THE CYPRUS ANCIENT SHORELINE PROJECT REPORT – 2014

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WITH A REPORT ON UNDERWATER SURVEY BY CARRIE FULTON (CORNELL UNIVERSITY AND ANDREW VIDUKA (FLINDERS UNIVERSITY)

THE HONOR FROST FOUNDATION

2016

Contents

SUMMARY

Since the earliest systematic archaeological exploration of the south-central of Cyprus by the Vasilikos Valley Project (VVP - Todd 2004; 2013), as well as the Maroni Valley Archaeological Survey Project (MVASP – Manning and Conwell 1992), archaeologists have identified a number of coastal sites via material remains that were exposed on the coastal scarp. Two of those sites, the Roman Zygi-*Petrini* (Manning *et al.*2000) and the Late Bronze Age (LBA) Maroni-*Tsaroukkas* (Manning *et al.* 1994b) have since been excavated. A number of other sites, however, including the LBA Tochni-*Lakkia* (Andreou and Sewell 2015), and the Roman and Byzantine Maroni-*Yialos* and Maroni-*Vrysoudhia*, have been investigated only through the exposed stratigraphy of the actively eroding coastal scarp (Manning *et al.* 1994a: 367; 2002: 78). Due to the limited information one obtains by the nature of this exploration, as well as the lack of knowledge regarding the extent of the archaeological sites, researchers have been reluctant to incorporate them in the studies of settlement patterns of their respective periods. As a result, a significant amount of archaeological material and the important information it holds for the maritime history of the south-central coast of Cyprus is both actively deteriorating due to erosion and, at the same time, not contextualised comprehensively in the relevant scholarship.

In 2011 archaeologists started investigating the eroding archaeological sites from the south-central coast of the island more systematically through biannual visits. During these visits, they have attempted to rescue as much information as possible with the use of photography and drawing of the scarp, archaeological survey of coastal fields, laser scanning of selected sections, as well as underwater survey (Sewell 2013; Andreou and Sewell 2015). Observations during the study of these sites between 2011 and 2014 made obvious that erosion is a major issue for the archaeological remains of the south-central coast of Cyprus. At the same time, it became clear that economic crisis has placed significant stress on the preservation and protection of antiquities (Andreou 2014). Given these conditions, a sustainable way to record archaeological remains and preserve their information for future generations requires a study of diachronic coastal alterations, and an examination of all factors that influence the preservation of coastal cultural heritage. This concern formed the basis of a research proposal submitted to the **Honor Frost Foundation (HFF)** in 2013**.**

The present report synthesises the bibliographic and field investigation conducted by the **Cyprus Ancient Shoreline Project (CASP)** under the auspices of the HFF. This report provides the first comprehensive documentation of the eroding archaeological sites of the south-central coast of Cyprus (from the Vasilikos River at the West to the Pentaschoinos River at the East). Furthermore, it explores the geographic and economic importance of this coast via historical cartography. In addition, it quantifies the diachronic loss of land through the comparison of georeferenced aerial photographs, examines the local drivers of coastal erosion, assesses the gravity of the threat that erosion poses on the maritime heritage of Cyprus and, finally, proposes mitigation measures.

PREFACE AND ACKNOWLEDGEMENTS

Our research was possible with the generous help of many people and organisations. We are very grateful for the support of the Honor Frost Foundation, which funded this project. Throughout the years, the HFF has been instrumental in the advancement and research of the maritime archaeology of Cyprus. Moreover, it has provided invaluable help to Cypriot students, who got the opportunity to actively engage with, foster and promote the maritime heritage of the island.

Our work was carried out initially in conjunction with Prof. S. Manning of Cornell University and members of the *Kalavasos and Maroni Built Environments Project* (KAMBE): K. Fisher (University of British Columbia), K. Kearns, J. Leon, P. Gerard-Little and T. Urban to which we are thankful. The underwater component of our research was undertaken by D. Sewell, A. Viduka, C. Fulton, E. Karyda and M. Michael.

We would like to thank the Cyprus Department of Geological Surveys, especially Z. Zomeni who provided a series of geo-referenced maps and satellite images of the area under investigation. Aerial photographs, digitised maps and geo-referenced data were also provided by the Cyprus Department of Lands and Surveys. X. Loizides of Isotech Ltd Environmental Research and Consultancy, who is also the coordinator of AKTI Project and Research Centre provided scientific reports and information regarding coastal erosion.

Our work was undertaken with the permission and continuous support of the Department of Antiquities of Cyprus. We are very thankful to the acting directors of the Department D. Pilidou and M. Solomidou-Ieronymidou, as well as the staff of the Larnaca Museum, the help of which facilitated our work. Finally, we would like to thank S. Manning, A. South, I. Todd, S. Demesticha, B. Knapp, G. Cadogan, E. Peltenburg, M. Iacovou and A. Georgiou for their useful comments, input and assistance.

CASP - From left to right: D. Sewell, L. McLean, G.M. Andreou, S. Pak, C. Fulton, J. Leon, S. Manning, K. Kearns, K. Fisher, T. Urban, A. Viduka.

LIST OF ABBREVIATIONS AND ACRONYMS

AAAG	*Annual Association of American Geographers*
AJA	*American Journal of Archaeology*
BAR	*British Archaeological Reports*
BASOR	*Bulletin of the American Schools of Oriental Research*
BEMRS	*British East Mediterranean Relay Station*
BOCCF	*Bank of Cyprus Cultural Foundation*
CAARI	*Cyprus American Archaeological Research Institute*
CASP	*Cyprus Ancient Shoreline Project*
cm	*centimetre(s)*
DLS	*Department of Lands and Surveys, Republic of Cyprus*
ha	*hectare(s)*
HFF	*Honor Frost Foundation*
ICCROM	*International Centre for the Study of the Preservation and Restoration of Cultural Property*
ICOMOS	*International Council on Monuments and Sites*
IJNA	*International Journal of Nautical Archaeology*
JCoastConservat	*Journal of Coastal Conservation*
JFA	*Journal of Field Archaeology*
KAMBE	*Kalavasos and Maroni Built Environment Project*
km	*kilometre(s)*
LBA	*Late Bronze Age*
m	*metre(s)*
MEDSPA	*Action (EEC) by the Community for the protection of the environment in the Mediterranean region*
MVASP	*Maroni Valley Archaeological Survey Project*
NGO	*Non-governmental organisation*
OpAth	*Opuscula Atheniensia*
RCHAMS	*Royal Commission in Historic and Ancient Monuments of Scotland*
RDAC	*Report of the Department of Antiquities Cyprus*
SIMA	*Studies in Mediterranean Archaeology*
TL	*Tochni-Lakkia*
UNESCO	*United Nations Educational, Scientific and Cultural Organisation*
UNIDROIT	*International Institute for the Unification of Private Law*
VVP	*Vasilikos Valley Project*

LIST OF FIGURES

UP TO DATE SUMMARY CHRONOLOGY OF PREHISTORIC CYPRUS

Archaeological Period	*Start after or by Cal BC*	*End before or by Cal BC*
Late Epipalaeolithic (Akrotiri)	11000	(9100-) 9000
Cypro-PPNA	(9000-) 8900	8600 (-8500)
Early Aceramic Neolithic	(8500-) 8400	(6900-) 6800
Late Aceramic Neolithic	6800	5200 (-5000?)
Ceramic Neolithic	(?5000-) 4600	4100/4000
Early Chalcolithic	4000/3900	3600/3400
Middle Chalcolithic	3600/3400	2700
Late Chalcolithic	2700/2600	2500/2400
Prehistoric Bronze Age (Philia-MCII)	2400	1690/1650
Protohistoric Bronze Age	1680/1650	1100/1050
Middle Cypriot III	1750 (1700)	1680/1650
Late Cypriot I (A-B)	1680/1650	≈145 (no 14C)
Late Cypriot IIC	1340/1325	1200

(Manning 2013)

SECTION 1 – INTRODUCTION

The island of Cyprus has a rich archaeological record, which is central to our understanding of the ancient Mediterranean world. The archaeologists who investigate the island have followed concurrent theoretical and methodological trends and have produced an astonishing amount of information through survey, excavation and material studies. As such, the extensive amount of material and corpus of publications renders Cyprus a significant source of information for regional studies, especially those focusing on the trade and economy of the Eastern Mediterranean.

In this report, the majority of material remains and the most extensively studied archaeological sites date to the LBA, which is a period of unparalleled networking and mobility. At the same time, the LBA connections are one of the most widely researched topics in the archaeology of the Eastern Mediterranean (e.g. Sherratt and Sherratt 1991; Cline 1994; Feldman 2006; Sauvage 2012). Researchers agree that, during that time, Cyprus was incorporated into the international trade and played a key role mainly through its rich copper resources (see summary in Knapp 2013: 348-349). In this report, however, we also investigate the role of seaborne trade in the economy of Cyprus from a more diachronic perspective. This perspective benefits from the extensive material that archaeological surveys have collected throughout the years. With this diachronic and regionally-based direction, the area of our investigation is the south-central coast of Cyprus, particularly the Vasilikos, Maroni and Pentashcoinos river valleys (*fig.1.1*). The first two valleys have been surveyed by the VVP (Todd 2004; 2013), and the MVASP (Manning and Conwell 1992). The Pentaschoinos valley has been investigated only through our coastal survey.

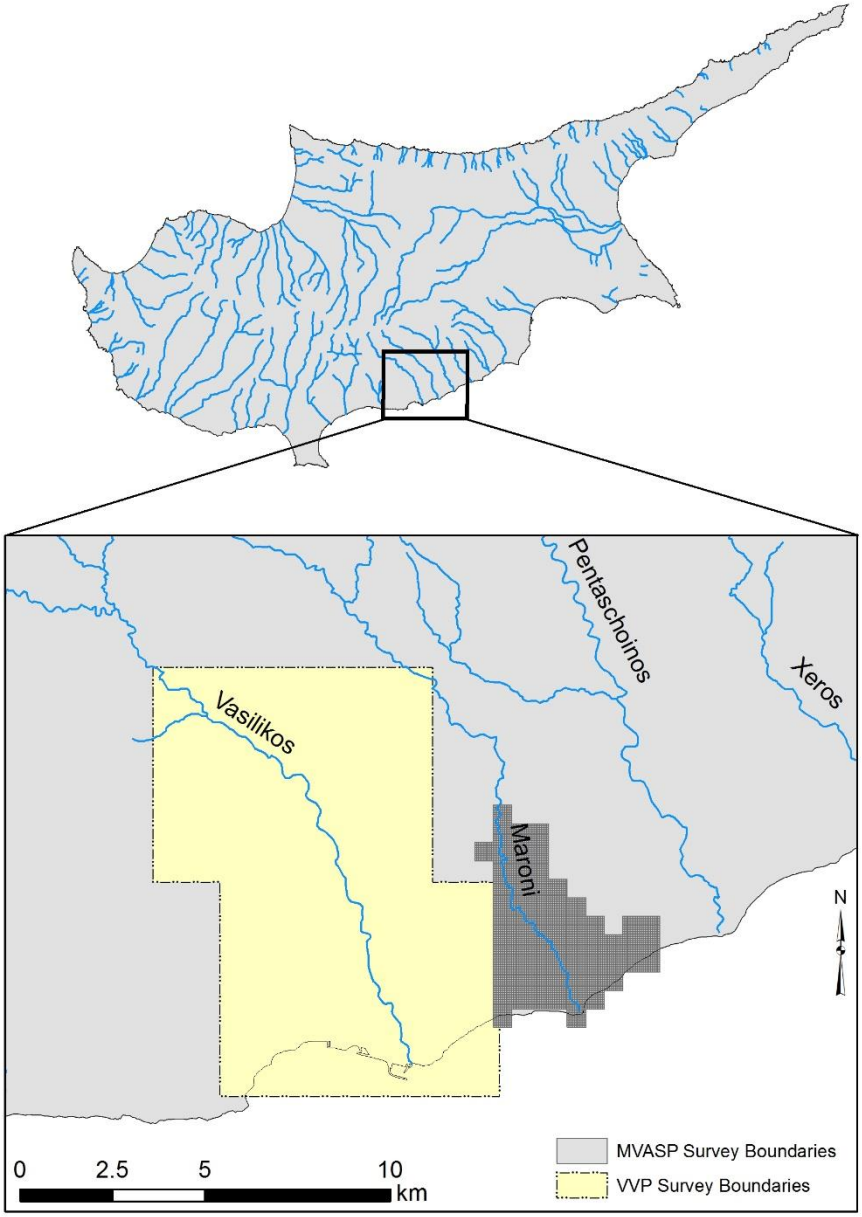

Fig.1.1 The Cyprus Ancient Shorelines Project area of study showing also the VVP and MVASP coverage areas (ArcGIS 10.3 – G.M. Andreou).

1.1 History of Research

Eroding coastal archaeological sites in Cyprus have been documented since Catling's (1962) archaeological survey of the island. They have, however, received limited attention, up until the early 1990s when MVASP recorded sites along the coast of Maroni and Zygi. Among these sites, an important production locus for amphorae at Zygi-*Petrini* (Manning *et al.* 2000), as well as eroding features from the LBA Maroni-*Tsaroukkas* were studied more closely (Manning *et al.* 1994b). In the Vasilikos Valley, among the large number of sites recorded by

the VVP between the mid-1970s and early 1980s, the coastal Tochni-*Lakkia*, or site 98, was described as an Iron Age settlement with few, but noticeable, diagnostic LBA specimens (Todd 2004: 133-134). The low material representation of the LBA at the time was insufficient to suggest a coastal site, port or anchorage in this locality during that period.

In the following years, J.R. Leonard (2005) undertook a coastal survey and documented eroding sites, as well as coastal sites not subjected to severe erosion. Although he focused on Roman coastal sites, he also incorporated information regarding pre-Roman sites, especially those located between Cape Kiti and the Vasilikos River. Leonard mentioned a probable embayment West of Dhekelia, which could have served as a location for an anchorage for the nearby LBA Pyla-Kokkinokremmos. He also discussed the probability that Cape Kiti provided a shelter for ships as early as the LBA. He additionally pinpointed Maroni-*Vrysoudhia*, Maroni-*Tsaroukkas* and Tochni-*Lakkia*, and the Roman port of Alaminos-*Latourou Chiftlik*, which he described as an "erosional scarp of 1-2m height". Finally, he stressed that the mouths of Pentaschoinos, Ayios Minas (Maroni) and the area surrounding Cape Dolos (Governor's beach) are archaeologically promising and should be considered in future underwater surveys (*fig.1.2*).

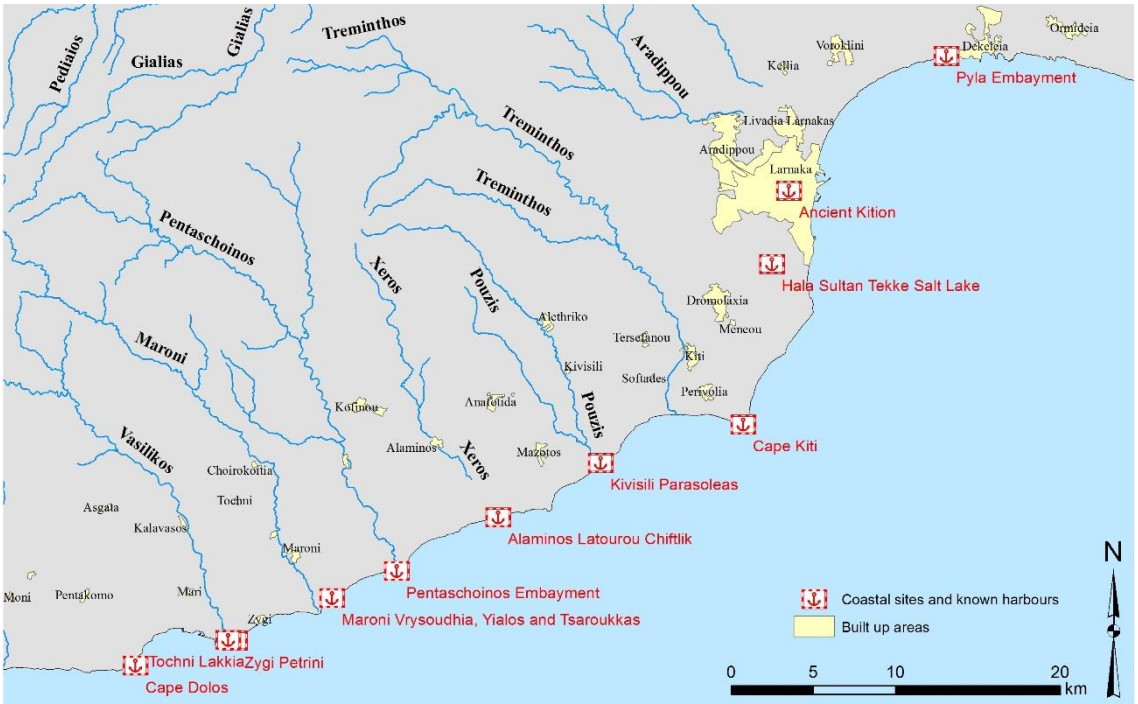

Fig.1.2 Known and possible coastal sites and harbours in the area under investigation (ArcMap 10.3 – G.M. Andreou).

Finally, Leonard mentioned a LBA site at Kivisili-*Parasoleas* on the mouth of Pouzis River, where, according to report, a LBA tomb was eroding into the sea. *In situ* visit by G. Andreou in 2014 photo-documented only eroding walls (*figs. 1.3-1.4*). No LBA pottery was identified among the exposed potsherds visible in the section and no chamber was visible at that time.

Figs.1.3-1.4 Wall and eroding features from Kivisili-Parasoleas (G.M. Andreou - March 2014).

Although general knowledge of eroding sites existed in scholarship, especially during the 1990s, it is during the past five years that the problem of coastal erosion in the archaeology of Cyprus is being discussed systematically, via the work of D. Sewell and G. Andreou at Tochni-*Lakkia*. At the moment, *Tochni-Lakkia* is the most extensive and the most severely eroding coastal site of the island (figs.1.5-1.6) (Andreou and Sewell 2015). At the same time, it is one of the most intensively explored eroding sites, as it has formed the case-study for a series of methodologies of recording that includes photography, archaeological drawing, archaeological and topographical survey, photogrammetry, as well as laser scanning (Andreou et al. 2017).

Fig. 1.5 Exposed section at Tochni Lakkia showing walls and rubble (D. Sewell – June 2011).

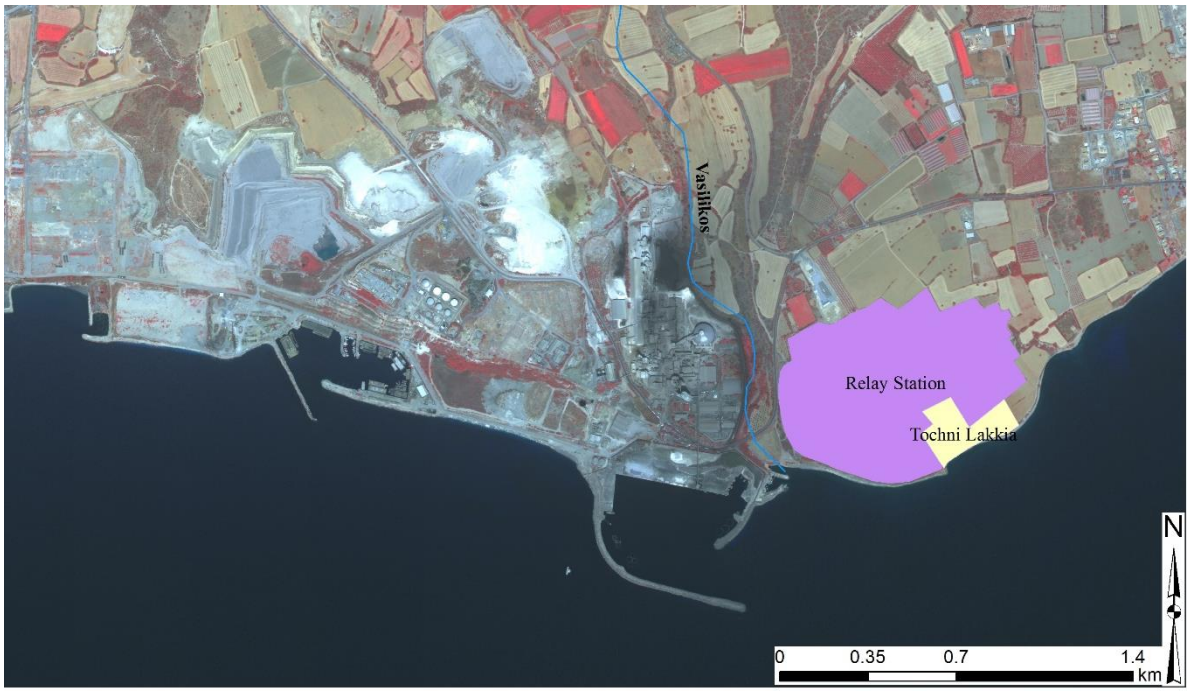

Fig.1.6 The spatial association of Tochni Lakkia and the modern industrial zone (ArcMap 10.3 – G.M. Andreou).

The current state of the site, as well as its location within the industrial zone of the mouth of the Vasilikos river have raised a series of questions regarding the association between natural and anthropogenic processes with the erosion of coastal archaeological sites. Although the fields that comprise the archaeological site (Cadastral map LV37, fields 125/1, 126, 127/2, 129, 129/2, 238; 1:5000 topography map series 55/XXI, 300424) are used for agricultural purposes, they are also located adjacent to the British East Mediterranean Relay Station (BEMRS), 600m East of the Vasilikos cement factory and within 4km of a power station and a naval base. In this geographic location, natural and cultural processes appear to operate at high capacities.

Unfortunately, the range of archaeological features recorded in the past 5 years have since eroded away. These include multi-period walls (*figs.1.7-1.8*), stratified floors, domestic installations *(fig. 1.9),* pits of various shapes and sizes *(fig.1.10),* a probable Bronze Age kiln *(fig.1.11),* as well as several clay-filled stone features (fig.1.12)(Andreou and Sewell 2015).

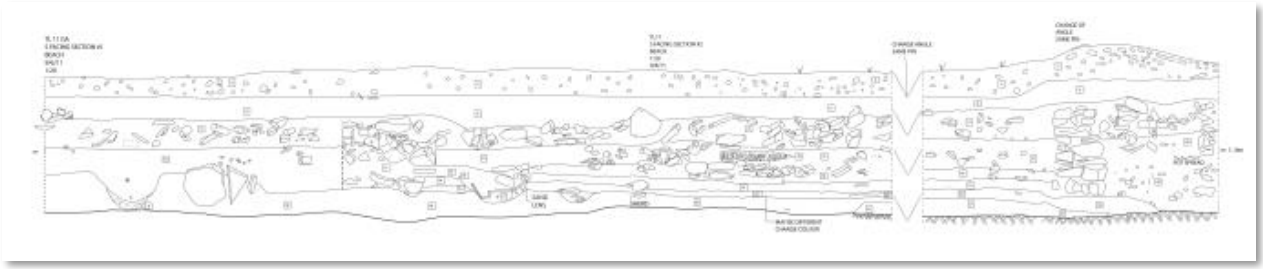

Fig.1.7 Tochni-Lakkia, section drawing of exposed wall (June 2011 – G.M. Andreou).

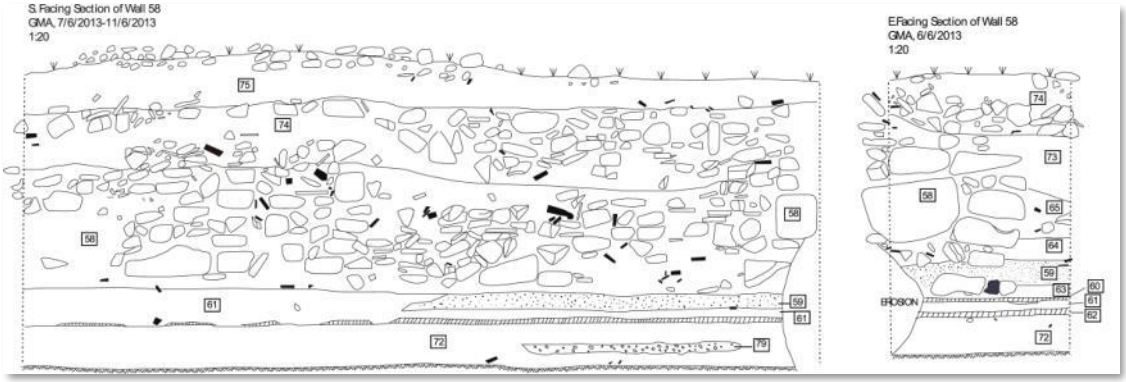

Fig.1.8 Tochni-Lakkia, section drawing of exposed wall (June 2013 – G.M. Andreou).

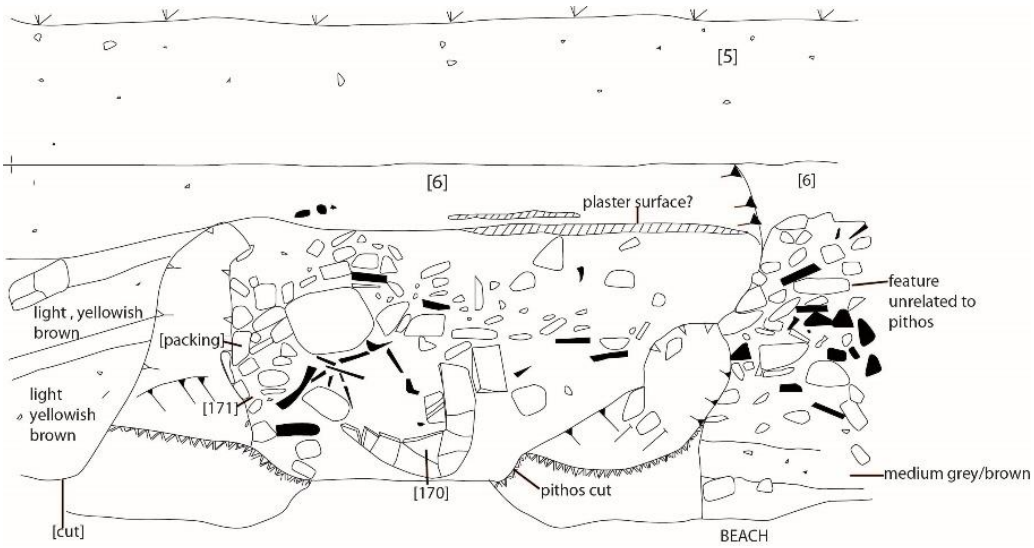

Fig. 1.9 Domestic installation including a probably in situ LBA pithos (June 2014 – G.M. Andreou).

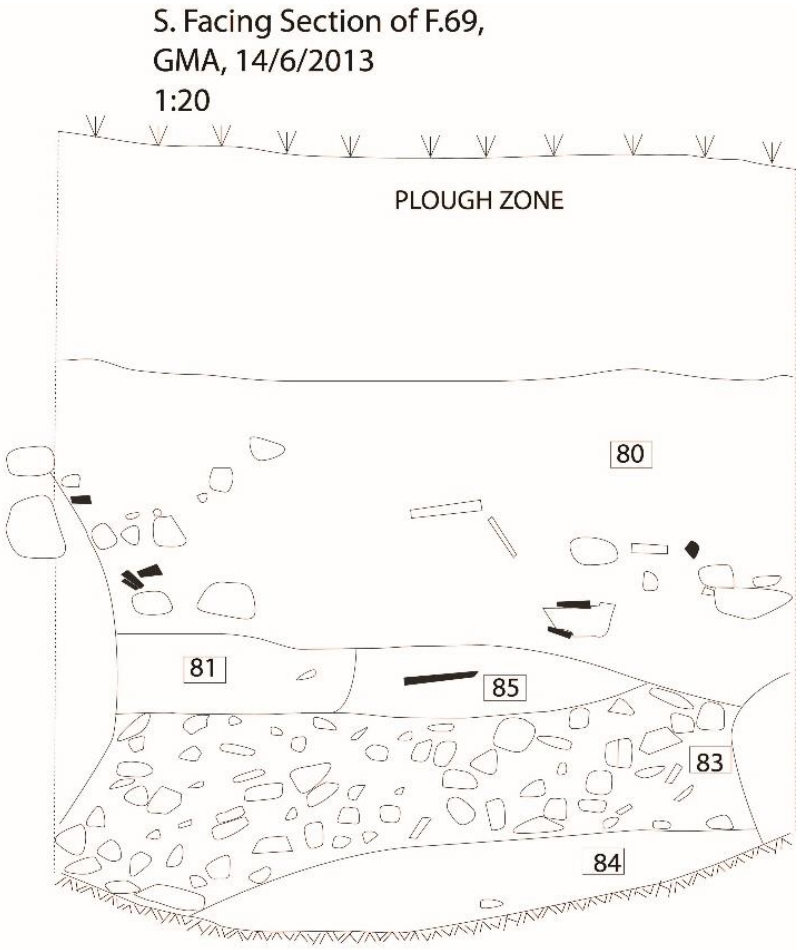

Fig.1.10 Stone-filled pit of unknown use (June 2013 – G.M. Andreou).

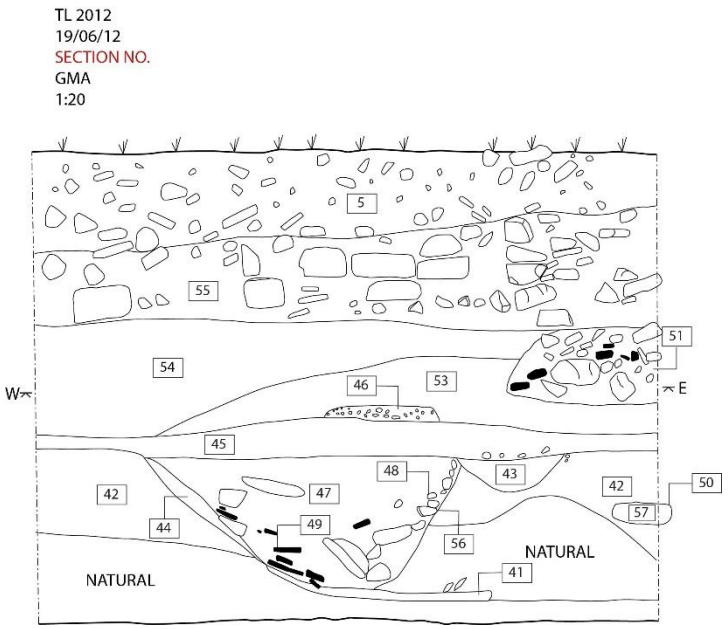

Fig.1.11 Cut for Bronze Age kiln containing burnt pottery sherds (June 2012 – G.M. Andreou).

Fig. 1.12 Tochni-Lakkia, example of diachronically eroding clay-filled, stone-lined feature (June 2011, June 2013 – D. Sewell).

Although the material evidence in the exposed sections of the site has been recorded intensively, the spatial extent of Tochni-*Lakkia* still remains to be determined. Pedestrian survey on the coastal field in 2012 recorded LBA and Iron Age pottery, stone tools and loom weights spread in an area covering 750m (E-W) x 250m (N-S). The extent of the survey was limited, however, in the area outside fenced fields at the North and West. The fenced area at the West of the exposed of Tochni-*Lakkia* (within the BEMRS) was examined with trial trenches in 2014. One of the trenches yielded a LBA floor and a pit filled with LBA pottery (*fig. 1.13*). These findings suggest that the size of the LBA Tochni-*Lakkia* needs to be reassessed.

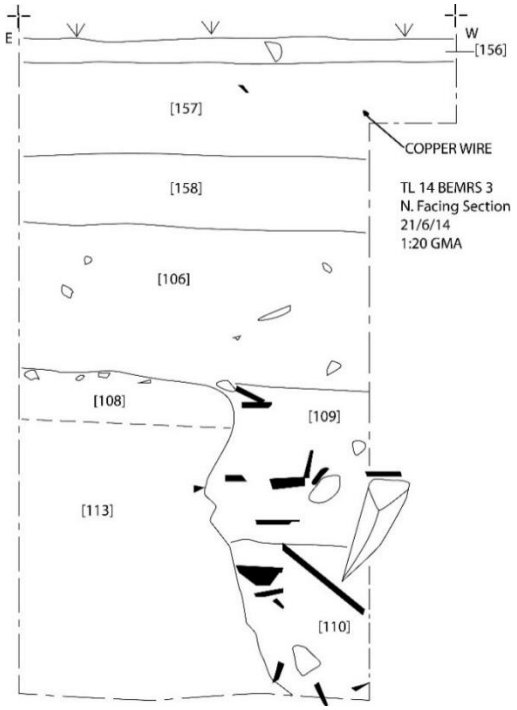

Fig.1.13 Trial trench within fenced area. [108] is a LBA floor, [109] and [110] are fills containing only LBA pottery (under examination by Dr A. Georgiou) (June 2014 – G.M. Andreou).

Furthermore, in 2013 an underwater survey aimed to provide a clearer understanding of the extent of the LBA coastline and record material culture with information regarding the site's character (Sewell 2013; Sewell et al. 2016). The current state of the seabed including stone debris, sediment, algal and plant growth were a significantly negative factor in archaeological visibility and artefact preservation. In these conditions, the survey did not locate any structures or anchors. It recorded, however, some fragments of utilitarian wares and storage jars (see Section 3).

The lack of anchors places significant stresses in any hypotheses regarding the potential role of Tochni-*Lakkia* as a LBA port. To be more precise, the lack of anchors in this area contrasts the

large number of anchors found off of the neighbouring and contemporaneous LBA Maroni-*Tsaroukkas* (Manning *et al.* 2002: 122). We would argue, however, that it is likely that lack of anchors and other evidence for maritime activities off of Tochni-*Lakkia* is related to the current state of the seabed and the rapid erosion of the site. These two factors made clear that any research of the maritime activities of the south-central coast of Cyprus needs to incorporate additional sources of information and would benefit from a more diachronic perspective. The current state of Tochni-*Lakkia* also suggests that we need to understand the impact of coastal erosion in the preservation of archaeological sites, and compare the scarce material remains of maritime activities with the more extensive historical, geographic and cartographic information for this area.

1.2. CASP, Aims and Methodology

The project's general aim is to undertake a diachronic study of the coast using historic maps, aerial photographs and satellite data in 20km stretching between the Vasilikos River at the West and the Pentaschoinos River at the East. The project goals are to:

- Study historic maps dating since the first cartographic representations of "Basili potamo" in a 15th century portolan chart, in order to understand the importance of the area under investigation for cartographers, sailors, local communities and the different administrative bodies (e.g. Ottoman Empire, British Colonial administration, the Republic of Cyprus). This study will contextualise the material remains of maritime activity within their historical framework and will subsequently provide a basis for a comparison between the material and the textual evidence of maritime activities in the area under study.

- Compare aerial photographs (1963, 1993 and 2008) to quantify coastal erosion, reconstruct how rapidly the coastline is changing and demonstrate how erosion rates fluctuate depending on modern development.

-Combine the results of the above studies to provide a comprehensive representation of archaeological sites under threat.

Following the results of this study, we aim to expand the scope and coverage area of CASP geographically. Future plans include a photogrammetric reconstruction of the coast and the development of a database for coastal sites, including risk-assessment forms that will be handed to the Department of Antiquities of Cyprus.

1.3. Arrangement and contents of this report

Section 2 provides a brief introduction to the coastal topography of the area under investigation, and deals primarily with historical cartography. It provides an analytical list of cartographic evidence related to the area under investigation, it contrasts the extensive cartographic evidence with the sparse material remains and eventually discusses the reasons behind this intriguing contrast. Section 3 presents the findings from the underwater survey. In Section 4, we discuss the problem of erosion and present the results of the comparative examination of aerial photography between 1963 and 2008We conclude with mitigation measures inspired by examples from the UK and Israel. The present report contains also three appendices (A-C), which summarise the legal framework regarding antiquities and coastal erosion in the Republic of Cyprus.

SECTION 2 - A SURVEY OF THE HISTORICAL CARTOGRAPHY

The area under investigation extends between a small port west of the Vasilikos industrial zone (33°18'22,371"E 34°43'22,542"N) to the West and the east bank of the Pentaschoinos river (33°24'44,82"E 34°45'1,618"N) to the East. The total length is approximately 20km. The examined coastal zone comprises primarily of "raised beaches" and exhibits an eroding cliffy appearance of soft material and narrow gravelly beaches (Thomas 1981: 4-5). The bathymetry slopes gently and the distance between the coastline (elevation: 0m) and the 20m depth contour is about 1600m (throughout the island it ranges between 760m and 2000m), and following that, it drops quite steeply (Delft Hydraulics 1993: 27; Triton Consultants 2002: 28). The material of these beaches originates mainly from inland igneous rocks and the marine terraces comprise of a conglomerate with rounded igneous pebbles. The nearby river systems have also introduced a large amount of pebbles to the beaches (Nir *et al.* 1993; Triton Consultants 2002: 29), especially prior to the construction of river-dams (fig.2.1).

Prior to their damming, the Vasilikos, Ayiou Mina (Maroni) and Pentaschoinos Rivers were major contributors to the sediment input of the south-central coast of Cyprus. Sediment output is a key factor for a balanced coastal topography (Delft Hydraulics 1993: 1) and the alteration of landscape caused by the damming of rivers has had a significant impact on the coast, because it cut off significant amounts of sediment (Κορωνίδα 2006: 3). However, there are, no precise estimations of the yearly river-borne sediment. Studies have estimated, nonetheless, that solely the damming of Pentaschoinos and Tremithos have cut approximately 87000 m^3 of sediment (Delft Hydraulics 1993: 48). As a result, the coast now is protected by more limited amounts of sediment - rain contributes to a rather insignificant degree (Triton Consultants 2002: 32) – and is exposed to erosion more directly.

Unfortunately, it is not possible to estimate the amount of land that has been lost diachronically due to coastal erosion, because each part of the coastline is exposed to different natural and anthropogenic processes. Moreover, we do not have locally specific and long-term historic data for many of the natural processes (e.g. wind, temperature, wave action). In addition, the change of the sea level is not known and there is currently no estimation based on historical data (Triton Consultants 2002: 31). Some information exists, however, on the direction of waves in the area under investigation; the waves are of east and south-west direction and the highest waves are occurring more frequently from the south-west direction. That being said, it is not possible to estimate tidal fluctuations; however based on the British Admiralty tide tables and the

Mediterranean Pilot Vol. V these fluctuations are generally argued to be minor (Delft Hydraulics 1993: 27; Triton Consultants 2002: 30).

An important factor to take into consideration in the studies of coastal erosion is the land-use of this area, and the more direct impact of people on the coastal topography. Although the south-central coast of the island contains large zones that the Ministry of Agriculture, Rural Development and Environment describes as agricultural, it is, at the same time, the most industrialised coastal area of the island. This is a development of the past 20 years, as the land-use of this area has been traditionally agricultural until 1996 when a new policy statement was published by the Town Planning and Housing Department. According to this statement the majority of coastal agricultural areas transformed into tourist zones (Delft Hydraulics 1993: 42; Triton Consultants 2002: 59).

Although there are no case-studies exploring specifically the diachronic impact of industrial and tourist structures on the coastal topography of the south-central coast of Cyprus (indirect mentions do exist), we should not omit to mention that the area under investigation is characterised by extensive industrial and tourist infrastructure. This includes the Vasilikos cement factory with a harbour and two breakwaters, the Archirodon port, a port related to a Naval Base, a small marina at Alaminos, the Zygi marina, groynes especially at Zygi and east of Zygi, revetments and offshore breakwaters, especially to the east (Triton Consultants 2002: 48-49). The large number of coastal defence measures mentioned in this report and shown in fig.2.2 were/are used to provide protection to private property that is exposed to erosion (Delft Hydraulics 1993: 1). Moreover, the defence structures contribute to the creation of sandy beaches though the accumulation of trapped sediment. These beaches are appealing to swimmers and assist in the tourist development of the area. They impact, however, the underwater visibility and the recording of potential ancient underwater features.

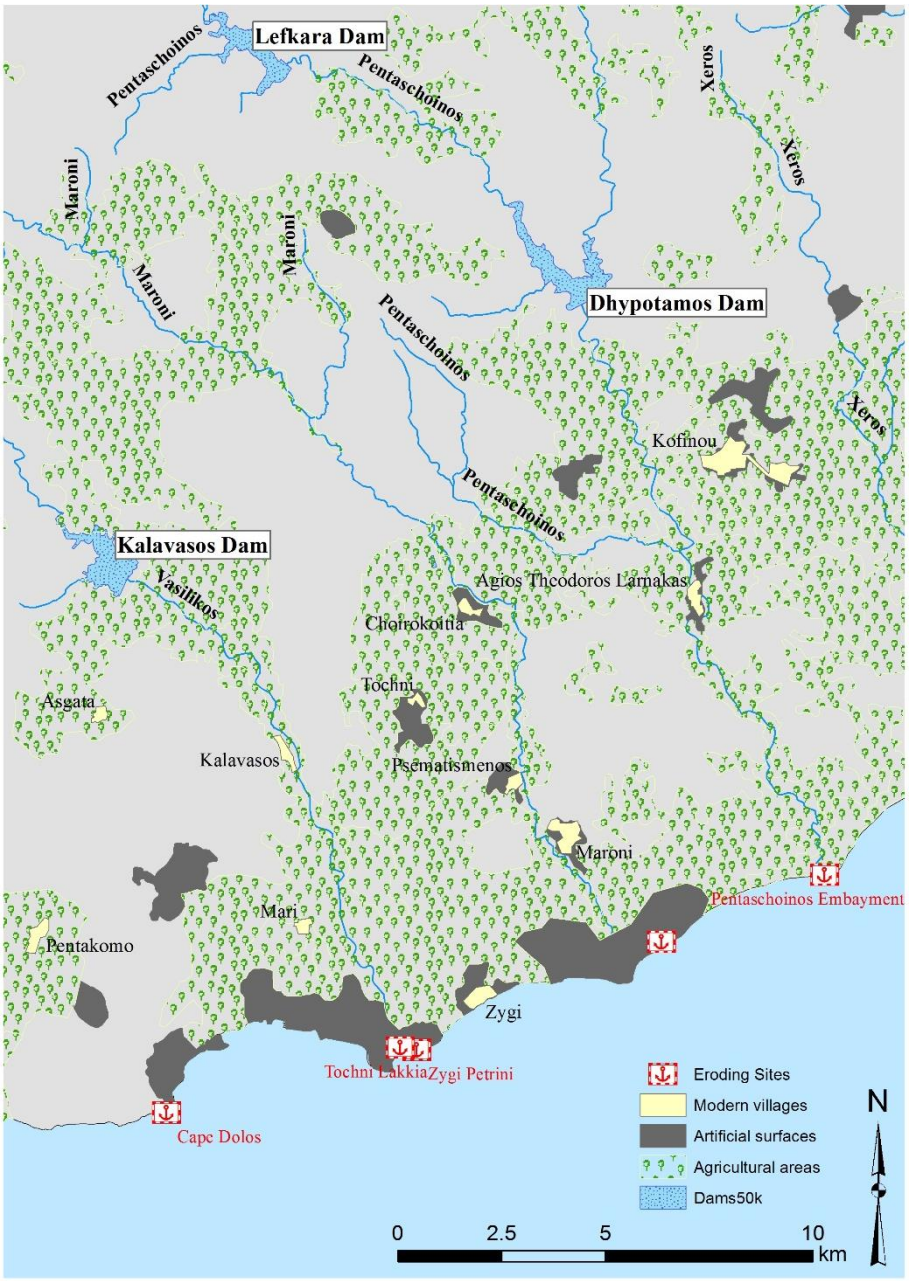

Fig.2.1 Map showing current land-use in the area under investigation (ArcMap 10.3 – G.M. Andreou).

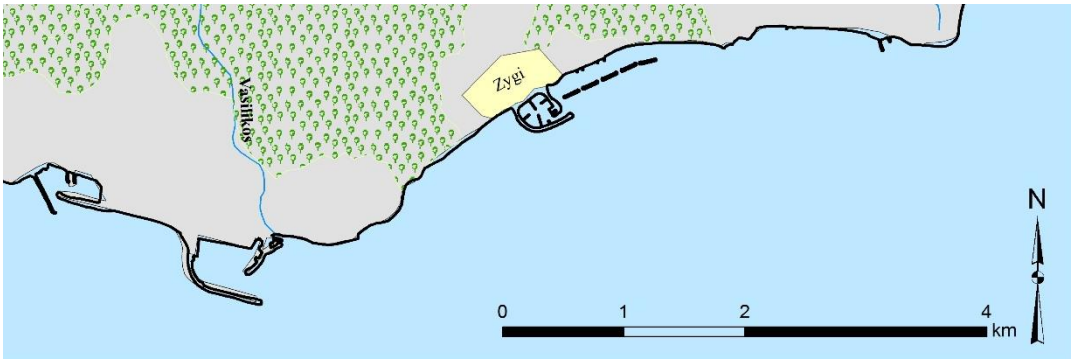

Fig.2.2 Map showing the extent of coastal defence structures around the Vasilikos River and Zygi village (ArcMap 10.3 – G.M. Andreou)

2.1. CASP - Coverage Area – Why do we need a diachronic perspective?

The current state of development of the area under investigation, gives little opportunity to locate, identify and investigate the material remains of pre-modern maritime activities. The lack of this material evidence may create the false impression that this area did not have an active maritime economy in pre-modern times other than small-scale activities (e.g. fishing). For that reason, CASP has examined additional sources of information regarding the maritime economy of the area, especially for the period following the 15th century AD. With the use of historical, cartographic and geographical information, we aim to:

- Reconstruct aspects of the maritime economic and cultural importance of the area under study for cartographers, sailors, local communities and the different administration bodies of Cyprus (Venetians, Ottomans, and British).

- Demonstrate the contrast between textual and material evidence for the maritime economy of this area, in order to contextualise the problems of archaeological visibility that affect the interpretation of pre-Medieval sites, especially Tochni-*Lakkia*.

The sources we have used in this study date between the first cartographic appearance of "Basilo potamo" in a c.1467 portolan chart, and Kitchener's first full triangulated survey of Cyprus (1878-1883). These maps have been accessed via the Bank of Cyprus Cultural Foundation collection of maps (www.boccf.org), the digital collections of RCHAMS (http://ncap.org.uk/) and New York Public Library (http://www.nypl.org/), as well as Stylianou and Stylianou (1980) published collection of maps. As our investigation was conducted within the time limits of a three-month investigation project funded by the HFF, it cannot be considered exhaustive at the present stage.

2.2. "Basili Potamo" in Medieval Maps

The name "Basili potamo" appears for the first time in a 15th century portolan chart of the Eastern Mediterranean, attributed to Alvine Cexano (Stylianou and Stylianou 1980: 8, figs. 12, 12a). It is unknown why the river is called what translates to 'Royal', however some association must exist with the use of this term in the 15th century Chronicle of Leontios Makhairas. In this chronicle, Makhairas, a medieval Cypriot historian associates "Βασιλοπόταμον" (Vasilopotamon) with St. Helen's arrival to the island in the mid-3rd century AD, after recovering relics of the Christian religion, including pieces of the alleged Holy Cross (Dawkins 1932: 6, f.3 v). According to Makhairas, St Helen's crew cast anchor at

"Βασιλοπόταμον", where she ate meat and fell asleep. After an ominous dream, she found a piece of the Holy Cross by the river bank. A voice from heaven guided her to construct a church in the nearby "Τόγνη" (Tochni) (Dawkins 1932: 8, f.4 r), and following this voice she built the church of the Holy Cross, which is widely identified with Stavrovouni. Despite the non-historical aspects of this narrative, its descriptive details are intriguing. The fact that the mouth of the Vasilikos River at the unknown time of the establishment of this legend was an anchorage is particularly interesting, especially considering the lack of any material evidence in the now industrialised Vasilikos port.

Following the first appearance of the Vasilikos River in maps, subsequent cartographic attempts map the river with name corruptions. For instance, in the c. 1480 Bartolomeo Dalli Sonetti's chart, which was based on observations of sailors, the river is mentioned as "Vasili potamo" (Stylianou and Stylianou 1980: 8-9, figs. 13, 13a). In other occasions the name of the river is not mentioned, but can be inferred based on its geographical association with other place names. For example the Vasilikos name is not written on a map produced by Martelus Germanus (c.1480-1496). However, the map illustrates a small river, the estuaries of which form a small bay that leads to "Santa Crux" (Stavrovouni). It appears that the river held an important position, the mapping of which was useful for future visitors. Moreover, the fact that Vasilikos was mapped by sailors may suggest that it was probably considered a suitable anchorage, especially in association with the route to Stavrovouni. As mentioned above, there is, unfortunately, no material information associated with this anchorage.

In the 16th century, place names from the interior of the island are mapped for the first time in a 1538 map attributed to Matheo Pagano (Stylianou and Stylianou 1980: 16-26, fig.22). As far as the area of investigation is concerned, the place names Cerochetica (Choirokoitia), Calauaso (Kalavasos), Docni (Tochni), Mari (Mari), Pismanmeno (Psematismenos) are mapped close to the areas where the modern villages are generally located (*fig.1.2*). These include also 'Lerico' to the east of the Vasilikos and close to its estuaries, which we could not identify with a modern village. This is not surprising considering inaccuracies occurring in this map, in which "Vasilpotamo" is describing a river located West of the Vasilikos River, which is, in this map, spatially associated with "Birgo" (Pyrgos). This inaccuracy is reproduced by geographers, such as Giovanni Francesco Camocio, who published a map in 1566 (Stylianou and Stylianou 1980: 30-31, fig.36).

Cartographers kept reproducing Bartolomeo Dalli Sonetti's chart, which they edited using sources that are, at present, unknown. For example, in a 1554 map by Baptista Agnese (Stylianou and Stylianou 1980: 27, fig.28), Vasilopotamo is located close to the "Cavo delle Grotte", which is possibly Governor's Beach. Gradually, however, more place names are introduced, such as "Masoto" in a map accompanying Florio Bustron Chronicles (c.1560), and C. Cito (Kition) in Bertelli's c. 1562 map (Stylianou and Stylianou 1980: 28-29, figs. 30, 33). In addition, Paolo Forlani Veronese's map of c. 1573 depicts rather inaccurately M. Lefcara (Lefkara) and Chirochitia (Choirokoitia) (Stylianou and Stylianou 1980: 34-35, fig.42). These inaccuracies may suggest a lack of empirical observation of the mapped areas and the likely bibliography-based edition of the maps.

2.3. The Ottoman Era

In the following years, a main theme in the cartography of Cyprus and the Eastern Mediterranean was the expansion of the Ottoman Empire. A non-signed map published in Augsburg in 1570 shows the village of "Calauaso" close to "Potamo" (Vasilikos) and Ottoman boats approaching various parts of the island, including the south-central coast (Stylianou and Stylianou 1980: 56, fig.63). During this period Iacomo Franco published a copper plate map (c.1570), which is widely considered a cartographic landmark (Stylianou and Stylianou 1980: 57-60, fig.66). The particularity of this map lies in the accuracy of shape, outline, orientation and contents of the island. Although it is not possible to discern place names from the south-central coast of Cyprus, it is possible to observe the Vasilikos shape and the mapping of several streams to its East.

With the shift of the core of cartographic activities from Italy to Germany, a new series of maps emerged, which often relied on preceding Italian maps. For example Abraham Ortelius 1598 atlas *Theatrum Orbis Terrarum* (Abraham 1606) depicts "Vasilopotamo" with relatively wide estuaries and placed "Masota" (Mazotos) at the area of modern Maroni. "Peraschino" is also depicted with what appears to be a small coastal community (*figs.2.3-2.4*) (Stylianou and Stylianou 1980: 60, fig.67a).

Fig.2.3 Abraham Ortelius' Cyprus Insula (c.1598).

Fig.2.4 Abraham Ortelius' Cyprus Insula (c.1598), close-up to study area.

Although Ortelius mentioned that the edition was based on extensive personal travelling and observations of agents he appointed to different places, this map is probably influenced by Pagano's map. Regardless of their sources, Ortelius' and Francos' maps became the most referred sources of information for future cartographers, who often supplemented with information from Ptolemy and Strabo (e.g. Stylianou and Stylianou 1980: 62-66, figs. 69-70).

One example is Ioannis Baptista Vrintius' 1609 work, which follows or reproduces Ortelius' maps, and mentions Calauaso but not Vasilikos. Its French version of 1602 depicts a stream between Vasilikos and possibly Maroni (Stylianou and Stylianou 1980: 66, figs. 71-72). This depiction is also observed in a c.1601 German edition of Ortelius' map by Johannes Keerbergen, who enriched it with information from Ptolemy (Stylianou and Stylianou 1980: 67, fig.74). This persistent cartographic pattern can be noted in different publishing centres. For example in the *Relationi Universali di Giovanni Botero* (Botero 1606), "Calauaso" is mapped, but the adjacent river is unnamed, a small stream is located to its east, while the general area up to modern Limassol is depicted as a wide bay with a boat towards this direction.

It is clear that the name and shape of Vasilikos depends on the sources of each edition. For example a rare loose-sheet map of the island by Stefano Lusignano, published by Ferrandus Bertelli in c. 1575/6, possibly relied on Pagano, but is possibly annotated through personal observations. Lusignano mapped "Vasilo potamo" with its estuaries forming a small bay/port (Stylianou and Stylianou 1980: 70-71, fig.80). This map influenced André Thevet's map (c.1576), in which he depicted the south-central coast as series of bays between the capes of Akrotiri and Kition *(fig.2.5)* (Stylianou and Stylianou 1980: 71-72, fig.82).

In c. 1593 Gerard de Jode's published a map based on Ortelius, which illustrates "Vasilipotamo", "Mari" and "Maroni" (Maroni). Maroni is also mentioned as "Marora" in a 1596 map by Giovani Antonio Magini (Stylianou and Stylianou 1980: 76, fig.91). In the late 16th century, two maps depict Vasilikos and Maroni rivers intertwined, with their estuaries forming a small bay (Stylianou and Stylianou 1980: 76-77, figs.91-92). This phenomenon is repeated by Matthias Quad von Kinckelbach, who used Ortelius as a main source and depicted "Marora" and "Vasilipotami" intertwined and their estuaries forming a bay (Stylianou and Stylianou 1980: 79-80, fig.97).

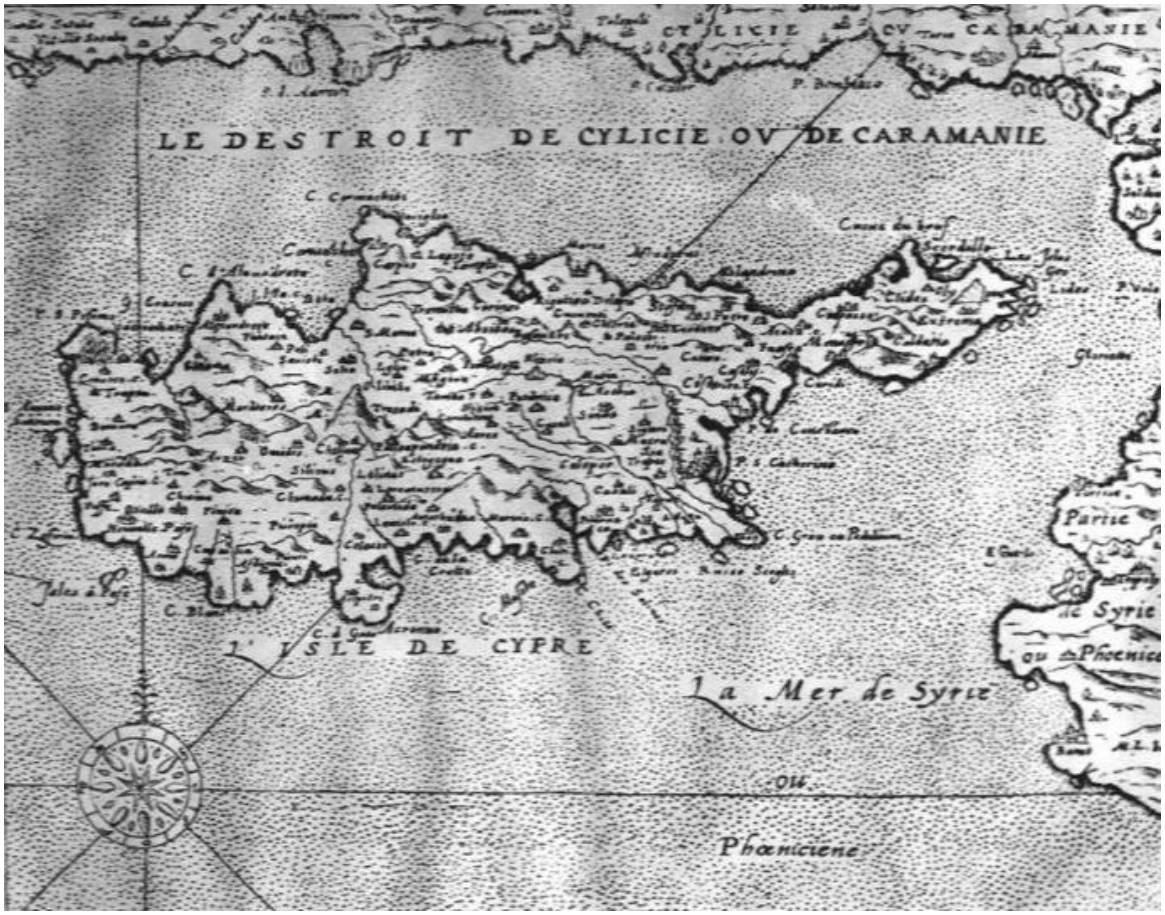

Fig.2.5 André Thevet's map of Cyprus (c.1576).

Another interesting cartographic work is Antonio Millo's c. 1576 map of Cyprus. This map is based on Millo's personal observations during sailing by, or calling, at different ports (*fig.2.6*) (Stylianou and Stylianou 1980: 75-76, fig.90). Despite obvious imprecisions, the area of interest is represented as a small bay and possibly call-point located between C. delle grotte and Masoto. This map may reveal indirectly information concerning sailing and trading strategies, as well as potential anchorages of this chronological period, and could be insightful to our understanding of such practices in earlier chronological periods.

In 1600, Corneille Nicolas (Glaesz) published a map of Cyprus, in which "Calauaso" and "Mari" are mapped alongside a village called "Phinica" (Stylianou and Stylianou 1980: 81, fig.98). Phinica is similarly mapped in a map by Jodocus Hondius II (c.1616). Hondius' map was edited and re-published in 1625 and depicts "Vasilopotamo", later edited by Joanes Janssonius in c. 1630, and copied for Jean Boisseau's *Trésor des Cartes Geographiques* in c.1643 (Stylianou and Stylianou 1980: 86-87, fig.105).

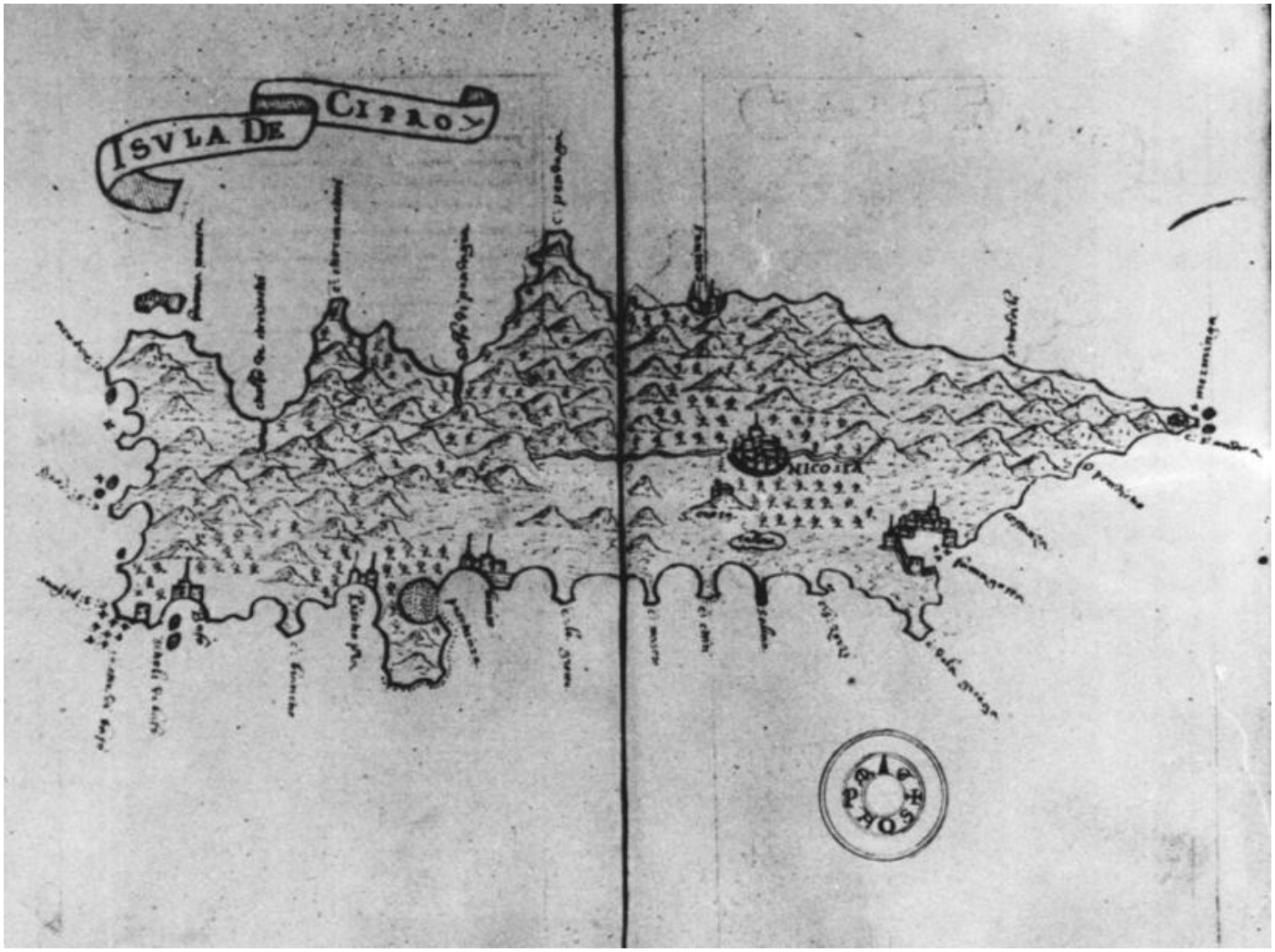

Fig.2.6 Antonio Millo's Insula de Cipro (Multiple Editions).

In 1630, Johannis Cloppenburg started a new series edition of maps with a larger format (Stylianou and Stylianou1980: 87, fig.106). Although based on the same prototypes as the Janssoniu's editions, Cyprus appears with more extensive and detailed contents. Nevertheless, "Marona" and "Calauaso" are placed inaccurately. The same configuration is observed in a several future versions of this map, such as the c.1734 Jannsonius van Waesberge map, a c. 1635 copper-plate double folio map by Willen Janszoon Blaeu, a 1641 replica of the same map, a 1649 copy of Blaeu's map by Joan L. Gotogred, a 1663 recension of Janssonius map by Nicolas Sanson and Pierre Mariette, a c.1703 map based on Blaeu and to a degree to Janssonius by Olfert Dapper, a 1690 edited map by Vincenzo Maria Coronelli, a post-1730 map by Covens and Mortier, and a 1747 edited version of Coronelli's and Blaeu's maps by Dominique Jauna (Stylianou and Stylianou 1980: 87-88, 92-94, 96, 98-99, 101, 107-108, 132-133, 135, figs. 106a, 114, 118a, 122, 130, 133, 138a, 162).

Finally, detailed place-names appear also at Gerard Valk and Petrus Schenk 1637 map, which bears the characteristics of Jannonius' plate and includes place-names such as: "Calavato" (Kalavasos), "Pendasino" (Pentaschoinos), "Marabi" (?), "Xeugalalio" (?), "Chierochitia" (Choirokoitia), "Marin" (Mari), "Marova" (Maroni), "Pendamia" (?), "Vasilopotamo" (Vasilikos) and "S. Marino" (?) (Stylianou and Stylianou 1980: 111-112, fig.147). It is not known if these areas were inhabited or used during the production of the map and if the cartographers have visited those areas. What is important to keep, is that those areas were considered worth recording in order to facilitate the navigation to and around the island.

2.4. Toward the British Colonial Period

With the establishment of a Colonial British Consul on the island Alexander Drummond, a consul, was assigned to map Cyprus. This venture involved recording the perimeter of the island, crossing the island from Larnaca to Nicosia and penetrating as far as the mountainous area of the Kykkos monastery. Drummond also mentioned that he annotated the Limassol bay (Stylianou and Stylianou 1980: 138, fig. 167). Despite the extensive information provided by this important c. 1754 map, Vasilikos, Maroni and Pentaschoinos Rivers are depicted without any detail.

A few years later, a 1762 map/report by Jean Baptiste Bourguignon d'Anville was published (Stylianou and Stylianou 1980: 142, fig. 172). This report mapped "Maroni" and "Kalavazo" but not the adjacent rivers (*fig.2.7*). However, the area the Vasilikos' estuaries are depicted as a bay and the general area appears to be protected by "Capo Chiti" to the East and "Capo Pirochizia" (Parrekklisia?) to the West.

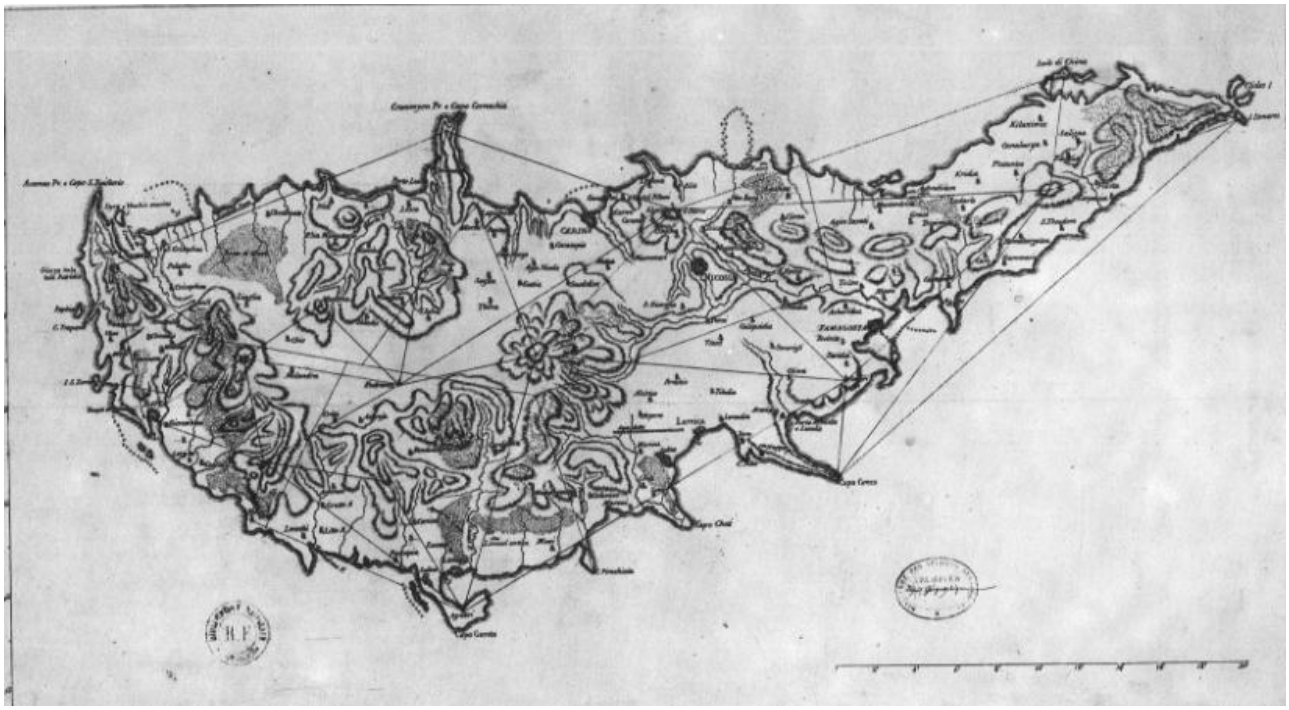

Fig.2.7 Jean Baptiste Bourguignon d'Anville's map of Cyprus (c.1762).

In the middle 19th century (1849), the British navy undertook the hydrogeological mapping of Cyprus, directed by Thomas Graves. Despite the relatively limited information on place-names, Vasilikos is depicted on the map (Stylianou and Stylianou 1980: 150-151, fig. 194). Similarly Vasilikos is depicted on an 1849 map by W.J. Conyeare and J.S. Howson (Stylianou and Stylianou 1980: 151, fig. 195). Overall, although a number of maps were produced between 1754 and 1855, one can argue that these maps do not depict the south-central coast of the island in much greater detail than the maps of the previous 100 years.

In 1855 Athanasios Sakellarios published the first map of Cyprus in Greek language, based on travelling (Sakellarios 1890). In this map the areas of interest are "Vasilopotamon", "Maronion" and "Zygi". Sakellarios identified Vasilikos with Tetios river (Sakellarios 1890: 18), which G. Marini, an official from the Imperial and Tuscan consulates revisited and discussed in the 18th century. Mariti also recounted St. Helen's legend, associated Vasilopotamo River with the nearby village of Mari, and described briefly the large numbers of carob trees in the area, as well as their seasonal exportation (Cobham 1908: 81).

A few years later, a new map of the island was published in 1862 by Louis de Mas Latrie. De Mas Latrie mentioned that he had collected all available ancient and contemporary information on the geography of Cyprus and he subsequently enriched his record with personal observations (Stylianou and Stylianou 1980: 152, fig. 198). In 1873 C.H. Coote compiled a new map of

Cyprus for the British Museum (Stylianou and Stylianou 1980: 153, fig. 199). In this map, although "Basilopotamos" is depicted in a fairly accurate position, Maroni is located to its west. Four years later, Henry Kiepert's 1877 map provides a much improved cartographic example (Stylianou and Stylianou 1980: 153, fig. 200). Kiepert's map was based on all material following Drummond, personal journeys of Dr Schroeder in 1870 and 1873, and Dr Seiff's 1874 travel notes. In this map, the area to the East of the Vasilikos estuaries is called "Carrubiere Pt". This name is reminiscent of the word carob and the importance these trees had in the local economy of the south-central coast of Cyprus.

Upon the British colonisation of the island in 1878, a new map was produced by E. Stanford. Along with geological, agricultural and agronomical information, Stanford identified and mapped ancient sites (Stylianou and Stylianou 1980: 154, fig. 201). In this map Vasilikos is represented along with "Marium" and "Carrubiere". Finally in 1879 Dr G.C. Schinas and L. Galizia produced a map of the island with agricultural information and limited place-names information, including "Basiliko" (Stylianou and Stylianou 1980: 155, fig.202). In this map, the west part of the Vasilikos estuaries (Cape Dolos), is depicted in a form of a bay. It is important to note, that this area has no material evidence of pre-modern maritime activities, as it is currently used for modern industrial and port facilities.

2.5. Kitchener's Survey of Cyprus

The most important map of Cyprus produced in the 19th century is H.H. Kitchener's first triangulated survey of Cyprus (*fig.2.8*). Kitchener was assigned to map the island with an economic-administrative perspective to facilitate revenue purposes. He, however, desired to provide additional historical and geographical detail (Shirley 2001: 16-17). This led to administrative opposition and even temporary suspension from his work (Cyprus State Archives, SA01/13229 and SA01/13235). Upon his return, however, he mapped some ancient sites and antiquities (Shirley 2001: 23-24), the location and description of which is valuable for archaeologists. In the area under investigation Kitchener mapped archaeological features as "ruins" at the location of Maroni-*Vournes* site and West of the Pentaschoinos River, where medieval maps were depicting a set of buildings (*fig.2.9-2.10*).

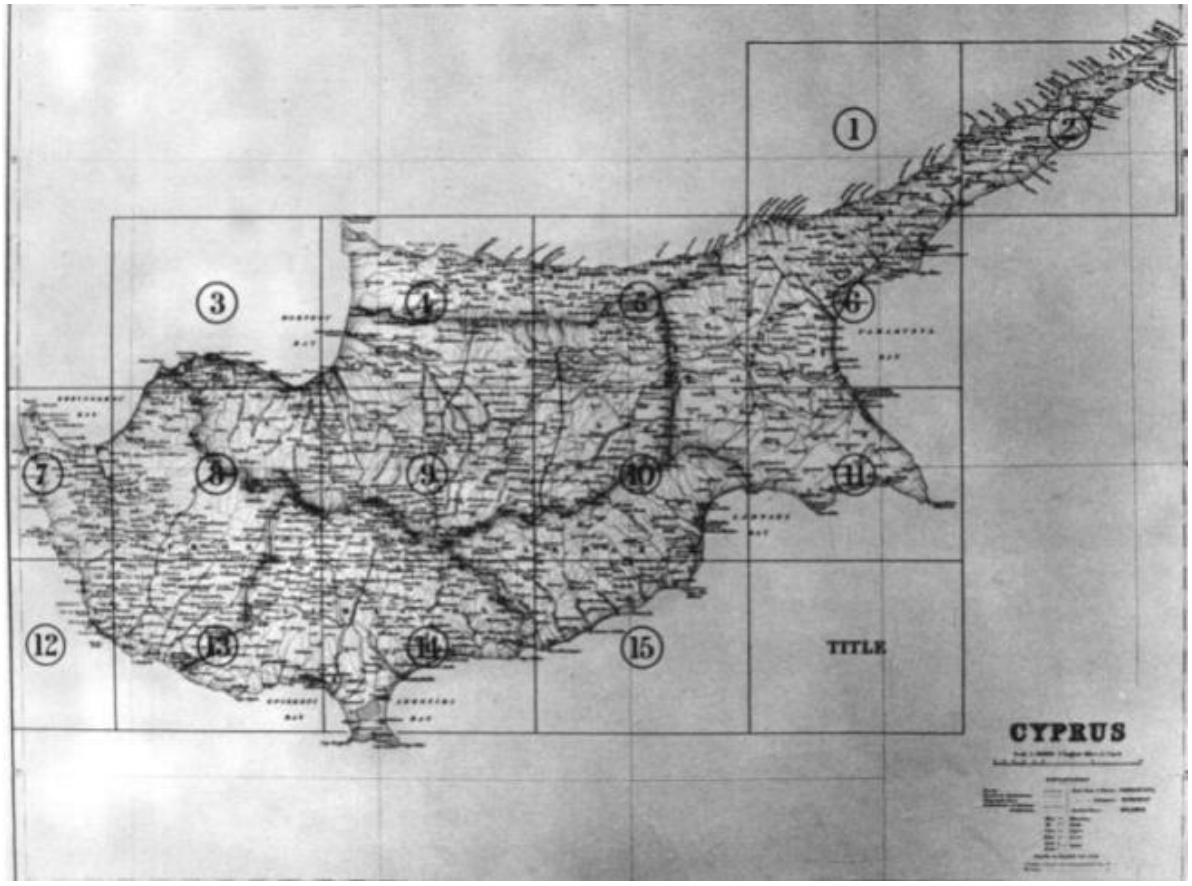

Fig.2.8 Kitchener's first triangulated survey of Cyprus map (1885).

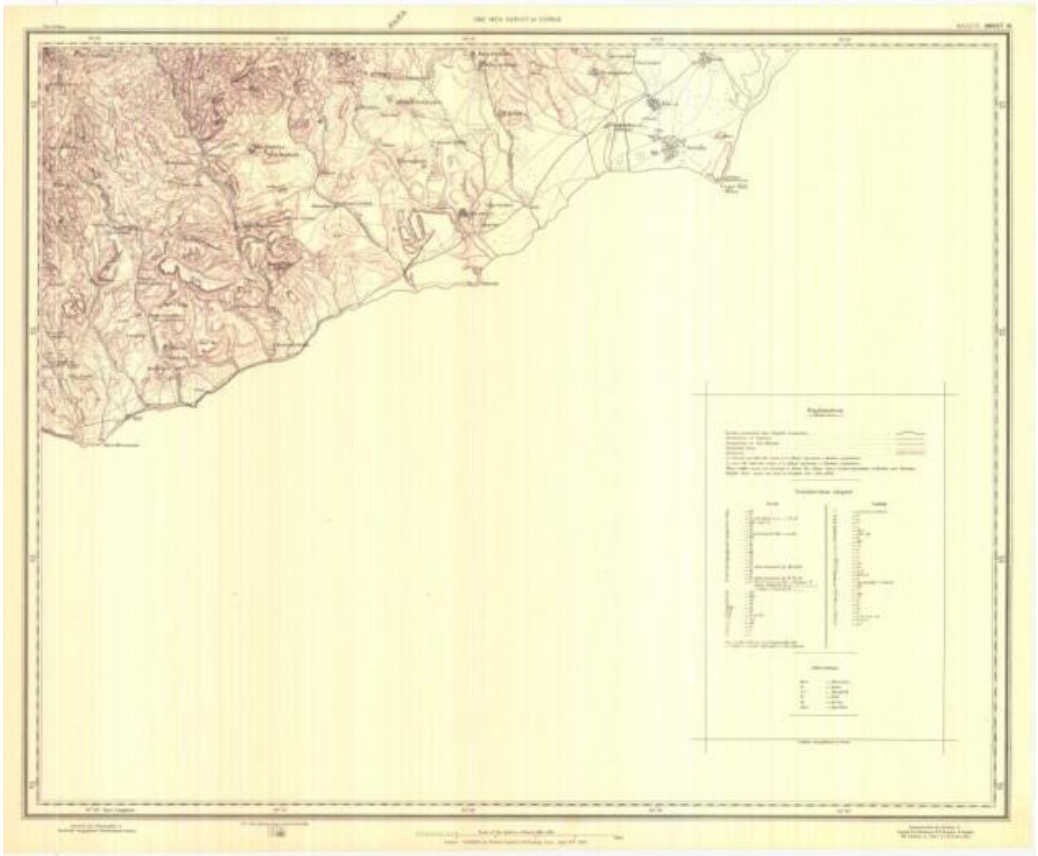

Fig.2.9 Kitchener's Map, Sheet 15, Study area.

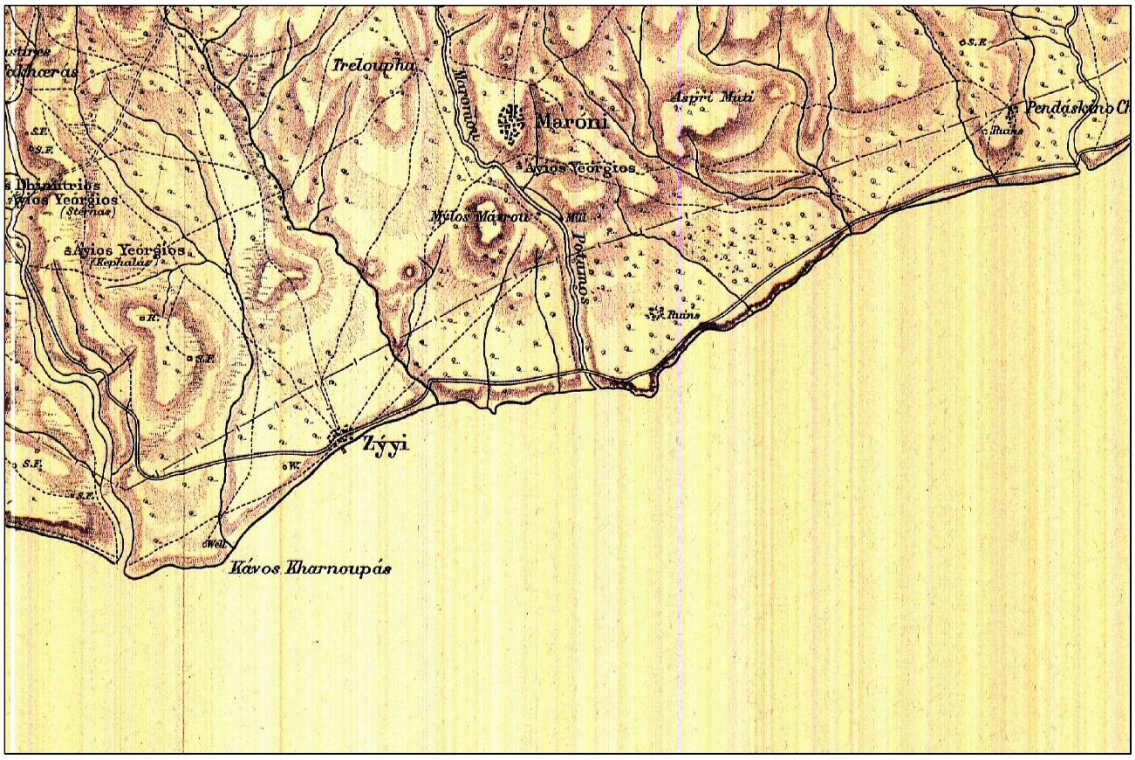

Fig.2.10. Close-up to the area under investigation. Note the word 'ruins' at the area where approximately Maroni Vournes is located (Map provided by the DLS).

Unfortunately, Kitchener's survey and mapping of the island is unavailable in a geo-referenced form. As part of this study we attempted to geo-reference sheet 15 (*fig.2.9*), with the use of the standard ArcGIS procedures for geo-referencing raster files (Longley *et al.* 2011: 123-145). We attempted to overlay a scanned raster image of Kitchener's map, provided by the DLS, with roads, streets and villages surveyed and geo-referenced by the DLS. The low degree of cartographic resolution, alongside the high standard deviation error could not contribute to the implementation of a precise geo-referenced map. Although it was possible to link via control points villages and streets, and observe a subtle difference between the 1885 and 1963 coastline, the RMS error was too high to provide an accurate coastline or evaluate erosion rate for a reliable and productive comparison and quantification. At a later stage, X. Loizides informed Andreou that Kitchener's survey was not mapping the coastline as the point where the sea meets the land. The survey, instead relied on coastal field boundaries, which usually do not correspond with the coastline (as the point where the sea meets the land – see discussion in Section 4).

Regardless of the problems we discuss in the previous paragraph, it is worth noting the place-name Kavos (Cape) Kharnoupas a few metres to the East of Tochni-*Lakkia*, at a stream located West of the access dirt road to the site. Although a cape cannot be determined in the 1963 aerial photography (Section 4, fig.4.2) or Kitchener's 1885 map, the place name may suggest extreme erosion in this area, and the presence of cape that no longer exists.

2.6. Beyond Cartography

Aside from the cartographic depiction of the area of interest, it is worth examining also written sources, especially those produced after *in situ* visits of the rivers under investigation. This study has identified two written sources that, along with Makhairas' chronicle, may provide additional indications toward the possibility of an anchorage at the Vasilikos mouth. One of them is a note by Ali Bey a Spanish traveller, who in 1806 travelled from Larnaca to Limassol through the coastal road and mentioned the existence of a small port at the mouth of the "St. Helena" river (Cobham 1908: 403). The same area was likely visited by G. Mariti during the 18th century, who recounted St. Helena's legend and mentioned that large numbers of carob trees were exported seasonally from this area (Cobham 1971: 81). At this point we should re-address the toponym 'Cape Caroubière', which in 1878, R.H. Lang argued that it coincides with the general Mari area (Lang 1878: 232-4).

Additional information can be provided by agricultural studies taking place during the British colonial period (1878-1960). Christodoulou's (1959: 52) seminal study of the rural land use patterns of Cyprus describes the general area under investigation as primarily agricultural, and the local population as farmers (see also Ionas 2000: 6). Moreover, many researchers (Davies 1970: 460; Catarino 1993: 14; Rhizopoulou and Davies 1991: 43) highlighted that the income of this rural population was supplemented by the exportation of carob via the Zygi port, the facilities of which were constructed by the British to serve the exportation of metal ores from the Kalavasos mines. Gradually, the local communities were involved in copper mining and some were later employed in a cement factory, constructed in the early 1960s.

One should note that the indirect, yet extensive and diachronic, information regarding the maritime activities of the area under study bears almost no material evidence. In fact, the only preserved material evidence are the storage and weighing areas for the export of carob at Zygi. Photographic documentation stored in the State Archives of the Republic of Cyprus, however, include more extensive information regarding the size and type of maritime activities in this

area. This contrasts with the lack of material remains of any other pre-modern coastal maritime activity, except for the Bronze Age, Roman and Byzantine sites mentioned in Section 1. This contrasting picture should be taken into consideration when investigating the maritime activities of pre-Medieval periods. That is not to suggest that the historical cartography can provide direct indications for the Bronze Age. However, it provides a useful paradigm when trying to contextualise the extensive stratified material remains of Tochni-*Lakkia* with the lack of underwater material remains and in general the lack of any clear evidence for maritime activities (e.g. harbour infrastructure, anchors etc. as discussed in Section 4).

2.7. Appraising the Possibility of an Anchorage in Pre-Medieval Times

Ancient sailing routes and trading patterns in the Eastern Mediterranean have attracted a lot of attention particularly in the studies of the Roman and Byzantine period, which are characterised by a rich inventory of written sources and shipwrecks (Arnaud 2011). Written sources of the aforementioned chronological periods are sometimes detailed enough to distinguish different types of coastal structures and groups of merchants (e.g. Hasebroek 1965). Notable is Leonard's (1997) work on exemplifying harbour terminology in the Roman *periploi*, which points to the complex nature and the multiple types of coastal sites and associated activities.

For the Bronze Age, the most comprehensive study on the typology and the paleogeography of Bronze Age harbours is Blue's discussion in *Res Maritimae* (1997)– one that is widely referenced by subsequent research (e.g. Sauvage 2012: 70-71). Blue classifies anchorages according to either "high" or "low" energy environments. High energy anchorages may involve natural bays, almost enclosed bays, bays on either side of an "anvil-shaped" headland (e.g. Maa Palaekastro), lees of promontories (e.g. Cape Kiti), sheltered valleys and offshore islands or reefs. Low energy anchorages may be riverine (at the *river mouth* or upriver), inland lakes, natural embayments (e.g. Kition Kathari), deltaic and lagoonal (e.g. Hala Sultan Tekke) (Blue 1997: 31-32; for Hala Sultan Tekke see also Gifford 1985).

One may assume that Tochni's anchorage, the material remains of which are probably not preserved, may be located close to the Vasilikos estuaries that have drastically altered in the last 100 years and are now part of an industrial port. They may also be located close to the now dry stream adjacent to the site's access road. This hypothesis may be argued also based on Karmon (1985: 2), who discusses how river estuaries were preferred for the establishment of

adjacent ports due to their agricultural significance. Moreover, Leonard has discussed the use of the Vasilikos River as a small port during the late Middle Ages, and finally, Raban (1985: 29) has discussed the almost exclusive construction of Bronze Age harbours in Israel's Mediterranean coast next to river outlets. In a later publication, Raban includes a potential outlet at the Vasilikos River along with Kouklia, Enkomi, Kition and Hala Sultan Tekke as Cyprus' 13th-century ports (*fig.2.11*) (1998: 429). Nevertheless, so far, only Kition appears to bear artificial harbour facilities (quays) (Sauvage 2012: 78; Bony *et al.* 2016).

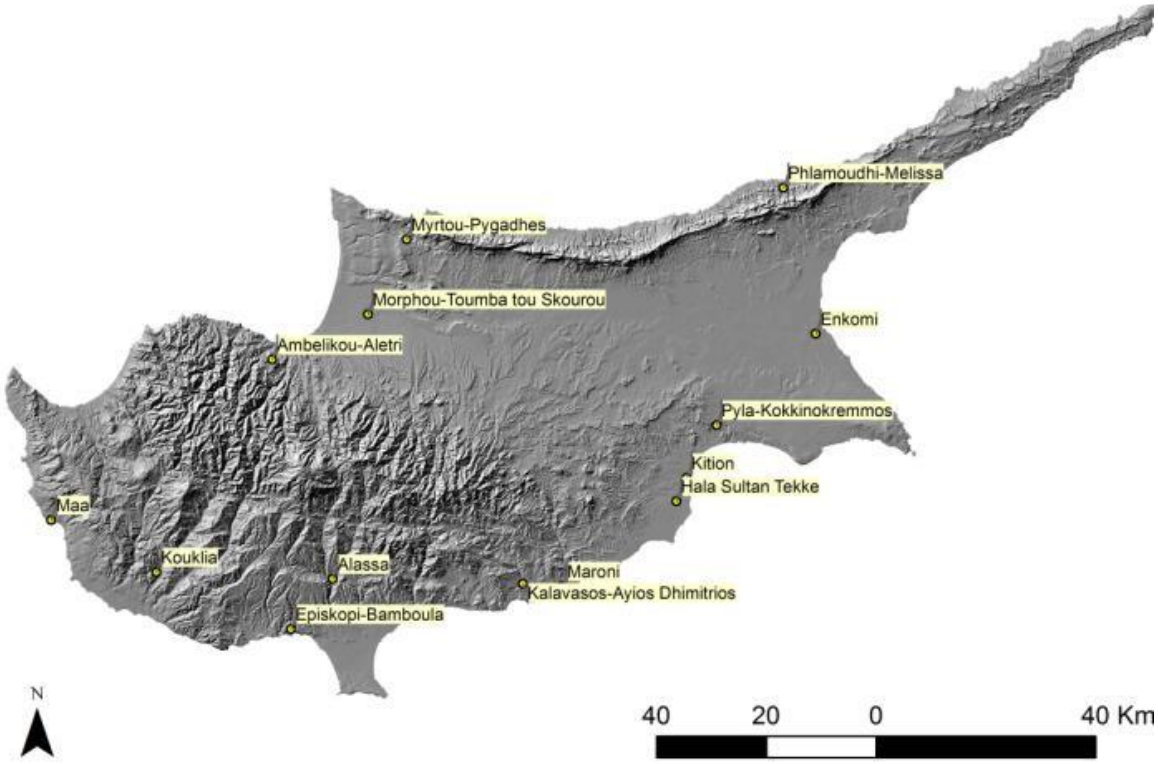

Fig.2.11 Map of Cyprus showing the most widely discussed LBA sites.

Karmon also demonstrates how examples from Israel may be used to suggest that ports were constructed, regardless of the existence of favourable conditions. He argues that a port establishment points initially to the high connectivity of an area rather than to its natural suitability for such infrastructure (Karmon 1985: 1). Raban (1985: 11) seems to follow this suggestion, viewing that the Mediterranean coastline of Israel has almost no natural haven or sites with 'favourable' conditions for harbour construction. Along the same line Sauvage (2012: 83) mentions that regardless of an area's natural suitability or necessity of improving measures, port sites are generally established in areas with an economy able and suitable to welcome marine traffic. Similarly, Schörle (2011: 93) argues that the development of ports is driven by trade and not natural suitability.

To conclude, it is likely that during in the LBA, the Vasilikos and Maroni valleys, which are characterised by urbanisation and economic intensification (Manning and DeMita 1997; Manning *et al.* 2014), probably required coastal outlets, and that the river estuaries are a considerable candidate for these establishments. Moreover, despite the fact that the underwater survey off of Tochni-*Lakkia* did not record any anchors or maritime infrastructures, the lack of this material cannot rule out convincingly the probability of anchorages on this general location. The lack of material evidence for these maritime structures and activities may be related to the use of perishable materials for the maritime infrastructure of this area, the diachronic anthropogenic alteration of the landscape until its most recent industrialisation, and/or coastal erosion that likely contributed to the material deterioration of the maritime history of the island of Cyprus. The last factor is the topic of the following chapter, in which we are comparing geo-referenced aerial photography between 1963 and 2008 to demonstrate the impact of erosion on the south-central coast of Cyprus and, by extension, its catastrophic results on coastal archaeological sites and, eventually, the irreparable loss of information regarding the maritime history of this part of the island.

SECTION 3 - UNDERWATER SURVEY OF CASP REGIONS (2014 REPORT)

3.1 Introduction and Survey Area

This section outlines the results of our underwater survey conducted between 9 and 22 June 2014. A total of 27 dives were undertaken along the coast between Tochni-*Lakkia* and Maroni-*Tsaroukkas*. While the 2014 data is presented here in detail, these results can be compared to 2013 data. The five areas of the survey included: CASP 1 Tochni-*Lakkia* to Zygi-*Petrini;* CASP 2 Zygi-*Petrini*; CASP 3 Maroni-*Limni* to Maroni-*Vrysoudhia;* CASP 4 Maroni-*Vrysoudhia* to Maroni-*Yialos;* and CASP 5 Maroni-*Yialos* to Maroni-*Tsaroukkas* (fig.3.1). Although this was largely a maritime survey, the nearest local toponyms were used to help guide the survey.

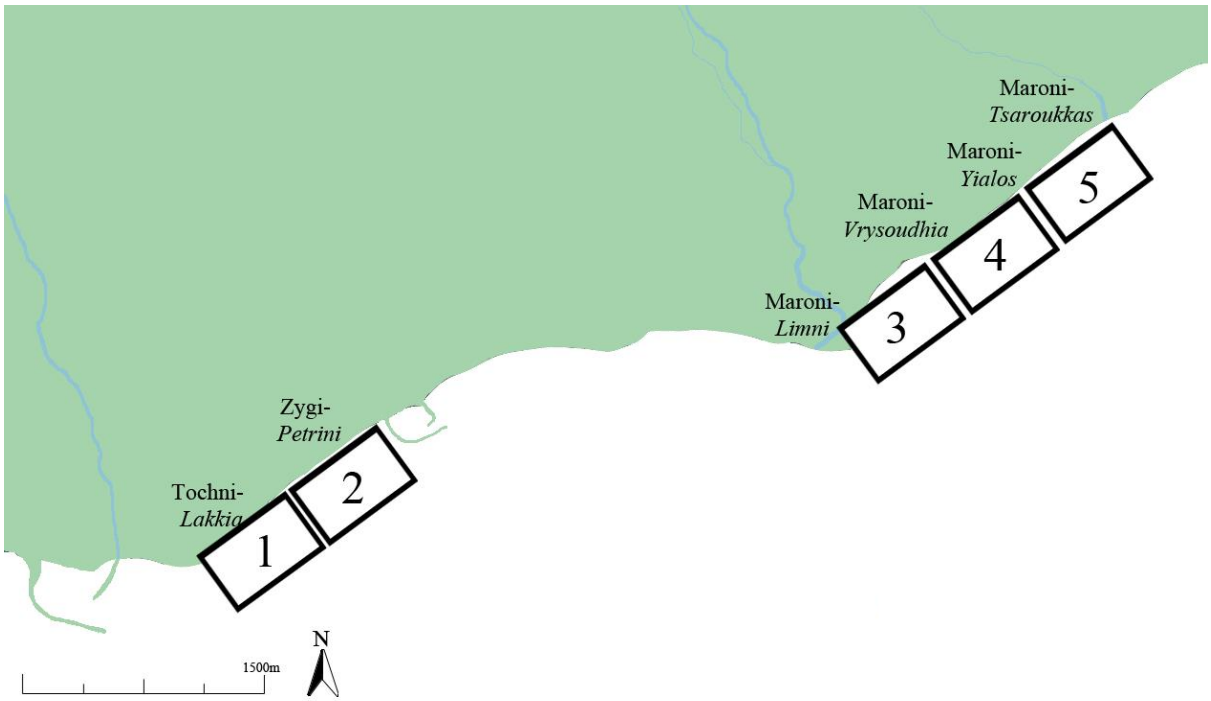

Fig.3.1. Map showing overall CASP areas of survey along the south-central coastline.

CASP Area 1 – Tochni-Lakkia**.**

This was the main targeted site and within this area walls, floors and features can be seen eroding from the low coastline scarp. The initial period of occupation is Late Cypriot with some Early and Late Archaic deposits stratified above. Survey into the field has shown that the

site continues into the area of the BEMRS radio transmission facility and this was confirmed by geophysical investigations and test excavations in 2014 (see Section 2 above).

To the east of Tochni-*Lakkia* is an old river course. There is a deposit of finer alluvial deposit in this area, and out into the water for 50-100 metres is a field of unconsolidated rocks on a limestone substrate. Pottery on the surface near the old river is a mixture of dates with Chalcolithic, Classical, Hellenistic, Roman and Medieval sherds noted. This suggests that the river has cut through sites of these periods and brought them down to the river mouth. This is interesting since this appears to be a specific hydrological basin quite separate to the Vasilikos river complex.

In 2013, the underwater area abutting the site from the Vasilikos River to the dry old riverbed to the east was thoroughly surveyed. This area was broken up into a number of five sub areas. In 2014, the underwater site was subdivided into only three areas. Due to our acquired knowledge of coastal erosion moving material along the coast in an easterly manner, the two areas designated to the east of the main site were required to be resurveyed out to 400 metres as these were the most weather prone and likely to show any material recently scoured out, or material transported eastward from the main site. The area to be surveyed was approximately 240,000 m^2 (600m x 400m).

CASP Area 2 – Zygi-Petrini,

Area 2 runs from the eastern watercourse of Tochni-*Lakkia* to the eastern extent of the site of Zygi-*Petrini*. The site at Zygi-*Petrini* is predominantly Late Roman and was first recorded by the Vasilikos Valley Survey in 1979, at that stage it was noted that coastal erosion was occurring (Todd 2004: 144, 2013: 107). A survey of the site was conducted by the MVASP project in 1997 and published in 2000. At least seven different buildings were noted. Rescue excavation also took place of a kiln producing Late Roman amphora (Manning et al 2000). Finally, in 2007 on a visit to the site Sewell and Manning noted 3 sherds in a much lower horizon sealed below the Late Roman remains. In collaboration with Joanne Clarke and the VVP these were noted as being of Early Chalcolithic date (Todd 2013: 148). The area off Zygi-*Petrini* was surveyed by the underwater team in 2013 and only one Roman sherd was observed. The sea floor erosion appears quite severe in this area with large amounts of scouring and it was not deemed necessary to resurvey the underwater section of the site in 2014.

CASP Area 3 – Maroni-Vrysoudhia

Survey involved a dive from Maroni-*Limni* at the mouth of the Maroni River down to the large house. Subsequently, a series of dives were undertaken in the water directly off the coast from the house. The area surveyed was approximately 210,000 m^2 (700m x 300m). This area is marked by a series of low terraces that gradually increase in height until a substantial cliff is met with height of 10m. The low terraces represent river scouring and deposition from the Maroni River with the cliff delineating the uneroded natural. The cliffs then gradually reduce in height to 2m towards the eastern side of the survey area.

CASP Area 4 – Maroni-Yialos

This area comprises a coastline typified by steep cliffs. Diving in this area was primarily conducted from a boat in order to maximize survey time since entry and exit points were not easily accessible. The area surveyed was approximately 120,000m^2 (400m x 300m). Survey activity in 2014 was concentrated in this area.

CASP Area 5 – Maroni-Tsaroukkas

The final area consists of cliffs gradually reducing in height as they run down to the next historic river mouth and encompassed a rocky beach with a large amount of seagrass deposited on it in the previous winter (*Posidonia oceanica*). After an initial shore-based dive in this region, all of the diving was based from a boat. The area survey was approximately120,000m^2 (700m x 300m).

3.2 Underwater Survey Methodologies

The environmental conditions often impacted survey methodologies, which were adapted to changing winds and seas. A summary of the general weather conditions and environmental issues impacting the maritime archaeological program include:

- predominantly shore based access over loose rocks;
- prevailing SW winds veering to SE winds gradually building to 15-20 knots;
- associated sea swell of 0.25-0.5m increasing with building wind conditions;
- reduced visibility near shore; and
- a prevailing, eastwards current of 0.5 knots.

While the weather conditions generally deteriorated in the afternoon, only one day of programmed diving was lost due to strong winds.

Since one aim of the underwater survey was to serve as a training opportunity for students, all tasks were developed to maximize and develop diving and archaeological skills. These techniques focused on maintaining group formation and visual contact while swimming a given transect. Survey activity was generally conducted by a three-person dive team swimming across a 20m swathe along a bearing, with different methods including:

- surface snorkelling transects in shallow water (generally with lower visibility);
- three divers holding the ends and middle of a 20m rope (for lower visibility conditions - divers 5-8m abreast following a determined compass bearing to cover a 25m swathe) (fig 3.2);
- four divers swimming abreast in a line (for better visibility and when current was less);
- variations on three divers swimming in a line at depth with a surface swimmer to guide the dive group (used during long transect swims to keep divers orientated and to produce a more accurate coverage of the transect line in medium to good visibility); and
- and towed survey (for very long transects in deeper waters and or shallow waters with good visibility).

These techniques were used flexibly to account for diver availability, depth of water, wind and current conditions, area of survey, and water entry via shore or boat.

Fig. 3.2. Maria Michael holds one end of a rope 20 metres in length, with three evenly spaced hand-holds. This method of survey assisted the divers in maintaining spacing during transect surveys in lower visibility conditions.

When accessing areas from the shore, the dive team created boxed areas as targets of survey using buoys to demarcate the extent. The selection of this methodology was based on the following three issues: (1) the improved speed of operation, and (2) accuracy could be achieved by swimming transects with a surface swimmer controlling direction. Retrieving buoys was often found to be problematic at the end of a diving day when the winds and swell had increased.

The placements of the buoys were directed from shore generally along a compass bearing of due south. Deployed buoy's positions were then fixed by GPS as a mark or encompassed within the track log record of the GPS unit. In order to systematically survey the areas, one person stayed on the surface as a swimmer, towing a dive float to which was attached a GPS unit. The surface swimmer directed the three divers deployed below within the buoyed area. Alternatively, when everyone was diving, the diver furthest from shore in the group would tow the float.

Due to the paucity of ceramic remains found during the 2013 survey beyond 20 metres from shore, the intent of the survey in 2014 was to recover for analysis and dating all sherds (both non-diagnostic, such as body sherds from *pithoi* or plain wares as well as diagnostic sherds with painted decoration or sherds with large sections of handle, rim or profile). Larger finds such as anchors or squared blocks were measured, photographed in situ and a GPS location acquired.

In addition to traditional recording methodologies that utilised tape measures, photogrammetry was also implemented to record anchors in situ. This methodology was applied to 10 single-hole weight anchors that were located off of Maroni-*Vrysoudhia* and Maroni-*Yialos* (CASP Areas 3 and 4) and 2 three-hole composite anchors off Maroni-*Tsaroukkas* (CASP area 5). To provide comparisons in accuracy, we also recorded 10 anchors previously recovered from the seabed (Manning *et al.* 2002: 114-6). The results of this study allow us to provide estimates of volume and mass for anchors still in situ (Fulton *et al*. 2016).

3.3 Results

This section presents the results of the underwater survey at each of the separate CASP areas.

CASP Area 1: Tochni-Lakkia Maritime survey

The results of the focus on Tochni-*Lakkia* have been published by Sewell et al 2016. Similar to the reported finds from survey during 2013, the subtidal zone, especially near the BEMRS facility, remained inundated with modern cultural material that had been dumped off the point. Rocks in this region had clearly been moved and rolled around by wave action. Within the 2-4m deep zone the rocks were covered with seaweed (*Padina pavonica* and *Cystoseira* sp.), making it difficult to identify cultural finds. Due to the heavy storms in the intervening winter months since last year's survey, a light covering of seagrass (*Posidonia oceanica*) had been deposited along the coastline near this site, possibly sheltered slightly by the harbour.

In 2014, six sherds were located no further than 150m offshore from Tochni-*Lakkia* (fig.3.3). Because these remains are all Late Roman and highly abraded, it is possible that they come from ceramic vessels that had been jettisoned from Roman ships or, based on prevailing currents, the sherds could have eroded from a coastal Roman site further to the west. This year's finds are consistent with those in 2013, in which Late Roman sherds were discovered up to 250m offshore. Due to the distance these finds have been located from shore and the prevailing

strong onshore breeze, the sherds are more likely to be indicative of Late Roman maritime activity rather than eroded from a coastal site (fig.3.4).

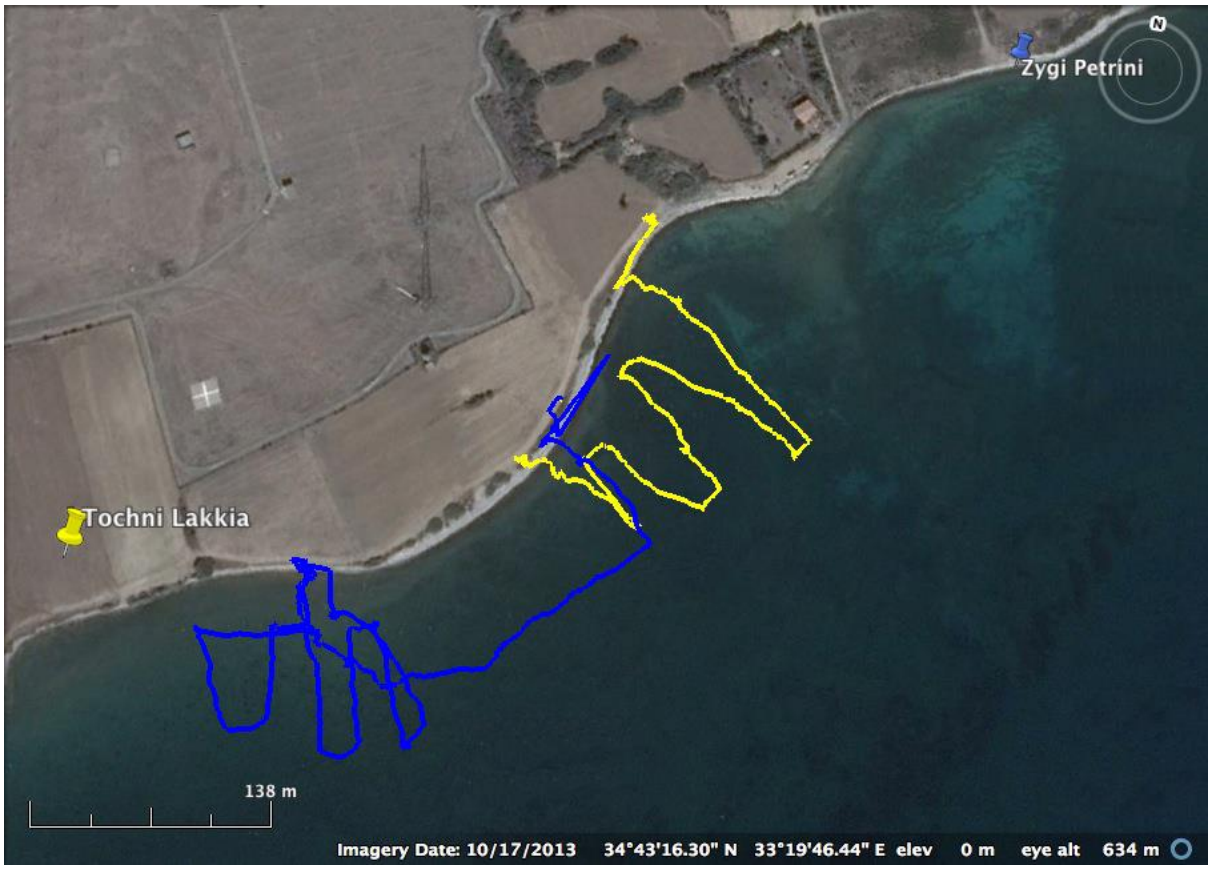

Fig.3.3. Map of area at Tochni-Lakkia surveyed in 2014. Tracks marked in blue and yellow are indicative of the track of the central diver in a survey three across.

Site	CASP Area	Late Roman	Unknown	Total
Tochni-*Lakkia*	1	6	0	**6**
Maroni-*Vrysoudhia*	3	1	0	**1**
Maroni-*Yialos*	4	12	1	**13**

Fig.3.4. Ceramic finds from 2014. Only Late Roman ceramics were observed in the three areas and one sherd of an unknown type.

CASP Area 2: Zygi-Petrini Maritime survey

No maritime survey was conducted in this region during the 2014 season.

CASP Area 3: Maroni-Vrysoudhia Maritime survey

This area encompassed a slight bay with shallow depths of about 3-4 metres out to 200m offshore. The substratum in this area was predominantly sandy with large rocky clusters and

occasional heads of *Posidonia oceanica*. A field of large boulders was observed in the area directly off of the Maroni River, likely indicative of past fluvial action.

Within this area, the cultural material was mostly comprised of ceramic remains with one stone object. One sherd, belonging to Late Roman transport amphorae, was discovered within the near shore environment out to about 120m offshore (fig.3.4). This sherd was recovered, photographed, and re-deposited in the area. One additional amphora, nearly complete but shattered, was also observed in the eastern extent of this area, having been concreted into the surroundings and consolidated with the stone that broke the vessel still in situ (fig.3.5). Due to the nature of the find and easy identification it was left unrecovered.

Fig 3.5. Broken but nearly complete amphora in area 3.

One pyramidal-shaped stone (A1) was discovered in this area with a circular hole that appeared to penetrate the rock to only approximately 9cm depth (fig.3.6). On close inspection, the hole did not appear to go all the way through the stone, and it is possible that this stone represents the beginning of an anchor or some weight; however, no definitive interpretation was immediately possible.

There were two artificial groynes built in this area, constructed by large rocks piled into a rough arc designed to trap sand. One of the groynes extends about 25m into the sea. Roman sherds were noted probably in situ only 2 to 3m from where the rocks ended.

Fig.3.6. Stone (A1) in area 3 with hole that appears only to partially penetrate the rock.

CASP Area 4: Maroni-Yialos *Maritime Survey*

The area had a maximum depth of 5m at about 300m offshore. Similar to Area 3, the substratum was predominantly sandy with occasional clusters of rocks and large heads of *Posidonia oceanica*. Many rocks in this area seem to have been covered over with large amounts of sand that had been deposited over the area, likely as a result of winter storm activities. In many cases, only the very ends of seaweed fronds were visible through the sand with the rest of the algae buried in sand. Cultural material was located up to 250m offshore.

Nine single-hole weight stone anchors were marked and recorded in this area (fig3.7). All of these anchors were measured and photographed for 3D imaging. There is one cluster of 3 anchors within an 8m area, and another cluster of 2 anchors within a 10m area. The other 4 anchors in this area were scattered in no discernible grouping. The smallest anchor was a 30cm x 30cm square anchor (A10) and the largest a 74cm x 54cm anchor (A2). In 2013, an anchor had been identified in Area 4 but was not able to be re-located in 2014. Since the area was very sandy near the recorded location of this anchor, it seems most likely that the anchor had been covered over with sand in the intervening year.

Within this area, 13 sherds were recovered, photographed, and re-deposited in the area. Out of these ceramic remains, 12 were of Late Roman vessels, and one was unidentifiable (fig. 3.4).

Anchor	**CASP Area**	**Length (cm)**	**Width at hole (cm)**	**Width at base (cm)**	**Depth at base (cm)**	**Depth at top (cm)**
1	3	64	61	--	22	--
2	4	74	52	57	18	--
3	4	66	54	75	6	13
4	4	72	42	46	14	14
5	4	56	49	48	17	10
6	4	47	24	39	10	8
7	4	50	44	44	12	16
8	4	44	43	36	17	16
9	4	40	26	32	18	15
10	4	30	28	30	9	7

Fig.3.7. Single-hole weight anchors observed in CASP areas 3 and 4.

CASP Area 5: Maroni-Tsaroukkas Maritime Survey

Similar to Area 4, the substratum was predominantly sandy with occasional clusters of rocks and large heads of *Posidonia oceanica*. The shoreline had large deposits of about a metre of *Posidonia oceanica* that had washed ashore as a result of the winter storms (fig.3.8). There was evidence of a lot of sand having been moved into the near shore areas. The area had a maximum depth of 6m at 300m offshore. Cultural material was located up to 210m offshore.

Fig.3.8. Shoreline in front of Maroni-Tsaroukkas with a large amount of Posidonia oceanica.

In 2014, in Area 5, no ceramic remains were observed; all of the cultural materials found were made of stone. Twelve stone blocks or fragments thereof were located and of those 5 were measured (fig.3.9). Only one block was observed as a solitary occurrence, otherwise blocks were either associated with anchors, more blocks, or both within a 5m area (fig.3.10). Additionally, in Area 5, 16 anchors were observed in 2014 and of those, 4 were measured (fig.3.11). Two of the anchors were large, three-holed composite type and these were imaged for 3D digital modelling. The remaining 14 anchors were single-hole weight anchors but varied in typology. In this region, an additional 6 anchors had been reported in 2013 but were not located in 2014 (fig.3.12). Observations of the seafloor conditions showed that all of the non-located anchors were in sandy areas.

	Length (in cm)	Width (in cm)	Depth (in cm)	Associated Remains	Seafloor	Depth
S1	100	32-36	30	3-hole composite anchor	sandy	5.1m
S2	*NR*	*NR*	*NR*	broken anchor	*NR*	*NR*
S3	*NR*	*NR*	*NR*	--	*NR*	*NR*
S4	*NR*	*NR*	*NR*	--	*NR*	*NR*
S5	*NR*	*NR*	*NR*	--	*NR*	*NR*
S6	*NR*	*NR*	*NR*	--	*NR*	*NR*
S7	131	58-69	48	Weight anchor	sandy	3.6m
S8	100	75	51	Weight anchor	sandy	3.6m
S9	*NR*	*NR*	*NR*	Weight anchor	sandy	3.6m
S10	141	51-67	26-30	3-hole composite anchor	rocky	4.6m
S11	*NR*	*NR*	*NR*	3-hole composite anchor	rocky	4.6m
S12	42	28	12	3-hole composite anchor	rocky	4.6m

Fig.3.9. Blocks identified in 2014. Only 5 of the 12 blocks were measured. NR = not recorded. Eight of the blocks were associated with an anchor within 5m.

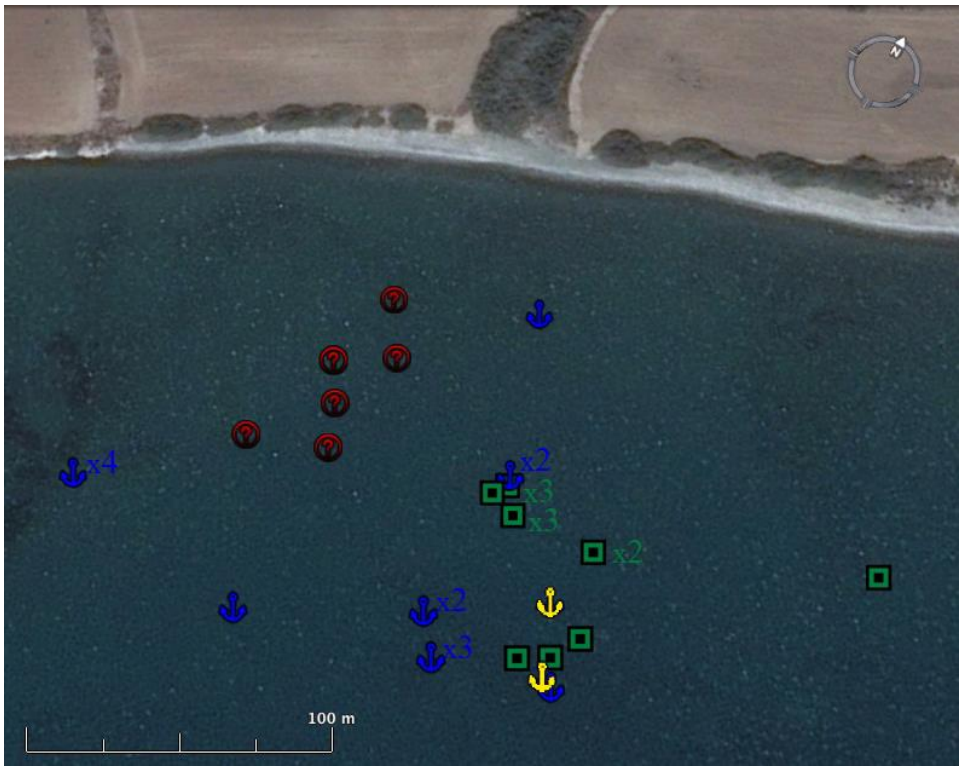

Fig.3.10. Remains off of Maroni-Tsaroukkas*. Note the location of the blocks (green squares); anchors reported in 2013 but not located in 2014 (red question mark); single-hole weight anchors (blue anchors); and three-hole composite anchors (yellow anchors).*

2014 GPS PT	2013 GPS PT	Holes	Description	No. of Anchors	Substratum	Depth
38		1	large weight anchor	4	sandy with rocks	2.6m
38		1	mid-sized weight anchor			
38		1	mid-sized weight anchor			
38		1	questionable			
31	326	1	weight anchor	3	sandy	4.5m
31		1	square weight anchor			
31		1	mid-sized weight anchor			
42		3	3-hole composite anchor	2	rocky	4.6m
42		1	small anchor			
32		broken	broken anchor	1	sandy	5.1m
33		broken	anchor split down middle	1	sandy	5.0m
37	324/325	1	single hole weight anchor	1	sandy	3.4m
43		1	single hole weight anchor	1	sandy	2.0m
50		3	3-hole large composite anchor	1	sandy with clay	1.7m
	320	1	small single hole weight anchor	1	sandy with rocks	4.3m
	327	1	single hole weight anchor	1	sandy	3.9m
	322		not located in 2014	1	sandy with buried rocks	1.7m
	323		not located in 2014	1	sandy	1.7m
	330		not located in 2014	1	sandy	3.2m
	334		not located in 2014	1	sandy with some grass	3.1m
	337		not located in 2014	1	sandy	2.0m
	339		not located in 2014	1	sandy	2.3m

Fig.3.11. Anchors identified by GPS point within Area 5 for 2013-2014. A total of 22 anchors had been marked for the two seasons but 6 of those were not viewable in 2014.

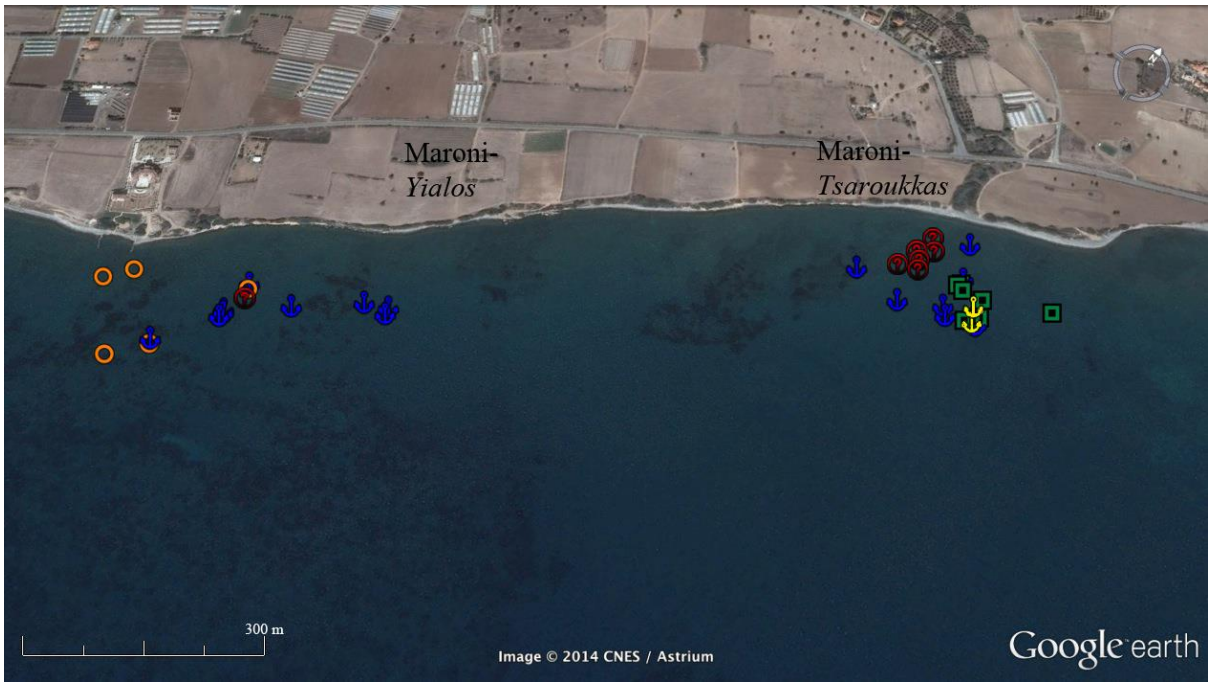

*Fig. 3.12. Marked approximate locations of observed remains from Maroni-*Yialos *to Maroni-*Tsaroukkas. *Blocks (green squares); anchors reported in 2013 but not located in 2014 (red question marks); single-hole anchors (blue anchors); three-hole anchors (yellow anchors); and ceramics (orange circles).*

3.4 Discussion and Recommendations

The fundamental environmental issue impacting survey activity is the movement of sand. Wave and current actions driven by seasonal storms dictate the deposition or scouring of sand in different areas. This natural process can cover material previously documented or scour out artefacts not previously observed. The impact of these phenomena is that areas have to be repeatedly surveyed over multiple seasons to get a complete inventory. Only by using a combination of GPS positioning and 3D imaging can anchors and other cultural material be sufficiently well recorded to enable unique identification of each object and the establishment of an accurate inventory of cultural material.

From a cultural resource management perspective, the movement of sand means that the resource manager cannot always be certain that an artefact has been removed when no longer visible. While GPS positioning is sufficient to relocate an anchor that is initially exposed and observable, the accuracy of +/- 3 metres is insufficient for relocation without extensive excavation should an anchor be buried by sand. Anecdotal evidence and direct observations in 2014 support the fact that anchors have been removed from the marine environment in the past, though how much of this happens contemporaneously is impossible to determine.

Analysis of CASP Areas

The division of regions into CASP areas for survey was arbitrarily assigned and has been proven to not reflect the observed material patterns as is the case with most survey methodologies but it does not provide any inherent bias either. CASP Area 1 coincides with the Late Bronze Age and Iron Age site of Tochni-*Lakkia* but only Late Roman transport amphorae sherds were observed in CASP Area 1 that can be associated with maritime activity. The cultural material observed in CASP Areas 3 and 4, is predominantly the remains of Late Roman transport vessels spread across the eastern edge of Area 3 and throughout Area 4. Single-hole weight anchors were clustered in the centre of Area 4 while both, single-hole weight and three-hole composite anchors were towards the eastern edge of Area 5. Preliminary observation is that interaction of river deposits and outflow is possibly a key factor in both observing material remains in a maritime context but also a driver impacting the ongoing erosion of coastal sites.

CASP Area 1 - Tochni-Lakkia

In 2013, extensive underwater survey activity was undertaken off the main site of Tochni-*Lakkia* (CASP Area 1), extending to the west of the current mouth of the Vasilikos river and to the east to the accumulated unconsolidated debris associated possibly with a smaller stream (fig.3.13). Over two seasons of survey activity, no cultural material that could be directly associated with maritime activity of likely Late Bronze Age date was located. A number of sherds and an assemblage of objects that had been exposed more recently from the eroding beach scarp were documented in 2013.

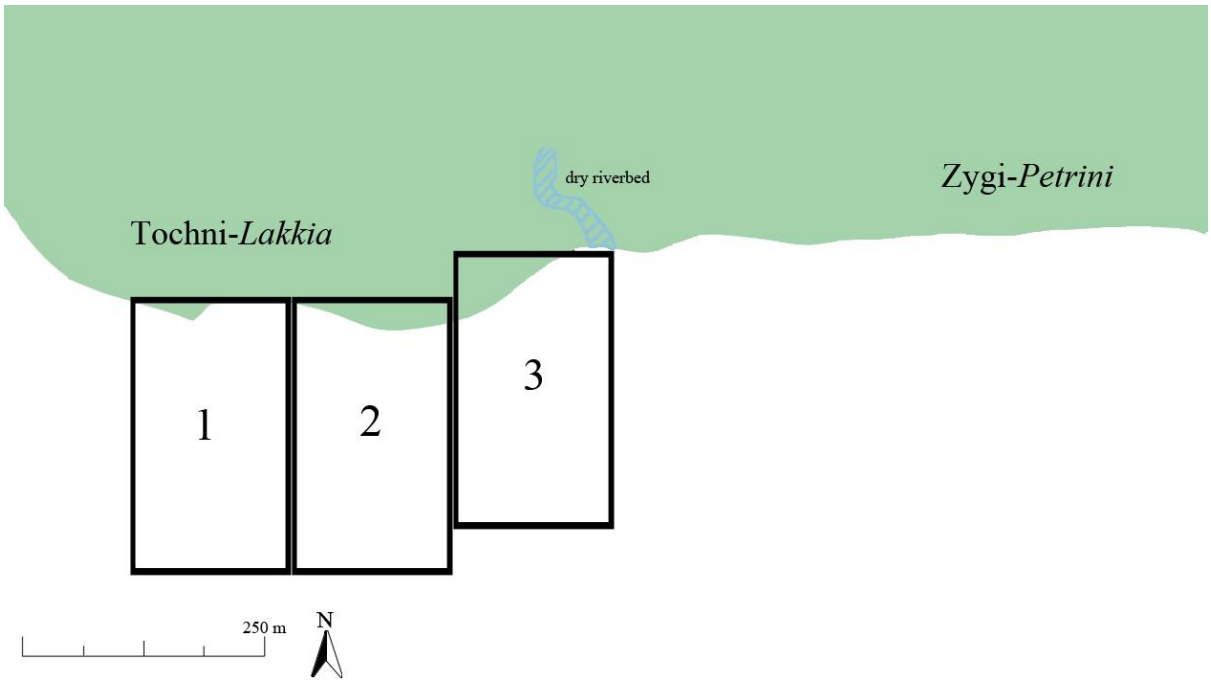

Fig.3.13. Sub-areas as labelled for survey off of Tochni-Lakkia (CASP Area 1). While the entire region was targeted in survey in 2013, only sub-areas 2 and 3 were surveyed in 2014. The remnants of a dry riverbed are visible towards the eastern edge of the survey area.

In 2014 survey activity was limited to dive surveys off locations to the east of the main site in sub-areas labelled as 2 and 3 (fig.3.13). As with observations in 2013, sea grasses and soft corals are not well established in these areas and where located are typically small. This lack of organic life is indicative of a highly mobile environment with lots of mechanical abrasion. As with 2013, efforts were randomly made in sub-areas 2 and 3 to establish the depth of overburden to the limestone bedrock. Excavation conducted by hand fanning resulted in locating modern synthetic material, near the bedrock of limestone but trapped under several large rocks consolidated by loose sand. The depth to bedrock was typically no more than 0.4 – 0.5m. Reported storm activity prior to the 2014 fieldwork season failed to uncover any new material.

While analysis of recent studies (see Section 2 above) would support maritime activity occurring off Tochni-*Lakkia*, no archaeology in the proximal marine environment where survey work can be conducted has confirmed this hypothesis. If there was material further to the west it has been lost or buried during the modern port's construction, any dredging activity, and/or the building of the retaining wall for the BEMRS facility.

Based on these observations, caution should be exercised when using sherd material to indicate maritime activity within 20 to 30m of shore along this region of the south-central coast of Cyprus. The majority of material located in this thin margin will be a mixture of recent material eroded from the near coastal environment or finds moved out of context that have been (re-) deposited.

Natural and cultural processes in the intervening years have likely negatively impacted the underwater record in a significant way with large amounts of material from the Vasilikos river now probably on top of the ancient seascape. The project has found significant sherd evidence of Roman date during survey on the east back of the Vasilikos right at the river mouth entrance. This may well be the source for the sherd material located off shore. The mouth of the Vasilikos river may have held more intact remains but significant landscape changes, dredging and sea reclamation in the modern period and in particular in the last five years have in effect placed this area outside archaeological research.

CASP Areas 3 and 4: Maroni-Limni *to the Roman site of Maroni*-Vrysoudhia *and Maroni*-Vrysoudhia *to Maroni*-Yialos

Within Areas 3 and 4 a small number of Late Roman type 1 amphorae sherds were observed across a length of 500m combining notional CASP Areas 3 and 4 (fig.3.14). Consequently, the observed cultural material associated with maritime activity could plausibly be attributable to the newly discovered Late Roman site found by the coastal survey or those inland such as Maroni Phouches and Petrera. Only one other sherd from the eastern edge of Area 3 was observed but it was neither diagnostic nor datable. All amphora remains were recorded in a band from approximately 50m to 220m offshore. As noted above, in this region small artefacts are generally moved by environmental activity in an easterly direction and towards shore, driven by a combination of wind, wave and current action. The extent of the area of the finds

and their location out to 220m from the coastline strongly supports a hypothesis that the objects were not eroded from the coastal scarp. One amphora was found in a near complete but broken state 120m from shore. The nearly complete vessel was wedged in amongst a limestone conglomerate outcropping, which would strongly indicate that its find spot was proximal to where it entered the water. The observed amphorae sherds are indicative of maritime activity in the late Roman period.

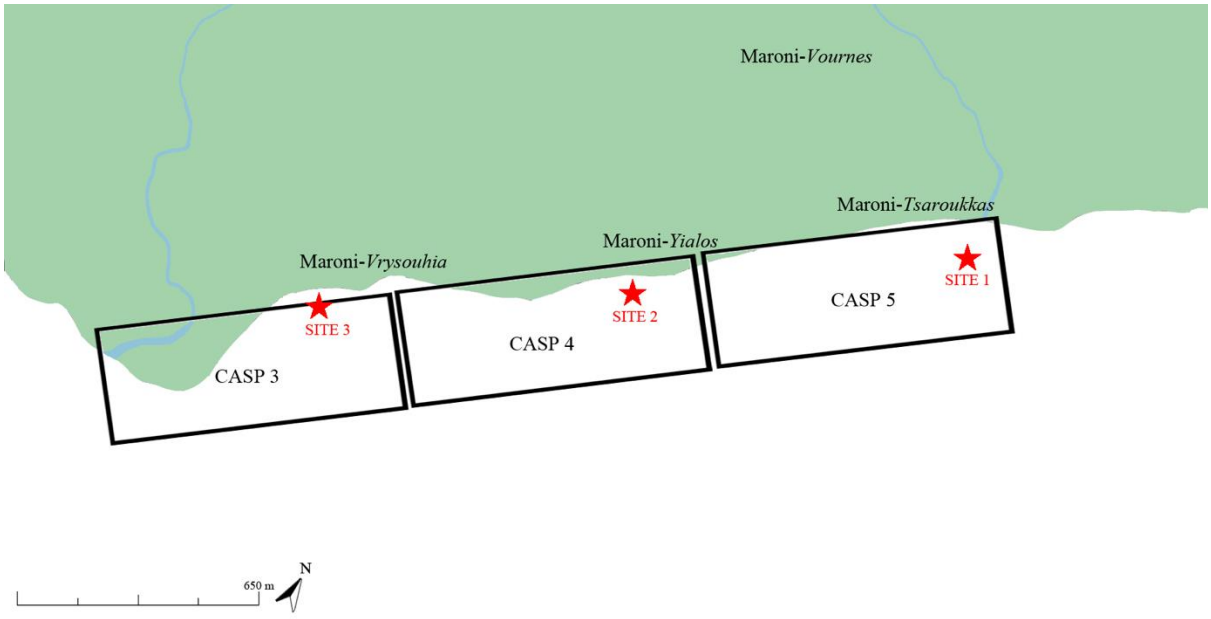

Fig.3.14. Area of survey with CASP areas number in boxes and sites from Manning et al. 2002 marked by red stars.

The western section of Area 3 is heavily influenced by the flow from the Maroni river which appears to have laid down large amounts of material and is a very turbulent environment. This would seem to replicate the situation found off the Vasilikos river. It is interesting to note here the findings of the recent underwater survey off Kouklia Achni which found 120 stone anchors (Howitt-Marshall 2012). This cluster does not lie directly off the site of Palaepaphos at Kouklia but is to the east of it. It is highly possible that there were many more anchors closer to Palaepaphos and the mouth of the Dhiarizos river but that they have been buried by river deposits and that all that is left is this eastern cluster. The single anchor therefore might not be an outlier but one which has so far escaped further damage.

Across the areas from Maroni-*Vrysoudhia* to Maroni-*Tsaroukkas* between 2013 and 2014, 33 stone anchors were located. Of those 33, we were able to relocate 26 in 2014, noting that 7

were not observable. These 7 all occurred in sandy areas of the seafloor and six of those were in one cluster off of Maroni-*Tsaroukkas*. The vast majority of these anchors had not been documented before by the previous survey (Manning *et al.* 2002).

In what corresponds to CASP Areas 3 and 4, Manning *et al.* 2002 surveyed the sites between 1993-1996 and reported cultural material and anchors (Fig.3.14). Patterns between the two decades offer very similar results. Off of Maroni-*Vrysoudhia*, Manning *et al.* (2002: 121) reported only one anchor but cultural material from the Roman period that includes a ceramic tile fragment and a marble breast weight. While the 2014 CASP survey observed 10 single-hole weight anchors off of Maroni-*Yialos*, Manning *et al.* (2002: 119) reported 11 anchors in total off of Maroni-*Yialos*: 4 single-hole weight anchors, 3 two-hole, and 4 three-hole composite anchors. As indicated above, these results are not in conflict but are explicable by the local deposition scouring behaviour associated with the movement of large bodies of sand by winter storms. It also indicates that there were at least 17 anchors observed off of Maroni-*Yialos*.

Anchors located in 2014 were predominantly to the east of Area 3 and to the west of Area 4 and are all of a single-hole weight type (fig.3.12). Sizes ranged in length from 30 to 72cm and in width at the base from 35 to 75cm (fig.3.7). This anchoring or mooring area today faces an eroded beach scarp of 1-2m in height with no cultural material visible in the section. There is no observable outflow point of an old river or scouring that would be associated with a river system in the adjacent fields. However, observation of the contour lines does indicate that there may be a small river system feeding into this area. Today the Maroni River outflows to the west of this area and to the east another old dry watercourse exits near Maroni-*Tsaroukkas*.

CASP Area 5 - Maroni-Tsaroukkas

The anchors found in 2013-2014 can be compared to the 35 anchors that were observed off Maroni-*Tsaroukkas* in surveys conducted from 1994-1999 and reported in Manning *et al.* 2002. Ten of the 35 reported anchors were composite three-holed anchors, 22 were single-hole weight anchors, and the remaining three were fragments of anchors with the hole number reported as uncertain (Manning *et al.* 2002: 114). Of these 35 anchors, 5 anchors were reported recovered and the rest reportedly left on the seabed (Manning *et al.* 2002: 114). Twenty single-hole weight anchors, 3 fragments, and 7 composite three-hole anchors. In the 2013-2014 survey, a total of 22 anchors were visible in this region of which only 16 were visible in 2014. Of these anchors,

all were single-hole weight anchors except for 2 composite three-hole anchors. As stated previously, these results are not in conflict but show the impact of seasonal deposition and scouring behaviour associate with the movement of large bodies of sand by storms.

Manning *et al.* 2002 reported finding 4 objects that were described as possible architectural elements in the area off Maroni-*Tsaroukkas* and observed that they were similar in size and shape to those at *Vournes* (Manning *et al.* 2002: 146). Cadogan remarks that the ashlar walls of Vournes were badly robbed, with evidence of robbing in the Roman period, but that some may have been standing above ground until as late as the last century (Cadogan 1988, 1989: 45). In 2014, an additional 8 squared blocks, or fragments thereof, of different shapes and sizes were found predominantly clustered with the anchors directly off the mouth of the old river in front of Maroni-*Tsaroukkas*, with one block slightly more to the east (fig.3.15). Research is yet to be conducted to ascertain if all these squared block sizes are consistent with blocks found in ashlar building constructions of the Late Bronze Age or another period.

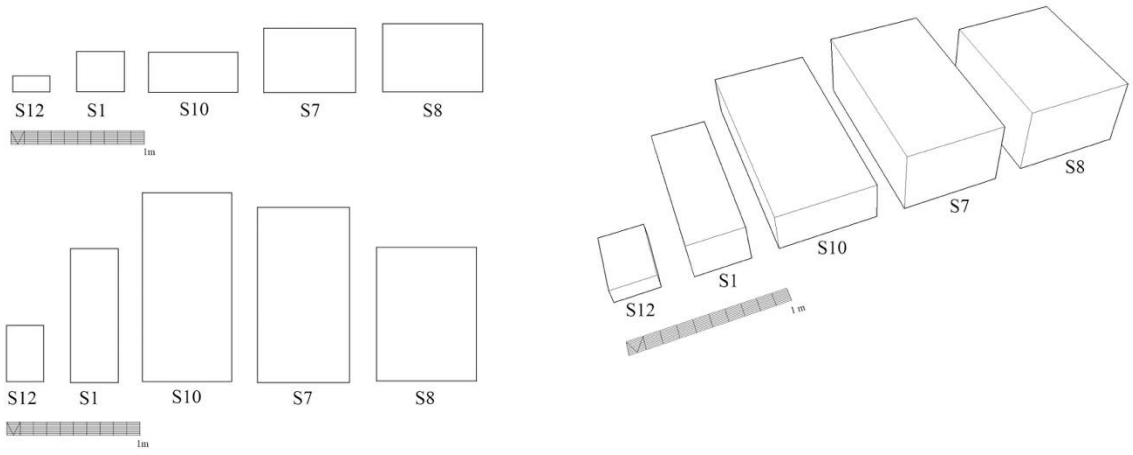

Fig.3.15. Outlines of 5 blocks measured in 2014 in Area 5.

The number, diversity and distribution of blocks suggest that there was, for an unidentifiable period of time, blocks being either loaded or unloaded at the anchorage in front of the site of Maroni-*Tsaroukkas*.

The distribution of the squared blocks is spatially associated with the stone anchor cluster suggesting a likely correlation of the two artefact types. While anchors are not good for definitive dating being potentially re-used and typologically consistent for an extended period

of time, the large three-holed composite anchors are frequently datable to the Late Bronze Age, albeit not exclusively (Frost 1963; 1970). In conjunction with the LBA pottery recorded from the 1990's this strengthens the hypothesis that the remains of the large blocks and their spatial association with three-holed composite anchors represents the first recorded evidence of lading practice in the Late Bronze Age off southern Cyprus (Manning (*et al.* 2002: 126) (fig.3.16). Of the remaining sherds found in the 1990's: 9 sherds were dated as post Bronze Age, 2 were probably Iron Age, 3 sherds were clearly Roman, 3 were Byzantine and 1 datable to the Ottoman period. The rest were un-diagnostic. No other ceramic material was observed off Maroni-*Tsaroukkas* by either the 1995-96 survey or during fieldwork conducted in 2013-2014, though, as noted above, visual observations are constrained by seasonal sediment deposition.

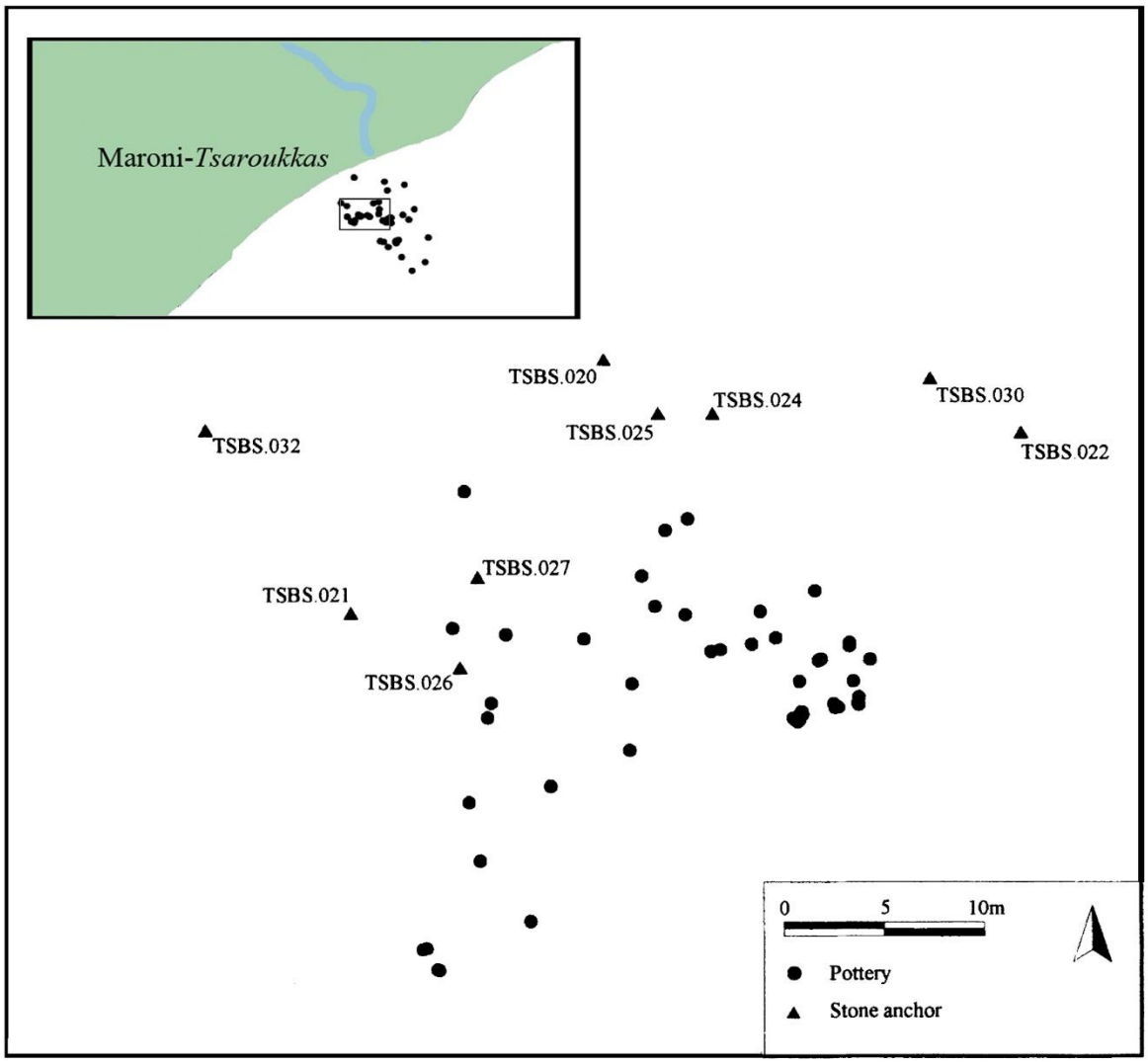

Fig.3.16. From 1996 survey (adapted Manning et al. 2002, Fig. 12), map off Maroni-Tsaroukkas *showing the roughly 75 LBA pottery remains (circles) in relation to a few of the notable anchors (triangles).*

It is possible that vessels moored up near the coast and river mouth and were loaded or offloaded offshore. The river, while very important to easily obtain fresh water, may have had another role. Rather than loading and unloading on a rocky beach subject to wind and waves, the river mouth may have offered the opportunity to more easily load or offload material in more sheltered conditions. While no maritime evidence exists to support this interpretation, such an interpretation if true would also give an indication to the type of vessel used to transport goods to and from moored vessels as it would ideally be both stable and shallow drafted.

Anchor summary

The anchors found in 2013-2014 can be compared to the 47 anchors that were reportedly observed off Maroni-*Vrysoudhia*, *Yialos* and *Tsaroukkas* in underwater surveys conducted from 1993-1996 in Manning *et al*. 2002. Five of the anchors from Maroni-*Tsaroukkas* were reportedly removed from the seabed (Manning *et al*. 2002: 114). Across the areas from Maroni-*Vrysoudhia* to Maroni-*Tsaroukkas* between 2013 and 2014, 33 stone anchors were located. Of those 33, we were able to relocate 26 in 2014, noting that 7 were not observable. These 7 all occurred in sandy areas of the seafloor and six of those were in one cluster off of Maroni-*Tsaroukkas*. Thus, given the number from the 2013-2014 survey, at least nine anchors have either remained buried, unobserved during survey activity or were removed. Importantly, the locations given for finds in 1996 do not correlate with the vast majority of positions marked using GPS in 2013-2014, neither by pattern or direct location (fig.3.17). Further interpretation of the 1996 data is required but this could be a result of methodological differences in recording as well as active scouring and deposition of sand, hiding or exposing cultural material.

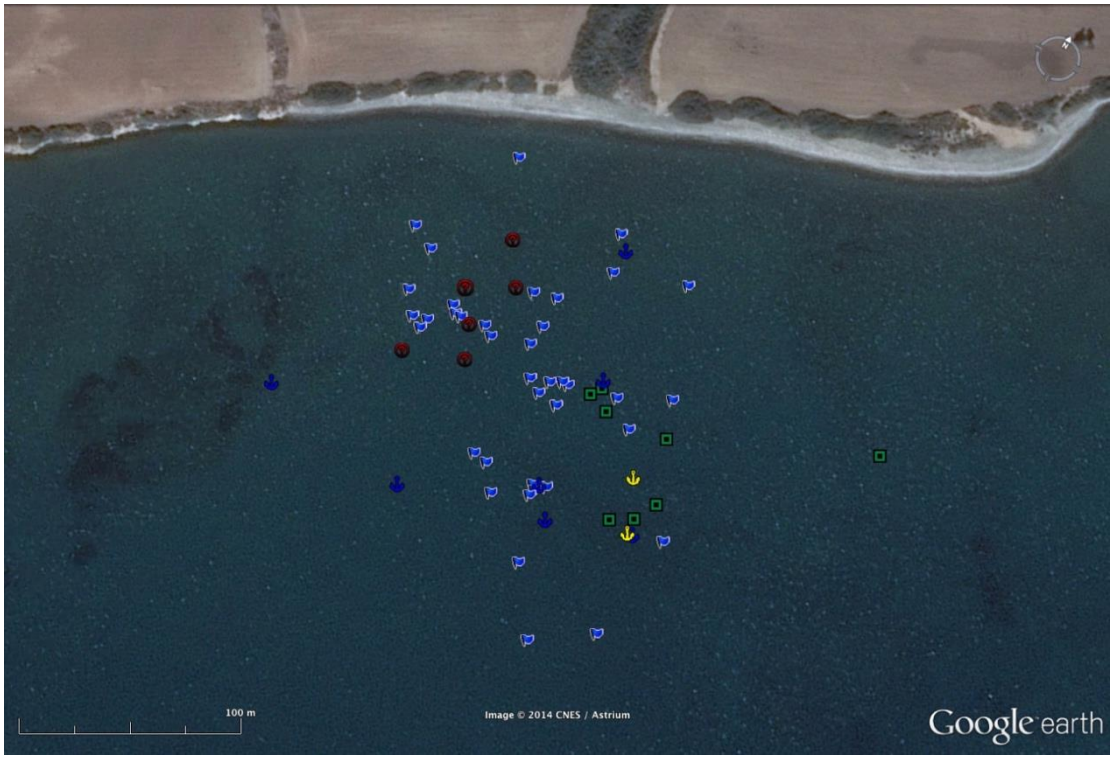

Fig.3.17. Cultural remains off of Maroni-Tsaroukkas (MTSB Site 1 = CASP Area 5). Blue flags mark the positioning of anchors from the 1996 survey reported in Manning et al. 2002. All other markings from 2013-2014 survey. While few positions align, the majority of the marks do not have a direct match.

3.5 Conclusions and Further Recommendations

A full survey of the Maroni-*Tsaroukkas* seabed is needed to fully define the anchorage. Since the work reported by Manning *et al.* in 2002 was prior to the standard use of GPS, further analysis is required to compare locations and ascertain how many of the anchors sighted in 2013-2014 were reported by Manning *et al.* in 2002 and how many are newly observed. Furthermore, the relationship between the set of anchors at Maroni-*Yialos* and Maroni-*Tsaroukkas* is of interest and would merit further investigation. There appears to be a distinct gap between the two clusters.

Furthermore, a study of the stone blocks across the site at Maroni-*Tsaroukkas* would assist us in understanding whether these were part of a harbour installation, evidence of later looting of land sites, or part of a cargo that was imported or exported.

An important observation from the two seasons of underwater survey has led to a greater understanding of the dynamic nature of the near shore underwater environment. Large quantities of sand appear mobile and are moved annually along the coastline, scouring or

burying cultural material. This was demonstrated both by the authors inability in 2014 to relocate 7 anchors discovered in 2013 and marked with GPS locations and the fact that many of the anchors located in the last two years do not match those from the 1990's survey. While cultural factors cannot be discounted, depth of sand deposition would appear to be the rate-determining step in masking or exposing underwater cultural material along the coastline. To mitigate the potential impact of this natural phenomenon on observing the archaeological record, affected sites should be continuously observed over a period of time to better gauge their extent and the material that they contain. In conjunction with this approach a method for recording when an anchor was last documented in situ now needs to be developed. Ideally this will, in conjunction with post survey analysis of anchors using photogrammetry, assist in better data management and comprehensive recording of the underwater archaeological record.

SECTION 4 - COMPARATIVE GEO-REFERENCED INFORMATION

Prior to any analysis of the problem of coastal erosion and its impact on cultural heritage in Cyprus, it is necessary to provide a terminological framework. According to EUROSION (2004b: 48), "Coastline can be defined as the interface between land, sea and air. However, due to the dynamic forces operating at the coastal margin, its position cannot be precisely defined". EUROSION's definition on coastal erosion is "the encroachment of land by the sea after averaging over a period, which is sufficiently long to eliminate the impacts of weather, storm events and local sediment dynamics" (EUROSION 2004b: 8). Finally, "Coastal erosion results from the cumulative impact of a wide range of natural and human-induced factors, none of which may be considered as the single cause of erosion" (EUROSION 2004b: 15).

It is generally argued that all coasts are to some extent affected by erosion. EUROSION estimated that in Europe in the early 2000s 20% of the coast, corresponding to 20000km was under threat. Among these 20000km, 15100km were actively retreating, at least 2900km of retreating coasts bore defensive structures and at least 4700km were artificially stabilised (EUROSION 2004b:2). The annual estimate of area impacted by severe erosion is approximately 15km^2, which often is damage to private property. In addition, based on current trends, it was estimated that by 2020 the extent of coastline with defensive structures will be over 10000km, which raises the issue of the sustainable monitoring and management of the European coastline (EUROSION 2004b: 26). Finally, researchers argue that the most vulnerable areas are low-lying, including coastal plains, barrier coasts, river deltas and estuaries (Roca *et al.* 2008: 400 with references).

Coastal erosion and its impact on archaeological resources is a world-wide concern and often coincides with areas of dense human occupation and anthropogenic changes in the environment (Erlandson 2008: 167; Reeder *et al.* 2012: 187). These may include dam construction, coastal modification such as land reclamation, destruction of wetlands, mining, dredging, population growth, looting, increased marine traffic, gas mining and water extraction (Erlandson 2012: 137). Erlandson estimated that 50% of world population lives within 100km of a coastline, whilst in the early 2000s approximately 100 million people occupied directly coastal areas with an elevation less than 1m (Erlandson 2012: 138 following Zhang *et al.* 2004: 41). A large number of archaeological and historical sites have coastal locations and are constantly eroding. These include the Pinnacle Point caves dating c. 160,000 years BP, Gibraltar's Vanguard coastal caves used by Neanderthals and the Easter Island (Rapa Nui) temples in the Pacific

(Erlandson 2012: 139-140 with references). Studies discussing the global aspects of coastal erosion in cultural heritage acknowledge that many countries lack sufficient resources and legal framework to protect coastal archaeological sites (EUROSION 2004b: 4; Rick and Fitzpatrick 2012: 135). In fact, only few countries have institutionalised coastal risk assessments (EUROSION 2004b: 17).

4.1. Coastal Erosion in Cyprus

The coastline accessible for scientific research in Cyprus is 772km and comprises only 13% of the island's area. Currently, 40% of Cypriot population works and resides in this area, which also provides hospitality to 90% of the tourist industry. This is a completely different picture from the traditional land use of the coastline, especially prior to the 1970s, which was mainly used for agriculture and fishing. The construction of tourist and industrial infrastructure has altered the character of the Cypriot coastline drastically and has contributed to a series of environmental issues, including erosion (Loizidou 2008, Monumenta: For the protection of natural and architectural heritage in Greece and Cyprus, www.monumenta.org).

Coastal erosion is a long acknowledged problem in Cyprus. Recent estimates indicate that over 30% of the coast is impacted by erosion and this percentage places Cyprus at a high ranking among other European states (Triton Consultants 2002: 4; Κορωνίδα 2008: 8). Since the 1980s the problem of erosion was addressed with hard solutions such as offshore breakwaters and groynes (Triton Consultants 2002: 19). In the following years, especially when private properties were threatened, a series of more specialised studies began in order to understand the coastal mechanics, especially of the south-central coast of Cyprus (e.g. Thomas 1981). As part of these attempts the Republic of Cyprus created an Integrated Coastal Zone Management, funded through the European MEDSPA Programme in the 1990s. A committee was created, which comprised a variety of specialists and technicians who recorded all problems related to the island's coastal zone. As part of this project, an *ad hoc* committee was created which included representatives of governmental departments and organisation involved with the coastal zone (Triton Consultants 2002: 14).

The first attempt to quantify coastal erosion in Cyprus was undertaken by Delft Hydraulics, who compared maps from the 1920s and the 1970s. Based on these maps, they created a table listing areas where the coastal recession was more than 0,5m per year, which they considered as 'accelerated' erosion (Delft Hydraulics 1993: 35t, tbl.5.1). According to this table, the

coastline between Zygi and Kiti, which includes the area under investigation, contains at least 6,25km subjected to accelerated erosion. The reasons behind this alteration in the landscape are not simple nor easy to discern.

Coastal Section		Receded Shoreline [Km]
No.	Name	
1	Tilliria	2,25
2	Chrysochou Bay	0,6
3	Akamas	0,5
4	Pafos – N	0,55
5	Pafos – S	2,5
6	Episkopi Bay	2,1
7	Cape Gata	0,3
8	Limassol	2,40
9	Zygi-Kiti	6,25
10	Larnaca	c. 2
11	Agia Napa	c.0,5
12	Protaras	c. 0,5

The problem of coastal erosion is relevant to the complex and geo-dynamic nature of the coastline (Davis and Barnard 2000; Erlandson 2012; Rick & Fitzpatrick 2012: 135; Mourtzas 2012: 884; Mourtzas and Kolaiti 2013: 411 with references), which is the point of contact between land and a body of water (Pajak and Letherman 2002; Sesli *et al.* 2009: 392; Ford 2014: 767). As such, the coastal zone is affected by a variety of natural (e.g. waves, tides, tectonic activity), past and more recent anthopogenic factors (e.g. intense human occupation, port infrastructure, coastal defence structures, river damming), the "signatures" of which have been identified in geomorphological studies of coastal deposits (Pye and Allen 2000; Davis and Barnard 2000; Petzelberger 2000; Coles 2000; Anthony *et al.* 2014: 336). The effect of these factors renders the definition and extent of coast and coastal zone, as an area where marine and terrestrial processes co-influence each other (Westley and Dix 2006: 13-14) different in different countries/contexts, and by extent this impacts the relevant archaeological approaches (Ford 2014: 764). In addition, although much of maritime activities on the coast are in most occasions observed to be archaeologically obscure, they remain in the historical, geological, sedimentological and geomorphological memory, assisting

archaeological and anthropological research (Marriner and Morhange 2007). Nevertheless, for areas that have not been subjected to geomorphological and sedimentological studies —including the case studies of CASP —their protection, understanding and exploration remain a challenge. Within this framework, our report can only be characterised as a preliminary investigation. We hope, however, to develop it into a more extensive and comprehensive and multidisciplinary study in the future.

The main case-studies in the investigation of coastal erosion in Cyprus comprises an area of 36km between Cape Dolos (Governor's Beach) to the west and Cape Kiti to the East. Vasilikos, Maroni and Pentaschoinos rivers are part of this area. This coastline, due to its rapid development was found to suffer from severe annual erosion of up to 0,5m, and the damming of rivers was considered a major factor leading to the acceleration of erosion. Another factor was the mining of sand and gravel in the adjacent coastal area, which was legally prohibited in the early 1970s (Thomas 1981: 27). The volume of mined material cannot be estimated in specific coastal areas, however an indicative estimation was provided for the Dolos-Kiti, where between 1955 and 1970 had 300 000m^3 of sand and gravel were removed (Triton Consultants 2002: 32). Delft Hydraulics (1993: 49, tbl. 7.2) provided a similar estimation for the years between 1975 and 1980, the rate of which appears to correspond with the aforementioned estimation, which covered 25 years.

Name	Year	Status	Material	Quantity (m^3)
Tilliria	1955-1965	Illegal	Sand	100000
Chrysochou Bay	1955-1970	Legal	Sand/gravel	300000
Akamas	1955-1965	Legal	Sand	10000
Pafos – N	1965-1990	Legal	Sand/gravel	1000000
Pafos – S	1965-1980	Legal	Sand/gravel	300000
Episkopi Bay	1975-1980	Illegal	Sand	10000
Cape Gata	?	Illegal	Sand/gravel	?
Limassol	1975	Legal	Sand	1000
Zygi-Kiti	1960-1980	Illegal	Sand/gravel	60000
Larnaca	1970-1980- today	Legal/illegal	Sand/gravel	20000

Sand mining on the beach and nearshore is generally recognised as a key agent in the alteration of coastal topography (Fitzpatrick *et al.* 2006: 255 with case studies and references), as it contributes to its destabilisation and increases dramatically foreshore steepness, which makes the foreshore larger than the sediment input (Fitzpatrick 2012: 180). Moreover, Thomas (1981: 27) suggested that during the 1970s when the mining of beach material ceased in Limassol, erosion appeared to decrease dramatically.

Finally, another factor generally argued to accelerate erosion is the construction of "defensive" structures such as harbours, groynes and break waters. Such structures often block the natural alongshore sediment supply and leave the coast exposed to erosion (Delft Hydraulics 1993: 54). As a result, although they are protecting their intended areas, they are concurrently negatively affecting other adjacent areas.

All above anthropogenic factors (river damming, beach mining, defensive structures) affect the balance between sedimentation and erosion. The rate of erosion, however, depends also on the natural characteristics of the areas, such as the geology and geomorphology of the coastal scarp, its exposure to wind and waves, as well as precipitation. These variables contribute to differing degrees of erosion within the same coastline. However, although the rates of erosion resulting from natural processes, specifically climate, topography, soil properties and vegetation (Vrieling 2006: 3) are unpredictable, it is possible with the employment of a long-term monitoring and investigation of coastal deterioration to reconstruct these patterns and observe their relation with climatic change and anthropogenic processes (Ma *et al.* 2011: 1535-1536 with case-studies).

4.2. Aerial-Photography and Reconstruction of Land-Loss

In our study, we use *in situ* investigation and GIS mapping of the retreat and accretion patterns of the coastline to provide quantifiable information for the creation of archaeological buffer zones, future planning, and direction of plans for land development. This investigation employed both *in situ* recording and data interpolation through the analysis of aerial photographs. The study of aerial photography in a digital environment is a methodology applied frequently in the study of erosion and its impact on coastal cultural heritage (e.g. Vasseur and Hequette 2000; Vrieling 2006; Sesli et al. 2008; Brunning 2012: 455; Bell 2012: 470-471).

Before proceeding to a presentation of the quantified results of erosion in the area of investigation, it is important to clarify that inaccuracies may derive from rectifying the aerial photography, geo-referencing, mapping the coastline of the following years and the resolution and RMS error when taking measurements with ArcGIS. Although the present study provides some measurements, these are best used to discuss the *relative* degree of erosion.

Before discussing the combined imagery we produced, it is useful to discuss the methodology we have employed. In the present study, cartographic analysis followed standard cartographic procedures (Longley *et al.* 2011), and processing was undertaken within ESRI ArcGIS 10.3. For the comparison of aerial photographs we followed five steps:

(1) Collection of geo-referenced, i.e. associated with the physical space, aerial photography taken in 1963, 1993 and 2008. Aerial photography was georeferenced by the Department of Lands and Surveys of the Republic of Cyprus (DLS) using first-order polynomial transformation.

(2) Mapping of the coastline following location of the coastline photographed in the aerial photography series provided by the DLS.

(3) Superimposition (layering) of aerial photographs to observe changes in coastal recession and advancement.

(4) Comparison of the coastlines of 1963, 1993 and 2008, which are marked with discreet colours in order to visualise significant changes in coastal recession and advancement.

(5) Quantification of land-loss based on comparative coastlines using the "measure" tool on ArcGIS 10.3 platform (Geographic Information Systems).

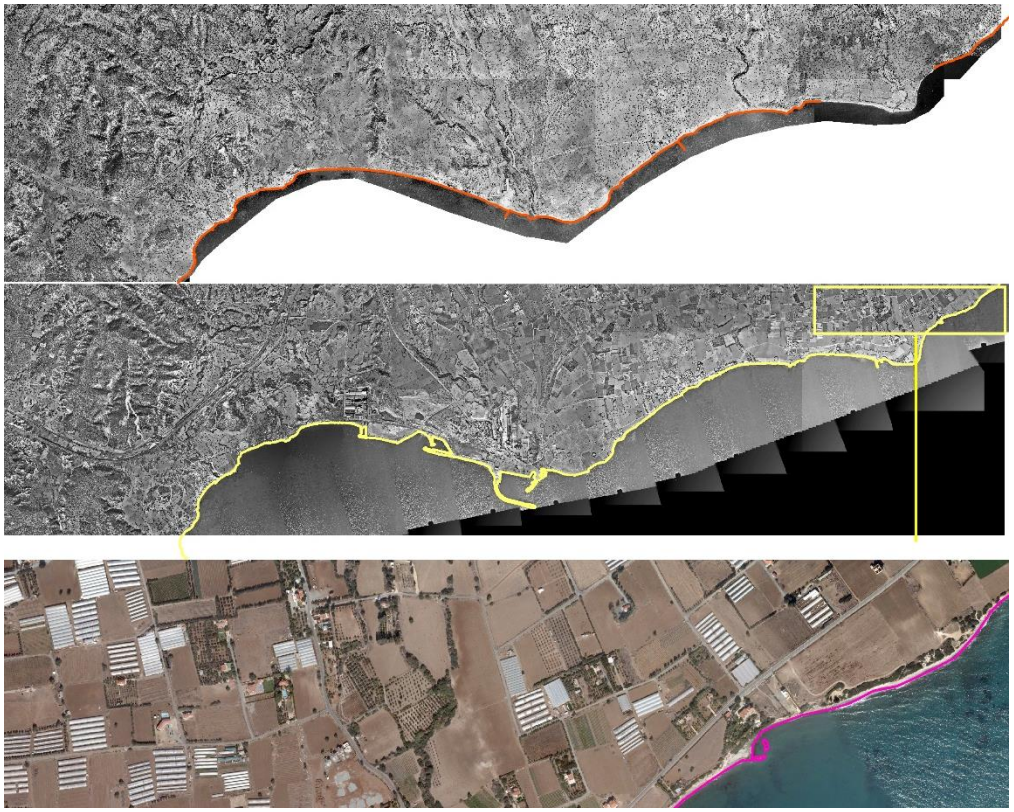

Fig.4.1 Top: 1963 aerial photograph with the coastline drawn in orange, middle: 1993 aerial photograph with the coastline drawn in yellow, botton: selection of 2008 aerial photograph with coastline drawn in pink (Aerial photographs and coastline geodatabase provided by DLS – G.M. Andreou).

4.3. Results

Based on comparisons between the coastline as shown in the 1963 photograph (orange coastline), the yellow line corresponding to the 1993 coastline and the pink line corresponding to the 2008 coastline, the land loss at the BEMRS field (between 1963 and 1993) can be measured at >10m at the main field of the archaeological site. The coastal section at the east of the archaeological site does not seem to have been affected by erosion (*fig.4.2*). Comparable rates can be observed for the erosion patterns of the coastline between 1993 and 2008. To be more precise, 5-6m of land have been lost during those 15 years.

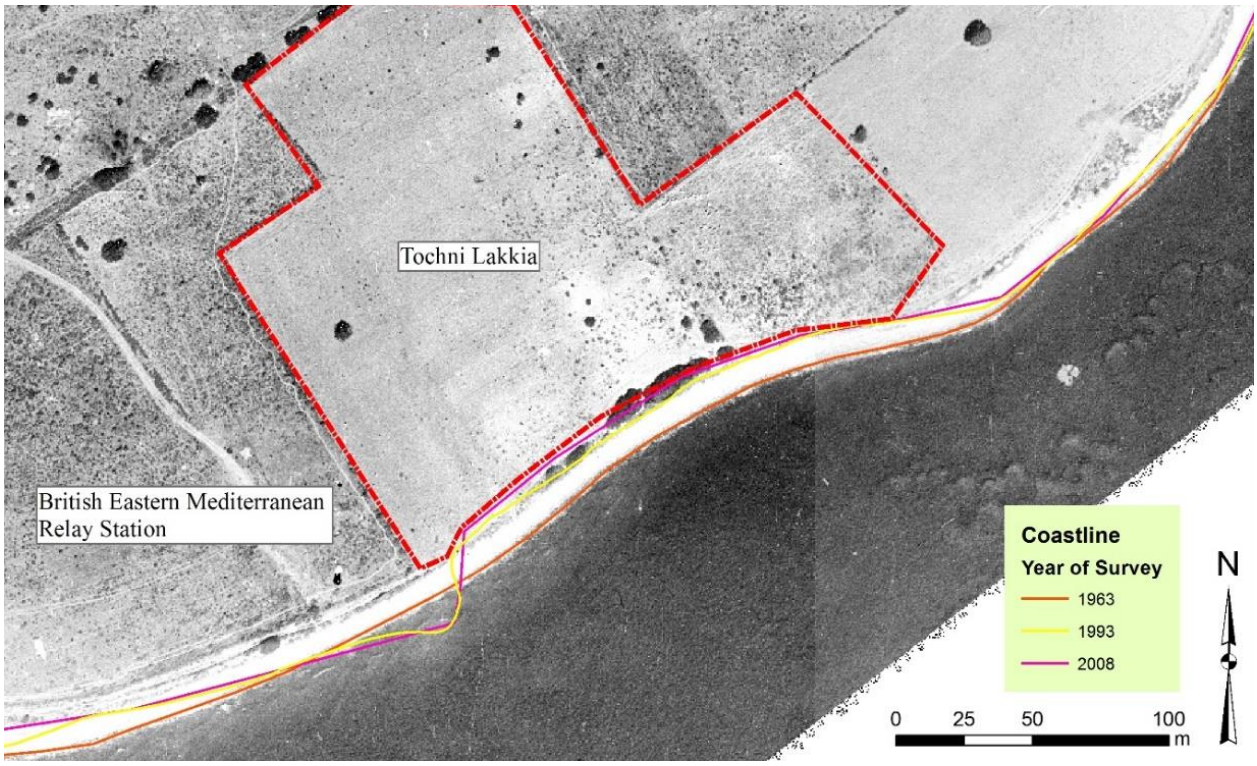

Fig4.2 Coastal erosion at Tochni Lakkia between 1963 and 2008 (Aerial photographs provided by the DLS – G.M. Andreou).

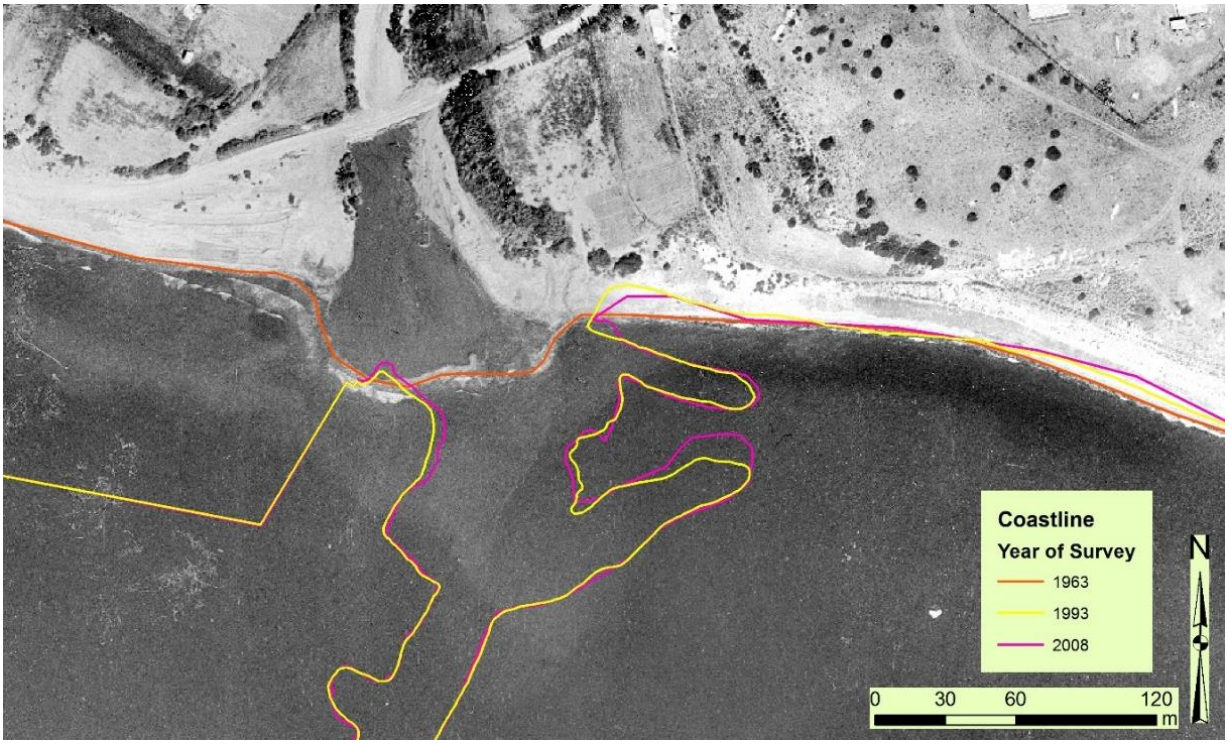

Fig.4.3 The estuary of the Vasilikos River prior to its industrialisation (*Aerial photographs provided by the DLS – G.M. Andreou*).

In fig.4.3, we can note the construction of the industrial port at the mouth of Vasilikos (1983). The industrialisation of this area likely contributed to the higher degrees of erosion observed in the 20th century along the south-central coast of Cyprus. Although the port is located close to the BEMRS field, the construction of break waters appears to have provided protection from high tide, which likely affected the more exposed area of Tochni-*Lakkia* that is located further to the east. It is worth noting that in the 1963 photograph, which dates prior to the construction of the port facilities, the mouth of the Vasilikos River can be measured at approximately 65m, which could accommodate the arrival of small boats.

The average land loss at fields to the east of the main archaeological section of Tochni is approximately 10m between 1963 and 1993. These numbers decrease further to the east and toward the dirt road that gives access to Tochni *Lakkia*. Average land loss in that area between 1963 and 1993 ranges between 1m and 2m, with a maximum recorded land loss a little over 4m and a minimum recorded land loss under 1m.

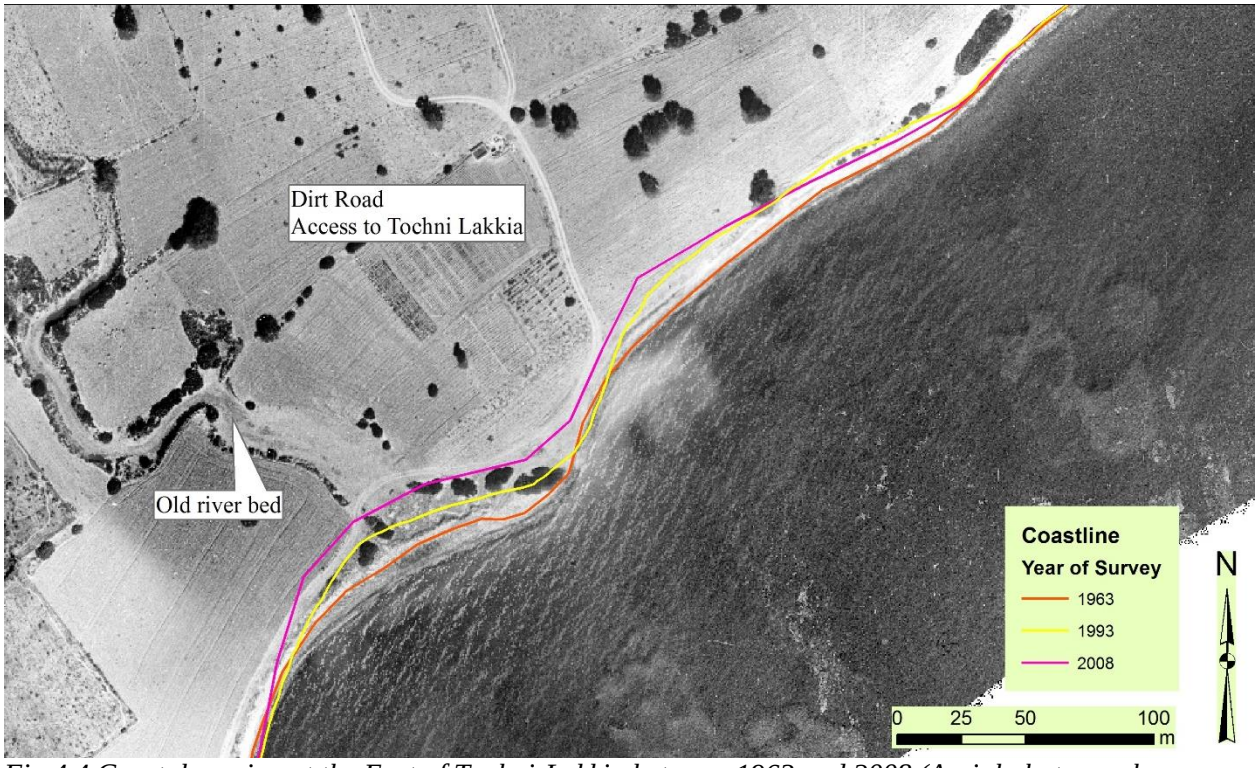

Fig.4.4 Coastal erosion at the East of Tochni-Lakkia between 1963 and 2008 (Aerial photographs provided by the DLS – G.M. Andreou).

The fields further to the east (c. 350m from Tochni-*Lakkia*) and toward the access road have also experienced severe erosion. One can observed in fig. 4.4 that more than 10m of land have been lost between 1963 and 1993 and an additional 10m between 1993 and 2008. It is worth noting that the part of the coastline with the highest amount of erosion is around an old river bed. It is

likely that the erosion has accelerated following the complete drying of this river and the decrease in the amount of sediment transported to the coast. Moreover, one can note that the fields, which contain the highest amount of archaeological information in their exposed sections, seem to suffer from the highest degrees of erosion. This may be related to the fields' orientation and their proximity to the industrial zone and the break waters. At the same time, although the archaeological features, especially the walls, are initially protecting the section from erosion, they are subsequently undermined and upon collapse they might result in a larger scale of erosion.

To the east side of the dirt road that provides access to Tochni-*Lakkia*, one now finds the almost completely eroded Roman site of Zygi *Petrini*. The general area surrounding *Petrini* and for approximately 100m E-W, the coastal erosion between 1963 and 1993 can be measured between 4m and 11m. When comparing the 1993 and 2008 aerial photographs, changes in the coastline of this area appear slightly more severe with erosion ranging between 3m and 6m (*fig.4.5*).

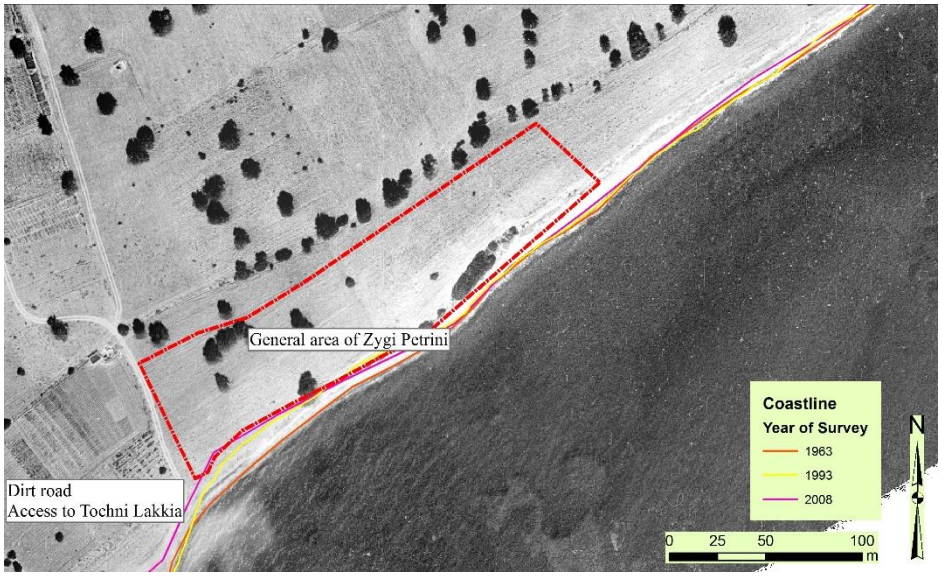

Fig.4.5 Coastal erosion at Zygi-Petrini between 1963 and 2008 (Aerial photographs provided by the DLS – G.M. Andreou).

The c. 1,3km coastline between Petrini and two sets of groynes at the East of Zygi does not demonstrate dramatic erosion, although it is probable that a series of alterations took place such as land reclamation, related to the touristic development of Zygi. Thus, while the quantity appears to be little changed, the preservation of the integrity of the landscape has greatly been altered. Having a closer look at the 1963 and 1993 coastlines, one may observe that the coastline between the groynes and for a distance of about 200m to the East, has retreated dramatically (*fig.4.6*). Land-loss ranges between 6m and 16m. These fields appear to be related to a river extending inland with a NE direction. In the following 15 years between 1993 and 2008 land-loss appears, however,

less dramatic. One can observe that by that time the main infrastructure of the Zygi Marina is complete and a series of 5 offshore breakwaters were place parallel to the coast. These defensive structures have undeniably contributed to the decrease of erosion.

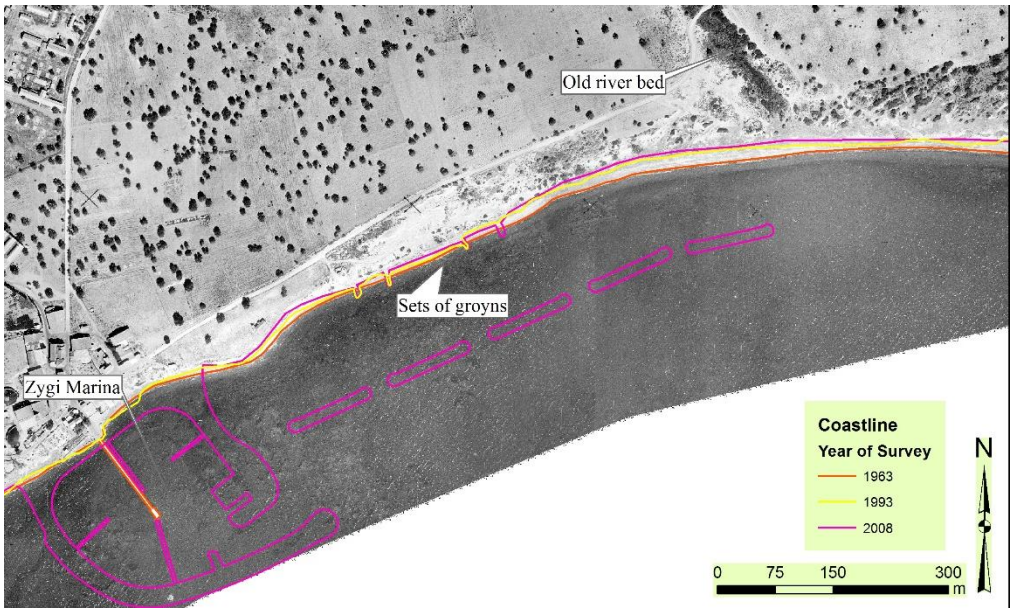

Fig.4.6 Coastal erosion around Zygi between 1963 and 2008 (Aerial photographs provided by the DLS – G.M. Andreou).

At approximately 0,5km to the East of Zygi Marina, the coastline appears relatively stable. Dramatic erosion is observed, as expected at the west of the Maroni River (*fig.4.7*). A breakwater has been constructed a few metres to the west. It is unknown, however, how this breakwater interacted with erosion and land-loss. In the comparison between the 1963 and 1993 coastline, one can observe land-loss between 10m and 25m, and in the following 15 years (1993-2008) erosion can be estimated at 5m.

Fig.4.7 Coastal erosion around the mouth of the Maroni River between 1963 and 2008 (Aerial photographs provided by the DLS – G.M. Andreou).

The coastline to the east of the aforementioned area and up to the mouth of the river adjacent to Maroni-*Tsaroukkas* does not demonstrate erosion at a high rate (*fig.4.8*). However, as expected, the area surrounding the estuaries of this now dry river demonstrates higher degree of land-loss of up to 6m between 1963 and 1993.

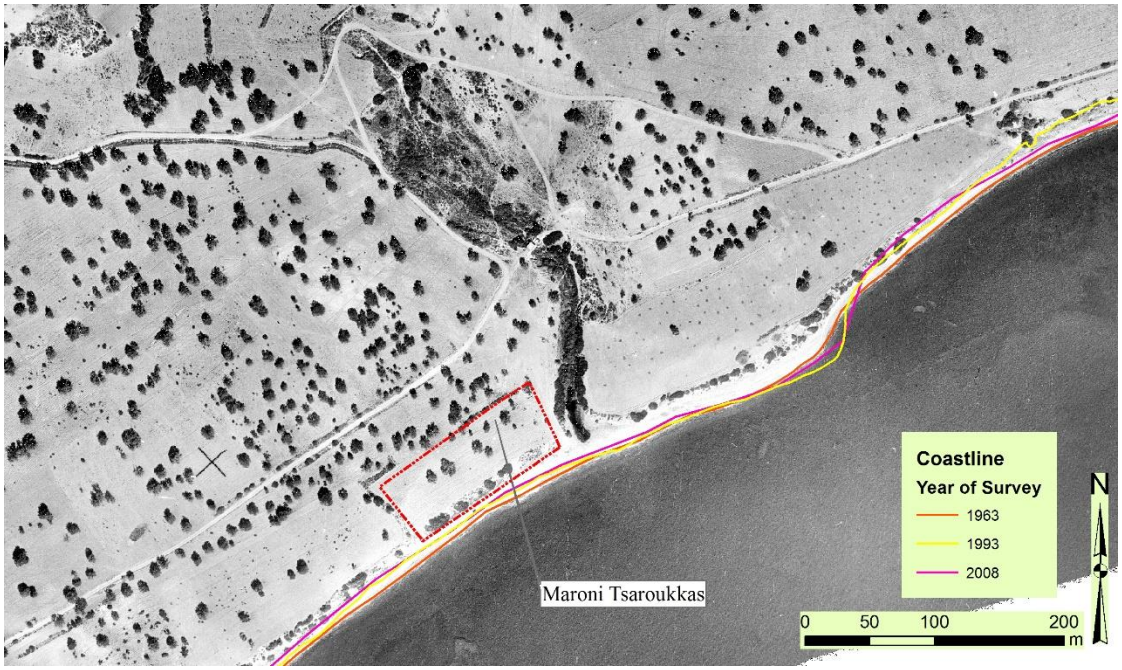

Fig.4.8 Coastal erosion around the mouth of the Maroni River between 1963 and 2008 (Aerial photographs provided by the DLS – G.M. Andreou).

One of the most severe cases of erosion was observed on the coastline located about 150m East of the Maroni river (*fig.4.9*). In a length of over 200m erosion can be estimated at a maximum of 28m between 1963 and 1993, and an additional 8-10m between 1993 and 2008. Severe erosion is also observed in the coastline further to the East and up to the Alaminos breakwater (*fig.4.10*). In this area about 45m of land were lost between 1963 and 1993. Erosion continues at a rather slower rate, however, between 1993 and 2008 with a maximum recording of 10m. The reasons behind the fluctuation of erosion rates in this area are not clear.

Fig.4.9 High erosion rates between Maroni and Alaminos in the years between 1963 and 2008 (Aerial photographs provided by the DLS – G.M. Andreou).

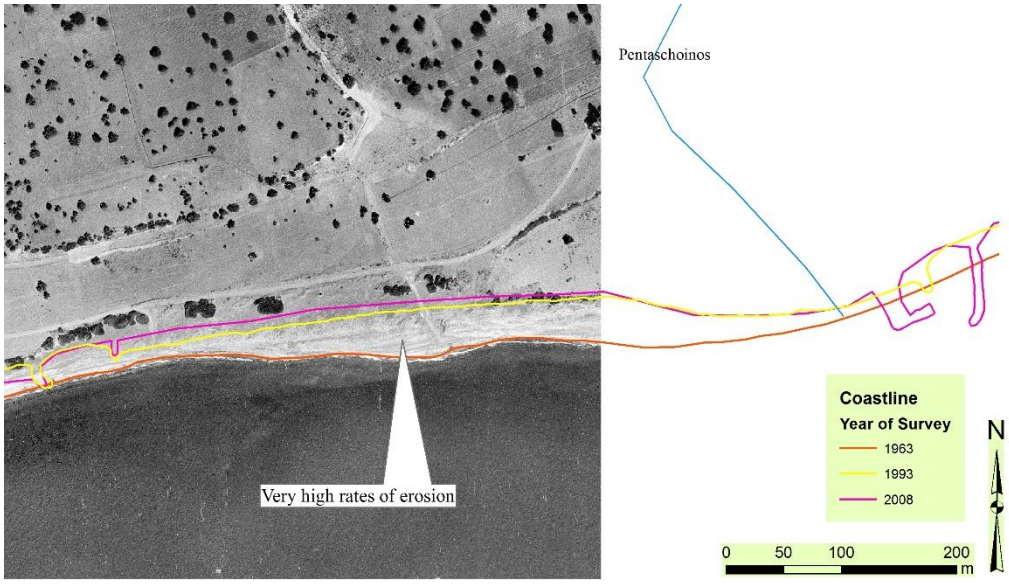

Fig.4.10 High erosion West of Pentaschoinos between 1963 and 2008 (Aerial photographs provided by the DLS – G.M. Andreou).

4.4. Estimating the Loss of Material at Tochni-Lakkia

Although it was possible to estimate loss of land due to erosion at the south-central coast of Cyprus for the past 50 years, it is very difficult to estimate how much land has been lost during and since the premodern times. It is probably unlikely, however, that Tochni-*Lakkia* after its abandonment in c. 1200 BC, was subjected to such high rates of erosion – that is an annual of >0,5m. That would be a remarkably and unrealistically large amount of lost land. It is most likely that dramatic erosion (more than 0,5m annual loss of land) is primarily a 20th century phenomenon. At the same time, we should consider that it is not clear if Tochni-*Lakkia* and the other coastal sites mentioned in Section 1 were coastal or near coastal.

Published coastal sites that are contemporaneous to Tochni are located within 300m and over 3km (Enkomi) from the present coast. Episkopi-*Bamboula* is approximately 2km from the coast, the Limassol Enaerios burials c. 300m from the coast, Kition over c. 750m, Hala Sultan Tekke is unknown, Palaepaphos over 1,5 km (although a port is now likely located in a silted up area) and Morphou-*Toumba tou Skourou* over 3km. These locations, of course, do not reflect the distance of these sites from the sea during the LBA. They are useful indications, however, that only Tochni-*Lakkia* and Maroni-*Tsaroukkas* are at present directly coastal LBA sites. It is necessary to examine if this distance is related to coastal erosion or it, in fact, reflects decision making process of the LBA.

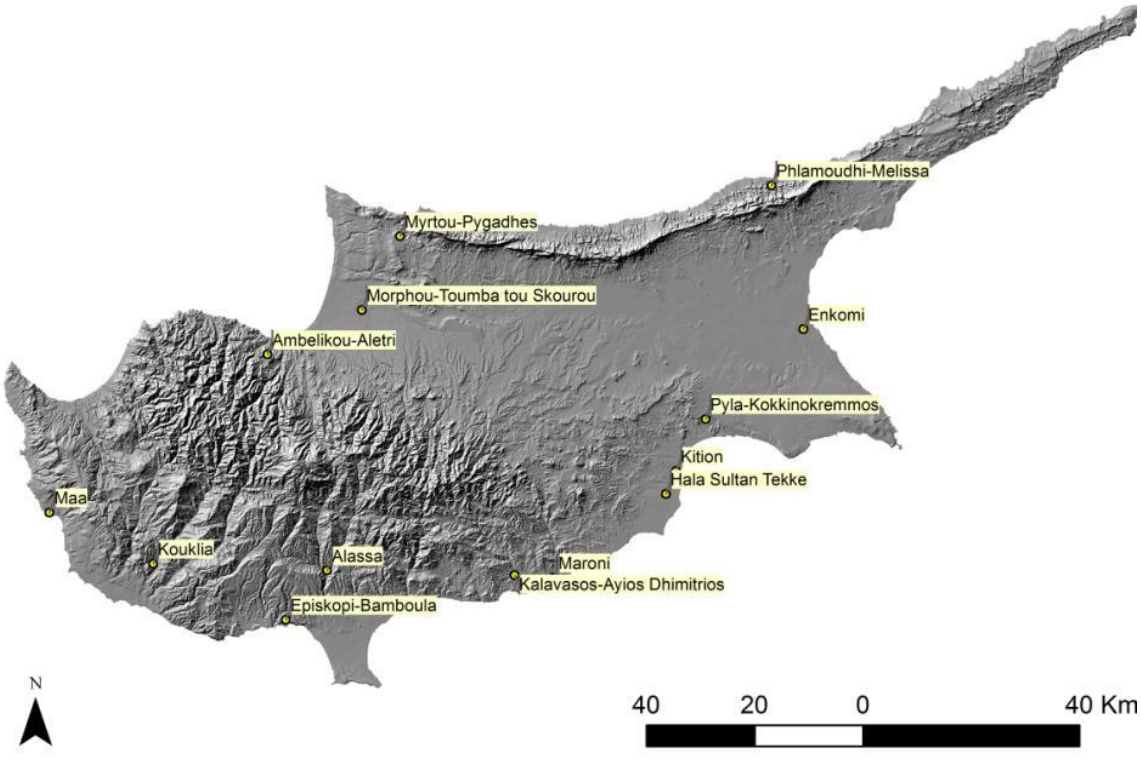

Fig.4.11. Known LBA coastal sites

If one hypothesises that both Tochni-*Lakkia* and the now directly coastal Maroni-*Tsaroukkas* had a maximum distance of 300m from the sea, it is likely that the extent of lost land does not contain exclusively archaeological remains and the loss of cultural remains is not as severe as it could have been, had the site been directly coastal in the LBA.

One way to try and reconstruct land loss takes into consideration site-size estimation for the LBA sites. Although this study recognises the limitations and challenges of such estimations, it considers useful to employ them as guidelines for the estimations of this report. Knapp (2013: 354) published a table of LBA settlement sizes ranging between 0,5ha and 24ha. Surface survey at Tochni-*Lakkia* estimated the dimensions of the pot spread to be at least 750m x 250m; that is 18,75ha. This does not reflect site size, but rather a maximum extent based on the available field condition and surface finds in 2012. This area may also represent dispersed activities and not the core or the limits of a LBA town (cf. Manning *et al.* 2014). If one assumes that Tochni-*Lakkia* spanned 24ha with an E-W dimension 750m, then at least 52500m^2 eroded away, which divided by 750m corresponds to 70m of coast potentially eroded to the sea.

However, when one considers the accelerated erosion rate, which characterises the site since the 1950s (60 years), and if we assume that about 0,5m were eroding every year, then land loss is approximately 30m. For the years prior to industrialisation and gravel mining, we may assume that sediment input and output was relatively balanced. Although 30m land loss could be dreadful for archaeological remains, it also provides a degree of optimism that not a great percentage of site has been lost, assuming that the site was not directly coastal.

4.5. Discussion and Final Thoughts

Considering the industrial development of the island in a period of economic recession it appears that a sustainable way to record archaeology and protect such information for future generation is the establishment of a coastal directory in an open and easily accessible form. Such work has been successfully employed in the U.K. and aids as well as informs a wide-ranging group of interested parties including geologists, archaeologists, fishermen, hikers etc. (Robson *et al.* 1996; Ashmore 2005; Hansom 2005; Langley 2009). Similarly, an open-access database combining GIS mapping of all marine and coastal archaeological sites is available for the coast of Israel. This multidisciplinary database evaluates the scientific and tourist potential of important sites and provides risk assessments that can help funding bodies evaluate the

necessary costs for the conservation of sites (Friedman and Galili 2004; Galili and Rosen 2010: 304).

Prior to the employment of such studies, *in situ* investigation and GIS mapping of the coastline's retreat and accretion patterns is necessary to provide tangible and quantifiable information for the creation of archaeological buffer zones, future planning, and direction of land development plans. Moreover, a multidisciplinary consideration of this problem is key for its future monitoring and management. For example, coastal erosion related to wave actions and other types of water movements is a long investigated issue in marine engineering (French 2001: 141-164), but has had unexpectedly little impact in the coastal archaeology of countries, especially those with imbalanced landscapes (Galili and Rosen 2010: 303).

Concluding Proposals

- Monitoring of eroding coastal sites at regular intervals. This may be achieved via georeferenced photogrammetry, which is at present one of the most efficient and cost-effective methods of recording of archaeological sites.

- Implementation of survey assessments at a local basis and creation of baseline data to identify degrees and varieties of cultural heritage threats.

- Establishment of open-access, interactive platform with information on marine and underwater archaeological remains, risk assessments and association with modern development. Incorporation of the above platform or database form into the guidelines for environmental impact assessments.

- Finance-focused investigation on case-studies in order to compare the economic sustainability of long-term protection vs. rescue excavation of eroding sites.

- Incorporation of eroding coastal archaeology in the Antiquities Law either through amendment or addition as a separate class of material under thread, as well as incorporation of eroding coastal archaeology in an integrated coastal erosion legal framework (e.g. Khakzad 2014a; 2014b).

APPENDICES

A. A coastal definition and legal frame

According to the Foreshore Protection Act of Cyprus (acts 59, 22/61, 17/64, 8/72) the land limit of the coastal zone is a distance of 100 yards from the winter tide. According to the Town Planning and Housing Law of 1972 (enforced in 1990) the coastal zone for reasons of town planning is a 100m wide strip from the coastline. Unfortunately, there is currently no official estimation of the winter tide, and the limits of the dynamic coastal zone are unknown (Triton Consultants 2002: 15; EUROSION 2004a: 5). This can be problematic, especially in cases where the position of the coastline in maps used for town planning purposes may be not be up to date. To be more precise, in an estimation of the 100 metres from the coastline, an updated coastline following the more recent erosion episode might not be included (Triton Consultants 2002: 15). As such, when investigating maps from the Department of Lands and Surveys one should make sure not to identify the coastline with the coastal property boundaries, which are often 25-50m from the actual shoreline position.

B. Antiquities Law and coastal erosion

The Department of Antiquities of Cyprus is participating in all discussions related to legislation amendments regarding the sea and off-shore activities. In addition there have already been suggestions regarding a more complete protection of underwater and coastal heritage. The Department is digitising all known sites of the island, including those underwater. It cooperates with the Archaeological Research Unit if the University of Cyprus for research and mapping purposes regarding underwater cultural heritage. Finally, new off-shore development requires co-operation with the Department of Antiquities and the department holds the right to request plan changes in order to protect sites and artefacts.

The legislative state of Cypriot antiquities subjected to natural and indirect anthropogenic deterioration is not clear, but it may be inferred in the general parameters of the Antiquities Law.

B. List of Legislation and Conventions signed by the Department of Antiquities and the Republic of Cyprus

- **The Antiquities Law** (Cyprus Bar Association, http://www.cylaw.org/nomoi/enop/non-ind/0_31/full.html)
- **The Export of Cultural Goods Law** (Department of Antiquities – Legislation, http://www.mcw.gov.cy/mcw/da/da.nsf/DMLlaw_gr/DMLlaw_gr?OpenDocument)
- **The Return of Cultural Goods Law** (Department of Antiquities – Legislation, http://www.mcw.gov.cy/mcw/da/da.nsf/DMLlaw_gr/DMLlaw_gr?OpenDocument)
- **The Law on Recognition of Private Museums and Museums of Local Authorities Act** (Department of Antiquities – Legislation, http://www.mcw.gov.cy/mcw/da/da.nsf/DMLlaw_gr/DMLlaw_gr?OpenDocument)

Conventions/Protocols/Memoranda

- **14 May 1954 - Convention for the Protection of Cultural Property in the event of Armed Conflict with Regulations for the Execution of the Convention, The Hague** (UNESCO – Legal Instruments, http://portal.unesco.org/en/ev.php-URL_ID=13637&URL_DO=DO_TOPIC&URL_SECTION=201.html)
- **14 May 1954 - Convention for the Protection of Cultural Property in the Event of Armed Conflict with Regulations for the Execution of the Convention, The Hague** (UNESCO – Legal Instruments, http://portal.unesco.org/en/ev.php-URL_ID=15391&URL_DO=DO_TOPIC&URL_SECTION=201.html)
- **14 May 1954 - First Protocol to the Hague Convention of 1954 for the Protection of Cultural Property in the Event of Armed Conflict, The Hague.**
- **19 December 1954 - European Cultural Convention, Paris** (European Council – Treaties, http://conventions.coe.int/Treaty/en/Treaties/HTML/018.htm)
- **05 December 1956 - Statutes of the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM), New Delhi** (International Environmental Agreements (IEA) Database Project, http://iea.uoregon.edu/pages/view_treaty.php?t=1956-InternationalCentreStudyCulturalProperty.AA19730412.EN.txt&par=view_treaty_html)
- **14 November 1970 - Convention on the Means of Prohibiting and Preventing the Illicit Import, Export and Transfer of Ownership of Cultural Property, Paris**

(UNESCO – Legal Instruments, http://portal.unesco.org/en/ev.php-URL_ID=13039&URL_DO=DO_TOPIC&URL_SECTION=201.html)

- **16 November 1972 - Convention for the Protection of the World Cultural and Natural Heritage, Paris** (UNESCO – Archives, http://whc.unesco.org/archive/convention-en.pdf)
- **03 October 1985 - Convention for the Protection of the Architectural Heritage of Europe, Granada** (European Council – Treaties, http://conventions.coe.int/Treaty/en/Treaties/html/121.htm)
- **October 1987 - Charter for the conservation of historic towns and urban areas, Washington** (ICOMOS – Charters, http://www.icomos.org/charters/towns_e.pdf)
- **1990 - Charter for the protection and management of the archaeological heritage, Lausanne** (ICOMOS – Charters, http://www.international.icomos.org/charters/arch_e.pdf)
- **16 January 1992 - European Convention on the Protection of the Archaeological Heritage (Revised), Valletta** (European Council – Treaties, http://conventions.coe.int/Treaty/EN/Treaties/Html/143.htm)
- **24 June 1995 - Unidroit Convention on Stolen or Illegally Exported Cultural Objects, Rome** (UNIDROIT – Conventions, http://www.unidroit.org/english/conventions/1995culturalproperty/1995culturalproperty-e.pdf)
- **26 March 1999 - Second Protocol to the Hague Convention of 1954 for the Protection of Cultural Property in the Event of Armed Conflict, The Hague** (UNESCO – Legal Instruments, http://portal.unesco.org/en/ev.php-URL_ID=15207&URL_DO=DO_TOPIC&URL_SECTION=201.html)
- **16 July 2002 - Memorandum of Understanding Between the Government of the United States of America and the Government of the Republic of Cyprus Concerning the Imposition of Import Restrictions on Pre-Classical and Classical Archaeological Objects, Washington** (Department of Antiquities – Legislation, http://www.mcw.gov.cy/mcw/da/da.nsf/All/083233D11A12C221422577CF00464EAC/$file/cy2002mou.pdf)
- **17 October 2003 - Convention for the Safeguarding of the Intangible Cultural Heritage, Paris** (UNESCO – Legal Instruments, http://portal.unesco.org/en/ev.php-URL_ID=17716&URL_DO=DO_TOPIC&URL_SECTION=201.html)

- **August 2006 - Amendment to the Memorandum of Understanding Between the Government of the United States of America and the Government of the Republic of Cyprus Concerning the Imposition of Import Restrictions on Pre-Classical and Classical Archaeological Objects and Byzantine Period Ecclesiastical and Ritual Ethnological Material, Washington** (Department of Antiquities – Legislation, http://www.mcw.gov.cy/mcw/da/da.nsf/All/325A7B8F99C49F37422577CF004663FA/$file/cy2006mouext.pdf)
- **July 2007 - Amendment to the Memorandum of Understanding Between the Government of the United States of America and the Government of the Republic of Cyprus Concerning the Imposition of Import Restrictions on Pre-Classical and Classical Archaeological Objects and Byzantine Period Ecclesiastical and Ritual Ethnological Material, Washington** (Department of Antiquities – Legislation, http://www.mcw.gov.cy/mcw/da/da.nsf/All/0BF97AF4EDED98A9422577CF00468044/$file/cy2007mouext.pdf)
- **25 November 2009 - Statutes of the ICCROM, as revised by the XXVI session of the General Assembly, Rome** (ICCROM – Statutes, http://www.iccrom.org/eng/00about_en/00_01govern_en/statutes_en.shtml

BIBLIOGRAPHY AND ELECTRONIC SOURCES

Abraham, O.

1606 *Theatrum Orbis Terrarum Abrahami Ortell Antuerp. geographi regii*. London: Officina Plantiana and Eliot's Press.

Andreou, G.M.

2014 Tochni-Lakkia: archaeology, legislation and economic crisis, *The Bulletin of the Council for British Research in the Levant* 9: 53-54.

Andreou, G.M. and D.A. Sewell

2015 Tochni-Lakkia revealed: reconsidering settlement patterns in the Vasilikos and Maroni Valleys, Cyprus. In H. Matthäus, B. Morstadt & C. Vonhoff (ed.) *PoCA (Postgraduate Cypriot Archaeology) 2012*: 198-219. Newcastle: Cambridge Scholars Publishing.

Andreou, G.M., R. Opitz, S.W. Manning, K.D. Fisher, D.A. Sewell, A. Georgiou and T. Urban

2017 Integrated methods for understanding and monitoring the loss of coastal archaeological sites: The case of Tochni-*Lakkia*, south-central Cyprus, *Journal of Archaeological Science: Reports* 12: 197-208.

Anthony, E.J., N. Marriner and C. Morhange

2014 Human influence and the changing geomorphology of Mediterranean deltas and coasts over the last 6000 years: From progradation to destruction phase?, *Earth-Science Reviews* 139: 336-361.

Arnaud, P.

2011 Ancient sailing-routes and trade patterns: the impact of human factors. In D. Robinson and A. Wilson (eds.) *Maritime Archaeology and Ancient Trade in the Mediterranean*: 61-80. Oxford: University of Oxford.

Ashmore, P.

2005 Archaeology and the coastal erosion zone. In T. Dawson (ed.) *Coastal Archaeology and Erosion in Scotland*: 1-5. Edinburgh: Historic Scotland.

Bank of Cyprus Cultural Foundation, www.boccf.org, Access April 2014.

Bell, M.

2012 Intertidal Survey and Excavation. In F. Menotti and A. O'Sullivan (eds.) *The Oxford Handbook of Wetland Archaeology*: 457-471. Oxford: Oxford University Press.

Blue, L.K.

1997 Cyprus and Cilicia: The typology and palaeogeography of second millennium harbors. In S. Swiny, R.L. Hohlfelder and H.W. Swiny (eds.) *Res Maritimae: Cyprus and the Eastern Mediterranean from Prehistory to Late Antiquity, Proceedings of the Second International Symposium "Cities on the Sea", Nicosia, Cyprus, October 18-22, 1994*: 31-43. Atlanta: Scholar Press.

Bony, G.M., N. Carayon, C. Flaux, N. Marriner, C. Morhange and S. Fourrier

2016 Évolution paléo-environnementale de la baie de Kition : mise en évidence d'un possible environnement portuaire (Larnaca, Chypre), *Colloque de Montpellier, BiAMA – Errance-Actes Sud*: 1-11.

Botero, G.

1606 *Relations of the Most Famous Kingdoms and Common-Wealth's through the World: Discoursing their Situations, Manners, Customs, Strengths and Polities*. London: William Laggard.

Brunning, R.

2012 Archaeological strategies for terrestrial wetland landscapes. In F. Menotti and A. O'Sullivan (eds.) *The Oxford Handbook of Wetland Archaeology*: 451-464. Oxford: Oxford University Press.

Cadogan, G.

1988 Maroni IV. *Report of the Department of Antiquities Cyprus:* 229-231.

1989 Maroni and the monuments. In *Early society in Cyprus*, edited by E.J. Peltenburg, 43-51. Edinburgh: Edinburgh University Press.

Catling, H.W.

1962 Patterns of Settlement in Bronze Age Cyprus, *OpAth* 4: 129-169.

Christodoulou, D.

1959 *The Evolution of the Rural Land use Pattern in Cyprus*, The World Land Use Survey. Cyprus, Great Britain: Geographical Publications Limited.

Cline, E.H.

1994 *Sailing the Wine-Dark Sea. International trade and the Late Bronze Age Aegean*. BAR 591, Oxford: Tempus Reparatum, Archaeological and Historical Associates Limited.

Cobham, C.D.

1908 *Excerpta Cypria; Materials for a History of Cyprus*. Cambridge: Cambridge University Press.

Coles, B.J.

2000 Doggerland: the cultural dynamics of a shifting coastline. In K. Pye and J.R.L. Allen (eds.) *Coastal and Estuarine Environments: Sedimentology, Geomorphology and Geoarchaeology*: 393-401. London: The Geological Society.

Costa, G. and F.T. Pinto

2012 Modelling the coastal defence scheme of Espinho, Portugal, *JCoastConservat* 16: 211-221.

Cyprus Bar Association, www.cylaw.org, Access April 2014.

Davies, W.N.L.

1970 The carob tree and its importance in the agricultural economy of Cyprus, *Economic Botany* 24(4): 460-470.

Davis, R.A.Jr. and P.L. Barnard

2000 How human anthropogenic factors in the back-barrier area influence tidal inlet stability: examples from the Gulf Coast of Florida, USA. In K. Pye and J.R.L. Allen (eds.), *Coastal and Estuarine Environments: Sedimentology, Geomorphology and Geoarchaeology*: 293-303. London: The Geological Society.

Dawkins, R.M. [ed.]

1932 *Leontios Makhairas. Recital concerning the Sweet Land of Cyprus entitled 'Chronicle'*. Oxford: Clarendon Press.

Dawson, T. (ed.)

2005 *Coastal Archaeology and Erosion in Scotland*. Edinburgh: Historic Scotland.

de Belleforest, F.

1575 *La Cosmographi Universelle*. Paris: Sebastian Münster.

Delft Hydraulics

1993 *Coastal Zone Management for Cyprus*, Report.

Erlandson, J.M.

2008 Racing a rising tide: global warming, rising seas, and the erosion of human history. *Journal of Island and Coastal Archaeology* 3(2): 167-169.

2012 As the world warms: rising seas, coastal archaeology and the erosion of maritime history, *JCoastConservat* 16: 137-142.

European Commission, Environment, www.europa.eu/environment/iczm/barcelona.htm, Access April 2014.

European Commission, Environmental Sector, www.climateadaptation.eu/cyprus, Access April 2014.

European Council, www.european-council.europa.eu, Access April 2014.

EUROSION

2004a Living with coastal erosion in Europe: Sand and Space for Sustainability. Guidance document for quick hazard assessment of coastal erosion and associated flooding, *EUROSION portal*: 1-30.

2004b Living with coastal erosion in Europe: Sediment and Space For Sustainability, Part I – Major findings and Policy Recommendations of the EUROSION project, *EUROSION portal*: 1-54.

EUROSION portal, Directorate General Environment, European Commission: www.eurosion.com, Access April 2014.

Feldman, M.H.

2006 *Diplomacy by Design: Luxury Arts and an 'International Style' in the Ancient Near East, 1400-1200 BCE*. Chicago: University of Chicago Press.

Fitzpatrick, S.M.

2012 On the shoals of giants: natural catastrophes and the overall destruction of the Caribbean's archaeological record, *JCoastConservat* 16: 173-186.

Fitzpatrick, S.M., M. Kappers and Q. Kaye

2006 Coastal erosion and site destruction on Carriacou, West Indies, *JFA* 31(3): 252-262.

Ford, B.

2014 Coastal Archaeology. In A. Catsambis, B. Ford and D.I. Hamilton (eds.) *The Oxford Handbook of Maritime Archaeology*: 763-785. Oxford: Oxford University Press.

French, P.W.

2001 *Coastal defences processes, problems and solutions*. London: Routledge.

Friedman, Z. and E. Galili

2004 Ancient harbors in Israel, *The NAVIS II Project*, Supported by the European Commission, European Commission Directorate General X Information, Communication and Culture, Brussels.

Fulton, C., A. Viduka, J. Hollick, A. Woods, A. Hutchison, D. Sewell, S. Manning.

2016 Use of Photogrammetry for Non-Disturbance Underwater Survey: An Analysis of In Situ Stone Anchors." *Advances in Archaeological Practice* 4: 17-30.

Galili, E.

1999 *Marine Archaeology. Coastal Waters of Israel, Policy Document*, The Committee for Coastal Waters: Ministry of Interior, Planning and Administration.

2006 *Risk Assessment Survey for the Ancient Coastal Settlements of Israel 2006*, Prime Minister Office, Israel.

Galili, E. and B. Rosen

2010 Preserving the maritime cultural heritage of the Mediterranean, a cradle of cultures, religions and civilizations- the holy land perspective, *JCoastConservat* 14: 303-315.

Galili, E. and J. Sharvit

1994 Classification of underwater archaeological sites along the Mediterranean coast of Israel: Finds from underwater and coastal archaeological research. In M. Lazarov and C. Angelova (eds.) *Tracia Pontica V. Les port dans la vie de la Thrace ancienne, 7-12 Octobre 1991 Sozopol*: 269-289. Sozopol: Centre d'Archéologie Subaquatique.

Gifford, J.A.

1985 Paleogeography of ancient harbour sites of the Larnaca lowlands, Southeastern Cyprus. In A. Raban (ed.) *Harbour Archaeology. Proceedings of the first international workshop of ancient Mediterranean harbours Caesarea Maritima, 24-28.6.83*, BAR 257: 45-48. Oxford: British Archaeological Research.

Hansom, J.D.

2005 Archaeological survivability and past coastal processes. In T. Dawson (ed.), *Coastal Archaeology and Erosion in Scotland*: 7-12. Edinburgh: Historic Scotland.

Hasebroek, J.

1965 *Trade and Politics in Ancient Greece*. New York: Biblio and Tannen.

Honor Frost Foundation, www.honorfrostfoundation.com, Access April 2014.

Howitt-Marshall, D.

2012 The anchorage site at Kouklia Achni, southwest Cyprus: problems and perspectives. In A. Georgiou (ed.) *Cyprus. An Island Culture: Society and Social Relations from the Bronze Age to the Venetian Period*, 104–121. Oxford: Oxbow Books.

Instructions Nautiques Afrique-côte Nord, Levant, entre la Mer Égée et le Canal de Suez, Série D, vol. VI, Service Hydrogeographique et Océanographique de la Marine (Paris), Paris, 1981.

International Centre for the Study of the Preservation and Restoration of Cultural Property, www.iccrom.org, Access April 2014.

International Council on Monuments and Sites - ICOMOS, www.icomos.org, Access April 2014.

International Environmental Agreements Database Project– IEA, iea.uoregon.edu/, Access April 2014.

International Institute for the Unification of Private Law – UNIDROIT, www.unidroit.org, Access April 2014.

Ionas, I.

2000 *Traditional Pottery and Potters in Cyprus*. Birmingham Byzantine and Ottoman Monographs 6, Aldershot: Burlington.

Karmon, Y.

1985 Geographical components in the study of ancient Mediterranean ports. In A. Raban (ed.), *Harbour Archaeology. Proceedings of the first international workshop of ancient Mediterranean harbours Caesarea Maritima, 24-28.6.83*, BAR 257: 1-6. Oxford: British Archaeological Research.

Khakzad, S.

2014a The necessity of a common language for coastal and underwater coastal and underwater cultural heritage, *Journal of Anthropology and Archaeology* 2(1): 17-31.

2014b Underwater cultural heritage sites on the way to world heritage: to ratify the 2001 convention or not to ratify? *Journal of Anthropology and Archaeology* 2(1): 1-16.

Knapp, A.B.

2013 *The Archaeology of Cyprus from Earliest Prehistory through the Bronze Age*. Cambridge World Archaeology, Cambridge: Cambridge University Press.

Κορωνίδα Κέντρο Έρευνας και Ανάπτυξης Λτδ

2006 *Διάβρωση Δέλτα Ποταμών και Παραλιών*, Ίδρυμα Προώθησης Έρευνας: Ορθολογική Αειφόρος Διαχείριση των Ομβρίων Υδάτων και των Ιζημάτων που Μεταφέρονται από τα Ύδατα: 1-16.

Lang, R.H.

1878 *Cyprus: Its History, its Present Sources and Future Prospects*. London: MacMillan and co.

Langley, S.

2009 Developing a 'maritime and marine historic environment research framework' for England, www.britarch.ac.uk/news/090522-framework, Accessed April 2014.

Leonard, J.R.

1997 Harbor terminology in Roman Periploi. In S. Swiny, R.L. Hohlfelder and H.W. Swiny (eds.) *Res Maritimae: Cyprus and the Eastern Mediterranean from Prehistory to Late Antiquity, Proceedings of the Second International Symposium "Cities on the Sea", Nicosia, Cyprus, October 18-22, 1994: 163-200.* Atlanta: Scholar Press: 163-200.

2005 *Roman Cyprus: Harbors, Hinterlands, and Hidden Powers*, PhD Thesis, Buffalo: State University of New York.

Loizidou, X.I. and M.I. Loizides

2007 Environmental issues. Social perception and coastal erosion management: case studies from Cyprus, *Proceedings of the Conference Medcoast, Alexandria*: 1-12. European Commission-Environment.

Longley, P.A., M.F. Goodchild, D.J. Maguire and D.W. Rhind (eds.)

2011 *Geographic Information Systems and* Science. New York: John Wiley & Sons.

Ma, Q., X. Yu, G. Lü and Q. Liu

2011 The changing relationship between spatial pattern of soil erosion risk ad its influencing factors in Yiment mountainous area, China 1986-2005, *Environmental Earth Sciences* 66: 1535-1546.

Manning, S.W.

2013 A New radiocarbon chronology for prehistoric and protohistoric Cyprus, ca. 11,000-1050 CAL BC. In A.B. Knapp *The Archaeology of Cyprus from Earliest Prehistory through the Bronze Age*: 485-533. Cambridge: Cambridge University Press.

Manning, S.W. and D.H. Conwell

1992 Maroni valley archaeological survey project: preliminary report on the 1990-1991 field seasons, *RDAC* 1992: 271-283.

Manning, S.W. and F. DeMita

1997 Cyprus, the Aegean, and Maroni-Tsaroukkas. In D. Christou (ed.) *Proceedings of the International Archaeological Conference "Cyprus and the Aegean in Antiquity". From the Prehistoric Period to the 7th Century AD. Nicosia 8-10 December 1995*: 103-141. Nicosia: Department of Antiquities.

Manning, S.W., D. Bolger, M.J. Pontig, L. Steel and A. Swinton

1994a Maroni Valley Archaeological Survey Project: preliminary report on the 1992-1993 seasons, *RDAC* 1994: 345-367.

Manning, S.W., D. Collon, D.H. Conwell, H.-G. Jansen, L. Steel and A. Swinton

1994b Tsaroukkas, Mycenaeans and Trade Project: preliminary report on the 1993 season, *RDAC* 1994: 83-106.

Manning, S.W., G.M. Andreou, K.D. Fisher, P. Gerard-Little, C. Kearns, J.F. Leon, D.A. Sewell and T.M. Urban

2014 Becoming urban: investigating the anatomy of the Late Bronze Age Complex, Maroni Cyprus, *JMA* 27(1): 3-32.

Manning, S. W., S.J. Monks, D.A. Sewell and S. Demesticha

2000 Late Roman type 1A amphora production at the Late Roman site of Zygi-Petrini, *RDAC* 2000: 233–57.

Manning, S.W., D.A. Sewell and E. Herscher

2002 Late Cypriot IA maritime trade in action: underwater survey at Maroni Tsaroukkas and the contemporary East Mediterranean trading system, *BSA* 97: 97-162.

Marriner, N. and C. Morhange

2007 Geoscience of ancient Mediterranean harbours, *Earth Science Rev.* 80: 137-194.

Ministry of Agriculture, Natural Resources and Environment, www.moa.gov.cy, Access April 2014.

Ministry of Energy, Commerce, Industry and Tourism, Republic of Cyprus, www.mcit.gov.cy, Access April 2014.

Monumenta: For the protection of natural and architectural heritage in Greece and Cyprus, www.monumenta.org, Access April 2014.

Mourtzas, N.D.

2012 Archaeological indicators for sea level change and coastal neotectonic deformation: the submerged Roman fish tanks of the gulf of Matala, Crete, Greece, *Journal of Archaeological Science* 39: 884-895.

Mourtzas, N.D. and E. Kolaiti

2013 Historical coastal evolution of the ancient harbor of Aegina in relation to the Upper Holocene relative sea level changes in the Saronic Gulf, Greece, *Paleogeography, Palaeoclimatology, Palaeoecology* 392: 411-425.

New York Public Library, www.nypl.org/, Access April 2014.

Nir, Y., E. Morisseau and C. Xenophontos

1993 *The Coasts of Cyprus*. Cyprus Geological Survey Department, Jerusalem: [n.p.].

Pajak, M. J. and S. Leatherman

2002 The high water line as shoreline indicator, *Journal of Coastal Research* 18(2):329–337.

Petzelberger, B.E.M.

2000 Coastal development and human activities in NW Germany. In K. Pye and J.R.L. Allen (eds.) *Coastal and Estuarine Environments: Sedimentology, Geomorphology and Geoarchaeology*: 365-376. London: The Geological Society.

Pollard, E.

2012 Present and past threat and response on the east coast of Africa: an archaeological perspective, *JCoastConservat* 16: 143-158.

Pye, K. and J.R.L. Allen

2000 Past, present and future interactions, management challenges and research needs in coastal and estuarine environments. In K. Pye and J.R.L. Allen (eds.) *Coastal and Estuarine Environments: Sedimentology, Geomorphology and Geoarchaeology:* 1-4. London: The Geological Society.

Raban, A.

1985 The ancient harbours of Israel in biblical times (From the Neolithic period to the End of the Iron Age. In A. Raban (ed.) *Harbour Archaeology. Proceedings of the first international workshop of ancient Mediterranean harbours Caesarea Maritima, 24-28.6.83*, BAR 257: 11-44. Oxford: British Archaeological Research.

1998 Near Eastern harbors: thirteenth-seventh centuries BCE. In S. Gitin, A. Mazar and E. Stern (eds.) *Mediterranean Peoples in Transition. Thirteenth to Early Tenth Centuries BCE*: 428-438. Jerusalem: Israel Exploration Society.

Raban, A. and E. Galili

1985 Recent maritime archaeological research in Israel – A preliminary report, *IJNA* 14(4): 321-356.

Reeder, L.A., T.C. Torben, J.M. Erlandson

2012 Our disappearing past: a GIS analysis of the vulnerability of coastal archaeological resources in California's Santa Barbara Channel region, *Journal of Coastal Conservation* 16: 187-197.

Rhizopoulou, S. and W.J. Davies

1991 Influence of soil drying on root development, water relations and leaf growth of *Ceratonia Siliqua*, *L. Oecologia* 88(1): 41-47.

Rick, T.C. and S.M. Fitzpatrick

2012 Archaeology and coastal conservation, *JCoastConservat* 16: 135-1136.

Robson, C.F., N.C. Davidson, J.H. Barne and J.P. Doody

1996 Coastal directories and beyond: providing multidisciplinary coastal zone resource information for resource management, *JCoastConservat* 2: 179-182.

Roca, E. G. Gamboa and J.D. Tàbara

2008 Assessing the multidimensionality of coastal erosion risks: public participation and multicriteria analysis in a Mediterranean coastal system, *Risk Analysis* 28(2): 399-412.

Rowland, M.J. and S. Ulm

2012 Key issues in the conservation of the Australian coastal archaeological record: natural and human impacts, *JCoastConservat* 16: 159-171.

Royal Commission for Historic and Ancient Monuments of Scotland - RCHAMS, hncap.org.uk, Access April 2014.

Sakellarios, A.A.

1890 *Τα Κυπριακά ήτοι Γεωγραφία, Ιστορία και Γλώσσα της Νήσου Κύπρου από των αρχαιοτάτων χρόνων μέχρι σήμερον*. Athens: Τύποις και Αναλώμασι Π.Δ. Σακελλαρίου.

Sauvage. C.

2012 *Routes Maritimes et Systémes D'Échanges Internationaux au Bronze Récent en Méditerranée Orientale*. Lyon: Travaux de la Maison de L' Orient et de la Méditerranée.

Schörle, K.

2011 Constructing port hierarchies: harbours of the central Tyrrhenian coast. In D. Robinson and A. Wilson (eds.) *Maritime Archaeology and Ancient Trade in the Mediterranean*, Oxford Centre for Maritime Archaeology Monographs: 93-106. Oxford: University of Oxford.

Sesli, F.A., F. Karslı, I. Colkesen and N. Akyol

2008 Monitoring the changing position of coastlines using aerial and satellite image data: an example from the eastern coast of Trabzon, Turkey, *Environmental Monitoring and Assessment* 153: 391-403.

Sewell, D.A.

2013 *Recording a Coastal Site in Cyprus. Tochni Lakkia 2013*. Honor Frost Foundation Report.

Sewell, D.A., C. Fulton, A. Viduka

2016 Interaction, production, and exchange in Late Bronze Age Cyprus: The case of Tochni Lakkia. In *Actas del V Congreso Internacional de Arqueología Subacuática (IKUWA V), Cartagena, 2014*: 496-503. Ministerio de Educación, Cultura y Deporte.

Sherratt, A.G. and S.E. Sherratt

1991 From luxuries to commodities: the nature of Mediterranean Bronze Age trading systems. In N.H. Gale (ed.) *Bronze Age Trade in the Mediterranean*, SIMA 90: 351-386. Göteborg: Paul Åströms Förlag.

Shirley R.

2001 *Kitchener's Survey of Cyprus 1878-1883. The first full triangulated survey and mapping of the island*. Cyprus Cartography Lectures 5, Nicosia: Bank of Cyprus Cultural Foundation.

Society of Antiquaries of Scotland - Scottish Archaeological Research Framework -ScARF, www.socantscot.org/scarf.asp, April 2014.

Stylianou, A. and J.A. Stylianou

1980 *The History of the Cartography of Cyprus*. Publications of the Cyprus Research Centre VIII, Nicosia: Zavallis Press.

Thomas, R.S.

1981 *Cyprus. Erosion on the Southern Coastline*, Paris: United Nations Educational, Scientific and Cultural Organisation.

Todd, I.A. (ed.)

2004 *Vasilikos Valley Project 9, The Field Survey of the Vasilikos Valley I*, SIMA 71: 9, Sävedalen: Paul Åstroms Forlag.

2013 *Vasilikos Valley Project 12: The Field Survey of the Vasilikos Valley III. Human Settlement in the Vasilikos Valley*. SIMA 71:12. Uppsala: Åströms Förlag.

Triton Consultants, Ltd

2002 *WP 3.1 – Local Information systems. Case Study in Dolos Kiti – Cyprus*, Eurosion Project Final Report, Nicosia: Triton Consultants, Ltd.

United Nations Educational, Scientific and Cultural Organization – UNESCO, en.unesco.org/, Access April 2014.

Vasseur, B. and A. Hequette

2000 Storm surges and erosion of coastal dunes between 1957 and 1988 near Dunkerque (France), southwestern North Sea. In K. Pye and J.R.L. Allen (eds.) *Coastal and Estuarine Environments: Sedimentology, Geomorphology and Geoarchaeology*: 90-107. London: The Geological Society.

Vrieling, A.

2006 Satellite remote sensing for water erosion assessment: A review, *Catena* 65(1): 2-18.

Westley, K. and J. Dix

2006 Coastal environments and their role in prehistoric migrations, *Journal of Maritime Archaeology* 1: 9-28.

Zhang, K., B.C. Douglas and S.P. Leatherman

2004 Global warming and coastal erosion, *Climatic Change* 64: 41-58.