the Alexandrian coastal zone have been collected, and provide a general picture of seasonal and inter-annual variability. There is a lack of wave data. Regular, long-term data on waves, currents and sea-level within and outside the Eastern Harbour are needed. Ocean current, wave refraction and forecasting models should be applied as necessary tools for the environmental impact assessment of any proposed coastal work on the site.

5. *Seismic and geophysical processes*
M. BACILY

Major seismic and tectonic features related to earth movements in the eastern Mediterranean were discussed. Historical earthquake records from 320 AD to 1900 AD were reviewed, followed by instrumentally recorded earthquakes from 1900 to 1998. The statistical treatment of the frequency and magnitude of the earthquakes leads to the conclusion that, within a radius of 200 km of the site, the largest expected earthquakes should have a magnitude of 6.3 to 6.7 and a recurrence of eight times in 900 years. The need for a comprehensive geophysical study of the site was underlined, including scanning of the sub-bottom, study of the bedrock setting of the Citadel, and seepage and its effects on the subsurface.

6. *Coastal dynamics and geomorphology*
O. FRIHY

Comparison between bathymetric surveys, carried out at an interval of about 50 years, reveals strong erosion along the main axis of the Eastern Harbour at an average rate of 13 cm per year and deposition at an average rate of 5 cm per year. The difference between the rates indicates that much of the eroded material escapes the harbour to settle in the vicinity of the Pharos site.

7. *Geological aspects, sediment transport and bottom topography*
M. EL-SAYED

Studies of the sediment in the Eastern Harbour shows a high copper and zinc content near the shipyard and an accumulation of organic matter downstream from the waste-water outfalls. The Aswan High Dam and the extraction of water inland diminish the sediment load that arrives in the Nile Delta. This has led to loss of land in the Delta and relative sea-level rise. This will be exacerbated by the impact of global climate change (El-Sayed, 1999, unpublished).

8. *Primary productivity and the rate of fouling of submerged artefacts*
M. DORGHAM

An abundance of biogenic material in and around the Eastern Harbour enhances two biological processes of concern to a marine park. It stimulates plankton productivity, thus reducing water transparency, and accelerates the rate of fouling growth on all submerged structures and artefacts. Literature published in the last four decades relative to these two processes in the Eastern Harbour has been collated. Information about the Pharos site remains very scant.

9. *Water quality and pollution control in the Eastern Harbour*
H. AWAD

Numerous pollution and water quality surveys have been conducted in the Eastern Harbour. Physical-chemical indices point to a slight but unmistakable improvement in the last five years. Further improvement is expected after the year 2003 with the closure of all on-site waste-water outfalls. It will then be possible to consider a development programme for tourism. However, a fully-fledged programme for an underwater museum will have to wait until the year 2010, by

which time all Alexandria's waste-water should be treated. A major concern will remain: the rates of re-mobilization of contaminants from the sediments (Awad, 1999, unpublished).

10. Alexandria's sewage system

N. SOHEIL

The current treatment and disposal systems for waste-water and their impact on the marine environment were discussed. Planned developments will take place in two phases. The first phase will be completed in 2003 and will consist of re-routing the Qait Bey discharge and upgrading the capacity of the two treatment plants, east and west. The second phase should be completed by 2010. There are two alternatives: secondary treatment with disposal in Lake Mariout and secondary treatment with lake-bypass. Although the environment around the sites of concern will undoubtedly be improved with the completion of phase one, the eastward current, originating in El Mex Bay, may still affect the archaeological sites but to a lesser degree.

Annex 7

Greco-Egyptian underwater archaeological survey near Alexandria

by Harry E. Tzalas

Carried out during 1998–2000 by the Hellenic Institute for the Preservation of Nautical Tradition and the Hellenic Institute for Ancient and Mediaeval Alexandrian Studies (A preliminary report)

Introduction

As President of the Hellenic Institute for the Preservation of Nautical Tradition, I was invited to participate at SARCOM '97 and present a paper on 'The Two Ports of Alexandria' (Tzalas, 2000). During the course of the conference, I had the opportunity to experience first hand the progress made in the underwater archaeological work that had been carried out in Alexandria by the Centre d'Etudes Alexandrines, under the direction of Prof. Jean-Yves Empereur, as well as of other foreign missions. Contacts with the Egyptian archaeological authorities resulted in the Institute being officially invited to apply for a license to undertake an underwater survey in the coastal area of Alexandria.

After much thought and careful planning, it was deemed necessary to form a Greek Institute for the research and study of the history and the topography of ancient and mediaeval Alexandria. Jointly with the Hellenic Institute for the Preservation of Nautical Tradition (already experienced in underwater archaeology), we submitted an application to the Supreme Council of Antiquities of Egypt requesting a license to survey the underwater zone that extends from ancient Cape Lochias (El-Silsilah) to the promontory of Montazah (possible site of the ancient Small Taposiris). The license was granted and the work began in May 1998 as a co-operative venture of the Greek mission and the Department of Underwater Antiquities of Egypt. Six further campaigns followed in June 1998, October 1999, May 2000, November 2000, May–June 2001 and November 2001.

Each campaign lasted four weeks; a total of 15 to 20 scientist-divers (archaeologists, historians, architects, marine geologists, topographers, photographers) took part in the work, under the direction of Harry E. Tzalas, an historian, and Ibrahim Darwish. Leading members were George Koutsouflakis, archaeologist-diver, Phaedon Andonopoulos, chief-diver, and George Nomikos, diver responsible for the local organization.

The Laboratory of Marine Geology and Physical Oceanography, Department of Geology of the University of Patras, collaborated with our mission. Under the direction of Prof. George Ferentinos and Prof. George Papatheodorou, marine geophysical surveys for the detection of ancient wrecks and man-made structures were produced using a side-scan sonar and a subbottom profiler, which were of great assistance. The team also included the following marine geologists: Maria Geraga, Athina Chalari, Dimitris Christodoulou and Aristofanis Stefatos.

The area of the survey and its historical context

The area allocated to the Greek mission extends along the shore of Ramleh from the eastern boundary of the Eastern Port of Alexandria, known in antiquity as Μέγας Λιμίν and *Magnus Portus*, to the Peninsula of Montazah. The Greeks called this area Η προς Ελευσίνι Θάλασσα[1], the Romans *Mare Eleusinium*. Eleusis was later renamed Juliopolis and Nicopolis. Since knowl-

[1]Αθήναιος Δειπνοσοφισταί, XII, 576f (Teubner).

edge of the topography of ancient Alexandria is imperfect and extremely confused, we can only assume that the Ptolemaic and Roman walls followed the littoral east of Cape Lochias perhaps to the extent of the present suburb of Ibrahimieh (El Falaki, 1872; Botti, 1898; Jondet, 1921). We know, however, that beyond the walls there were coastal suburbs with a diversity of constructions and activities. The remains of numerous burial grounds, military installations, villas and residences, shrines and small monuments of various periods, including the Tomb of Stratonice and the *Martyrium* of Saint Mark, were visible before the urban expansion that has obliterated most of the ancient ruins (Bartocci, 1995). A number of activities that would not be permitted within the city walls, because they were viewed as detrimental to the environment, were established *extra muros*. So it is to be expected that such a large city as Alexandria – which at the end of the Roman period may have counted nearly a million souls – had, on the shores outside its boundaries, various stone quarries, tanneries, mummification workshops, dying basins, salt works, as well as fish-salting and -drying industries.

One of the aims of the survey programme was to trace the ancient and possibly mediaeval shorelines and discover the faint remains of these activities, which due to the rise of the sea and the subsidence of the land are now partially or totally submerged, while in deeper water we expect to discover remains of maritime activities. The ports of Alexandria experienced uninterrupted use for over 2,300 years. Most of the maritime trade was with the East, so it is logical to assume that the sea area just outside the entrance to the harbours holds remains of shipwrecks, scattered cargoes and ship equipment lost over the centuries.

The two first dive surveys focused on locating sites where ancient remains of structures or ancient artefacts could be found. During the 3th and the 4th campaigns, we solicited the co-operation of the Department of Marine Geology of Patras University. Their side scan sonar revealed suspected targets in the deep that may indicate the presence of shipwrecks, man-made structures and artefacts.

The archaeological finds

The zone of our survey extends 14 km along the Alexandrian coastline and covers an approximate area of 44 km². We started by spot dive surveys of the zone extending from Cape Lochias to Stanley Bay. There was also a superficial survey of the area off the suburb of Sidi Bishr near the remains of a deep ventilation shaft, probably part of an early burial complex, today submerged and called by local tradition 'the devil's well' (Bir Maasoud). A complete survey of the same areas by side scan sonar followed, in order to understand its geomorphology.

With the experience gained during our campaigns, we now have a better understanding of the area and can concentrate our efforts on five sites that have revealed submerged antiquities (Figure 14).

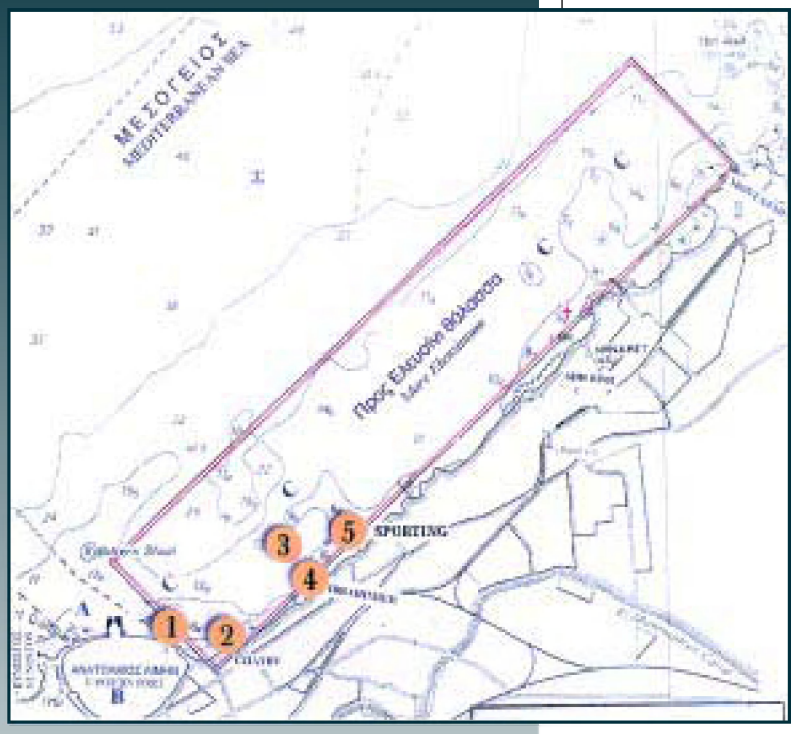
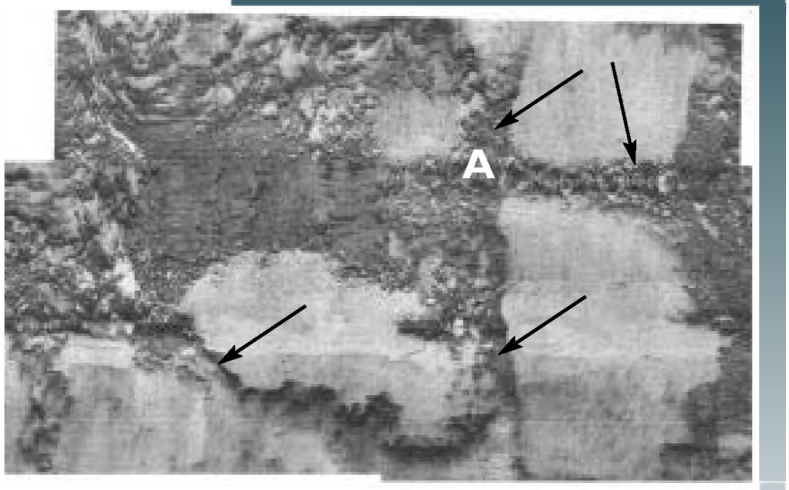


Figure 14. Plan of the zone allocated to the Greco-Egyptian underwater archaeological survey, showing the 5 sites of interest.

Site 1 at Chatby

This site is adjacent to the submerged eastern contour of the Royal Quarters, which were partly located on the Cape having at its tip the temple of Isis Lochias. Man-made targets were detected by the side-scan sonar survey. Some deep-water targets can be interpreted as shipwrecks (we must assess whether those are ancient or modern wrecks); others may indicate man-made structures (Figure 15). Our 5th campaign was most rewarding. The calmness of the sea during most of November 2000 meant that our divers were able to work very near the tip of the Cape. At a depth of circa 7 m, several architectural elements, most made of red granite, were located scattered on the sea floor. More important because of their size are three very large pieces. A complete pedestal weighing over 12 tons, part of the framing of a gigantic door preserved up to a length of 3,60 m, weighing some 10 tons and a complete architectural element that was part of a pylon of 2,60 m height, weighing some 4 tons. The pylon piece is of particular interest because it is known that such monumental entrances were placed in Ptolemaic times in front of temples imitating the pharaonic style; and this piece was found in the immediate vicinity where it is known that the Temple of Isis Lochias stood.[2]

Figure 15.
Side scan sonar mosaic showing elongated features which may represent man-made structures. Two of these features cross at point A. (Vectors indicate the elongated features.)
Source: G. Papatheodorou



Site 2 at Chatby

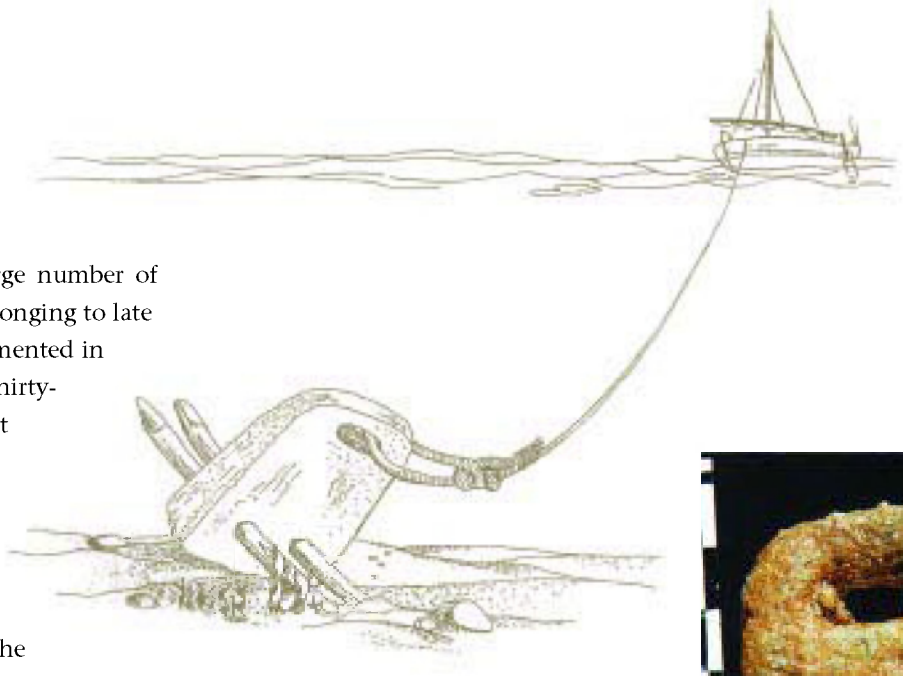
This is a coastal area extending immediately southwards of site 1. Aerial photography has clearly shown man-made structures in the shallows near the beach. In the immediate northern vicinity of these structures, in deeper waters, the side-scan sonar has detected a number of abnormalities on the seabed showing elongated contours running parallel to the cape. There is also a line of structures parallel to the coast. The depth varies from 1 to 5 metres.

A preliminary excavation was carried out near the Chatby Casino in November 2000 and another in May–June 2001. The reason for this survey was to investigate if, as it is believed, the Casino stands on the ruins of the *Martyrium* of St Mark, a revered monument of the 4th century AD. Two trenches were opened under the stilts of the Casino in 2000 and, at a depth of 1.5 to 2 m, a large number of pottery shards as well as small pieces of broken marble, granite and other man-worked stones were found. All can be dated from the end of the 4th to the 6th century AD. Two more trenches were opened in May–June 2001, 40 m west of the Casino, with negative results. In both cases, the infiltration of seawater makes any digging impossible under a depth of 2 m, so we will have to revisit this site with proper excavating devices.

Site 3 at Ibrahimieh

This is a reef surrounded by sand at a distance of 560 m from the shore. A very important concentration of small stone anchors and stone weights, the largest and densest known in the Mediterranean, was discovered there. Of the 55 stone anchors and weights found, thirty have been lifted and delivered for conservation to the Kom El-

[2] These architectural finds are in the vicinity of other granite blocks and sculpted elements found in 1962 by the late Kamel Abul-Saadat. They include a mutilated anthropomorphous granite sarcophagus lid, now in the garden of the Maritime Museum at Stanley. Most of the objects noted on Abul-Saadat's map, except for those raised, have probably been covered by the eastern extension of the El-Silsilah Promontory and the protective concrete blocks placed as buttresses to the action of the sea in the 1970s (Morcos, 2000, pp. 42–43 and plate 4).



Dekkah Laboratory. A large number of pottery shards, mostly belonging to late Roman amphorae, are cemented in the cavities of the rocks. Thirty-four shards of different types of amphorae were lifted and delivered for conservation to the same laboratory.

We believe that the stone anchors – all of the 'three-hole-composite' type – as well as the stone weights belonged to small fishing vessels, and were lost when they became entangled in the rough seabed (Figure 16). Thin sections of a stone anchor were made and a sample of stone from the Ibrahimieh quarry were analysed at the Department of Geology of the University of Patras. They were found to be similar to oolitic limestone taken from the same quarry. The same analysis will be carried out on all stone anchors and weights. We can already say that at least one of the anchors was of local provenance, which may indicate that the ship that lost it was local.

The most important find on this site came at the very end of our dives when the lead elements of a very large composite anchor were found and raised. There is a lead stock of 2 m length weighing over 250 kg and a heavy lead assemblage collar to secure the two arms to the wooden stock. The wood has been lost over the centuries of immersion in the sea, but we calculate that when the anchor was complete, its height must have been over 3 m and its weight around 600 kg. This is one of the largest anchors of this type ever found in the Mediterranean Sea, and it may be dated as between the 1st century BC and the 1st century AD.

After conservation, all the material will be drawn and studied, and the results published.

Site 4 at Ibrahimieh

In the shallows neighbouring the Corniche, we found the remains of an unusually large stone quarry, extending along the coast for some 300 m and northwards into the sea for circa 70 m. The depths vary from 0,25 to 5 m. An artificially cut channel runs through the quarry and was probably used for removing stone blocks on rafts. The void resulting from quarrying has formed basins of various sizes and depths. These basins may have had a secondary use as tanneries and/or dying tanks. A number of cist burial sites coexist with the quarry and also some coastal constructions that are partly submerged and need further study to be understood. The whole of this site is being carefully surveyed and a topographic plan is being drawn. Sand has amassed in the basins and will have to be removed by hydro-lift to ascertain the depth of the carvings and eventually trace ancient remains that may hold valuable information for understanding the use of this site after its quarrying activities were abandoned.

On the beach between the quarry and the wall of the Corniche, superficial removal of sand has exposed an enormous quantity of large and small stones. Some of these limestone blocks are similar to the ones found in the sea and are the remains of the final quarrying activities before the quarry was abandoned. However, pieces of granite, basalt, marble and some limestone constitute the remains of architectural elements. At this early stage of study, it is premature to say which are ancient or mediaeval and which are modern. We believe that a number of years will be needed before a definitive publication on this site is possible.

Figure 16.
Stone anchor found on site 3 at Ibrahimieh.
Photo: Hellenic Institute for Ancient and Mediaeval Alexandrian Studies

Above:
Artist's impression of the use of this stone anchor.
Drawing by: Y. Pantzopulos
Study by: H. Tzalas

Site 5 at Sporting

This site was discovered during our last survey and was noted when taking aerial photographs of the coastal area of Sporting. A large zone in the shallows is covered with the foundations and remains of a complex of man-made structures. The main building, of which the foundations can be seen deeply cut into the levelled rock, is square shaped and divided longitudinally into three parts. The total dimensions are approximately 57 by 18 m.

The direction is approximately east to west. There is an adjacent structure to the west that is a nearly circular elliptical shape with a diameter of circa 50 m. All structures preserve the deep cuttings in the rock as well as scanty remains of masonry. There are also some broken drums of columns and capitals. The area between the rectangular building and today's shore is covered with deep carvings, which are the result of stone quarrying activities that probably preceded the large constructions and may have been part of the levelling of the site. Preliminary drawings were made of the submerged structures, but it will take a lot more time to completely study, draw and understand the nature of these very extended and important ancient remains. No dating can be advanced at this stage.

Recent finds and observations

During our 6th campaign of May–June 2001, besides excavating Site 2 at Chatby, we continued our survey of Site 1 at Chatby, and eight more architectural granite elements weighing circa. 1,000–3,000 kg were found. More stone anchors were detected and raised from Site 3 at Ibrahimieh while the stone quarry (Site 4 at Ibrahimieh) was extensively aerial-photographed and drawn. From Site 5 at Sporting, we raised two small stone capitals which were found in some unidentified submerged structures. We expect that, after conservation, these capitals will help in dating the submerged complex. Our 7th campaign followed in November 2001.

Concerning the ongoing project of widening the Cornish, there is no doubt that this has destroyed and/or covered ancient remains. At Chatby in particular (although the Casino will not be removed), irrevocable damage will affect the ancient coastline and the existing ancient remains. The submerged quarry at Ibrahimieh is, at this moment, being affected by the widening of the coastal road, and all ancient remains will probably be irrevocably destroyed. We were however pleasantly surprised to note that the work did not affect Site 5 at Sporting.

The site environment and local dynamics

It is known that, since the melting of the glaciers some 10,000 years BP, the sea-level of the Mediterranean has been raising steadily by an average of 1 m for every thousand years. Of course there cannot be a uniform pattern because other natural phenomena (such as tectonics, sliding of the continental sea shelf, subsidence of land due to the weight of sedimentary formations) can drastically modify the pattern. The shores of Alexandria, as well as those of the Nile Delta, are the result of sedimentary deposition and, although we know that the ancient littoral is submerged, there is no uniformity and no continuity in its submergence. Underwater surveys carried out recently in Alexandria by French missions at the Pharos site, as well as in the Eastern Port, indicate that the subsidence of the land could reach 5 m in certain areas. It will be the task of geologists, specialized in the study of the rise of the Mediterranean and the subsidence of the Alexandrian shores, to study the morphology of the submerged ancient coast.

The mission also focused attention on understanding the local environment and the dynamics that influence the various points of interest. The Alexandria coast is exposed to weather from all directions – with the exception of southerly winds. The combination of wind exposure and the influence of the open waters of the Mediterranean, which impact directly on the coast, are therefore primary factors in the understanding of any site of interest. Depending on the depth of individual locations, the marine environment can affect the topography and distribution of material on the seabed. This is more pronounced

on the immediate coastal zone where wave action and erosion have serious impacts. There are numerous examples, but suffice it to say that the stone anchors located on the Ibrahimieh reef, according to the map produced by the dive team during the previous campaign, could not be found later on, as they had been removed by the action of swells and currents. The artificial rock cuttings at the Ibrahimieh quarry represent another indicator of the local marine dynamics which affect not only this location but any other unprotected coastal site along the Alexandria littoral. The rock cuttings were covered and uncovered several times by sand. With regard to the deeper rock cuttings lying approximately 40 to 50 m from the shore, the depth when checked two years ago was 2 m, but the depth of the same cuttings is now only one metre.

The marine dynamics of the area may, however, also be assessed from the side-scan surveys carried out by the marine geologist who re-scanned several targets of possible shipwrecks. Because in some areas the marine dynamics had shifted large quantities of sand and material, some points where covered and invisible to the re-scanning, while at the same time new materials were exposed in other areas.

In conclusion, it is evident that the marine dynamics both along and off the coast of Alexandria affect the individual sites and the distribution of material found on them. The large swells, experienced in the area and noticeable to divers at depths of as much as 12 m, are primary factors in the redistribution of material on the sea bed. Similarly the effects of longshore drift and erosion play an important role in the visible topographic features and the overall nature of the sites.

Taking into consideration the extent of the area of our survey, as well as the difficulties encountered by the divers because of its exposure to strong winds, we believe that at least 15 years of assiduous work will be needed in order to complete the general survey of the entire area. Depending on the finds that may come to light, lengthier periods may be justifiable to individually excavate sites of interest and proceed with the publication of scientific results.

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