Port and Harbour Networks in Crete during Late Antiquity (4th – mid-7th c. AD): A Modern Approach

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Introduction

Ports and harbours were of paramount importance for past human societies, since they played multiple roles in many different historical periods. In recent decades, port and harbour studies in archaeology have moved towards a social and economic approach, focusing on the localized meanings of these infrastructures as well as on various key topics including human-environmental interaction, material culture, settlement systems, human behavior and action, identity, ideology, communication networks and trade, war and peace, and technological evolution, etc.[1] Especially in the context of the Mediterranean islands, ports and harbours have played vital roles in wider social, economic, and political networks. Crete, which was diachronically a diverse and interactive insular world within the Eastern Mediterranean, offers a fertile ground for investigating meticulously a wide range of key topics related to ports and harbours in Late Antiquity (the 4th – mid-7th centuries AD).

During Late Antiquity Crete benefitted from its localized environmental advantages, the island's strategic location and the favourable historical circumstances, achieving considerable prosperity.[2]Archaeological investigations have shown that a large number of sites developed both in the interior and along the coastline of the island. Regarding the maritime and coastal cultural landscape, however, important aspects of this situation have not been studied in detail, while a synthetic and comparative work focusing on the entire island is lacking. The multiple roles played by the Cretan ports and harbours, as well as the challenges faced by ancient mariners in moving around the island have not been fully understood.

This paper intends to shed more light on issues regarding: a) the interaction between human activity, which took place at the interface between land and water, and local environmental conditions and topographical features in all their complexity, b) the meanings associated with maritime spaces (i.e. ports, harbours and coastal settlements) for past society; and c) the roles played by the ports and harbours of Crete within micro- and macro-scale networks between the 4th and the mid-7th century AD.[3] Ports and harbours are not regarded as isolated dots on a map, but instead, they are viewed as parts of various networks with different types of interaction and as cultural products of political, social and economic circumstances. This human-centered approach puts at the centre of attention people, their actions and experiences, as well as their engagement with natural environment. Maritime mobility and interaction are considered as key factors of island life. Due to the complexity of the topic, this research adopts an interdisciplinary framework,

[1] For more about social archaeological approaches in port and harbour studies see Roger 2013.
[2] For a useful overview of Crete in Late Antiquity see Zanini 2019.
[3] This study is part of a broader postdoctoral project entitled 'Προσεγγίζοντας τα λιμάνια της Κρήτης κατά την Πρωτοβυζαντινή περίοδο (4ος – πρώιμος 9ος αι.)'. The project seeks to highlight the developments related to the Cretan ports and harbours between the 4th and the early 9th century AD, aiming to provide a framework for understanding the social nature of human engagement with land and sea. It is co-financed by Greece and the European Union (European Social Fund ESF) through the Operational Programme 'Human Resources Development, Education and Lifelong Learning' in the context of the project 'Reinforcement of Postdoctoral Researchers 2nd Cycle' (MIS-5033021), implemented by the State Scholarships Foundation (IKY).

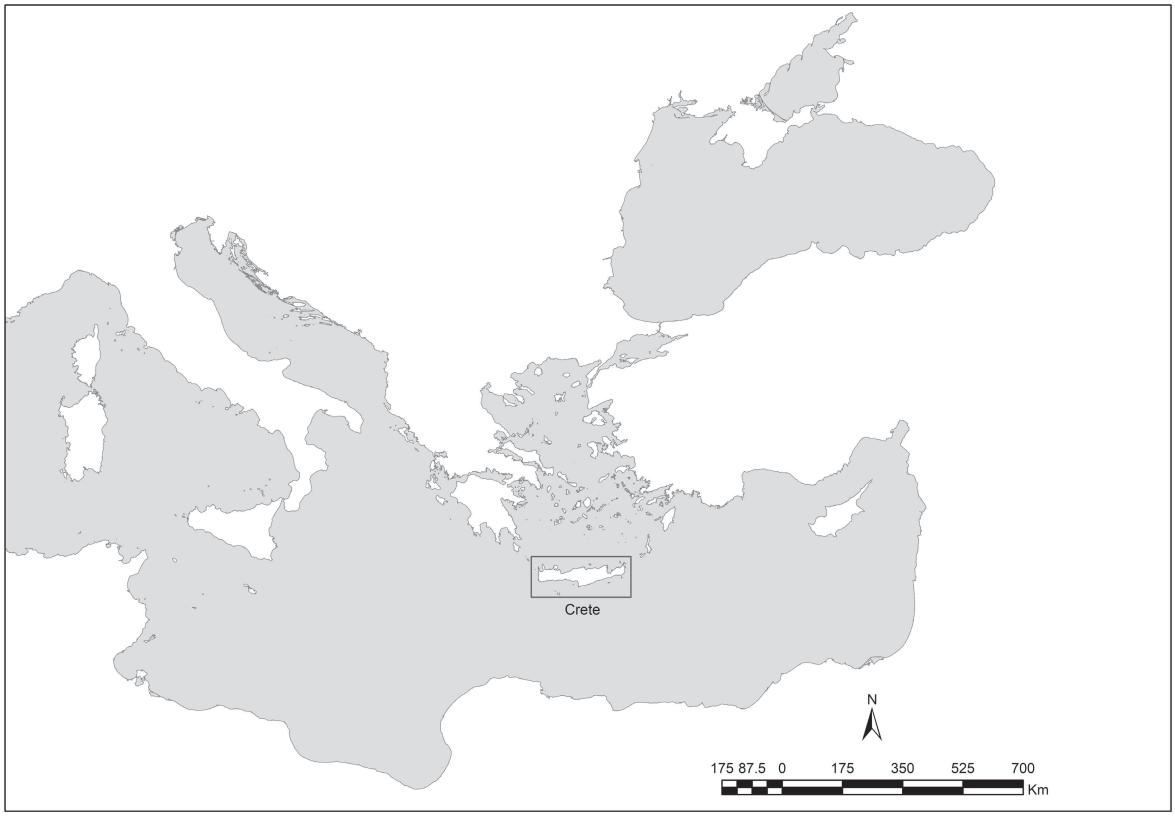


Figure 1. Map of the Eastern Mediterranean showing the strategic position of Crete.

which includes historical and archaeological approaches, combined with spatial analytical tools offered by the Digital Humanities (Geographical Information Systems).[4]

The topography of Crete

In order to ensure an insightful approach to complex issues that are related to ports and harbours of Crete between the 4th and mid-7th centuries AD, it is primarily essential to understand the diverse topographical features of the island. Crete forms the southern limit of the Aegean Sea, holding a strategic position in the broader area of the Eastern Mediterranean (Figure 1). It has a rectangular shape, with its longer axis oriented towards east-west. Cretan topography is primarily mountainous and rugged, with most of the island's territory covered by mountain ranges (Figure 2). The inland of Crete is dominated by an almost continuous chain of mountain groups from east to west. On the western and central part of the island are located the highest peaks, that reach approximately 2450m (Lefka Ori: 2453m – Idi: 2456m). The eastern part, however, is covered by mountain ranges with lower crests (Dikti: 2148m, Thripti: 1476m, Sitiaka Ori: 817m). Between these impressive mountain groups numerous gaps are carved. The most important gap is found in the modern prefecture of Rethemno between the two highest mountain ranges of Lefka Ori and Idi. The length of the gap in the north-south axis reaches 25km, with a width of 30–40km. The topography consists of numerous rolling hills and smaller mountains that range from 100–600m in elevation.

The coastline of Crete extends over 1046km in length. This extensive coastal zone is one of the most dynamic and changing parts of the Cretan landscape. In general terms, the Cretan coastline presents various topographic features, including rocky coasts or coastal cliffs, and medium/coarse

[4] My most special thanks goes to Professor Dr. Apostolos Sarris (University of Cyprus Research Director. GeoSat ReSeArch Lab, IMS/FORTH). Prof. Dr. Sarris with his great experience in archaeological projects in Crete and his expertise in the application of GIS technology in archaeology provided me with the most valuable advices and strategic thinking in the implementation of GIS analyses.

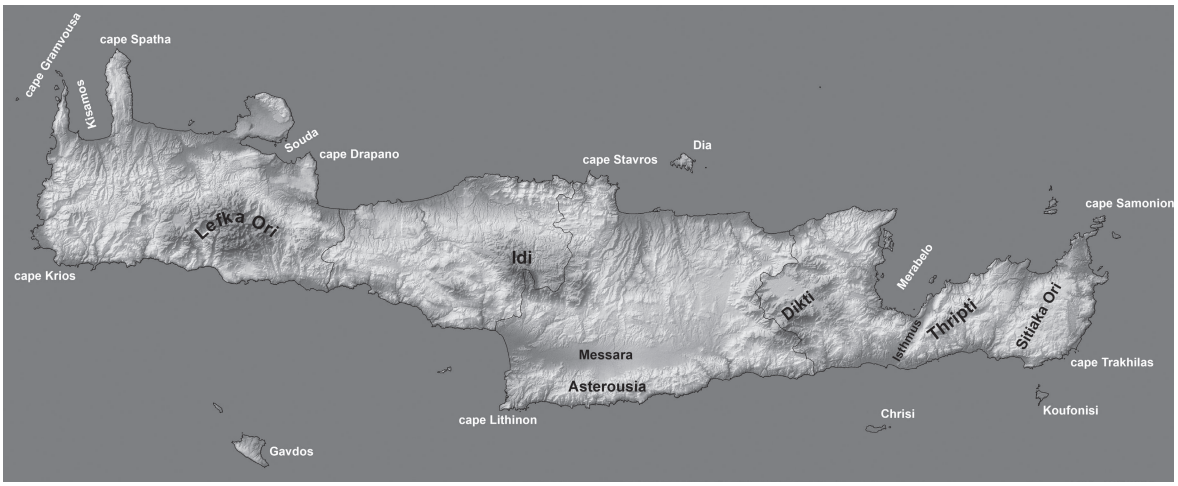


Figure 2. Map of Crete with regions discussed in the article.

Figure 3. The gradually sloping north facing coast of Crete around modern Chania (ancient Kedonia).

sediment beaches.[5] It is dominated by high coasts with sea cliffs over 10m, while only about 15% of the coastline's length is formed by sandy beaches. The gradually sloping north-facing coast of Crete provides several coastal plains (Figure 3). Instead, the south coast is backed by a continuous range of steep and high mountains (Figure 4), which are interrupted only in the area of the isthmus of Hierapetra, where an extensive coastal plain is located. Numerous gorges carve the entire coastal landscape of Crete, from the highest mountain peaks to the coast. Several short rivers, most of which are seasonal, run from the mountainous interior down to the coast.

Along the Cretan coasts a wide range of types of beaches are encountered, on the basis of size, situation (horst or filled grabens), configuration (pocket or straight beach), profile (cliff, bluff or dunes), whether a river runs on to the beach or not, and the length of the fetches in the direction

[5] Monioudi *et al.* 2014.

Figure 4. High mountains along the southern coast of Crete.

of prevailing or predominant waves.[6] The size and profile of the beaches vary from small pocket beaches (sandy or pebble) at a cliff to beaches that stretch over several kilometers with a well-developed berm. Beaches with a width of less than 50m represent the largest percentage (90%) along the coasts of the central and eastern Crete (the modern prefectures of Heraklion and Lassithi). Beaches with a width of 50-100m are fewer and located east of the city of Heraklion, east of the city of Ierapetra and at the coastal part of Messara plain.[7] Due to the more complex configuration of the shoreline, the north coast of Crete contains several deep gulfs (e.g. Kisamos, Souda, and Merabelo) or smaller bays (Figure 2). Instead, the rocky and rugged south coast contains only a few naturally protected bays (e.g. Kali Limenes), but a large number of small and partially protected coves. The east coast is fairly barren and possesses only a few bays that could be attractive as anchorages. Finally, the west coast has a more complex configuration and contains numerous bays.

Environmental parameters and transformations

Understanding the complexity of environmental parameters and transformations is equally significant in order to study ports and harbours of Crete in Late Antiquity. Environmental factors, such as the prevailing wind patterns, sea surface currents, sea level changes, tectonic activity and erosion, are taken into account in this study.

The winds and the surface currents were the most significant environmental factors for sailing in ancient times, serving as the primary means of propulsion for ships. In most days of the year, the winds are always present in Crete. The analysis of wind data from functioning weather stations of Crete shows that the annual average wind speed around the island ranges from 7 to 13 knots with

[6] Pyökäri 1999: 538.
[7] Monioudi *et al.* 2014, figure 1.

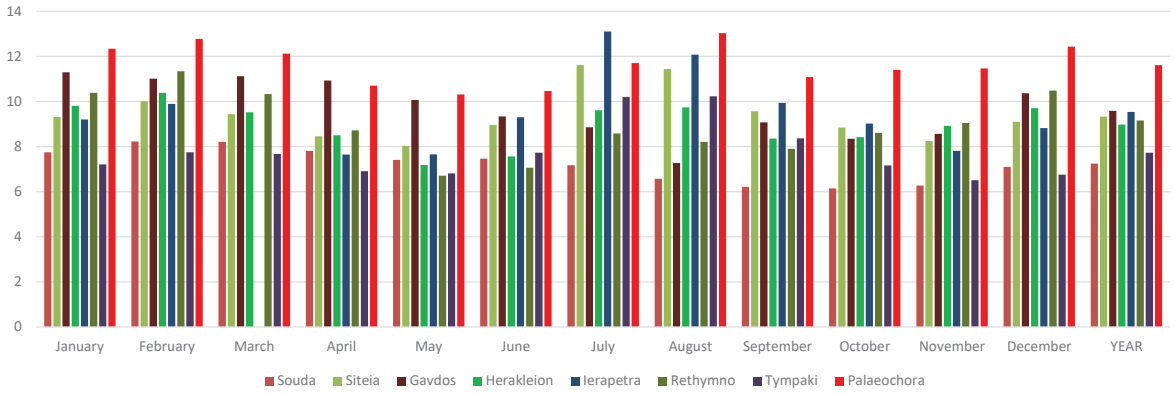


Figure 5. Average Wind Speed for functioning weather stations on the coasts of Crete (A. Sarris).

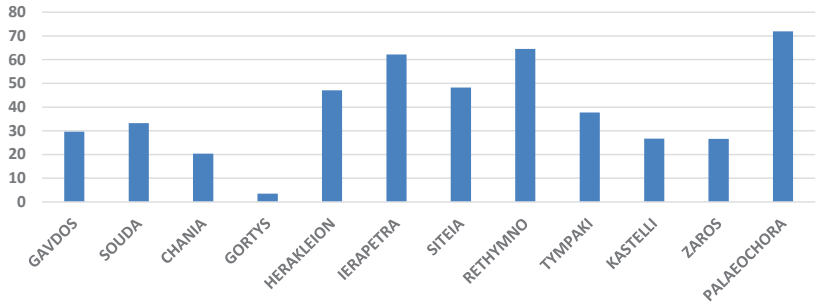


Figure 6. Number of days with wind >=22 knots per year (A. Sarris).

local variations (Figure 5).[8] Furthermore, the results of the analysis of the extreme wind data show that in some areas the annual average number of days with wind >= 22 knots is relatively high: 71 in Paleochora, 64 in Rethymno, 62 in Hierapetra, 47 in Heraklion and 46 in Sitia (Figure 6). The north, northeast, west and southwest winds represent the largest frequency percentage for the four weather stations on south Crete (Paleochora, Ierapetra, Tympaki, and Gavdos Island) between June and September, the period during which ancient mariners mainly preferred to travel. The northern, northwestern and western winds represent the largest frequency percentage for the four weather stations on north Crete (Heraklion, Rethymno, Sitia, Souda) (Figure 23) between June and September. In general terms, winds around Crete are more variable in direction during winter than summer. They tend to change direction unpredictably far more often than in summer. During the winter, the entire south costal is exposed to the south winds, which create extremely rough sea conditions.[9] Needless to say, in both south and north coasts locally many variations can be seen due largely to the complex topography of Crete, and in summer to land and sea breezes.

It is worth noting that modern studies suggest that the interaction of the northern wind flow (Etesians or meltemia) with the mountainous landscape of the island produces a deceleration zone with a horizontal extent of about 90km over the maritime area north of Crete, a westward and mainly eastward deflection of the air as this approaches the mountains and an intensification of the winds at the southern coasts accompanied with a temperature increase.[10] The westward

[8] Wind data from functioning weather stations in the vicinity of the coastline of Crete were analyzed for the needs of this project. Average winds and extreme winds histograms as well as rode diagrams have been generated. The following primary wind data were provided by the Hellenic National Meteorological Service: a) Monthly Dominant Wind Direction, b) Average Monthly Wind Intensity, c) Average Monthly Wind Speed, and d) Number of Days with Maximum Wind Intensity ≥22 knot. The data derive from 11 surface meteorological stations of Crete (630 Gavdos, 746 Souda, 477 Chania, 751 Paleochora, 753 Gortys, 754 Heraklion, 756 Ierapetra, 757 Sitia, 758 Rethymno, 759 Tympaki, 760 Kasteli) and in some cases covers the period from 1970 to the present day. Most of these stations are distributed along the coastline and gives us an overall picture of the sailing conditions offshore of Crete.

[9] Mediterranean Pilot V, 129.

[10] For more on this phenomenon see Kotroni *et al.* 2001; Koletsis *et al.* 2009; Koletsis *et al.* 2010; Koletsis 2010.The Etesians can blow steadily for several days during July and August, where they exhibit their maximum duration and reach the highest intensity. In terms

deflection is a result of flow deflecting around the mountain range of Lefka Ori. The winds veer to the northwestern end of the island, the Gramvousa Peninsula. Additionally, in the upstream of mountain Idi (central Crete) there is a noticeable gradual leftward turn with intensification of the wind flow offshore, of the central and eastern part of the north coast of the island. The wind turns to northwest as it forces its way through the maritime area off the eastern coast of Crete, within a relatively narrow maritime zone between the island itself and Karpathos and Rhodos. As such, the wind flow is deflected around Crete, giving rise to strong winds offshore of the western and eastern coasts. The maximum wind flow intensity is observed over the eastern and western edges of the island.[11] Furthermore, recent studies have shown that the Etesians blow through the gaps between the mountains or through the small and large gorges that are open on the south, producing localized very fierce and unpredictable gusts in many sections of the southern coastline.[12] The gap between the mountain ranges of Lefka Ori and Idi is an excellent example.

Additionally, sirocco events (southeast to southwest winds) affect mainly Crete and the southern Aegean, and tend to occur year-round without a favoured month or season.[13] They cause dusty dry conditions in Crete with low visibility both on land and sea. The south-facing coast of the island is particularly vulnerable to sirocco. It may last either half a day or several days.

Sea surface currents, which are mainly wind-generated, are important environmental parameters that need to be taken into account. Their direction and intensity is determined by the wind that blows on the surface of the sea.[14] There are two main sea currents that run cyclonically throughout the entire Aegean and relate to Crete are the 'north-east Aegean current' and the 'eastern Mediterranean current'.[15] The first one crosses the east coastline of the Greek Mainland in a southward direction and, moving through the islands or the maritime area between the Cyclades and the Peloponnese reaches as far as Crete. It crosses the north coastline of Crete in an eastward direction and periodically reaches as far as the maritime channel between Crete and Kasos. A branch of the eastern Mediterranean current crosses the southern coastline of Crete in a westward direction and continues to the straits of Kythera. Apart from this general picture, according to the Mediterranean Pilot, locally the currents offshore to the south coastline of Crete are variable.[16] A slightly higher frequency of west setting currents occurs in spring (December to February) with a rate rarely exceeding 1kn. In summer (June to August), the west currents turn to south and then to east-southeast. On the north coastline of Crete currents are also variable. A higher frequency of west setting currents occurs in summer in the central and western parts, while east setting currents occur in the eastern part.

Beaches are the most sensitive and complex components of the coastal environments.[17] They are particularly vulnerable to erosion as a result of environmental parameters or human pressure. When beaches erode, the available ecosystem space shrinks.[18] This coastal 'squeeze' can impact the ancient harbour infrastructures to the point of extinction. Cretan beaches have been actively retreating during the past decades. Modern studies of the coastline of the Lassithi Prefecture have shown that about 70% of the examined beaches are retreating, while only 30% are stable. [19] It is interesting to note that these changes have mainly occurred to longer coastlines, which have

of wind speed, they can reach gale force, creating problems to sea transport: for more see Poupkou *et al.* 2011; Koletsis *et al.* 2009. 1845.
[11] Kotroni *et al.* 2001.
[12] Koletsis *et al.* 2009; Koletsis *et al.* 2010; Koletsis 2010
[13] The sirocco is originating as hot, dry desert-air over northern Africa, flowing northward into the southern Mediterranean basin. For more seeTartaron 2013: 94.
[14] For more about sea surface currents see Papageorgiou 2008: 201-202.
[15] *Id.*, fig. 3.
[16] Mediterranean Pilot V, diagram 1.139.1 and 1.139.2
[17] Monioudi *et al.* 2014.
[18] Beaches are the components of the coastal environment that mainly hosted ancient ports, harbours and maritime settlements. The vulnerability of these ecosystems poses many obstacles to the identification of ancient maritime sites and infrastructures by archaeologists.
[19] Foteinis and Synolakis 2015.

lost up to 30% of their mean width during the last decades, while pocket beaches have remained approximately stable. The northern coast of Crete is relatively vulnerable to erosion.

Furthermore, the entire coastal zone of the island (beaches, steep cliffs, offshore rocks and islands) is diachronically vulnerable to sea level fluctuations and tectonic activity. As has been proposed, the so-called 'Early Byzantine Tectonic Paroxysm' period, which extended between the middle of the 4th and the middle of the 6th century AD, affected the island of Crete and especially the south coastline.[20] Due to a major tectonic event – which has been connected to the AD 365 earthquake, while other studies place it in the 5th or 6th century AD (480-500 AD)[21] – the western tectonic block of the island split off the eastern block. An uplift of the western half of the island (the modern prefecture of Chania and part of the prefecture of Rethymno) occurred, with a considerable fall of relative sea level. Evidence from different regions of the western half suggests a rather diverse picture. The western coastline uplifted by 9.15m and 7.90m in its southwest and northwest extremities respectively.[22] The uplift of the southwest coastline ranges from 8.25m to 2m and the northwest coastline from 6.45m to 1.60m. At the same time, it seems that the central and eastern half of the island (the modern prefectures of Heraklion and Lassithi and a small part of north Rethemno) remained stable or slightly subsided. However, a recent study has proposed that the shoreline of Crete was not uplifted in one major event, but instead by a series of earthquakes in the early centuries AD.[23]

Sailing around Crete

The evidence discussed above shows that the intensity and direction of currents and winds create either hazardous or favourable conditions for navigation around Crete. Even during the summer months, the coasts of Crete are at times subject to very strong winds that create rough seas. Therefore, if we accept that winds and currents were similar in antiquity as in the modern era, it is reasonable to assume that it was not always an easy task for a ship to sail along the Cretan coasts, especially when it coped with unfavourable winds.[24]

More specifically, on the one hand, if a ship had to follow the route along the north coastline of the island, from the northeastern edge (cape Samonion) to the northwestern edge of Crete (Cape Gramvousa) (Figure 2), it might have frequently been sailing against the prevailing wind and currents. The wind typically accelerates and brings with it large and confused seas. On the other hand, if a ship had to sail following the opposite direction, from the northwestern edge of Crete (cape Gramvousa) to the northeastern edge (cape Samonion), it could frequently experience adversities when sailing in the area of Kisamos, but then it might find more favourable conditions.

The environmental conditions for navigation during summer along the east and south coasts of Crete from cape Samonion (northeast) to cape Trakhilas (southeast) and then to cape Lithinon (central part) and finally to cape Krios (southwest) (Figure 2), when the northerly winds blows, might have not been favourable in every section of this route. Ships that navigated close to the eastern coast of the island were frequently experienced hazardous sailing conditions. Reefs and sudden gusts of winds might have been very dangerous for passing vessels.[25] The entire area does not contain enough naturally well-protected bays, with the exception of Eremoupolis (ancient Itanos), Kouremenos and Kato Zakros. At the same time, the southern coast is not particularly

[20] Pirazzoli 1986
[21] Price *et al.* 2002.
[22] Mourtzas *et al.* 2016: 67.
[23] Ott *et al.* 2021.
[24] Murray 1987. According to Murray, the cycle of winds in the Mediterranean has not differed over the course of history. As such, modern wind data can be used as a reliable source.
[25] For more about sailing along the unfriendly eastern coast of Crete see Chryssoulaki 2005. As she points out, in the middle of the eastern Cretan coastline, there is a perilous spot that modern sailors called 'Αδιάβατος' (the 'Impassable'), a name that reflects their fear.

hospitable, due to the fact that most of its sections are vulnerable to bad weather from the south in winter and the strong northerly squalls year-round. Wind forces could be on the side of a passing ship, given the fact that air masses send violent winds down the lee side of the mountains to the southern coast, and spawn squalls and gales. In such conditions the winds can dash the ship against shallows or completely disorientate it. It is not surprising that modern sailing manuals contain warnings about sudden and unpredictable, violent squalls that blow down from the mountains.[26] The phenomenon of channelling discussed above creates localized hazardous sailing conditions offshore of Cape Lithinon and mainly over the maritime region between Agia Galini and Fragkokastello. Episodes of localized intensification of the flow downstream along the southern coast occur at the southwestern edge of Crete, associated with the wake, which is observed in the region downstream of Lefka Ori, and in the maritime area between Leven and Arve, associated with the presence of mountain wakes downwind of the higher peaks of Asterousia.

Multi-scalar networks in Crete during Late Antiquity

General features of the Cretan harbours

A thorough bibliographical research produced a number of 85 sites along the shores of Crete and its numerous offshore islands, that can be characterized either with certainty or with a certain degree of possibility as ports and harbours during Late Antiquity (Figure 7). Unfortunately, most of these sites are not well-studied while the relevant archaeological information are widely scattered in the literature.[27] The number of systematic archaeological researches focusing on harbour infrastructures in Crete during the Roman and the Late Antique periods is limited.[28] Most archaeological research conducted at coastal sites on the island (systematic or rescue excavations, surface surveys, geophysics, fieldworks, etc.) have placed considerable attention on the investigation of the maritime settlements rather than their harbour infrastructures.

In several sites, ancient harbour infrastructures are preserved (e.g. moles and breakwaters, etc.), mainly submerged beneath the current sea level.[29] In most cases, however, ancient harbour structures have been totally destroyed or never existed (e.g. anchorages with no permanent structures). Nevertheless, these sites can be understood adequately by analyzing a wide set of data such as i) terrestrial archaeological evidence on the coasts (surface ceramics, ruined structures, spolia, inscriptions, etc.) that suggests the development of maritime settlements,[30] ii) the existence of inland towns or rural settlements located in the immediate vicinity of maritime areas (close to the shoreline and well-connected with them though land routes),[31] iii) underwater archaeological material (ceramics, anchors, shipwrecks, etc.) that indicates the use of certain sea spaces (i.e. small creeks) by ancient ships,[32] iv) results of geophysical surveys,[33] v) mentions in written sources (i.e. Anonymous Stadiasmus of the Great Sea, the Acts of the Apostles, etc.) or maps (e.g. Tabula

[26] Mediterranean Pilot V, 129.
[27] The archaeological material is found recorded in the excavation reports of the Greek Ephorates of Antiquities, short notes in old and recent publications, and the results of surface or underwater surveys, catalogues and articles.
[28] Studies (indicative) that focus on harbour infrastructures are the following: For Hierapytna see Mourtzas and Kolaiti 2017; Theodoulou 2019. For Chersonesos see Leatham and Hood 1958-1959: 266-173; Brandon *et al.* 2005. For Kisamos see Flemming and Pirazzoli 1981: 70; Theodoulou *et al.* 2018: 309. For Tholos see Haggis 1996. For Itanos see Vafidis *et al.*2003. For Priniatikos Pirgos see Sarris *et al.* 2014. For general studies see Leatham and Hood 1958-1559; Flemming and Pirazzoli 1981; Hampsa 2006; Theodoulou *et al.* 2015; 2018; Fragkopoulou 2013.
[29] Kourememos, Hierapytna, Lasea, Preveli (beach of Dionysos), Kisamos, Georgioupoli, Dia (Agios Georgios), Chersonesos, Olous.
[30] Mirtos, Arve, Keratokampos, Tris Ekklisies, Lentas (Leven), Tsoutsouros (Inatos), Kali Limenes, Matala, Kokkinos Pirgos, Agia Galini, Agios Pavlos (Rethemno), Plakias, Souda (Plakias), Fragkokastelo, Loutro (Phenix), Chora Sfakion, Agia Roumeli (Tharra), Sougia (Syia), Lissos, Paleochora, Nopigia (Methemna), Menies (Diktyna), Agii Apostoli, Kedonia, Agios Onoufrios, Stavros, Marathi (Minoa), Limni, Almirida, Georgioupoli, Rethemno, Panormo, Almirida (Sisses), Kalo Chorafi, Agia Pelagia, Heraklion, Stalida, Malia, Kolokitha, Bourouni (Agios Nikolaos), Agios Nikolaos (Kamara), Priniatikos Pirgos, Karavostasi, Vrionisi, Alatzomouri, Agriomandra, Tholos, Psira, Mochlos, Sitia, Itanos, Chrissi, Gra Lighia, Gavdos.
[31] Kato Zakros, Fodele.
[32] Agios Ioannis Sostis, Damialis, Agios Pavlos (Kisamos), Chironisi, Dia (Kappari, Panagia, Agrielia, Aginara), Atherinolakos.
[33] Itanos, Priniatikos Pirgos.

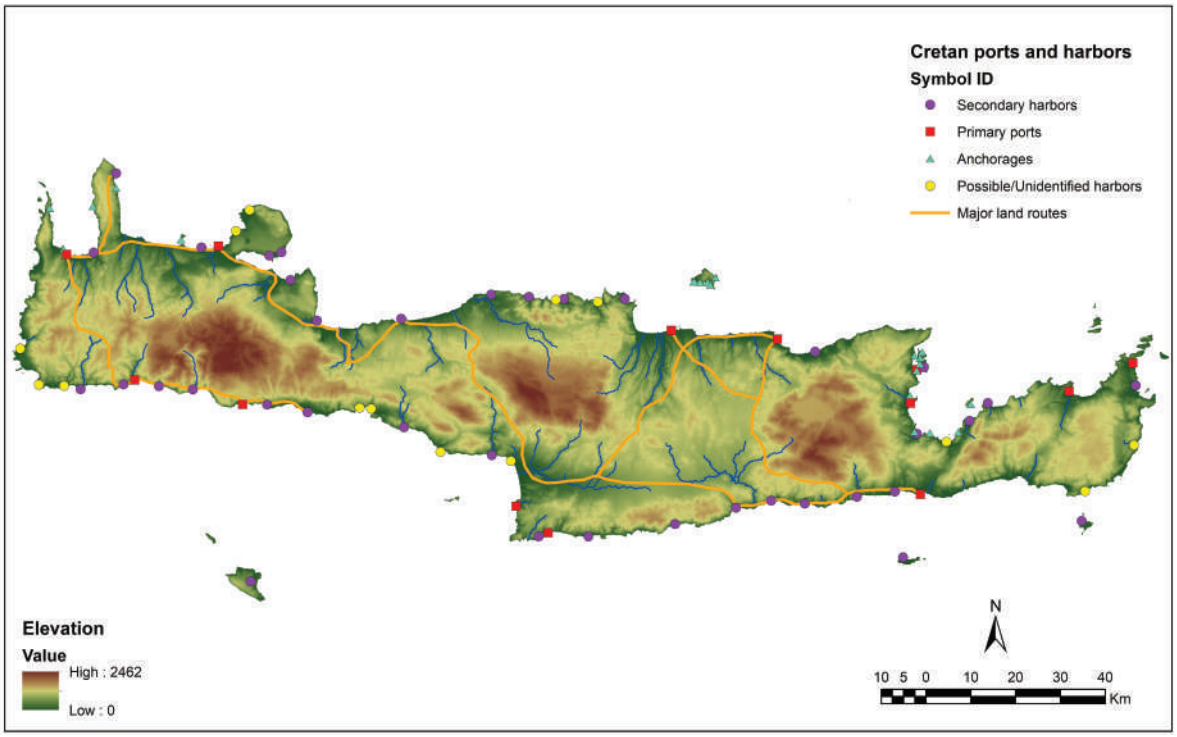


Figure 7. Port and harbour network along the coasts of Crete during Late Antiquity.

Peutingeriana, maps from the Venetian period, etc.),[34] and vi) topographical and environmental parameters.[35] Based on the available archaeological material from the entire island it is quite possible to assume that no major harbour infrastructures were built in Crete during Late Antiquity. It seems that most of them, if not all, were constructed in previous periods, such as the Early-Mid Roman era, and remained in use between the 4th and mid-7th centuries AD with some restorations or modifications.[36] Most of the recorded sites along the coasts of Crete dated to Late Antiquity can be generally classified as natural harbours. However, there is also a small number of artificial harbours, as evidenced by the examples of Kisamos, Chersonesos, Hierapytna, Lasea and Preveli/beach of Dionysos (Figure 8).

An issue of critical importance is to define particular criteria that were used by the ancient inhabitants of Crete for the selection of ports' and harbours' locations. Many studies have pointed out that a wide range of variables played a significant role in the selection such as i) the configuration of the coastline (headlands, bay, creek, estuary, etc.), ii) the aspect or degree of confinement (open or closed), iii) the presence of a sandy or rocky beach, iv) the availability of water, salt and food, v) the impact of maritime environmental conditions (wind speed and direction, wave height, sea bed quality for anchoring, visibility), vi) terrestrial accessibility and connection with fertile productive zones (coastal or inland), and vii) the existence of natural landmarks (e.g. mountain ranges, headlands, islets, etc.).[37] These features had an impact on the foundation and evolution of harbour sites, since they define their quality and suitability, as well as the extent to which they could provide favourable natural conditions for the development of maritime activities.

[34] Kali Limenes, Keratokampos, Matala, Agia Galini, Agios Pavlos (possibly Psycheion), Loutro (Phenix), Agia Roumeli (Tharra), Sougia (Syia), Menies (Dyktina), Thodorou (possibly Koite), Hydramia, Georgioupoli (possibly Amphimatrion), Bali (Astali), Heraklion, Agios Nikolaos (Kamara), Sitia, Itanos, etc.

[35] Agios Pavlos (possibly Psycheion), Stavros, Bali (Astali), Atherinolakos.

[36] For example the port of Hierapytna was constructed in the earlier Roman period. For a reconstruction of the palaeogeography of the Roman coastline at the Hierapytna in relation to the relative sea-level changes that have occurred during the last 2,000 years see Mourtzas and Kolaiti 2017; See also Theodoulou 2019. For Chersonesos see Brandon *et al.* 2005. For Kisamos see Flemming and Pirazzoli 1981: 70; Theodoulou *et al.* 2018: 309.

[37] For more see McGrail 1983; Morton 2001; Marriner and Morhange 2007; Arnaud 2005; 2014; Safadi 2016; Mauro 2019.

Figure 8. Submerged harbour infrastructures just off the beach of Dionysos, east of Preveli (Google Earth).

Taking into account all these criteria, as well as the available studies that provide significant information about the ancient coastline of Crete (e.g. sea level changes, erosion, etc.),[38] a wide range of features turns out to have been important for the development of a harbour site on the Cretan coastline.

A closer look at micro-topography suggests that Cretan ports and harbours occur:[39]

- In natural bays or creeks (e.g. Agii Apostoli, Kalo Chorafi, Dia/Agios Georgios, Olous, Bourouni/Agios Nikolaos, Prinitatikos Pirgos, Tholos, Itanos, Lentas/ ancient Leven, Kali Limenes, Matala, Sougia/ancient Syia, Lissos, etc.) (Figure 9).
- On promontories (e.g. Agios Ioannis Sostis/ancient Agnio, Damialis, Agios Pavlos/ Kisamos, Georgioupoli, Rethemno, Chersonesos, Sitia, Hierapytna, Loutro/ancient Phenix, Paleochora, etc.) (Figure 7).
- On estuaries of rivers or/and at the end of gorges that provide communication channels with the hinterland (e.g. Georgioupoli, Fodele, Kato Zakros, Mirtos, Arve, Keratokampos, Tsoutsouros/Inatos, Lentas/ ancient Leven, Chrisostomos/ancient Lasea, Preveli/beach of Dionysos, Agia Roumeli/ancient Tharra, Sougia/ancient Syia, Lissos, etc.) (Figure 10). However, here are a few examples of harbour sites, such as Tris Ekklisies, that are completely cut off from inland by massif mountain ranges.
- In relation with major land routes (e.g. Kisamos, Menies/Dyktina, Kedonia, Heraklion, Chersonesos, Tholos, Hierapytna, Arve, Inatos, Phenix, Tharra, Syia, Lissos, etc.) (Figure 7).
- In relation with offshore islets and reefs (e.g. Marathi/ancient Minoa, Almirida/Souda, Heraklion, Kolokitha, Bourouni/Agios Nikolaos, Agios Nikolaos/ancient Kamara, Tholos, Hierapytna, Lasea, Kali Limenes, Preveli/beach of Dionysos) (Figures 8, 11-12).

[38] Mourtzas 1988; 1990; 2012; Stiros 2001; Stiros and Drakos 2006; Pavlopoulos *et al.* 2007; Theodorakopoulou *et al.* 2009; Sarris *et al.* 2014; Foteinis and Synolakis 2015; Mourtzas *et al.* 2016; Mourtzas and Kolaiti 2017; Werner *et al.* 2018; Petrakis *et al.* 2019; Fragkopoulou 2013.
[39] Cretan ports and harbours share one or more of these features.

Figure 9. Harbours in natural bays or creeks: the examples of Matala (south coast) and Tholos (north coast).

Figure 10. The relation between the harbour of Georgioupoli (ancientAmphimatrion) and the river Almiros (Google Earth).

- In offshore islets and islands (Thodorou, Dia, Psira, Vrionisi, Koufonisi/Lefki, Chrisi, Gavdos) (figs 7, 12).
- In immediate vicinity with small or large fertile coastal plains (e.g. Kisamos, Kedonia, Georgioupoli, Rethemno, Priniatikos Pirgos, Tholos, Sitia, Hierapytna, Arve, Matala, Sougia/ancient Syia, etc.) (Figure 3).
- In sandy beaches for loading, unloading, and dockyard activities. The only exceptions are Agios Ioannis Sostis (possible Agnio) and Damialis in the gulf of Kisamos where the beach is rocky (Figure 16).
- In locations with available water sources (e.g. Georgioupoli, Arve, Lasea, etc.).

Concerning the impact of maritime environmental conditions, especially winds and waves, in terms of afforded protection, Cretan harbours vary significantly due to their orientation and the local peculiarities. As discussed above, the coastline of Crete does not posses natural harbours that are entirely secured from all winds and all seasons, with the exceptions of the gulf of Souda and

Figure 11. The relation between the ancient harbour of Almirida (Souda bay) and the offshore islet of Karga (Google Earth).

Figure 12. The ancient harbour in the offshore island of Psira. The bay of Tholos is discernible in the background.

the lagoon of Elounda (ancient Olous).[40] The majority of the recorded harbour sites could offer partial protection from winds and sometimes sheltering might have been uncomfortable and dangerous. For example, the bay of Sougia (ancient Syia) does not afford shelter from the north winds, which, as was discussed above, can be extremely violent in many sections of the south coast of Crete.[41] The ports of Phenix and Matala, although they are well-protected from the south winds, are also particularly vulnerable to the north gales.[42] The port of Kali Limenes affords good shelter from winds from the between southwest and north directions.[43] The bay of Lentas (ancient Leven) is sheltered from the westerly but it is exposed to winds from almost all the other directions.[44] The bay of Tsoutsouros (ancient Inatos) affords good protection from western and northwestern winds, while the bay of Keratokampos affords shelter only from north winds. [45] Finally, a number of harbours could provide shelter in calm weather only.

The hierarchy of harbour sites in Crete during Late Antiquity

Cretan harbours can be generally classified into three main types while they were able to carry out several functions and fulfil various purposes. The picture derived from the analysis of the sites is rather diverse, consisting of primary ports, secondary harbours, and lesser sites such as anchorages with permanent or temporary use (Figure 7).

Primary ports are associated with important coastal cities or mid-size towns, which are generally equipped with harbour infrastructures, facilities and monumental buildings (e.g. moles, breakwaters, warehouses, religious buildings, lighthouses, etc.).[46] Illustrative examples of primary ports are Kisamos, Kedonia, Heraklion, Chersonesos, Itanos, Olous, Hierapytna, Lasea, Matala, Phenix, and Syia (Figure 7). All of these primary ports played a crucial role in the economic activity of the island, acting as hubs for regional and supraregional commerce and trade. Some of them were administrative centres and episcopal seats with active and powerful local ecclesiastical and civic elites. In Chersonesos, for instance, eight lead seals of someone called *Ioannis kouvikoularios* dated to the late 6th or early 7th century AD were discovered in the excavations of a building close to the promontory of Kastri.[47] It seems that this area was the administrative centre of the city that hosted a local official who had frequent correspondence with members of the central government. At the same time, the study of the imported ceramics found in excavations testifies to relations of the city with Constantinople, North Africa, Egypt, Cyprus and Asia Minor until at least the 8th century AD.[48] The port of Matala and, possibly Lasea, could have been used by Gortyn, the capital of Crete, as *epinia* (satellite harbours or towns).[49] A similar function can be proposed for the port of Heraklion as *epinion* of Knossos, and the port of Syia as *epinion* of Elyros. Finally, some mid-size towns can be classified as primary ports due to their great importance for regional and supraregional commerce and trade. Phenix and Itanos are the most characteristic examples. The study of the ceramics discovered in excavations in Itanos suggests the existence of numerous examples of Cretan amphorae (TRC 1) as well as large quantities of imported amphorae from regions outside the island such as the Aegean, the Eastern Mediterranean and North Africa (LRA 1 from Asia Minor, Syria, Cyprus; LRA 2 from the Aegean; LRA 3 from Asia Minor; LRA 4 from Gaza; LRA 5/6 from Palestine, etc.).[50] In addition, most of the recorded fine wares were imported from famous production centres in North Africa (African Red Slip Ware) and Asia Minor (Phocaean

[40] For the lagoon of Elounda see Alexandrakis *et al.* 2014; Petrakis *et al.* 2019.
[41] Mediterranean Pilot V, 131.
[42] *id.*,132, 134.
[43] *id.*, 134-135.
[44] *id.*, 135.
[45] *id.*, 136.
[46] For more about the definition of ports see Ginalis 2014: 13-15; Casacuberta 2018: 244-245.
[47] Sythiakaki and Mari 2019: 10.
[48] *id.*
[49] For the definition of the term *epinion* see Casacuberta 2018: 119-135
[50] Xanthopoulou 2004; 2015.

Figure 13. The modern church of Agia Kiriaki on the lower slopes of the mountainous promontory that defines the cove of Kalivaki close to modern Georgioupoli.

Red Slip Ware) and can be dated to the 6th and 7th centuries AD.[51] The vast amount of imported pottery testifies to the integration of the harbour of Itanos within regional and supraregional networks from the 5th to the mid-7th century AD. It attests to a high commercial connectivity for this coastal society.

The secondary harbours are associated with coastal settlements or towns of smaller size and had more modest installations and facilities compared to the primary ports. Illustrative examples in Late Antiquity are Almirida and Marathi at the entrance of Souda gulf, Georgioupoli, Agia Pelagia, Malia, Kolokitha, Priniatikos Pirgos, Tholos, Mochlos, Kouremenos, Gra Lighia, Mirtos, Arve, Inatos, Leven, Kali Limenes, etc (Figure 7). In several cases small breakwaters or moles were constructed in order to improve the quality and suitability of the harbour (e.g. Kouremenos). Secondary ports could have been orientated towards a specific port-city and/or they might have been connected with fertile rural production sites (coastal or inland) acting as gateway communities (import-export points). As such, they played a crucial but more local or regional role in the commercial activity of the island. Secondary ports could have also facilitated the intra-island maritime circulation or functioned as control points for mobility within large gulfs. A characteristic example is Georgioupoli on the north coast of Crete (Figure 10). The remains of a Christian basilica beneath the modern church of Agia Kiriaki, which is located on the lower slopes of the mountainous promontory that defines the cove of Kalivaki to the north (Figure 13), and the surface material (ceramics and remains of structures), strongly suggests the existence of a relatively large maritime settlement with port infrastructures in Late Antiquity.[52] The northern part of the small bay was the most suitable area for anchorage (less exposed to the winds). The Christian church was placed in a striking location on the promontory, which was visible from passing ships. Thus, it could

[51] *id.*

[52] The coastal settlement existed at least from the Early Roman period and has dominant phases during Late Antiquity and the Venetian era (personal observation). See also Andrianakis 1982: 32-33; Andreadaki-Vlazaki 2001-2004.

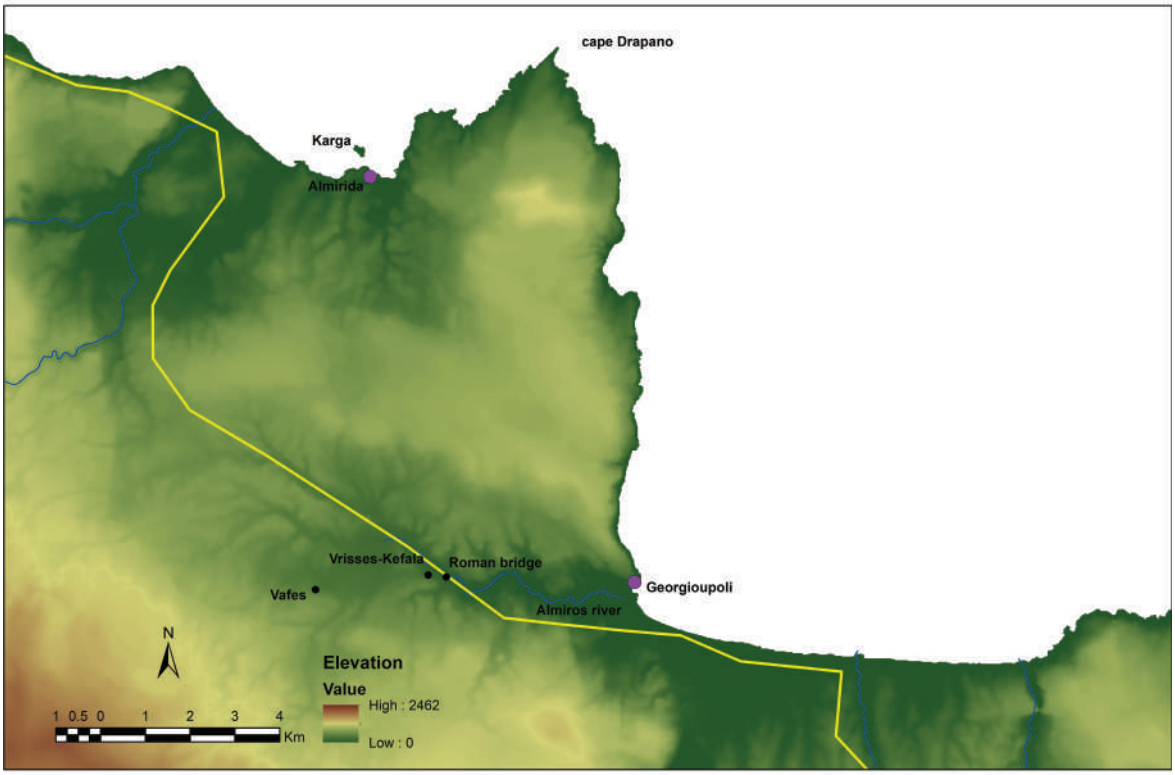


Figure 14. The relation between the harbour of Georgioupoli (ancient Amphimatrion) and rural sites in its hinterland during Late Antiquity.

have served as a geospatial reference point, which was visible from the sea and provided a visual aid for the orientation of ancient mariners.[53] Georgioupoli's harbour was located at the exit of a river (Figure 10) and close to a spring of fresh water.[54] Due to the existence of the river and the mild topography, it was easily accessible from the fertile hinterland of the region of modern Apokoronas. It was, then, well-connected with rural sites in its immediate vicinity (Figure 14).[55] As such, the harbour of Georgioupoli could have acted as export centre for the local rural production (gateway community) and an import point of goods that could cover the needs of the small communities of the area.[56] At the same time, it could have provided passing ships with fresh water and supplies. This evidence points to Georgioupoli as the site of ancient *Amphimatrion*, mentioned by the Stadiasmus.[57]

Finally, small anchorages with permanent or temporary use could have acted simply as stepping stones facilitating navigation, as suitable shelters for anchoring in case of bad weather, or as auxiliary points of anchorage to be used in addition to specific port-cities, depending on their availability or the weather conditions.[58] Characteristic examples are Agios Ioannis Sostis, Damialis and Agios Pavlos within the gulf of Kisamos, Chironisi, Dia, Vrionisi, Agriomandra, Psira, etc (Figure 7). The cases of Agios Ioannis Sostis, Damialis and Agios Pavlos, alllocated within the gulf of Kisamos, are quite interesting (Figure 15). A recent underwater survey has discovered large

[53] For more on this issue see Casacuberta 2018: 112.
[54] The spatial relationship between the port and the river is also marked by Francesco Basilicata (1618) in his map of '*Spiaggia del' Armiro*' (*Cretae Regnum*). See Danezi-Lambrinou 1994.
[55] Recent excavations unearthed a Byzantine rural house at Vrisses-Kefala and the remains of a small church with burials at Vafes beneath the later chapel of Agii Asomati. For more see Andrianakis 2012: 338-339.
[56] Similar functions have been proposed for other ports of the period in many regions. For more see Veikou 2015: 42-45.
[57] See Uggeri 2003: 107; Casacuberta 2018: 91.
[58] For more about the definition of anchorages see Ginalis 2014: 19-20.

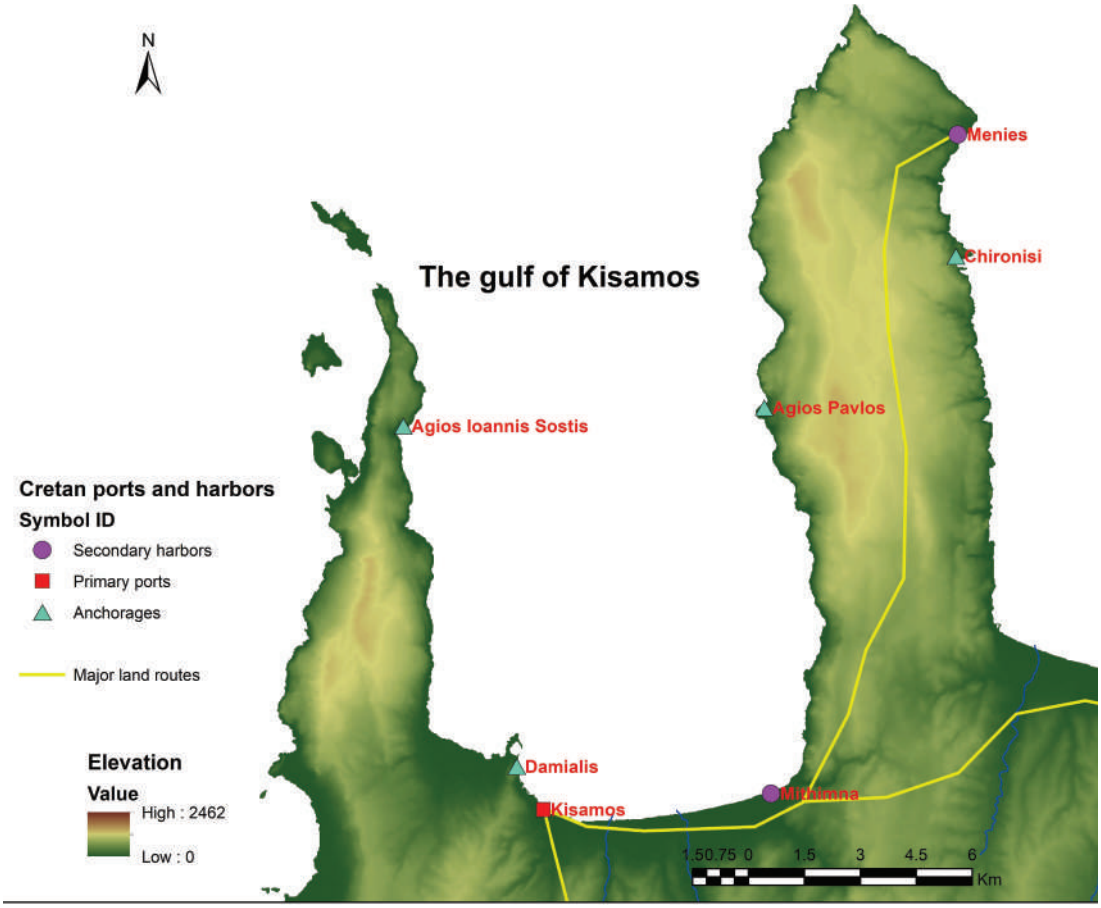


Figure 15. The harbour network in the gulf of Kisamos.

quantities of anchors and ceramic sherds scattered at the bottom of these coves.[59] This material spans a wide chronological spectrum, ranging from Classical to the Byzantine period, suggesting a diachronic use of these tiny maritime spaces as safe anchorages. Despite the fact that the small east-facing coves of Agios Ioannis Sostis and Damialis have rocky coasts unsuitable for landing, they provide excellent shelter for vessels when strong north and east winds blow within the gulf of Kisamos (Figure 16).[60] Sailors could not reach the land so they had to drop anchor in the sea a few meters away from the rocky shore. Furthermore, the northwestern-facing cove of Agios Pavlos offers protection from the strong western and southern winds. The main port of the area, the city of Kisamos, was particularly vulnerable in many of these bad weather conditions. As was mentioned above, ancient mariners could have faced hazardous conditions when sailing in the area of Kisamos. On the one hand, it is quite possible the Agios Ioannis Sostis, Damialis and Agios Pavlos were auxiliary points of anchorage depending on weather conditions in addition to the main port of Kisamos. On the other hand, they could have acted simply as stepping stones facilitating navigation along the north coastline of Crete, offering many options to passing ships. It is worth noting that, Francesco Basilicata (1618), in his map of the gulf of Kisamos marks all of them as harbour sites.[61] Finally, a small number of sites cannot be classified into the categories described above due to the lack of secure archaeological and historical evidence.

[59] For more see Theodoulou *et al.* 2015; Theodoulou *et al.* 2018: 309.
[60] The present-day name 'Sostis' (the Savior) indicates that the cove affords ships a sheltered heaven from prevailing winds.
[61] Map of *Colfo E Spiaggie D' Chissamo'* (*Cretae Regnum*). See Danezi-Lambrinou 1994.

Figure 16. The rocky cove of Agios Ioannis Sostis in the gulf of Kisamos.

A complex interacting harbour network: an overview of the entire island

In antiquity, coastal sailing could offer sailors the advantage to quickly find safe shelter in the case of changing or deteriorating weather conditions.[62] For instance, a rapid change in wind direction could force sailing ships to seek temporary safe shelter. It was, then, important for sailors to have multiple options and to be able quickly to locate the nearest harbour. By maximizing available ports along the nearest coast it was possible to minimize risks in unpredictable stormy conditions. As discussed above, ancient mariners were frequently experienced hazardous sailing conditions traveling along the coasts of Crete. In this context, the topographical features of the shoreline of Crete described above, such as promontories, offshore rocks or islets, bays, coves etc., were fully exploited in antiquity with the development of a dense network of closely-spaced port and harbour infrastructures along the shoreline of the island (Figure 7). Among other reasons, this complex, interacting and well-organized network can be seen as a response to the unpredictable and dangerous sailing conditions around the Crete during Antiquity. There are no large sections of coasts in Crete that totally lack areas that could have functioned as harbours, regardless of their quality and suitability. Instead, in most sections of the Cretan coastline shelter was available if needed. Most of these could provide fresh water and supplies for passing ships, given the fact that they might find themselves unable to leave their shelter for many days. According to Morton, this advantage tends '*to be most valued at the beginning and end of the traditional sailing season, and indeed outside it altogether, when the more changeable weather conditions and the periodic passage of depressions with their various winds made it more likely that a ship sailing initially in favourable conditions might find itself overtaken by adverse conditions before the end of its journey*'.[63] But even in the summer sailing season, when hazardous conditions frequently occur, especially in the south Crete, an important number of available harbours would have been welcome.

As described above, however, the protection provided by most of harbour sites in Crete was clearly neither complete nor guaranteed to last any great length of time. On the one hand, due to the constantly changing winds and the topographical features of some locations, it is clear that not

[62] Morton 2001: 145.
[63] *id.*

all port and harbour facilities could create sheltered conditions in all weather and all seasons. A rapid change in wind direction may not only cause difficulties to ships sailing along the coast (e.g. speed deceleration, disorientation, etc.) but also leave an already sheltered ship exposed to the wind with the risk of being blown onto the shore of the island.[64] On the other hand, not every type of ship could have used every harbour on the coasts of Crete. For instance, larger vessels might have not access all maritime infrastructures. The dense network of ports and harbours in Crete with various diversities in the afforded quality, suitability, capacity, protection, and maritime accessibility might have offered sailors the advantage to have options for every type of ship in all weather and all seasons. Passing sailors judged the advantages and the relative risks and dangers of the different options at their disposal, taking into account various parameters such as the strength and direction of prevailing winds, the nature of weather conditions and the capabilities of the vessels.

In this context, the well-known passage from the Acts of Apostles (Acts 27) vividly describes the adversities that could have been faced by ancient mariners when sailing along the eastern and southern coast of Crete, especially during the winter period. It is particularly interesting because it reflects human agency, by highlighting decisions being made according to developing weather conditions, as well as the relationship between the sailing conditions occurring in the coastal waters of south Crete and the operation of a dense network of multiple closely-spaced ports and harbours in this area. The passage illustrates the fact that passing ships, whose Crete was a leg of their journey, had not always decided the intermediate stations on the island at their initial point of departure, but they decided their stops according to developing weather conditions.[65]

According to the text, the ship taking St. Paul to Rome made a slow progress against adverse winds and reached cape Samonion, the northeastern promontory of Crete, close to the port-city of Itanos. Then, it started sailing along the east and south coastline of the island. As Morton notes, sailing to the south coast of Crete was the crew's response to the northerly winds slowing their ship, which could have led it onto the north coast of the island.[66] Indeed, hugging the coast, the ship reached the port of Kali Limenes, nearby the coastal city of Lasea. Shortly thereafter due to weather conditions and the harbour's unsuitability for wintering, this decision changed and the shipped sailed to another Cretan port, Phenix, which is located approximately 46nm west of Lasea. This mention makes it clear that the quality of port and harbour facilities located along the Cretan coasts varied. In other words, not all ports and harbours could provide the ultimate safety in all weather and all seasons. However, before reaching Phenix a strong wind of hurricane force, called the Northeaster, swept down from the island. It changes the ship's direction and led it to reach the small island Gavdos, which is located 26nm south of Crete. Thus, the ship never reached the port of Phenix. This sudden strong wind illustrates the phenomenon that occurred throughout the days of northerly prevailing flow in the Aegean, causing gale winds at some parts of the southern coasts of Crete. As discussed above, the north wind was accelerated and descended rapidly from the hills and mountains to the sea. The passage is indicative for the dangerous sailing conditions occurring along the south coasts of Crete and posing a serious threat to passing ships. Strong winds could unpredictably appear, maximizing risky condition of travelling. Because of these winds a ship captain could never know exactly where he was going to end up. The evidence discussed above, among other reasons, provides a convincing explanation of why more than forty port infrastructures were closely spaced along the east and south coastline of Crete and why they were remained in use during Late Antiquity, a period of increasing maritime mobility across the Mediterranean.

[64] *id.*, 122. As Morton states, '*the storms of winter, [....] pose far more danger, because even if shelter is taken in an area of relative calm, there is no guarantee that the wind will not change to a direction which exposes that area to the full force of the wind, and, in so doing, also cause the waves and the sea generally to become far rougher*'.
[65] *id.*, 175.
[66] *id.*,118.

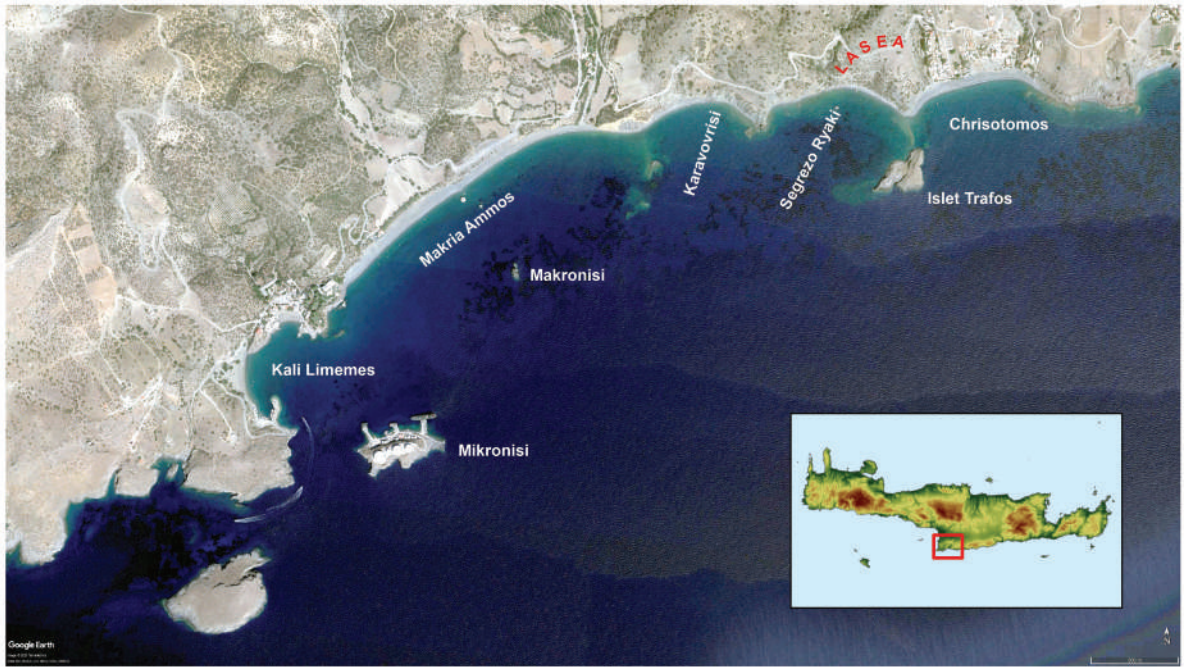


Figure 17. The complex coastline between Lasea and Kali Limenes.

Furthermore, we should not forget that most of the coastal zone of the Crete is characterized by fragmentation due to the extremely mountainous character of the natural environment.[67] Some coastal sites are completely cut-off from the interior of the island while others are hardly accessible. Due to the steep and fragmented character of the Cretan natural environment, in some cases maritime transportation was either quicker than intra-island connectivity or the only option available. As such, the network developed along the shoreline could facilitate not only inter-regional commercial navigation, but also the internal communication between the different coastal and inland parts of the island.[68]

A closer look at micro-regions: local harbour networks on Cretan coasts

Taking into account that harbour sites cannot be regarded as isolated dots on a map, a closer look at specific micro-regions suggests the existence of several local, micro-scale networks, which functioned within the broader interacting harbour system developed along the coasts of Crete in Late Antiquity. They consisted of interlocking harbours of different types, interacting with their surrounding environment, with one another, as well as with macro-scale commercial networks.

A very illustrative example of these networks can be found at Lasea and Kali Limenes, both situated midway along the south coast of Crete (Figure 17). A closer look to the micro-topography of the region from Kali Limenes to Lasea less than a nautical mile to the east shows that this part of the Cretan coastline is quite complex, forming many adjacent basins separated by tongues of land (Figure 17). Starting from the east (Lasea) the shoreline forms three consecutive and separate shallow basins with sandy beaches. The cove to the east called Chrisotomos, the bay in the middle called Segrezo Ryaki and the bay to the west called Karavovrisi. To the west of Karavovrisi is located the sandy beach of Makria Ammos and further west the cove of Kali Limenes. Additionally, there

[67] For more on this see Fragkopoulou 2013: 9-10.
[68] A similar network developed along the shoreline of the mountainous island of Naxos in the Cyclades and facilitated not only inter-regional commercial navigation but also the internal communication between the different parts of the island. For more see Roussos 2017: 266-270.

are three offshore islets, Mikronisi opposite Kali Limenes, Makronisi opposite Makria Ammos and Trafos at the point where Chrisostomos and Segrezo Ryaki coves meet.

Although the harbour of Kali Limenes is mentioned in the Acts of the Apostles as a stop on St. Paul's voyage to Rome (§27.8-12), unfortunately, there are no visible remains of ancient harbour installations in or beside the water. As evidenced by a considerable scatter of sherds on the promontory hill close to the modern chapel of Agios Pavlos, by the west end of the harbour, a coastal settlement developed in the Roman and Late Antique periods.[69] There might have been a special relationship between Kali Limenes and the offshore islet of Mikronisi. A large number of texts indicate that ancient harbours could have been benefitted from an offshore island.[70] Mikronisi, located a few meters opposite the entrance bay, shelters the access to the port of Kali Limenes by providing protection from the south and south-west winds.[71]

The nearby city of Lasea preserves interesting traces of a large ancient harbour.[72] At the point where Chrisostomos and Segrezo Ryaki coves meet forming a small promontory, a manmade structure (structure 1) runs out towards the islet Trafos, which is also called Palios Molos (Figures 18-19). It is a loosely piled bank of large blocks of stone, 90m long, leaving a channel 10-15m wide between it and the islet. Just west of the western tip of the islet of Trafos a second structure (structure2) has been identified submerged at -2m (Figure 18).[73] It starts from the western tip of the islet and extended 150m towards west. Its width ranges between 60 and 80m. It has west-east orientation and runs parallel to the opposite beach of Segrezo Ryaki. Its eastern end is at the tip of Trafos islet. It consists of large stone blocks with a pyramidal arrangement. The two structures and the rocky islet were joined together in order to create a large breakwater, partially artificial and partially natural, that defined the Segrezo Ryaki bay and provided protection against the prevailing strong west and southeast winds. At the same time, it protected the eastern part of the Chrisostomos cove from the

Figure 18. The large breakwater, partially artificial and partially natural, that defined the ancient port of Lasea.

[69] Blackman and Branigan 1975: 17, 22-25.
[70] See Casacuberta 2018: 89-90, 96-97.
[71] Mediterranean Pilot V, 134-135.
[72] Blackman and Branigan 1975: 28-32; Hampsa 2006: 119-122, n.13; Fragkopoulou 2013: 13-22; Mourtzas and Kolaiti 2021.
[73] Chatzi-Vallianou 1990: 382-383; Mourtzas and Kolaiti 2021.

Figure 19. Lasea: The manmade structure that runs out towards the islet Trafos, which is also called Palios Molos.

south and southwest winds. The fact that the large breakwater was constructed mainly to protect the Segrezo Ryaki cove is an indication that this was possibly the main basin of Lasea's harbour. This is further supported by archaeological remains along the coast and submerged structures just off the current shoreline, which are possible traces of moles, quays and other harbour facilities (Figure 20). Furthermore, a spring with fresh water is located on the west end of Segrezo Ryaki basin. The channel may have functioned as a secondary entrance to the main basin, allowing its communication with auxiliary harbour facilities that possibly existed along the adjacent cove of Chrisostomos to the east. It would have been very convenient for moving ships from one basin to the other when the wind changes. Simultaneously, the channel could have functioned as an instrument to deal with the problem of siltation in order to create currents within the main harbour basin. Looking further west to the adjacent cove of Karavovrisi, it is quite possible that the inhabitants of the city might have used it as an auxiliary harbour. At the western end of the cove there are two extensive rocky reefs, consisting of massive beachrock, protruding today from the

Figure 20. Lasea: Archaeological remains along the coast and submerged structures just off the current shoreline.

Figure 21. The view from the chapel of Agios Pavlos. The port of Lasea is The port of Lasea is discernible in the background.

water and running 300m from the shore to the sea with a south orientation. Taking into account sea level changes it is possible that these reefs could have functioned as the western breakwater of the harbour. As such, the cove of Karavovrisi could have been another basin of the port of Lasea.

The fact that Kali Limenes and Lasea are situated in close proximity with each other indicates a special relationship between the two important harbour sites. The settlement on the promontory hill by the chapel of Agios Pavlos overlooked the bay of Kali Limenes, the offshore islet of Mikronisi and the whole coastline to the east from Kali Limenes to Lasea (Figure 21). It is reasonable to assume that Kali Limenes was in the territorial unit of Lasea, and it was not considered as a different entity to this coastal city. It is quite possible that a micro-scale harbour network was developed in this particular region favoured by the topographical and environmental variables. It included the primary port of Lasea (coves Chrisostomos, Segrezo Ryaki and Karavovrisi), the secondary harbour of Kali Limenes and possibly a lesser harbour site in Mikronisi.[74] This local network took advantage of the indented coastline and presented various harbour alternatives (depending on the direction of the wind). It seems, then, that the harbour of Kali Limenes was a 'compartment' within the ensemble of this local network. It could have functioned as an auxiliary point of anchorage from winds between the southwest and north directions, to which the main port of Lasea was exposed. This is, presumably, why the Stadiasmos mentions only Halai (= Lasea) and not Kali Limenes.[75] In this case, the λιμένες/limenes in the plural probably refer to the whole coastline as far as the cove of Chrisostomos.

Heraklion, and the offshore island of Dia, which is located some 7nm to the north, and Agia Pelagia set another interesting example (Figure 22). A serious disadvantage of the coastline around Heraklion is that it does not include natural protected bays, which can provide safe shelter for

[74] Although, the islet Mikronisi is completely destroyed by the establishment on it of an oil bunkering station, it is quite possible that it could possess auxiliary harbour installations.
[75] See also Uggeri 2003: 95.

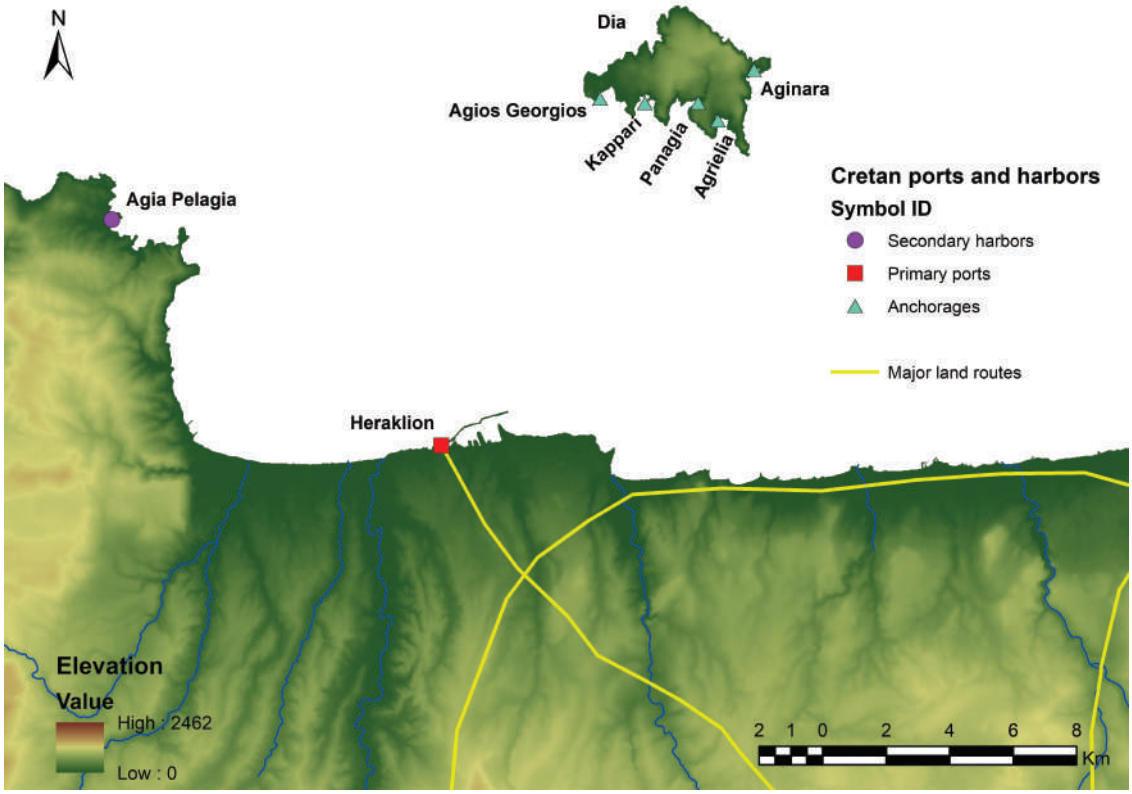
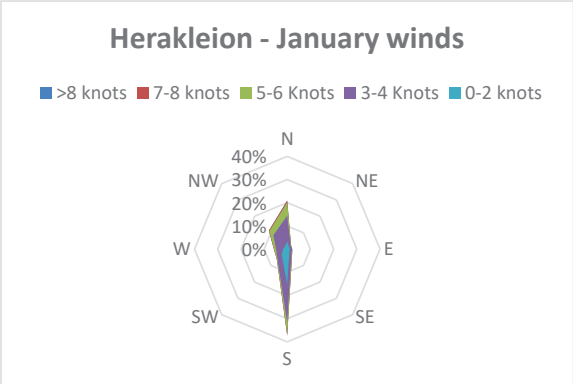


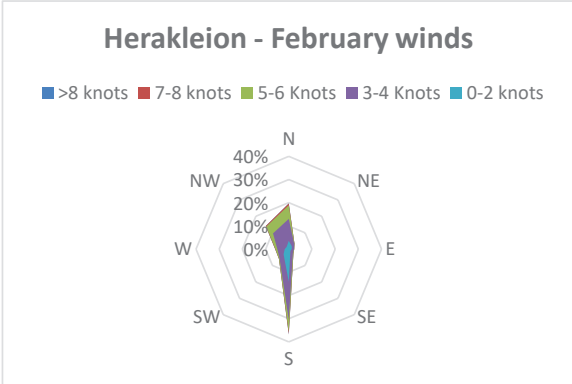
Figure 22. The local harbour network in the area of Heraklion.

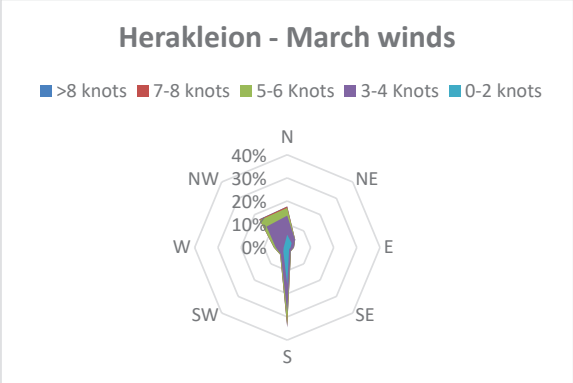
ships. Concerning weather conditions, modern wind data from functioning weather stations at Heraklion[76] suggest that from June to September winds blow predominantly from the north and northwest and are often strong (Figure 23). At the moment, we do not have reliable archaeological evidence for the ancient port of Heraklion in Late Antiquity and the Byzantine period (potential capacity, techniques, facilities, etc.). It seems that it was located more or less at the site of the later Venetian harbour and its north orientation made it extremely vulnerable to the prevailing northerly and north-westerly winds.[77] As evidenced by modern weather data, winds from those directions blow very frequently throughout the summer season (Figure 23). In other words, when bad weather conditions arose, shelter might have been inadequate in the main port of Heraklion and vessels should have been moved to a safest anchorage or could not have been able to approach it. It is worth noting that, due to its vulnerability to northerly and northwesterly winds, the port of Heraklion faced problems of siltation during the later Venetian period. Continuous conservations works took place in order to ensure the harbour's functional longevity.[78]

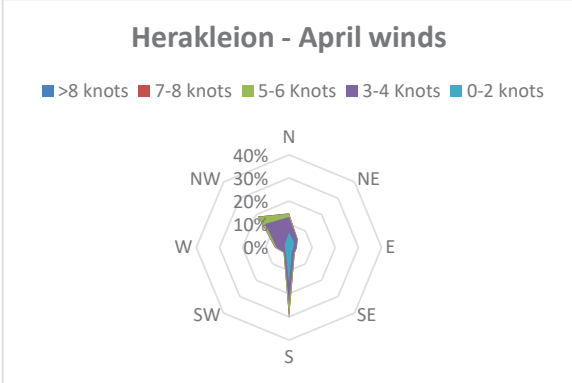
In order to overcome this obstacle, it seems that the ancient maritime community of Heraklion benefitted from the existence of the offshore island of Dia in multiple ways.[79] The offshore island of Dia, which is visible from a distance, marks, even today, marks the approach to the modern port of Heraklion for ships sailing either from the Cyclades to Crete or along the north coast of the island. It is worth noting that Dia is recorded by the *Stadiasmus*, in relation to the ancient port of Heraklion.[80] In order to support the operation of the primary port of the region, a local network of

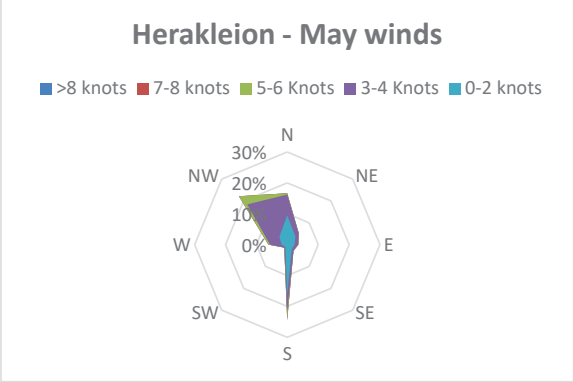
[76] The available data cover a period between 1970 and 2019. It is worth noting that the extreme wind data show that in this area the average number of days with wind >= 22 knots is 47 per year.
[77] An interesting possible reconstruction of the coastline in the 6th century AD has been published by Ch. Tzompanaki: See Tzompanaki 2000: 166-167.
[78] Theodoulou *et al.* 2015: 622-623.
[79] *id.*
[80] § 348: From Astale to Herakleion 100 stades. A city, with a harbour and water. From there 20 stades the city Knossos; There is also an island 40 stades to the west, called Dios.


Herakleion - January winds
>8 knots
7-8 knots
5-6 Knots
3-4 Knots
0-2 knots
N
NE
E
SE
S
SW
W
NW
40%
30%
20%
10%
0%


Herakleion - February winds
>8 knots
7-8 knots
5-6 Knots
3-4 Knots
0-2 knots
N
NE
E
SE
S
SW
W
NW
40%
30%
20%
10%
0%


Herakleion - March winds
>8 knots
7-8 knots
5-6 Knots
3-4 Knots
0-2 knots
N
NE
E
SE
S
SW
W
NW
40%
30%
20%
10%
0%


Herakleion - April winds
>8 knots
7-8 knots
5-6 Knots
3-4 Knots
0-2 knots
N
NE
E
SE
S
SW
W
NW
40%
30%
20%
10%
0%


Herakleion - May winds
>8 knots
7-8 knots
5-6 Knots
3-4 Knots
0-2 knots
N
NE
E
SE
S
SW
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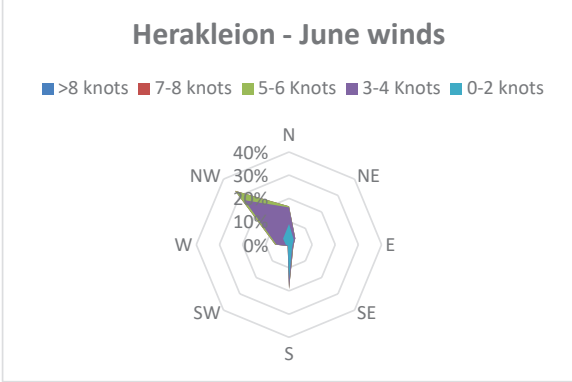
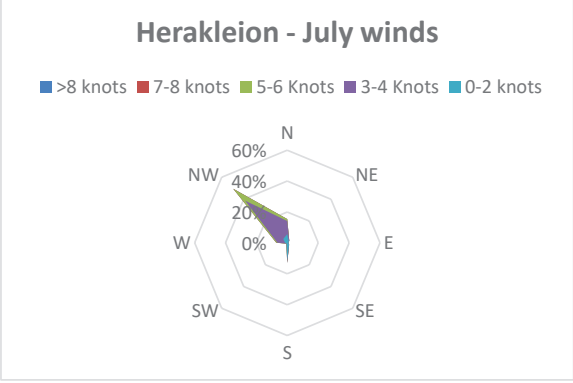
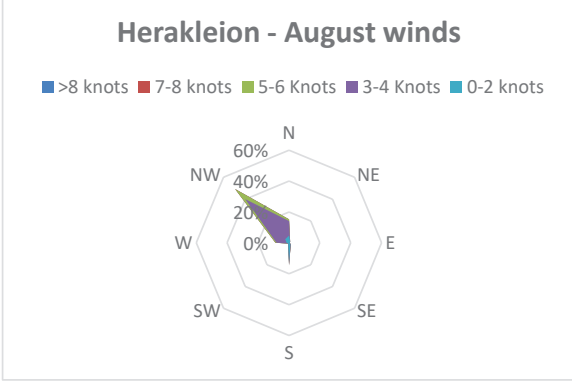
NW
30%
20%
0%


Herakleion - June winds
>8 knots
7-8 knots
5-6 Knots
3-4 Knots
0-2 knots
N
NE
E
SE
S
SW
W
NW
40%
30%
0%


Herakleion - July winds
>8 knots
7-8 knots
5-6 Knots
3-4 Knots
0-2 knots
N
NE
E
SE
S
SW
W
NW
60%
40%
0%


Herakleion - August winds
>8 knots
7-8 knots
5-6 Knots
3-4 Knots
0-2 knots
N
NE
E
SE
S
SW
W
NW
60%
40%
0%

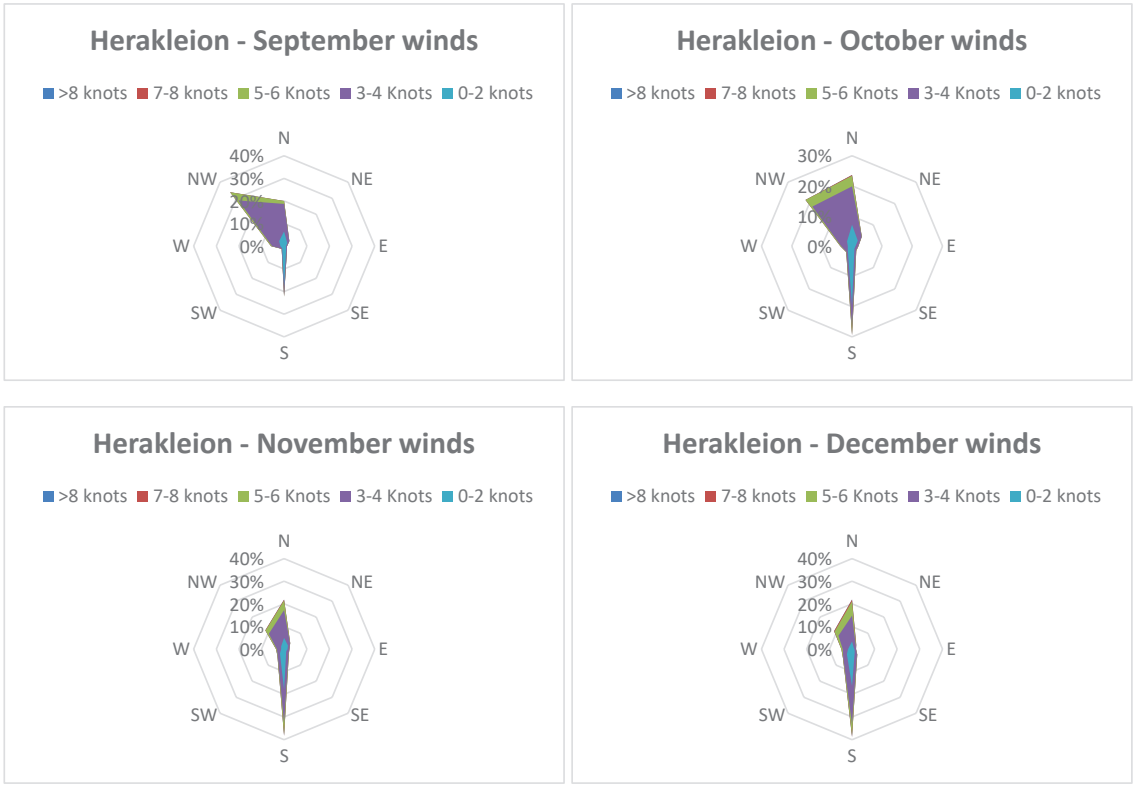


Figure 23. Wind roses for Heraklion (A. Sarris).

secondary small harbours and anchorages was developed along the complex south-facing shores of Dia, where the natural topography created sheltered conditions for the prevailing north and northwesterly winds (Figure 22). Four tiny coves are formed at the southern coast of the island – the Agios Georgios, Kappari, Panagia, and Agrielia – and one, the Aginara, at the eastern side. They are all well-protected from the northerly and northwesterly winds, offering the safest havens when winds blow from those directions. In the case that the opposite main port of Heraklion was extremely busy, these coves might have functioned as places where ships could wait to get a mooring place for loading and unloading. Additionally, during strong north and northwestern winds, ships, which had already been landed to the port of Heraklion, could move to Dia's coves in order to be safe. Furthermore, ships sailing along the north coast of Crete from all directions could find safe places here to wait for the storm to pass.

The most important harbour of Dia was located at the cove of Agios Georgios. It has deep waters and it is defined on the west by the rocky promontory of Korakia. It is well protected from the north, northwest, southwest, west winds. A submerged breakwater that protects part of the bay from the southern wind has been identified. It is built of rubble and measures about 100 x 60m.[81] Evidence such as surface ceramics and other artefacts as well as traces of structures, suggest the existence of a small settlement on the coast.[82] This small maritime community could provide reliable supplies of water and food to the ships while at anchor. It is worth noting that, Francesco Basilicata (1618), in his map of Dia uses the term 'porto' for the three of them (Agios Georgios-Porto Di S. Zorzi, Panagia-Porto della Mantona, and Agielia-Porto di Agroglia).[83]

[81] Theodoulou 2015: 35.
[82] Kopaka 2012: 449-450.
[83] See Danezi-Lambrinou 1994.

The function of the southern leeward side of Dia as auxiliary maritime infrastructures to the main port in Late Antiquity is further supported by the remains of several shipwrecks.[84] However, the various shipwrecks from different periods indicate that the south coast of Dia could not provide ultimate safety in all weather and in all seasons. Wind data from weather stations at Heraklion suggests that the percentage of the south winds is relatively high during the whole season (Figure 23). From January to May strong winds from the south represent the largest percentage of winds that most frequently affect the area. From June to August south winds continuously blow in the area, but they are less frequent compared to the north winds. From September to December strong southerly winds become again the prevailing winds in the area. As such, more frequently than one expects, the south-facing coast of Dia is being affected by the south wind generated waves. This creates hazardous conditions for sailing and partially explains the various shipwrecks that have been found in the vicinity.

When south winds blew in the area, ships could find safe shelter at the main port of Heraklion or at the secondary harbour of Agia Pelagia.[85] The latter is located northeast of Heraklion (Figure 22). The indented coastline of the area is characterized by small multiple bays with sandy beaches. The bay of Agia Pelagia is well protected from the north and south winds. Underwater research, although not systematic, suggests that the bay was used as a harbour in Late Antiquity. Amphorae sherds that can be attributed to well-known Late Roman types were discovered on the seabed.[86] In addition, terrestrial archaeological researches have shown that a coastal settlement was developed in relation with the harbour, from Minoan to Byzantine times.[87] It is worth noting that Agia Pelagia was one of the most important harbours in the region during the Venetian period.

Similar relationships can be proposed between many other ports and harbours of Crete, such as Kisamos, Agios Ioannis Sostis, Damialis and Agios Pavlos within the gulf of Kisamos (Figure 15); Bourouni and Agios Nikolaos (ancient Kamara); Psira, Tholos[88] and perhaps Agriomandra, Hierapytna and Gra Lyghia; and Thodorou, Agii Apostoli and Kedonia.

Conclusions

The rich material from Crete discussed above underlines the importance of moving to a more localized one, with emphasis on the small-scale of the Mediterranean islands, alongside large scale interpretation (Mediterranean, macro-scale) in order to shed more light on a wide range of topics related to ancient port and harbours studies. This study illustrates the fact that ports or harbours were not isolated sites but were integral parts of wider networks, which also include bays, coves, settlements, ecclesiastical complexes, farming zones, land roads, sea routes, etc. As such, they played diverse roles to fulfil various purposes.

It is no exaggeration to say that during Late Antiquity the inhabitants of Crete exploited almost all harbour locations at their disposal along the coastline of the island and made a systematic effort to benefit from the maritime environment. The rich data collected and analyzed for a large number of active ports and harbours reveal that the entire island possessed a complex, interacting and well-organized harbour network between the 4th and mid-7th centuries AD. What is also important is the fact that this broad picture is subdivided into smaller local micro-scale networks, which had different types of interaction. This complex situation can be seen as a cultural product of political, social and economic circumstances, and as a result of topographical, nautical and environmental variables. It also makes it clear that access to the sea and sailing routes was of crucial significance

[84] Theodoulou *et al.* 2015: 616-617.
[85] Hampsa 2006: 251-254; Theodoulou *et al.* 2015: 622.
[86] Theodoulou *et al.* 2015: 622.
[87] Alexiou 1972; Ioannidou-Karetsou 1978.
[88] Haggis 1996.

for the economic and social life of Crete during Late Antiquity. It indicates a high level of mobility around the island for various purposes. The picture that emerges from the material discussed in this paper fits well with Zanini's hypothesis about the renewed central role of Crete in the political, administrative, economic and strategic context of the Mediterranean in the 6th century AD.[89] According to him, this situation changed between the end of the 6th and the 8th century AD. During this period the economy of Crete moved from a Mediterranean macro-economic dimension to a more local micro-economic dimension.[90]

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[89] Zanini 2019: 152-153.
[90] *id.*, 158.

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Enregistrement

Ports and harbours of Crete between the 4th and the 8th c. AD

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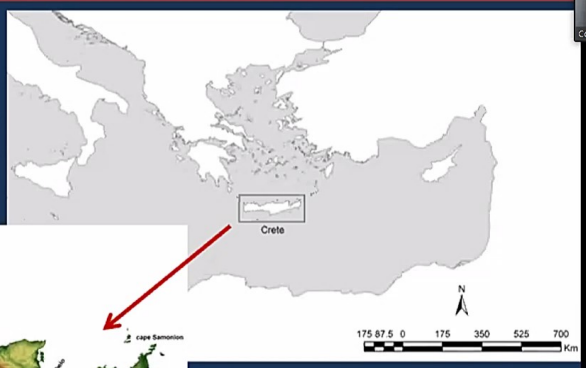
Port and harbour archaeology in Crete

This paper aims to:

- **investigate the dynamic human-environmental interaction that shaped the coastal landscapes of the island in Late Antiquity.**



It tests questions concerning how ports and harbours interacted with:

- one another
- environmental conditions and topographical features in all their complexity
- the interior of the island
- other places across water
- maritime navigation

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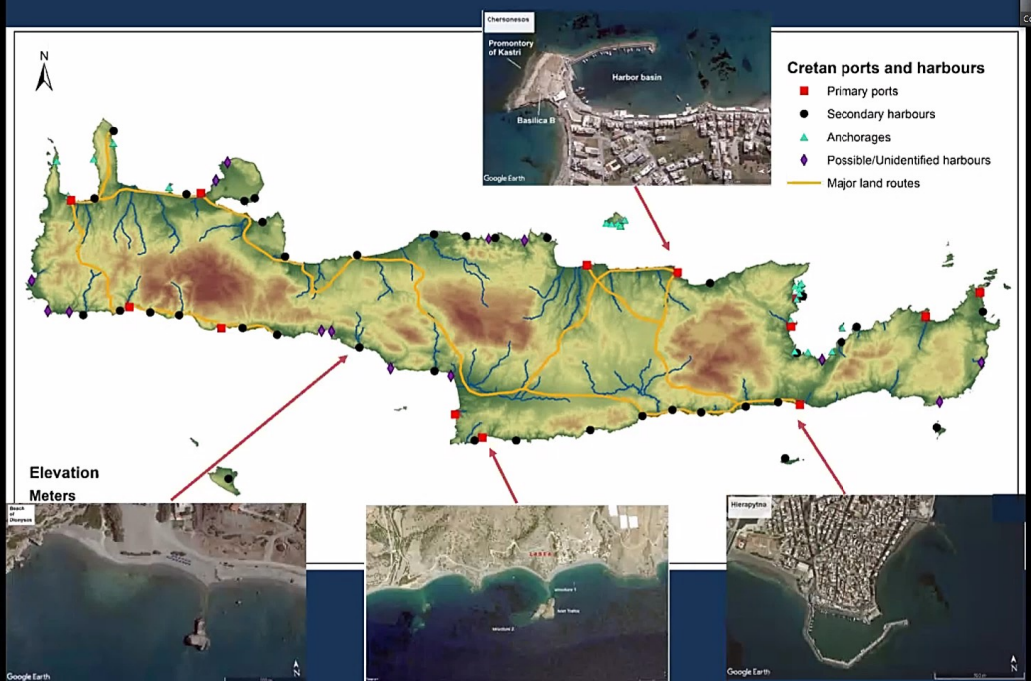
Structures preserved beneath the current sea level



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Data facilitating the understanding of sites with no harbour structures

- **Terrestrial archaeological evidence on the coasts** (surface ceramics, ruined structures, spolia, inscriptions, etc.) that suggests the development of maritime settlements.
- The existence of **inland towns or rural settlements** located in the immediate vicinity of maritime areas (close to the shoreline and well-connected with them though land routes).
- **Underwater archaeological material** (ceramics, anchors, shipwrecks, etc.) that indicates the use of certain sea spaces (i.e. small creeks) from ancient ships.
- Results of **geophysical surveys**.
- Mentions in **written sources or maps**.
- **Topographical and environmental parameters**, such as the prevailing wind patterns, sea surface currents, sea level changes, tectonic activity and erosion.

Terrestrial archaeological evidence on the coast of the bay of Kalivaki, close to Georgioupoli

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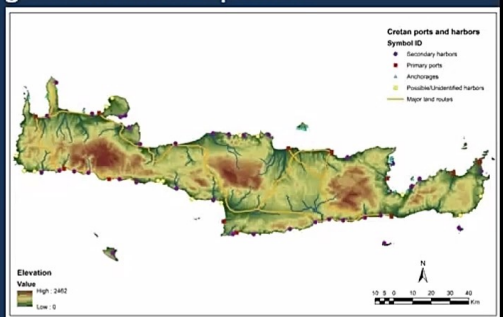
General features of the Cretan harbours

- In natural bays or creeks.
- In promontories.
- In estuaries of rivers or/and at the end of gorges that provide communication channel with the hinterland.
- In relation with major land routes.
- In relation with offshore islets and reefs.
- In offshore islets and islands.
- In immediate vicinity with small or large fertile coastal plains.
- In sandy beaches for loading, unloading, and dockyard activities.
- In locations with available water sources.



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The impact of maritime environmental conditions

The port of Matala although is well-protected from the south winds, it is also particularly vulnerable to the north gales.

The port of Kali Limenes affords good shelter from winds between southwest and north direction.

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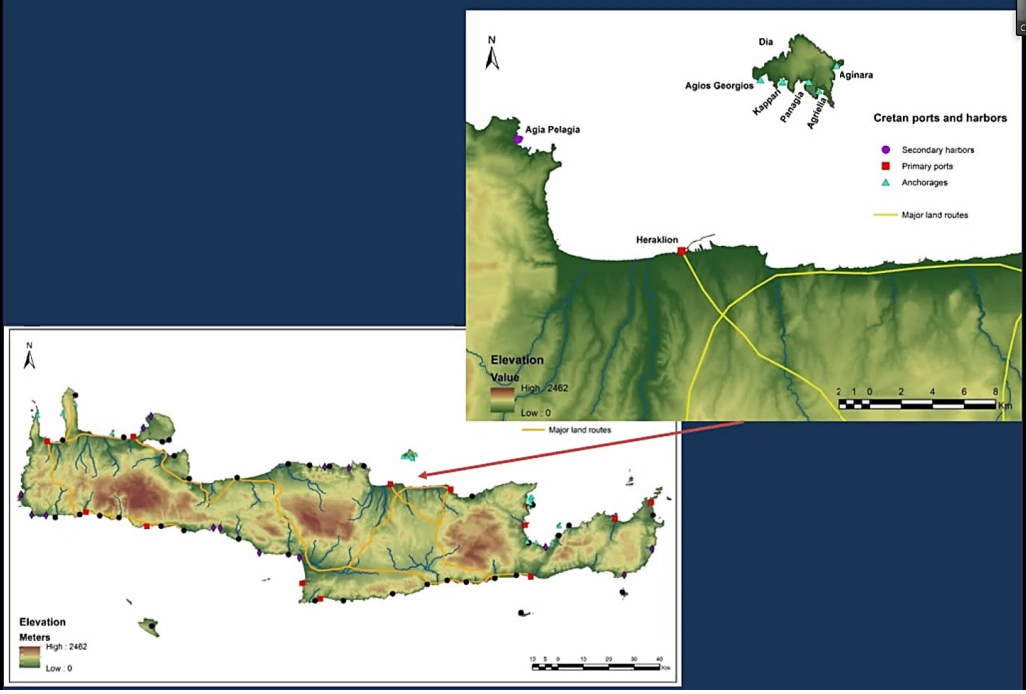
Regional harbour networks in Cretan coasts: Heraklion, Dia, Agia Pelagia



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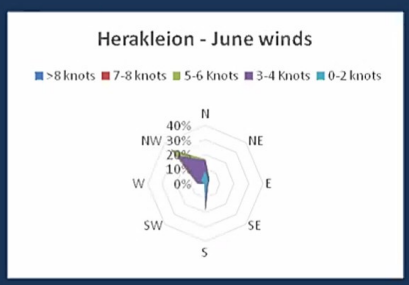
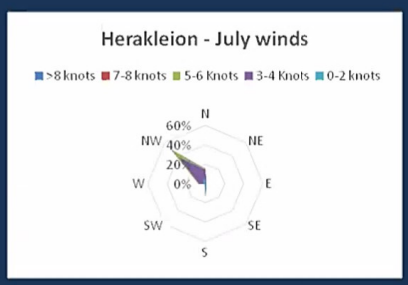
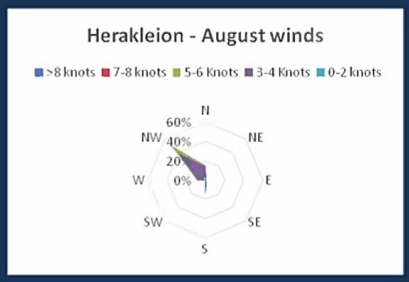
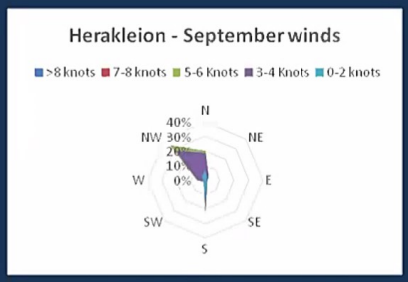
Regional harbour networks in Cretan coasts: Heraklion, Dia, Agia Pelagia









Wind rose diagrams. Wind data (1970-2020) from functioning weather stations at Heraklion was provided by the Hellenic National Meteorological Service.

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Regional harbour networks in Cretan coasts: Heraklion, Dia, Agia Pelagia

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Regional harbour networks in Cretan coasts: Heraklion, Dia, Agia Pelagia

Dia, which is visible from a distance marks, even today, the approach to the modern port of Heraklion for ships sailing either from the Cyclades to Crete or along the north coast of the island.

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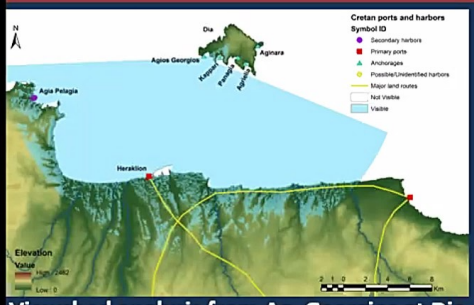
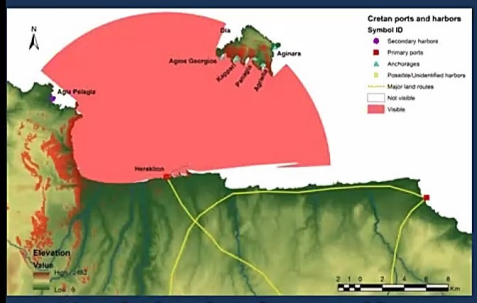
Regional harbour networks in Cretan coasts: Heraklion, Dia, Agia Pelagia



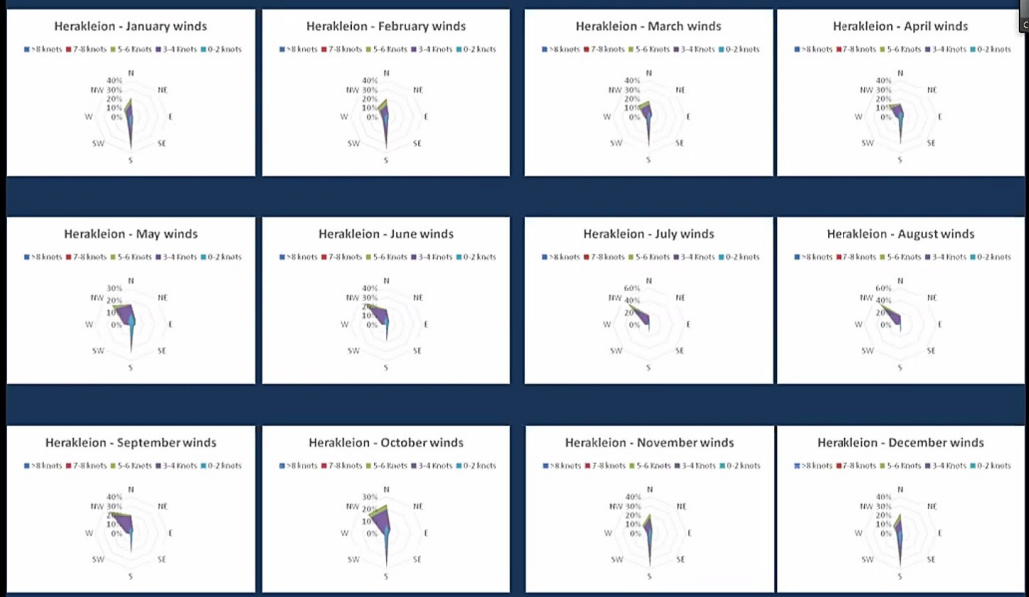
Viewshed analysis from Ag. Georgios at Dia



Viewshed analysis from Heraklion

Enregistrement

Regional harbour networks in Cretan coasts: Heraklion, Dia, Agia Pelagia



Wind rose diagrams. Wind data (1970-2020) from functioning weather stations at Heraklion was provided by the Hellenic National Meteorological Service.

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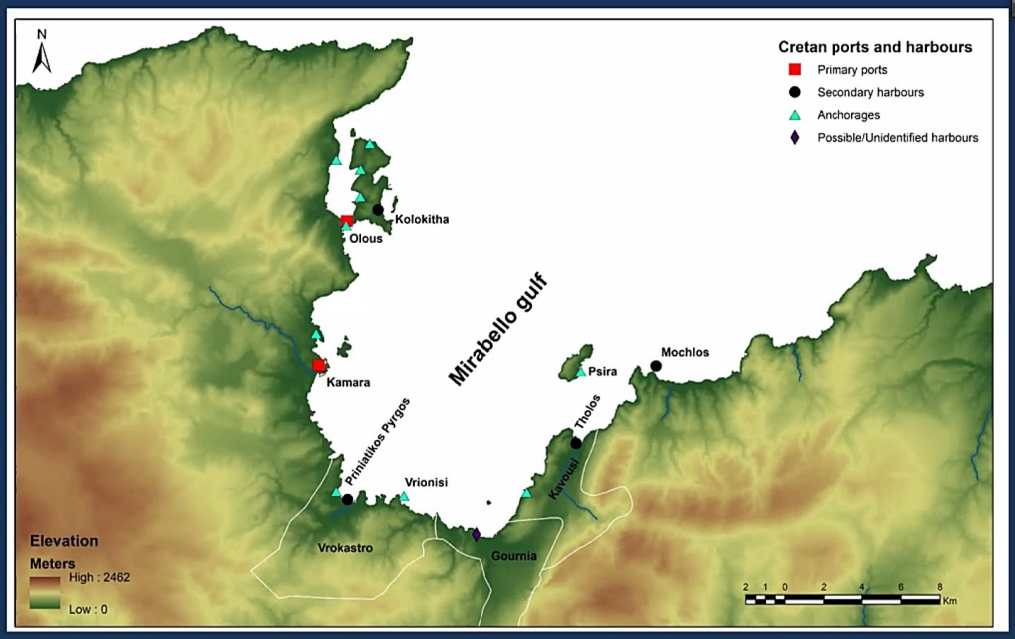
Interaction between Cretan harbours and inland agro/pastoral sites



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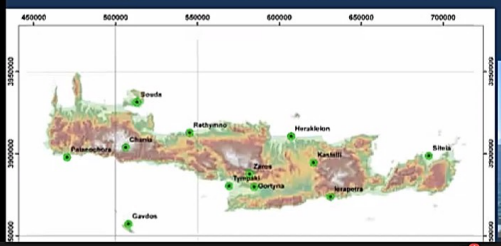
Wind patterns in Crete

- **Primary wind data** were provided by the **Hellenic National Meteorological Service**:
  - i. Monthly Dominant Wind Direction
  - ii. Average Monthly Wind Intensity
  - iii. Average Monthly Wind Speed
  - iv. Number of Days with Maximum Wind Intensity ≥22 knot
- The data derive from **11 surface meteorological stations of Crete**:

  630 Gavdos, 746 Souda, 477 Chania, 751 Paleochora, 753 Gortys, 754 Heraklion, 756 Ierapetra, 757 Sitia, 758 Rethymno, 759 Tympaki, 760 Kasteli
- In some cases covers the period from 1970 to the present day. Most of these stations are distributed along the coastline and gives us an overall picture of the sailing conditions offshore of Crete.



Paramètres audio

Discussion

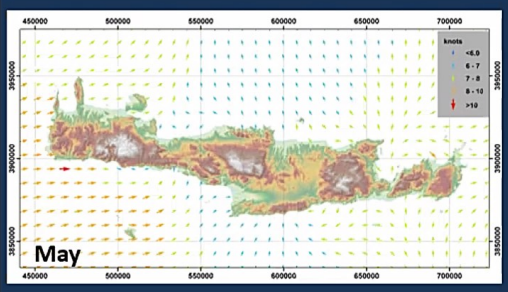
Lever la main

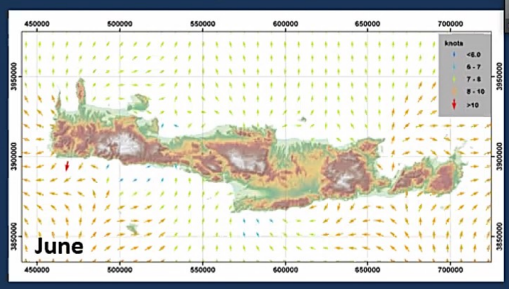
Q. et R.

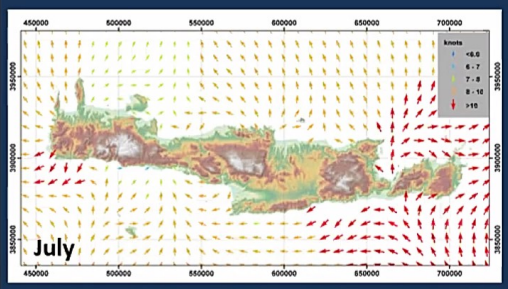
Quitter

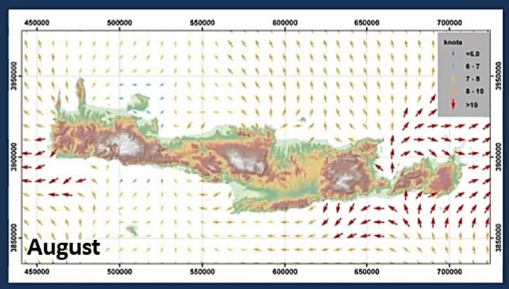
Enregistrement

Understanding sailing conditions around Crete





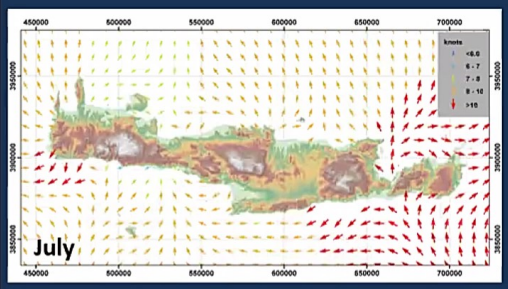


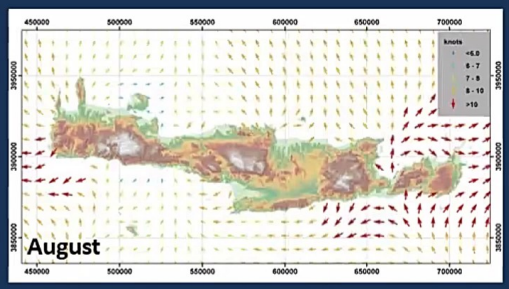


Paramètres audio | Discussion | Lever la main | Q. et R. | Quitter

Enregistrement

Understanding sailing conditions around Crete





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