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Six Late Roman Ports in the Eastern Mediterranean: maritime structures and capacity (from the 4th to the 7th century CE)

By

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Abstract.

This thesis examines six ports located in the Eastern Mediterranean region during Late Roman period, Alexandria in Egypt; Caesarea in Judea; Paphos in Cyprus, Elaiussa Sebaste and Soli-Pompeopolis in Cilicia and Patara in Lycia. To address the stud's aims, published books, articles, excavation reports and discoveries are used. The geography of the Roman empire shifted in the 4th century CE, with the Eastern area becoming the core of a distinct empire known as Byzantine. Christianity was formally recognized as the Empire's faith. The port network of this part most likely received the majority of maritime activities while the western part declined. The aim of this thesis is to investigate the characteristics of the structures of these ports and their building techniques and technology. Why not even one new port was built there during this period and how the existed ports were adapted to the maritime needs. As well as the capacity of each port in their respective locations in terms of basin area, quay length and the number of ships that a port could accommodate. GIS is utilized to compute the dimensions of estimated basin areas and quay space, while AutoCad is employed to generate some hypothetical drawings for specific ports when ships would be moored on their expected quay.

According to the results of this study, the Late Roman period probably did not employ hydraulic concrete as the most sophisticated technique in port renovation projects, but instead depended on alternate materials. It suggests that a new port was not established owing to economic concerns, as creating a port needed a significant budget, and the existing ports were meeting their demands by developing better facilities and maintaining current port infrastructure. Alexandria, as predicted, stands out in terms of capacity. Caesarea and Paphos are somehow comparable, while others are significantly smaller. However, it appears that these ports were effectively functioning as economic and sociopolitical centers for their respective areas.

Acknowledgements.

I would like to express my sincere gratitude to my supervisor Dr. Stella Demesticha, for her invaluable guidance and support throughout my master's program. Her expertise and encouragement helped me to complete this research and write this thesis. I would also like to thank Professor Sarris Apostolos for his support in GIS technique. Many thanks to my family and friends for serving on my thesis committee and providing helpful feedback and suggestions.

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Chapter 1: Late Roman Port Structures, Facilities and Related Buildings.

1.1: Introduction.

It is the purpose of this study to examine the structure, facilities and related buildings of six Late Roman ports in the Eastern Mediterranean region. Throughout antiquity, the port structure has been constantly evolving in response to human economic needs and technological advancement (Morhange, et al., 2014, 249). Modifications in ship design also had a direct impact on the design of ports layout (Oleson, 2014, 510). The construction of a port in antiquity was determined by the natural condition of the site and the availability of construction materials. These standards were considered as the determining elements for the composition of the port. A variety of techniques were employed to construct a waterfront structure to support maritime activities (Preiser, 2015, 41-42; de Graauw, 2022a, 1). Political decisions, on the other hand, have left their mark on the map as a dominant factor in port construction. The power and economic capabilities of the Roman emperors influenced the formation of the port, and sometimes even the location: in the instance of Caesarea, Herod the Great (72 to 4 or 1 BC) financed the complete construction of an entirely new port with master builders, to carry out a very elaborate port design (Patrich, 2011, 91). Strabo (14.5.6) and the Jewish historian Josephus (JA. 16.4.6) noted that the final king of Cappadocia, Archelaus (36 B.C. – 17 CE), constructed a harbour at Elaiussa Sebaste to mitigate any threats from piratical invasions (Panichi, 2005, 202-208) and to have exclusive control over the Cilician shoreline. Also, according to Strabo (17. 1.2-4, 1. 6-8), Alexander the Great (356–323 B.C.) selected Alexandria as a favourable site for a distinctive port. Furthermore, Nicocles, the last king of the city-state of Paphos (325/321 to 311/309 BC), most probably constructed a port on the natural anchorage of Nea Paphos (Mlynarczyk, 1990, 67; Gordon, 2018, 16-17).

The development of ports in the Eastern Mediterranean dates back to prehistory. This region is regarded as one of the centers of this industry due to its strategic location between Egypt and Mesopotamia, which are the centers of riverine navigation cultures (Marriner, 2007, 1288). Eastern Mediterranean cultural heritage encompasses a diverse range of religions, cultures, and traditions. Significant traces of maritime life have been associated with ancient communities throughout history; archaeological evidence and discoveries bear witness to the coast's critical role as a shelter for human dwelling in antiquity, as well as the sea as a communication force that drew people, ships, goods, and ideas across the waves (Braudel, 1973, 103-120; Galili, et al., 2010, 192-195). The region's ecology, geographical location (connecting three continents), and climate (suitable for sailing almost half of the year), (Morton, 2001, 17-27; Beresford, 2013, 2-7) provided a unique environment for maritime activities within a vital network of ports that pushed humans toward the coasts. As a consequence, ports and seafaring became essential tools in people's daily lives (Leidwanger, 2020, 154-165).

Once Rome conquered Egypt in 30 BC, it unified the whole Mediterranean basin for the first time in history (Tomorad, 2014, 239-240). The Romans took advantage of sea transport by constructing a port network, which they utilised to increase their economic and political hegemony in the region known as Mare Nostrum. The port network allowed Romans to move their armies, as well as their agents and merchants. Throughout the late 4th century CE, the western part of the empire fell apart due to intensifying local conflict, a decline in the army and economy, and Germanic invasions (Ermatinger, 1959, 55-65; Bowman, et al., 2005, 437-487; 437-487; Ward, 2005, 5-10). But the eastern part, known as the Eastern Roman Empire, was able to endure until the 15th century despite countless conflicts and invasions in the 7th century, when Arabs and then Turks conquered the region (Vasiliev, 1964, 580-600 and 676-690). Several events occurred during the Late Roman period (between the 4th and 7th centuries CE), on which this thesis focuses, that marked one of the most important transitional phases of the Empire and shaped the Late Roman period. Constantine I (324-337) established Constantinople as a new capital and legalized Christianity as the faith of his empire at the start of the period. The empire's borders were unstable. They expanded during Justinian's reign (527-565) after regaining much of the western territories (Bowman, et al., 2005, 437-487; Ward, 2005, 5-10). At the end of the period, under Heraclius' rule (610–641), the Empire still had to contend with long-standing foes like the Sassanid Persians and the emerging Arab menace (Kaegi, 2003, 256-300).

Archaeological discoveries in the Eastern Empire demonstrate its abundant maritime heritage. Ports supported a variety of activities, including the commerce, fishing, military and social services. This idea can be further supported by several shipwrecks and other findings from the Late Roman period in the Eastern Mediterranean (Galili, et al., 2010, 192-194; Pomey, et al., 2012; Kocabas, 2015; Leidwanger, 2020, 156-158). The ports are considered one of most significant engineering achievements of the Roman Empire due to their distinctive characteristics, adaptations, and innovations in design and materials that were employed in their construction; several of them or their structure remains are still standing as a testament to their superior engineering skills and ingenuity (Oleson, 2014, 509-517; Leidwanger, 2020, 156; Dündar and Kocak, 2021, 127-146). In order to study the structure of the Roman ports, comprehending construction technology and techniques is essential. It is believed that Roman engineers were continuously seeking innovative methods to construct and maintain port structures. As a consequence, they invented and developed construction techniques and technologies, the most important one was hydraulic concrete. Before the last quarter of the 2nd century B.C., hydraulic concrete was revealed for use in underwater buildings somewhere around Puteoli in the bay of Naples, where the volcanic ash is originated (Brandon, 1996, 27-35; Oleson et al., 2004, 199-203). Hydraulic concrete was first discovered in the harbour of Cosa, Italy (late 2nd or early 1st century BC), and is the oldest datable example of its application in an inundated construction (McCann, 1988, 102-105; Gazda, 1987, 155; 2001, 163; 2008, 265-268; Oleson, et al., 2004, 202). Much has been written about this Roman invention, in the top of the list is the project of ROMACONS (Oleson, et al., 2004; 2006; Hohlfelder, et al., 2007; Brandon, et al., 2010, 390, 395; Hohlfelder, et al., 2014, 227-228). Vitruvius's "De architectura", (2.6.1,5.12.2-3) is regarded as the earliest document to discuss the use of concrete in waterfront constructions, but Strabo, Pliny, and Dionysios of Halikarnassos also provide a few brief and useful observations (Oleson, et al., 2004, 199-203; 2006, 33-4). The development of ancient port construction technology was not entirely linear; it was influenced by the topography of the region, the availability of building materials, and economic conditions (Oleson, 1988, 147-157; Hohlfelder, 1997, 379; Blackman, 2008, 644-645; Wilson, 2011, 47).

Natural and physical threats to the coast, such as earthquakes, tsunamis, siltation, erosion, excessive currents, tides, and waves, all have an impact on port structures. There is ample evidence that large natural disasters caused destruction in coastal areas, particularly in the ports under consideration here (Croke, 1981, 124-130; Pararas, 2011, 253-260; Morhange, et al., 2014, 249). Despite this, due to the resistance of cement technology, many parts of the port structures could be preserved even after the Late Roman period (Hohlfelder et al., 1983, 133-134; Oleson, 1988, 147-157). This, combined with the Roman Empire's expertise in building techniques and technology, enabled Late Roman engineers to repair and, in some cases, enlarge port installations (Hohlfelder, 1988b, 2-5; 1997, 367-375). It appears that no entirely major port was built in the Eastern Mediterranean during the Late Roman period, with the exception of two ports in the Bosporus of Constantinople that were highlighted in Procopius of Caesarea's passage, De Aedifictis (1.11.18-20). Thus, all six ports chosen for this study were built in previous eras and were developed and adapted in accordance with the period's environmental, political, and economic conditions.

Over the past decades, the maritime infrastructure of ports in the Mediterranean basin in general and the Eastern Mediterranean region in particular has been the focus of several explorations and research projects, resulting in valuable information and data collection. Geophysical and underwater archaeological surveys were frequently followed by archaeological excavations and analysis of findings. The ports of Caesarea and Alexandria have received the most attention in the Eastern Mediterranean. This is undoubtedly related to the geostrategic location of these ports, particularly Alexandria's, as well as their remarkable size and complex structure. Furthermore, the sophisticated construction techniques and technology of Caesarea port drew the attention of many scholars, who thoroughly studied them and provided valuable information (Appendix 1, no 1 and 2). Not all of the physical remains of the port structures examined in this study could be confidently dated to the Late Roman period. Earlier Roman sections appeared to have been used in some cases, though it was not always possible to prove that those parts were still standing and serving maritime activities after the 4th century AD. However, the investment of state governments and elite in the construction of port infrastructure and related buildings, as well as discoveries testifying to maritime activities at these sites, suggest that these ports were effectively functioning throughout the Late Roman period. Ancient references in literary sources are used in this study to further enhance this idea, such as: Strabo (Geography), Procopius of Gaza (Paneyricus in Imperatorem Anastasium), Procopius of Caesarea (VII: Buildings), Eusebius of Caesarea (Church History), Stadiasmus Maris Magni (Anonymous), Sozomen (Ecclesiastical History), Ammianus Marcellinus (Roman Antiquities) and Flavius Josephus (Jewish War (JW) and Jewish Antiquities (JA).

This thesis attempts to build on the structures, facilities, related buildings and the capacity of six Late Roman ports in the Eastern Mediterranean region: Alexandria in Egypt; Caesarea in Judea; Paphos in Cyprus, Elaiussa Sebaste and Soli-Pompeopolis in Cilicia and Patara in Lycia. They were all built over natural shelters or unprotected or poorly protected anchorages. In most cases, the port structures consisted of breakwaters, quays, jetties, lighthouses, access channels, warehouses, ship sheds and slipways (Blackman, 1982a; Galili, et al., 2010, 192-198; Leidwanger, 2020, 13-24; Graauw, 2022a, 1). These Eastern Mediterranean ports were selected because they share nautical, cultural, and sociopolitical backgrounds, notably during the Late Roman period. They were the major ports of their respective regions and they were part of a dense port network throughout the Eastern Mediterranean. Furthermore, the material remains of these ports provide enough information to address the research questions on which this thesis is build.

The present study aims to broaden our understanding of the selected ports' similarities, commonalities, and differences. It is divided into four chapters: after the general introduction in Chapter one, it examines port structures, facilities, and related buildings, which are then compared to one another. Chapter two investigates Roman technology and techniques in port construction. Chapter three attempts to provide and compare the estimated capacity of the six selected ports, calculated in GIS. Although the measurements cannot be exact, they do provide an overall size of each port’s basin area, quay length, and the number of ships that could be accommodated. In addition to this, the management of a port (i.e., maintenance, loading and unloading processes) could also influence its capacity. In order to calculate the number of ships that could call at each port, sizes of diverse Late Roman shipwrecks are investigated, and their sizes are used to calculate the number of ships that could call at each port. AutoCAD is utilized to produce some hypothetical drawings as a conventional estimation for the needs of this study. Ultimately, this research (in Chapter four) addresses the following questions: 1- What are the characteristics of Late Roman port structures, facilities, and related buildings, and how do they compare to between sites? 2-Why have most quay structures been demolished? 3-What criteria determined the capacity of a port? 4-Why large church structures were erected in vicinity of ports? 5- How the lighthouse was used? 6-Did Roman construction technology and techniques continue or change during Late Antiquity? 7-During the Late Roman era, why was not a single port created in the whole Eastern Mediterranean region? Chapter five, however, addresses some general conclusions.

1.2: Port Structures: basin, breakwater, quay and lighthouse.

A port basin comprises of quays and breakwaters (Oleson, 1988, 147-152; Preiser, 2015, 2). Breakwaters encompasses and defines the basin's layout. The port structures examined in this study have three distinct layout designs: the less prevalent one, is an enclosed layout like in the case of Patara (see Appendix 1, no 4). The inner harbour basin was connected with the open sea through a long access channel **(Fig. 1)**. The port of Seleucia Pieria **(Fig. 2)** on the Pamphylia plain, is another example with a similar basin layout in the region (Pamir, 2014, 180-181; de Giorgi, 2016, 137).

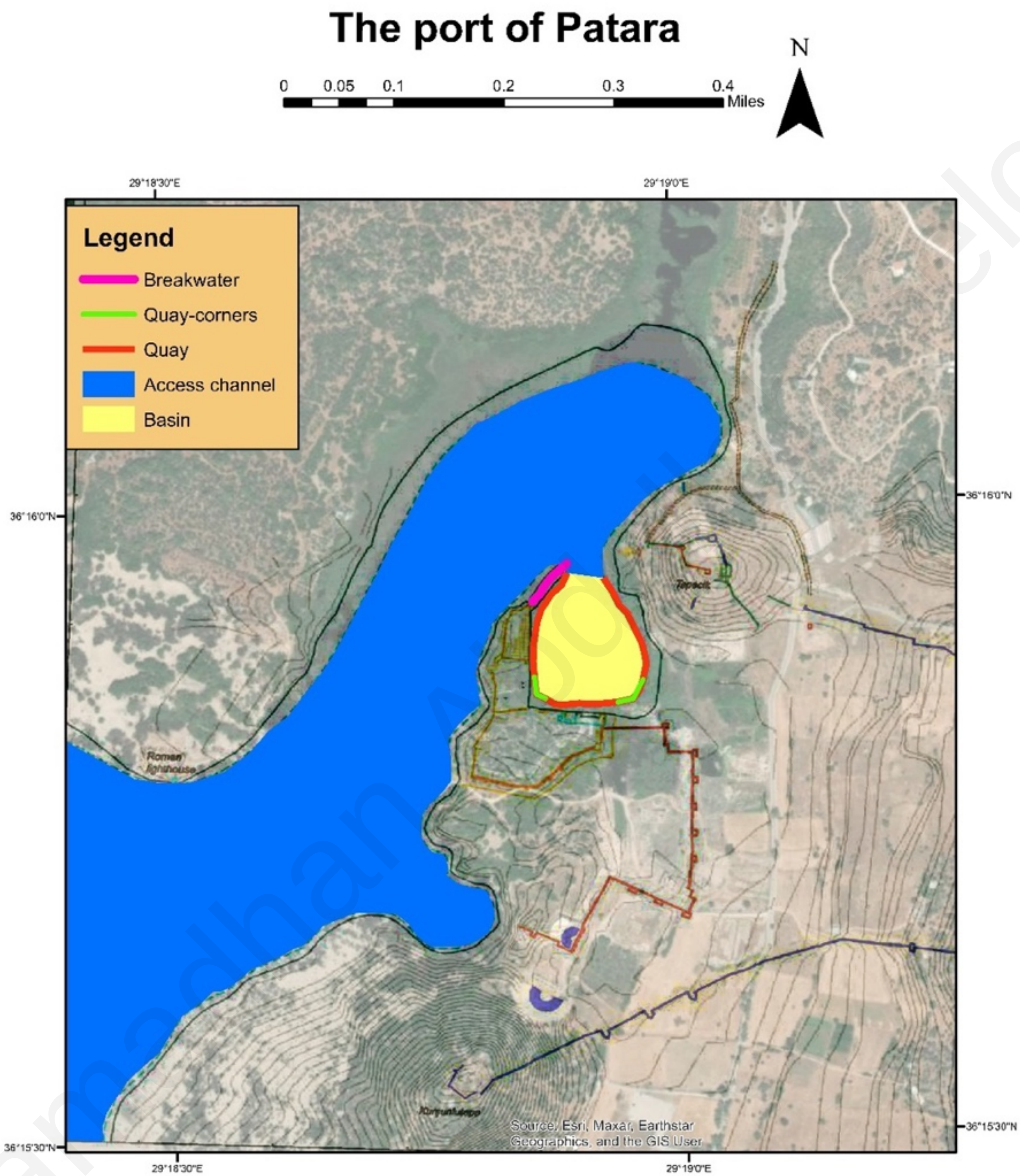


Figure.1. *The layout of Patara's port (map from Kocak, 2019, 74 – made up in GIS).*

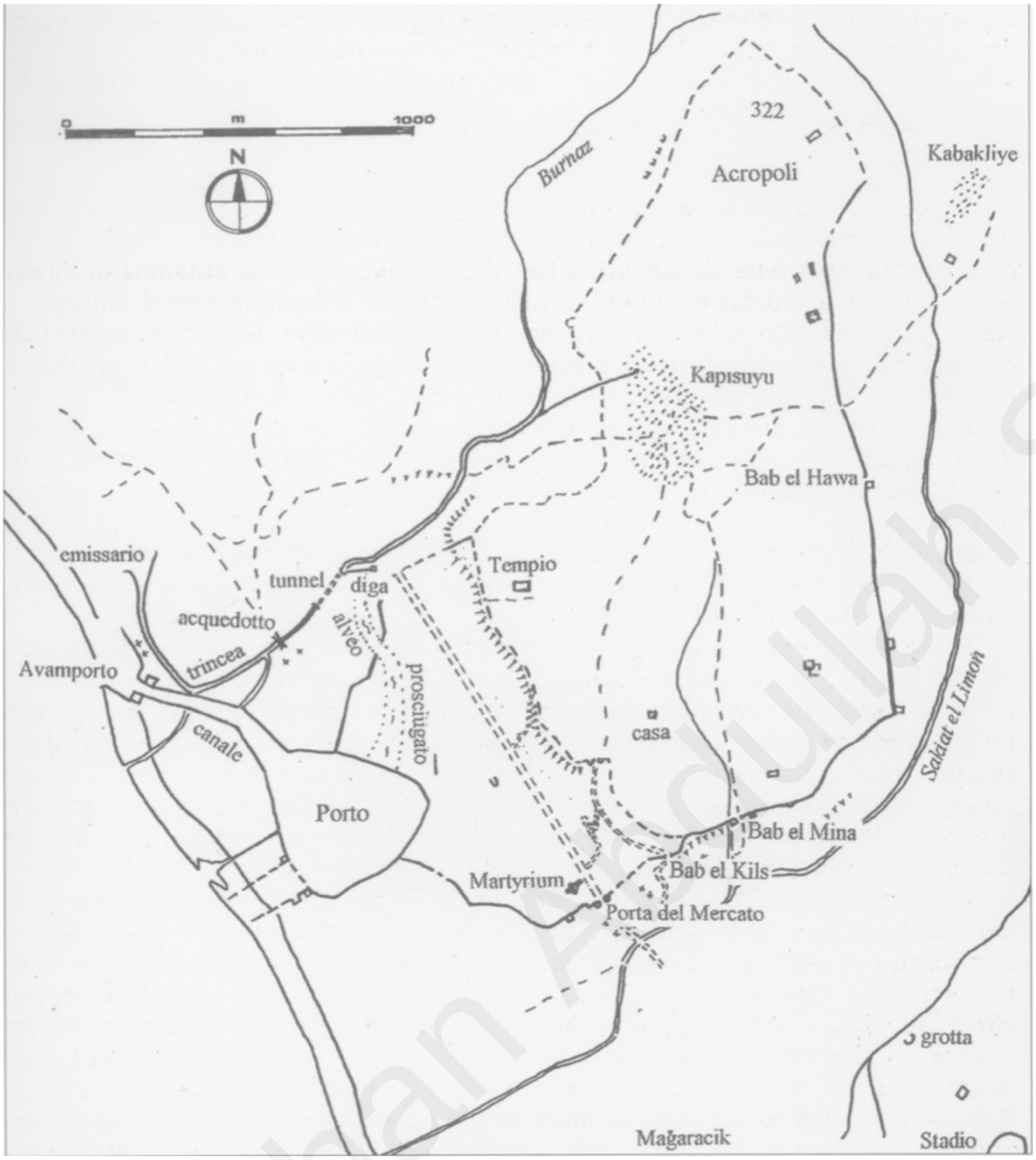


Figure.2. *Drawing shows the port composition of Seleucia Pieria (de Giorgi, 2016, 137).*

The second type of basin layout is an open one, surrounded by two breakwaters, as seen in Caesarea, Paphos and Soli-Pompeiopolis **(Fig. 3),** (see Appendix 1, no 2, 3 and 5). Even today, the formation of this layout is the most desirable port planning because it provides better navigation conditions and protects the basin from siltation. Caesarea is distinguished by its large artificial layout, which somehow resembles the Paphos layout in shape. An L-shaped breakwater encircled both of them, and another breakwater on the opposite side created a harbour entrance. Pompeiopolis had two symmetrical breakwaters (Appendix 1, no 5) that were running parallel to each other and had curved ends which made them distinctive and different from others (Rogers, 2013, 186).

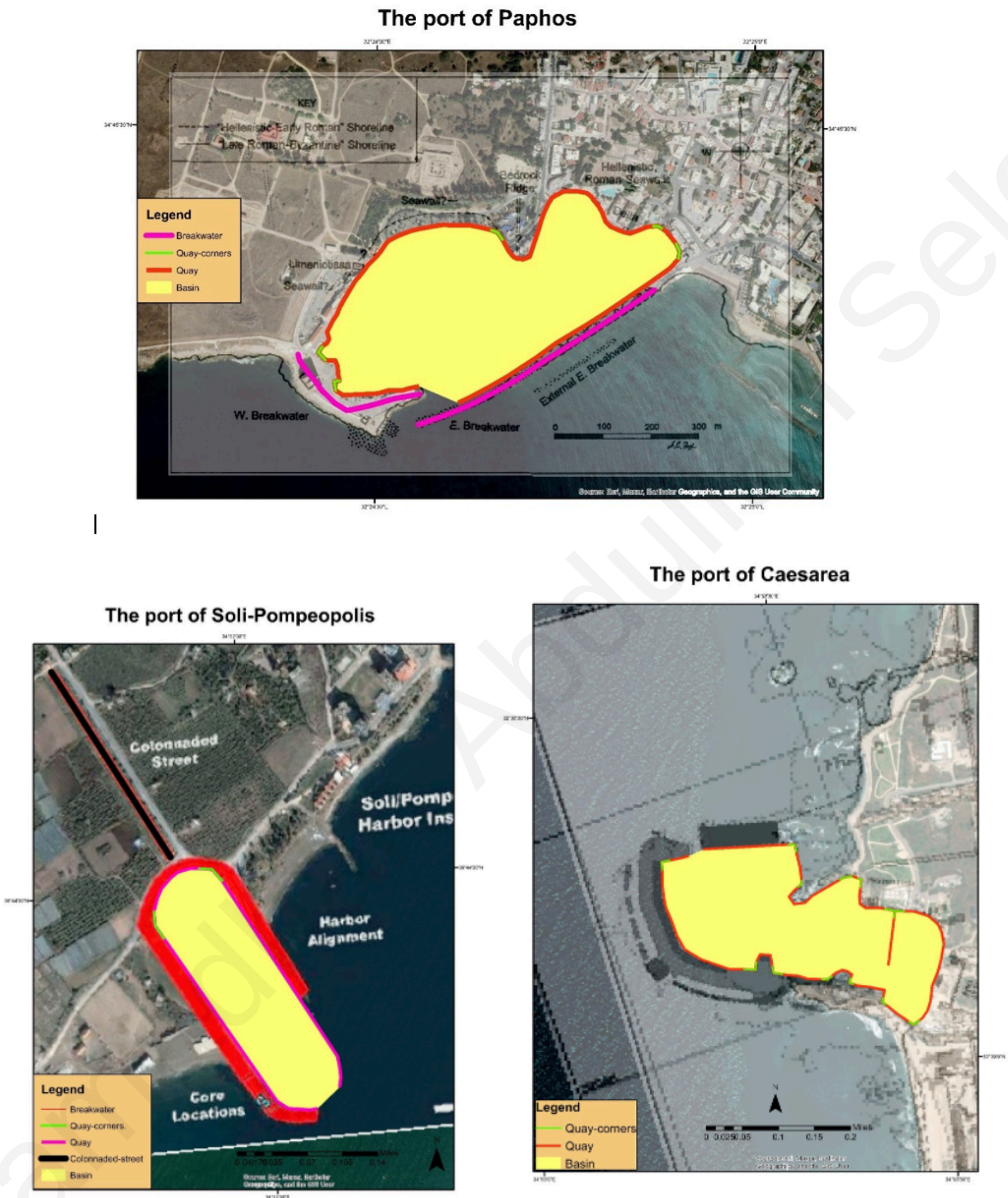
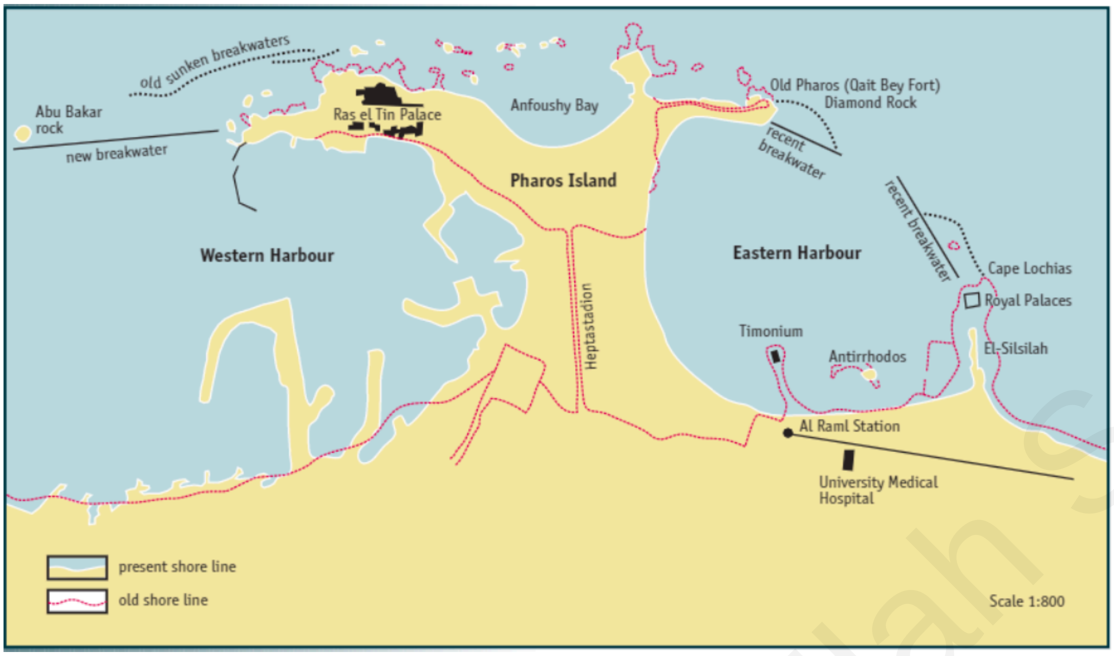
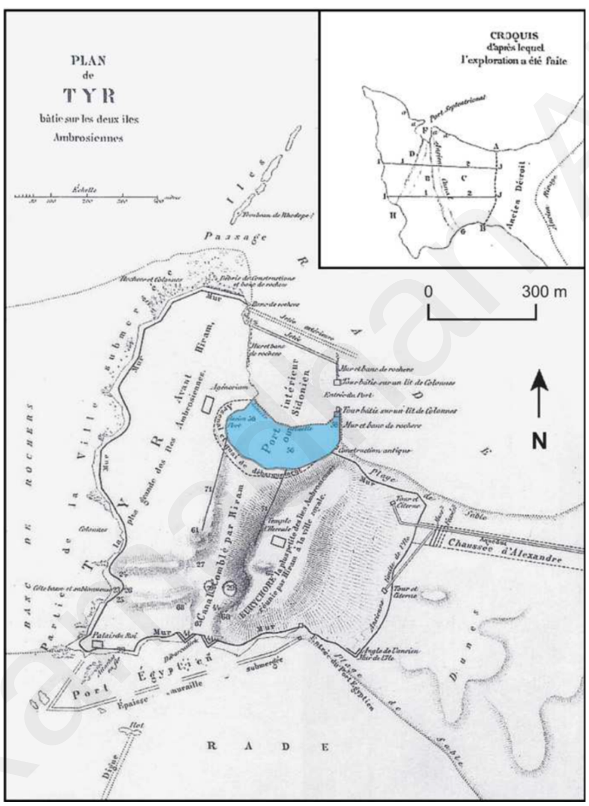


Figure.3. *Top: map of the basin layout of Paphos port (from leonard, et al., 1998, 151). Right: map of the basin layout of Caesarea port (from Blakely, 1988, 36; Rogers, 2013, 186). Left: map of the basin layout of Soli-Pompeiopolis port (from Brandon, et al., 2010, 393 - made up in GIS).*

A third common port layout was the one with two bays separated with a central isthmus which linked an island to the mainland. De Graauw (2022b, 241-250) and Marriner (et al., 2008, 377-398), have extensively described it as a creation of two independent basins surrounded by breakwaters. Such cases are this of Alexandria (Appendix 1, no 1), Elaiussa Sebaste (Appendix 1, no 3), and Tyre **(Fig. 4)**, (Carmona and Ruiz, 2004; Marriner and Morhange, 2006; Noureddine and Mior, 2018)**.** De Graauw (1998, 53), stated that this layout created favorable conditions because maximum mooring protection was ensured. Furthermore, the central isthmus served as a breakwater, which occasionally housed a lighthouse. Another advantage of this layout was that ships could be moved from one basin to another over land, using channels like the ones built on the Heptastadium of Alexandria (de Graauw, 2022b, 15). Goddio and Fabre (2014, 89 and 94) identified two channels leading to Alexandria's large port; the main one was near the port's center, and the second was between Pharos Island and the Hehptastadium. A bridge connected them, allowing ships to pass. However, there is no evidence to support the existence of such a bridge during the Late Roman period.



The port of Elaiussa Sebaste



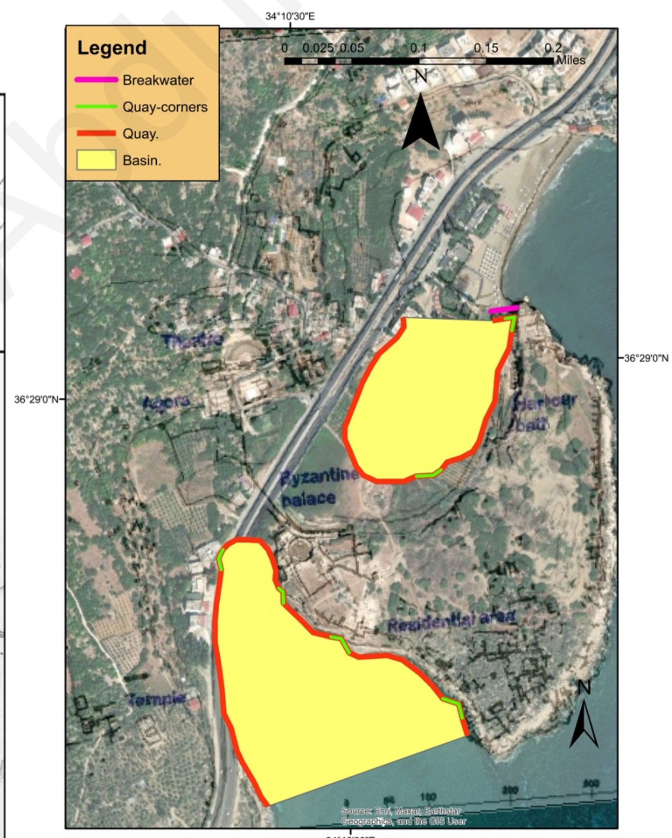


Figure. 4. *Top: map shows the basin layout of Alexandria's port (Morcos, et al., 2003, 14). Right: map shows the basin layout of Elaiussa Sebaste's port (map from Borgia, 2021, 2 – made up on GIS). Left: map shows the basin layout of Tyre's port (Marriner, et al., 2008, 1283).*

De Graauw (2022a, 1) notes that artificial breakwaters are the most basic form of harbourwork; their primary purpose was to resist severe waves to provide a calm environment for ships and avoid siltation (Blackman, 1982b, 198). The western harbour of Alexandria has the most impressive breakwater and the largest in the region **(see in Table. 1), (Fig. 4),** (Appendix 1, no 1). Then, Caesarea's L-shaped southern breakwater **(Fig. 3)**, (Appendix 1, no 2) seems smaller than the western breakwater of Alexandria but larger than others. If the estimated length of eastern breakwater of Paphos with 494 m is correct, it means that it was larger than the Caesarea's one. In addition, the western L-shaped breakwater of Paphos **(Table. 1), (Fig. 3)** is today fully covered by a contemporary quay built. Daszewski (1981, 330; 1987, 134 n. 39) estimated its length in antiquity to be between 270 and 280 m, with an extra spur wall of 50 to 70 m included in the total (Appendix 1, no 3). The Soli-Pompeiopolis breakwaters **(Fig. 3)**, on the other hand, were smaller than the aforementioned breakwaters (Appendix 1, no 5). Moreover, the breakwater of Patara **(Fig. 1),** (Appendix 1, no 4) and the one at Elauissa Sebaste's northern harbour are measured by GIS **(Table.1), (Fig. 4).** They appear significantly shorter than others in the area. Regarding the breakwater of Elaiussa's southern harbour is still unknown. Tempesta (et al., 2020, 42) reported finding the remnants of a trapezoidal-shaped breakwater composed of limestone, mortar, and concrete along the northern bank of the southern harbour. In addition, he indicated that there might be a second breakwater that enclosed the basin of the harbour (Appendix 1, no 6). So far, there is no more information available on these breakwaters.

Table. 1. *The length and width of breakwaters.*

Ports	Breakwater length-m	Breakwater width-m
Alexandria (western basin)	2,300	60 to 80
Caesarea	southern 480 northern 280	40 to 70 60
Paphos	western 280 eastern 494	20 to 25 10 to 18
Soli-Pompeopolis	320	23
Patara	77	…….
Elaiussa Sebaste (southern harbour)	……	…….
Elaiussa Sebaste (northern harbour)	29	……

It is difficult to determine how high breakwaters were originally, because some may have lost their top stones or entire layers. For instance, the eastern breakwater of Paphos is fragmentarily preserved (Hohlfelder, 1995, 200) and the limestone slabs of upper part of northern breakwater of Elaiussa Sebaste were removed and reused in the wall construction (Tempesta, et al., 2020, 42); or their structures may be submerged due to the rise of the sea level, as seen in Caesarea and Alexandria. Moreover**,** another feature of the breakwaters of the second type of ports layouts was a sluice gate or channels. It is referred to as "de-silting channels" by Blackman (2008, 662-663) and aimed to prevent siltation by allowing the coastal current and waves to bring in silt-free water into the basin. For instance, the southern breakwater of Caesarea had four gaps near the inner basin **(Fig. 5)**, (Bergin, 2018, 282; Joseph, et al., 2004, 124). According to Hohlfelder's (1995, 205; 1996, 92-101) this technique employed by the same Caesarea builders who supervised the renovation of Paphos port, with the goal of saving it from siltation. Most likely, after using this technique successfully in Caesarea and Paphos, later, when the engineers of the empire built the port of Pompeiopolis, this technique was implemented in its eastern breakwater with only one channel 3 m wide (Vann, 1994, 531-532). Nonetheless, the same procedure was most likely attempted in Seleucia port in Syria and Sidon in Lebanon, but because the current flow was not as powerful in Seleucia due to its narrow access channel, it is considered that it worked better in Sidon (Blackman, 1982b, 196-202; Various authors, 1965, 162-167).

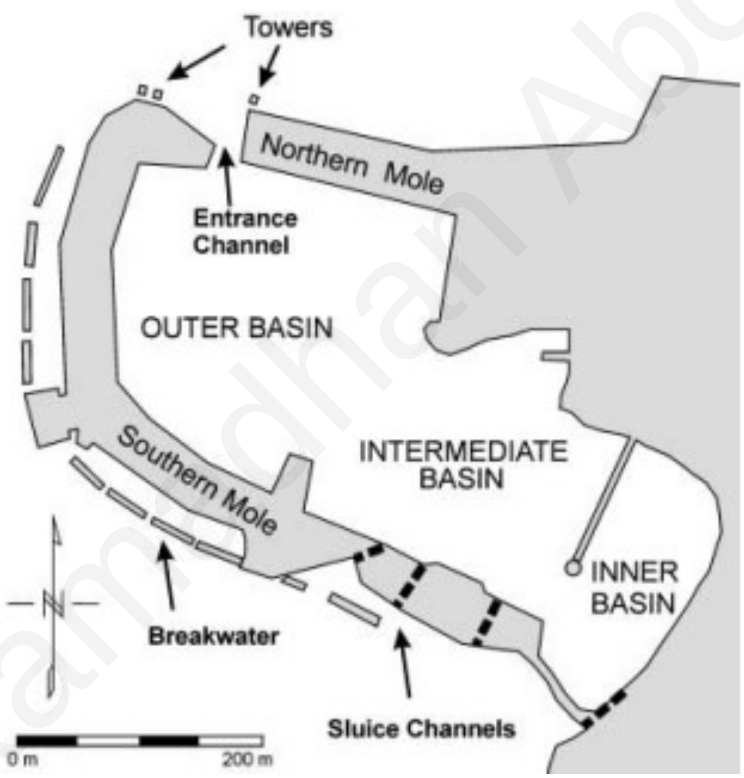


Figure. 5. *The Sluice Channels at the southern breakwater of Caesarea (Joseph, et al., 2004, 124).*

Quays were also an important component of the port structure and were often created along the inner part of the breakwater (Blackman, 2008, 649). Their structures are rarely preserved, possibly due to their smaller size and low resistance to natural disasters and phenomena; they were also touched directly by ships and human activities which consequenced in their destruction. At Alexandria, where the quays are still submerged to this day (Appendix 1, no 1) and could be considered as the best-preserved example of Eastern Mediterranean. In other places, however, only fragmentary remnants have been uncovered, such as Caesarea (Appendix 1, no 2). According to Flavius Josephus (JA, XV) a wide curved quay surrounded its port basin, confirmed by the excavation of a single course of regular ashlar blocks that followed the north-south portion of the southern breakwater's curve (Oleson, et al., 1984, 291-292). In addition, Tempesta (et al., 2020, 42) asserted that the northern breakwater of Elaiussa Sebaste was its quay in the same time. At its southern harbour, there are indications of another quay made of limestones with mortar and concrete. Regarding Paphos, Leonard (et al., 1998, 145-156) reported that remains of a structure were discovered on the bedrock ridge that divided the enclosed basin into two smaller bays; he suggested that it was a quay structure probably built in Late Roman period. In Patara, Bruer and Kunze (2010, 72) uncovered a Late Roman quay wall approximately 40 m northeast of the edge of the promontory. It is preserved in a space of 7,5 m long, 2,4 m wide, and 2 m in height (Dündar and Kocak, 2021, 138). Some sites, such as Pompeiopolis, have revealed no evidence of a separate quay structure; this may indicate that the inner edge of its breakwaters was exploited as a quay.

According to Vann (1991, 134), lighthouse became a standard feature of major ports after the 1st century BCE. Natural topography, such as reefs, headlands, and islands, as well as environmental circumstances, provided a challenging road for ships to enter ports and approach their quays at certain locations, such as, in Alexandria (Baker, 2017, 28-28; Mattson, 2018, 22). Hence, a lighthouse or signal tower would have been expected to be built at large Roman ports, especially those with heavy trade (Trethewey, 2019, 4). The lighthouse's location was essential as a navigational aid. It depended on the natural and physical conditions of the site, as well as the elevation of the light above sea level, which was important for navigators to see it as far as possible. Though since Alexandria's topography is flat, the western edge of the entrance to the Great Harbour (the eastern point of Pharos Island) was chosen for the construction of the lighthouse **(Fig. 6).** This position was selected because most likely it was the most imposing point above the harbor's entrance (Jondet, 1916, 47-50; Bernand, 1966, 31-32; Goddio, 1998, 12; Strauss, 2006, 60; McKenzie, 2007, 41; Belov, 2014, 5). In this position, it was able to illuminate the mouth of the Great Port while also marking the island and reefs in front of the port's entrance, guiding sailors to enter the inner basin of the port with caution (Baker, 2017, 28-28; Mattson, 2018, 22). It could also point the entrance to the western harbour, which didn't require as much caution as the eastern one but was still not easy to approach (McKenzie, 2007, 41).

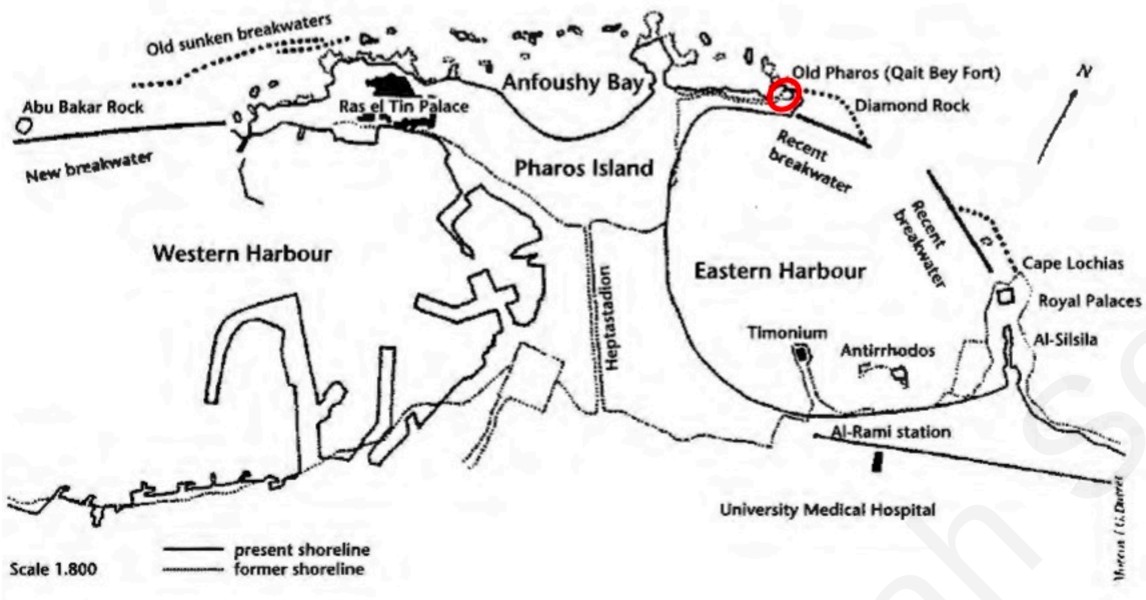


Figure. 6. *This map demonstrate (red circle) the location of Alexandria's Pharos* (Mostafa, et al., 1990, 41).

The lighthouse of Patara was built high on a cliff on the left side of the outer channel leading to the main entrance **(Fig. 7).** The reason it was built there instead of at the entrance to the inner harbour, was because probably, the narrow stream that was connected the inner harbour with the open sea posed a greater hazard to mariners than the main entrance (Iskan, et al., 2008, 91-94). It appears that the port entrance of Caesarea was also difficult to approach, due to its narrowness and the area's complex geophysical conditions. Consequently, Roman engineers constructed two lighthouses or guide towers, as has been recommended, on the port's entrance, at the tip of its breakwaters **(Fig. 8)**, (Oleson, et al., 1984, 293-296; Vann, 1991, 127-139; Blackman, 2008, 644).

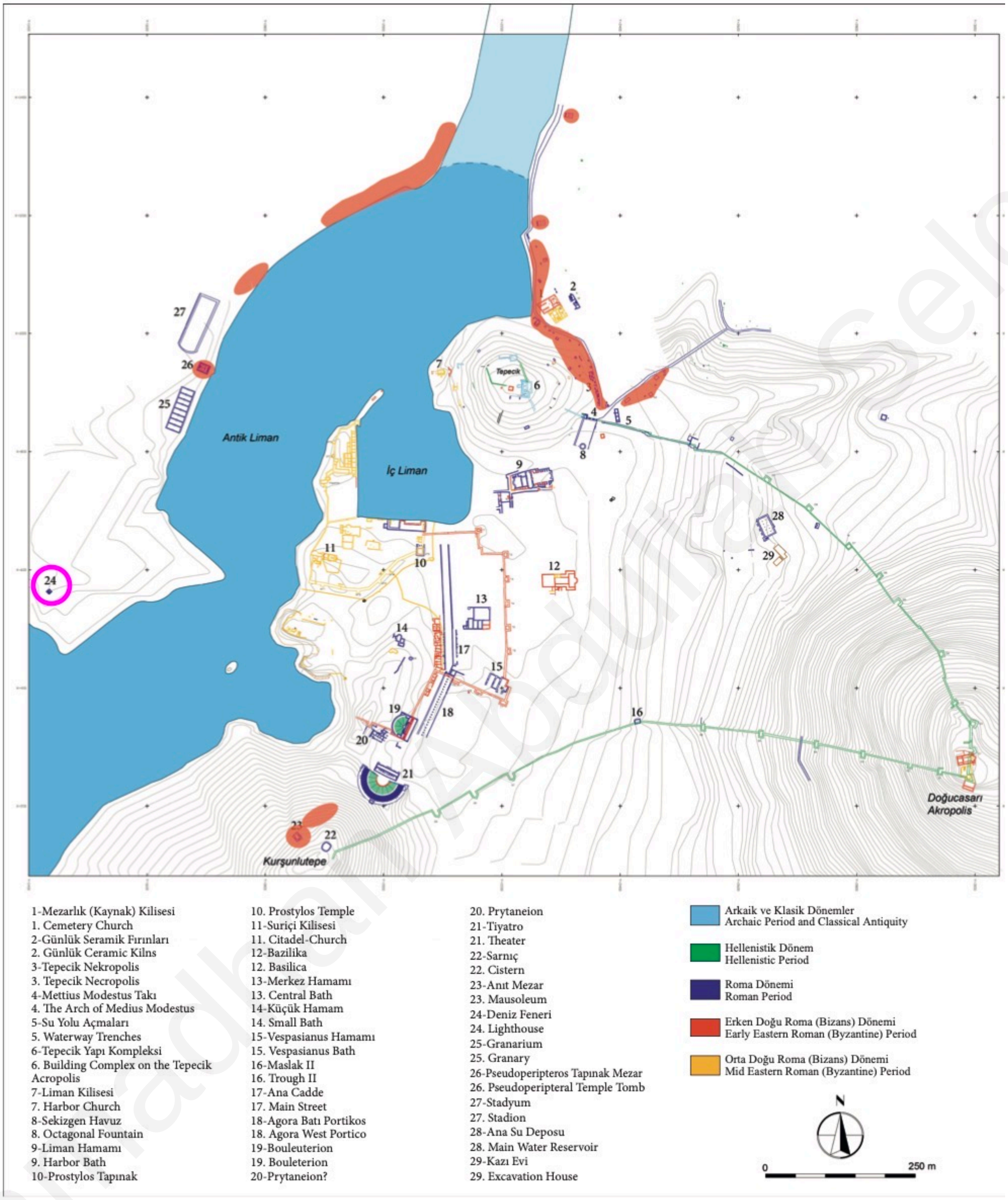


Figure. *7. Map demonstrating the lighthouse location of Patara in a purple circle (Kocak, 2019, 74).*

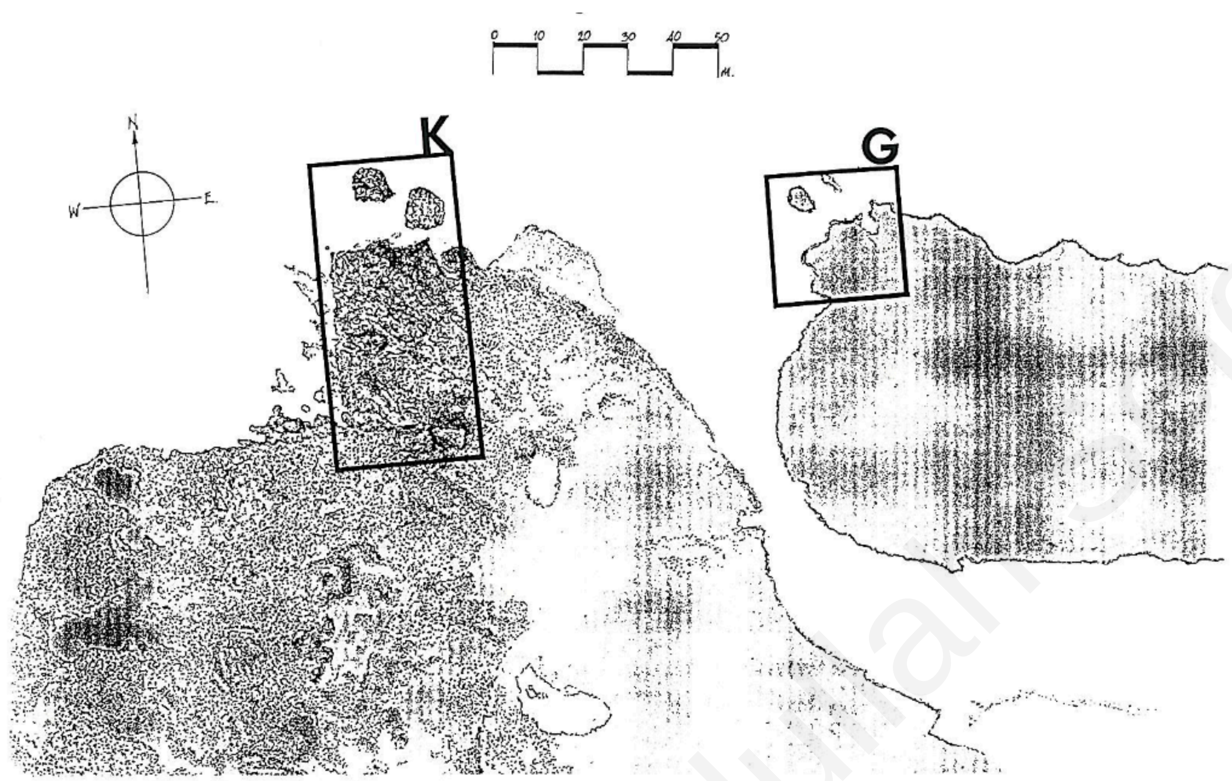


Fig. 1. Site locations of areas G and K (cf. frontispiece) (C. Brandon).

Figure. 8. *Drawing depict two guide towers or lighthouses at the entrance of Caesarea's port (Brandon, 1999, 169).*

Breakwaters\moles with a lighthouse like in Caesarea's port appears also in Soli-Pompeiopolis, with a single lighthouse on the western breakwater **(Fig. 9)**, (Boyce, 1958, 68; Vann, 1994, 530). Such a discovery in several Roman major ports, including Alexandria, Caesarea, Ostia, Leptis Magna, and Apollonia in Cyrenaica, lead to the hypothesis that in the cases of two lighthouses-towers, the main one was located on the western breakwater/mole of the port (Leonard, et al., 1995, 242; Vitas, 2010, 273). Nonetheless, the remains of a tower were discovered at the eastern end of Paphos' breakwater (Vitas, 2010, 273-276). Hohlfelder (1995, 199-201) argued that the size of the ruins suggests that it was either a guard tower or a lighthouse that protected the port's entrance **(Fig. 10).** In contrast, the lighthouse or guide tower in Elaiussa was located on the north-western edge of the promontory, close to the breakwater **(Fig. 11. no. 7).** This strategic location dominated the eastern part of the sea and the northern harbour entrance. Tempesta (et al., 2020, 43-44) postulated that a similar installation was created at the end of the eastern outer breakwater of the northern harbour, but it has not yet been excavated (Polosa, 2019, 174).

Figure. 9. *A bronze coin of Antoninus Pius that depicts the breakwaters of Soli-Pompeiopolis port with a lighthouse on the western breakwater (Boyce, 1958, 79).*

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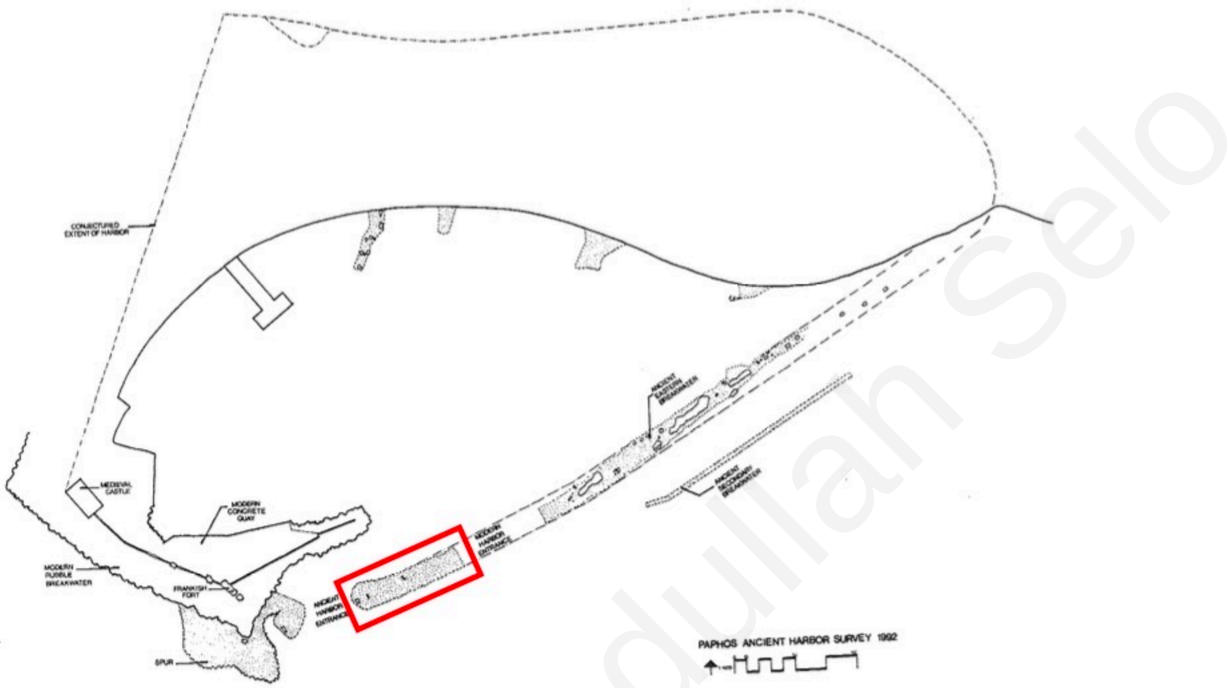


Fig. 3

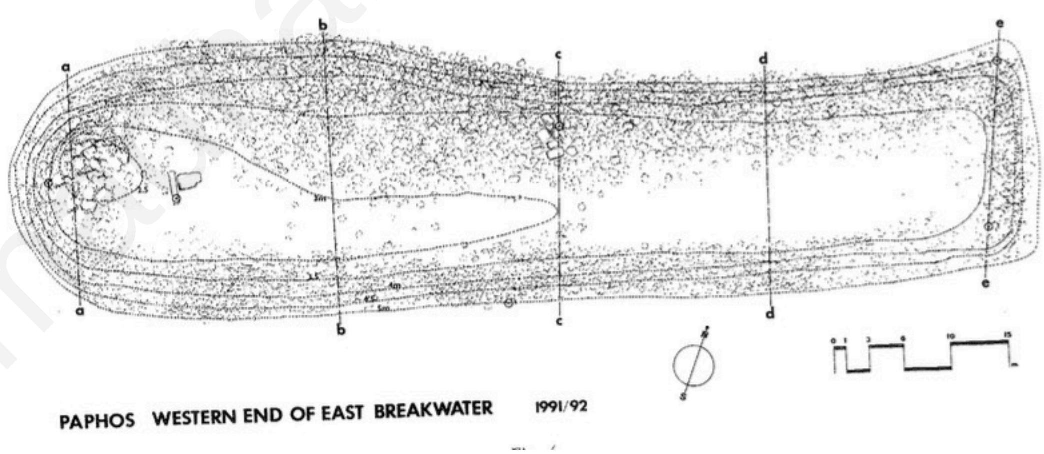


Figure. 10. *Top: Plan of the Paphos port. Bottom: The guard tower or the lighthouse remains at the end of the eastern breakwater of Paphos and its fragmentary preservation* *(Hohlfelder, 1995, 200).*

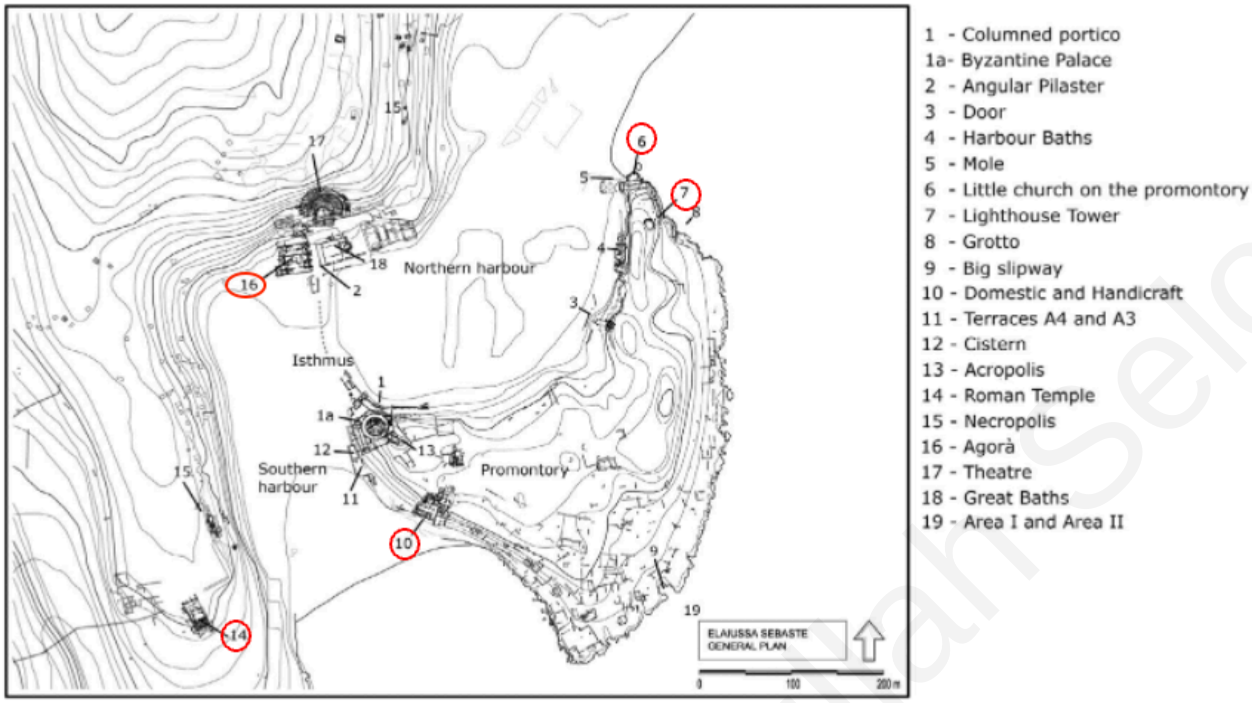


Figure. 11. *Elaiussa Sebaste: map of the main sites: (6) the small church, (7) lighthouse, (14) the basilica which was beside the Roman temple, (10) Domestic and handicraft production area and (16) Agora-Basilica (Tempesta, et al., 2020, 44).*

Examining the architecture of the lighthouses would be important, but there is not a single remaining lighthouse building that allow for critical description. Their structures are either submerged or buried in sand, or their remnants are scattered throughout the ground. Lighthouses of Caesarea, Pompeiopolis and Paphos are similar since they were constructed directly on the breakwaters/moles now submerged. Nevertheless, the remnants of Patara and Elaiussa's lighthouses are scattered on the ground of the port area (Iskan, et al., 2008, 92).

The fragments of Alexandria's Pharos (Appendix 1, no 1) are dispersed at the Qait Bey location at the bottom of the sea. It was the largest and most distinctive of all lighthouses, and all Roman lighthouse structures were designed after it. The Hellenistic Pharos structure consisted of three tapering floors, the bottom one was square, the middle octagonal and the upper floor was circular. In addition, a statue was standing on the top of the last floor. However, a depiction of its structure in a mosaic found at Qasr el-Lebia, Cyrenaica dated to the 6^{th} century AD, demonstrate that in Late Roman period probably it had only two floors with a statue on the top **(Fig. 12),** (McKenzie, 2007, 42). The remnants of Patara's lighthouse, called Turino (Appendix 1, no 4) seems to have been a considerably smaller and cylindrical, so with a completely different architectural layout **(Fig. 13).** According to the interpretations of Iskan (et al., 2008, 92), it was an exceedingly basic construction, with no evidence of adornment, but only three bas-relief blocks have remained (Kocak, 2019, 73). Elaiussa's possible lighthouse (Appendix 1, no 6) has only been partially studied. Its structure is recognised as a three-sided circular shape with one square side of the double perimeter wall and a pentagonal shape in the lower levels **(Fig. 14)**, (Tempesta, et al., 2020, 43-

44). According to Oleson (et al., 1984, 294), the foundation remnants of Caesarea's towers (Appendix 1, no 2) were square-shaped**.** The discovery of a silver and lead Tessera, of the 3^{rd} century CE **(Fig. 15)** depict that it had a circular shape structure positioned on a square base and crowned by a sculpture (Ringel, 1988, 70-71; Raban, 1998, 218-219). Similarly, the depiction on the Antoninus Pius coin from Pompeiopolis represents a circular structure on a pedestal **(Fig. 9).** This indicates that Caesarea, Pompeiopolis, and Patara's lighthouses probably shared some architectural characteristics (Boyce, 1958, 68; Vann, 1994, 530). Regarding Paphos, a number of columns that are regarded as decorative elements suggests a colonnaded structure for the lighthouse tower on its eastern breakwater (Appendix 1, no 3). Yet, based on its presumed location, it is considered that its structure was not very large and that it may have been an appropriate size for Paphos port. However, it may be presumed that it was similar to Caesarea's towers; according to Hohlfelder (1995, 199-201) the same engineers that built the port of Caesarea oversaw the renovation of Paphos in the 1^{st} century BC (Vitas, 2010, 273-275).

Figure. 12. *Depiction of the Pharos of Alexandria ßin a mosaic found at Qasr el-Lebia, Cyrenaica (McKenzie, 2007, 42).*

Figure. 13. *The remains of Patara's lighthouse on the northern edge of its canal (Kocak, 2019, 75).*

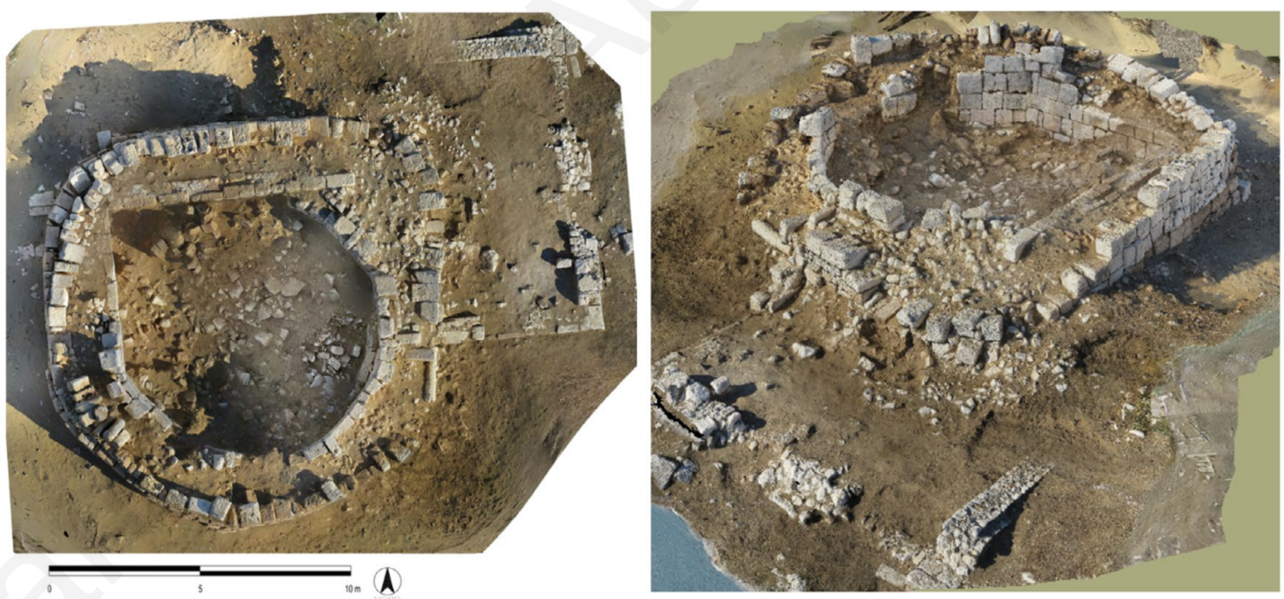


Figure. 14. *The structure remains of Elaiussa Sebaste's lighthouse on the north-western edge of the promontory (Tempesta, et al., 2020, 44).*

Figure. 15. *Silver and lead tessera depicting the lighthouse-towers of Caesarea with a ship in front of its entrance (Ringel, 1988, 70).*

1.2: Churches.

During the Late Roman period, Christianity was adopted as the state religion in the Eastern Mediterranean. The church played a significant role in the Empire's economic life as a landowner and motivator of trade and industry (Kingsley and Decker, 2000, 9-11). Despite the fact that Christianity had grown steadily since the first century CE (Jones, 1978, 80-90; Bowman, et al., 2005, 437-487; Holum, 2004, 191; Ward, 2005, 5-10), it was further developed in Late Antiquity, when significant investment raised in Christianization with church construction, particularly in port cities (Athanasios and Papantoniou, 2017, 263-264; Bayliss, 2001, 19-24). This appeared especially in the eastern part of the empire, between the 3rd and the 7th centuries (Downey, 1975, 128-138; Jacobs, 2012,125-135; Horster and Nicolaou, 2018, 13-15). Thereby, the ecclesiastical and local elites of the study cases areas invested significantly in religious building as a prominent emblem that transformed the townscapes. Within their landscape context these structures conveyed the new faith in relation to society, politics and economics. The presence of the church structures behind the study ports, in addition to being of outstanding architectural merit, serves as a reminder of the substantial religious role in society beyond acting as houses of worship. Most of these religious structures, particularly in rural areas, served as local central points of agricultural production and distribution within the territory of their settlement as income sources for the empire, in addition to their functions as Sunday worship, pilgrimage, baptism, burial, and monasticism (Athanasios, 2017, 141-157; Athanasios and Papantoniou, 2017, 265-277). Greece is another example, in late antiquity, where churches were widely constructed and were provided income to the economy of the districts, especially in the Peloponnese coast (Sweetman, 2015, 296-305), Athens, Tanagra (Athanasios, 2017, 153-157) and Naxos (Athanasios and Papantoniou, 2017, 265-267). As well as Crete, which was strategically located on the grain route connecting Egypt and Constantinople (Sandres, 1982, 35; Sweetman, 2017, 5-13).

The relationship between churches and ports is well-known throughout the eastern region of Roman Empire. It is important to notice that pilgrimage played the most important promotional role in attracting a large number of travelers at the time. Consequently, each region's religious leadership oversaw a substantial contribution for worship-related objectives, especially in church buildings between the 4th and 7th centuries (Kingsley, et al., 2000, 10-11; Perdiki, 2021, 2-3). The large ecclesiastical structures situated close to the port area, served as a landmark, beacon, and protector for sailors. This was one of the reasons besides many others that local people and authority invested in them: as sailors and passengers, particularly pilgrims would have had an easy access to the church to express gratitude after a successful voyage and absorb the spiritual energy of the place. In addition, those ports served as a stopover for pilgrims traveling to and from the Holy Land. Large structures were built for this purpose in order to attract ship commuters from afar to anchor there for praying and rest (Katsioti and Mastrochristos, 2018, 83; Keane, 2021, 4). This maritime traffic brought trade to the port and transformed the port's surroundings into a commercial zone, provided work for locals to profit financially (Holum, 2017, 317; Keane, 2021, 8-10). The investment in religious structures appears earlier in Alexandria (Appendix 1, no 1) than in any other sites. Sozomen, a Late Roman lawyer and historian of the Christian Church (*Ecclesiastical History,* Book VII, 7.15) provides the important primary evidence for the destruction of Serapeum temple in 391 CE; when the destruction occurred, stones with hieroglyphic figures of crosses were found which led many people to convert to Christianity. Subsequently, two churches were constructed outside of the temple **(Fig. 16)**, (Rowe and Rees, 1957, 503-504), Empereur (1998, 113-114) and McKenzie and Reyes (2004, 105) described the temple's location as a height that was visible from the sea and it is likely that these churches served as a marker for sailors sailing at a distance. Moreover, when Arabas conquered Alexandria in the 7th century, they described a church in this location known as "the church of the Caesareum" as the greatest in the city and the hope and comfort of incoming and outgoing sailors. They also claim that it had two ancient obelisks in its courtyard that were visible from the sea, comparable to the "Acropolis, with the Serapeum and the Diocletian's Column (Butller, 1978, 375-377). To further support this, Empereur (1998, 111-121) mentioned the obelisks of Cleopatra close to Caesareum **(Fig. 17)**

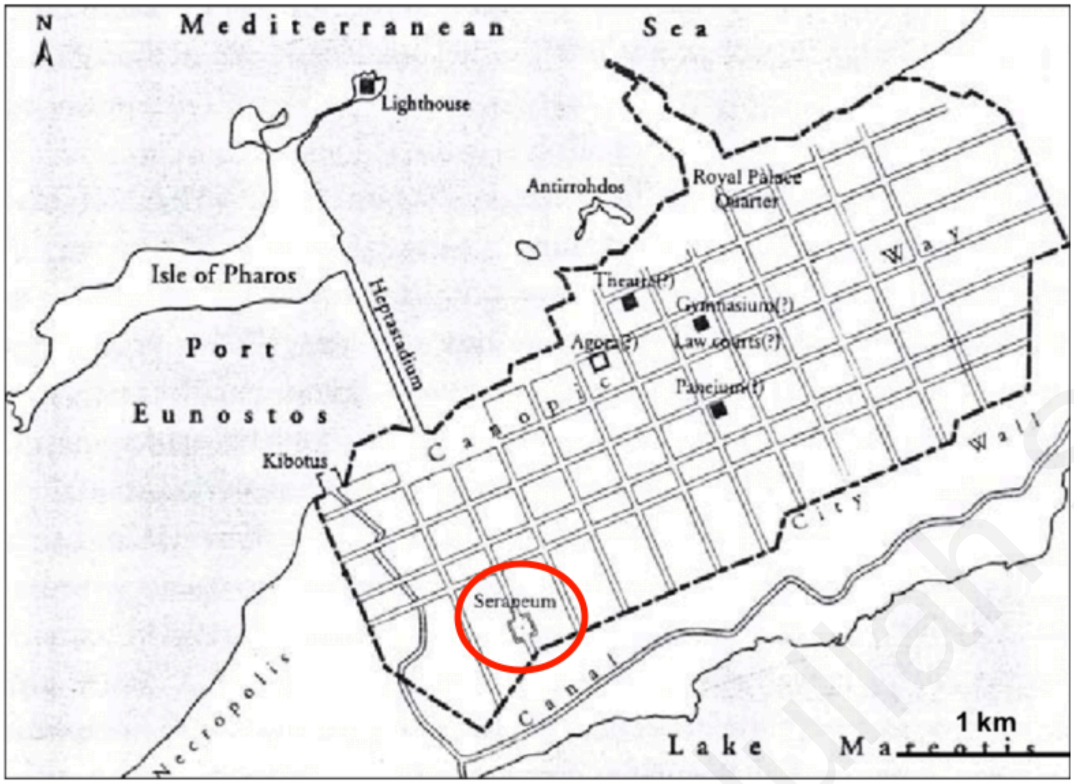


Figure. 16. *A map shows the location of Serapeum temple where two churches were constructed after its destruction (Forster, 1961, 18).*

Figure.17. *A drawing that portrays Cleopatra's obelisks, which serve as a prominent landmark visible from the sea (Empereur, 1998, 111).*

In Patara (Appendix 1, no 4), the remains of three Late Roman churches **(Fig. 18)** have been recorded. Patara as the bishop seat of Myra, was the native city of Saint Nicholas, the patron saint of sailors who was born near Aperlae. The city's main basilica, which was dedicated to St. Nicholas, was situated to the southeast of the harbour. On the western side of Tepecik Hill, a second church known as Harbour Chucrh stood as a significant landmark facing the harbour bay. The third one, known as Cemetery Church, was located on the channel's edge to the northeast of Tepecik Hill (Ercan, 2020, 11; Peschlow, 2017, 282-287; Sweetman, 2017, 23-26; Sahin, 2019, 332-335).

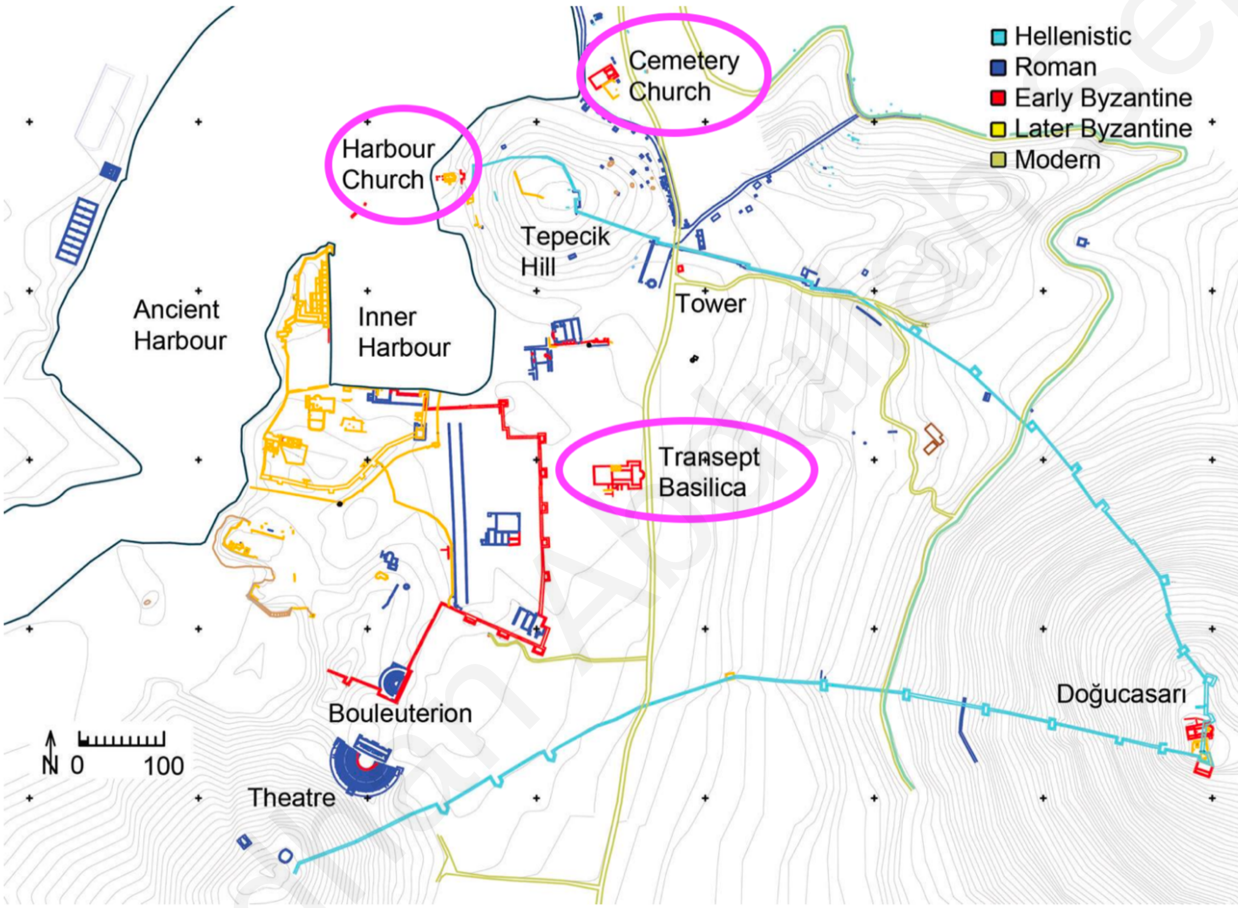


Figure. 18. *A map shows the location of Late Roman Harbour church, Cemetery church and Basilica of Patara (Peschlow, 2017, 281).*

This evidence designates Patara as the capital of Lycia, which served as an important religious center in the region, as opposed to Pompeiopolis in Cilicia, where only a chapel was discovered in the southern end of the colonnaded street of the port **(Fig. 19)**. It is unknown if there were additional churches in Pompeiopolis, which has yet to be discovered. However, if it had only one chapel, it indicates that it was not an important religious center; instead, it appears to be a more commercial city with a long colonnaded market street (Yagci and Kaya, 2011, 63; Yagci and Yigitpasa, 2017, 114-118; Burns, 2017, 189. This chapel was architecturally similar to the church found on the peripheral row of columns of the Roman temple in Elaiussa Sebaste (Yagci and Kaya, 2011, 103-105).

Figure. 19. *The 3D restoration of the south end of the Colonnaded Street and the Late Roman chapel of Soli-Pompeiopolis (Yagci and Kaya, 2011, 105).*

On the other hand, Elaiussa Sebaste (Appendix 1, no 6) was prima in Cilicia regarding Christianity with four churches and a seat of the bishop at the Council of Chalcedon in 451 CE (Schneider, 1999, 43-47). At the southeastern end of the temple which is the southern extremity of a low peninsula that overlooked the harbour **(Fig. 11. no. 14)**, a church was built in the 5th century (Gough, 1954, 54-59). One of the main reasons the state invested in this church was most likely because it was the most prominent landmark for navigators in the district. A small church that dates to the 5th century was also located close to the island's highest point facing northeast **(Fig. 11. no. 6).** Its proximity to the northern harbour quay suggests that passengers could enter to it easily. On the eastern side of the island, directly above the rocky outcrop, laid a basilica. The scattered structure elements of another basilica lay on the southern tip of the island (Hild and Hellenkemper, 1986, 69-71). In addition, Schneider (1999, 46) noted that despite the island of Elaiussa's limited size, it appears that a sizable amount of the land was devoted for religious purposes. Thus, some coins from the 6th century and later that include religious figures holding crosses further indicates how the city state contributed to the importance of religion (Schneider, 1999, 319-325).

Caesarea (Appendix 1, no 2), as the first and main station in the Holy Land of Judea, at the end of the 5th century, the bishop, assisted by the clergy and the municipality of the area, re-employed the remains of the Herodian temple for the construction of an octagonal church on its artificial mound at about 12.7 m above sea level **(Fig. 20)**. When it was still a temple, Flavius Josephus (Josephus, JW. 1.414) described this location as a structure that was prominently situated on a hill at the port's entrance and was visible to sailors from a distance. This mound was the most prominent feature of Caesarea's landscape, dominating the entire city and linked to the port by an 11-meter-wide staircase, allowing passengers to enter the church directly from the port's quay (Levine, 1975, 18-19; Holum, et al., 1988, 188; 2004, 192-195; Evans, 2006, 45).

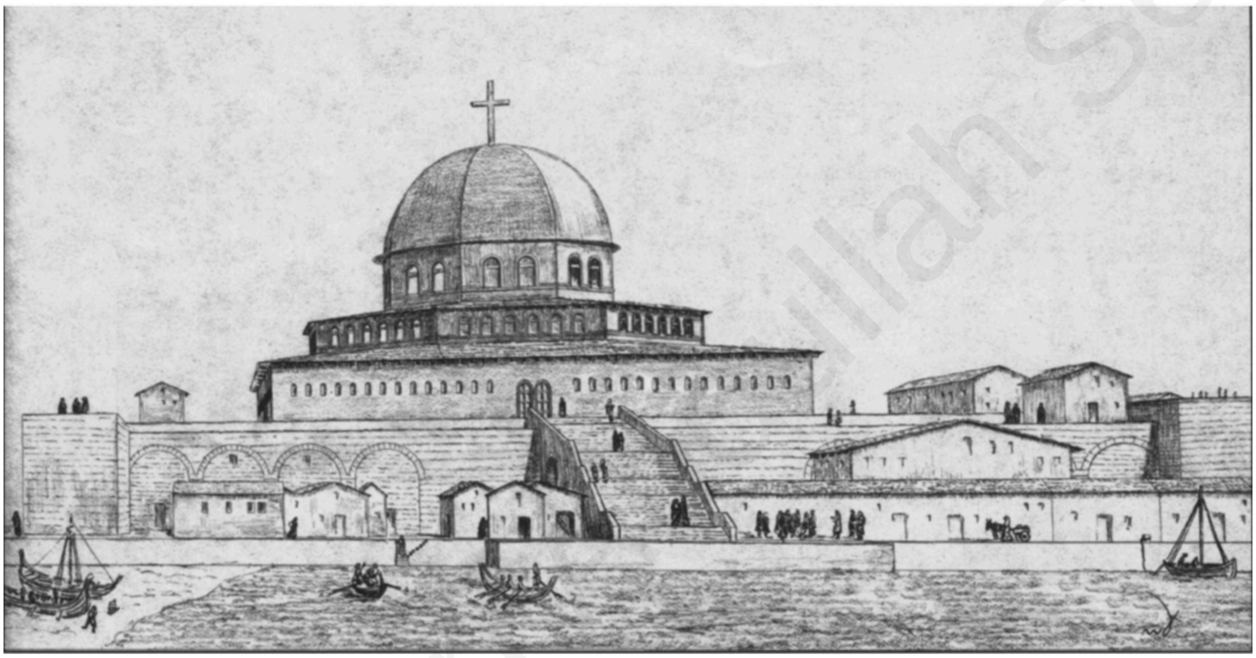


Figure. 20. *Drawing demonstrating the dominant location of the octagonal church of Caesarea close to the port (Holum, 2004, 193).*

Cyprus served as a stopover from east to west, north to south, and vice versa, due to its strategic geographical location on the Mediterranean Sea. Paphos, as one of its major ports, was linked into the Eastern Roman economy, namely in maritime trade activity (Athanasios and Papantoniou, 2017, 273; Coesentino, 2013, 94; Mlynarczyk, 1990, 31-33; Sweetman, 2017, 17-23). Paphos seems to have had a prominent religious role in the region from the 4th to the 7th century (Athanasios and Papantoniou, 2017, 273; Kyriakou, 2019, 50-52; Mikocka, 2018, 129). At the end of the 4th to the beginning of the 5th century, this position led to a significant increase in church buildings (Appendix 1, no 3). This may be explained by the fact that the two churches, Ayia Kyriaki Chrysopolitissa and Panayia Limeniotissa are large structures composed of expensive materials like marble **(Fig. 21),** (Maier and Karageorghis, 1984, 192-194; Hayes 2003, 449; Barker, 2016, 147). Additionally, between these two churches, where the "Saranda Kolones" castle is situated, another church was located (Hayes, 2003, 449).

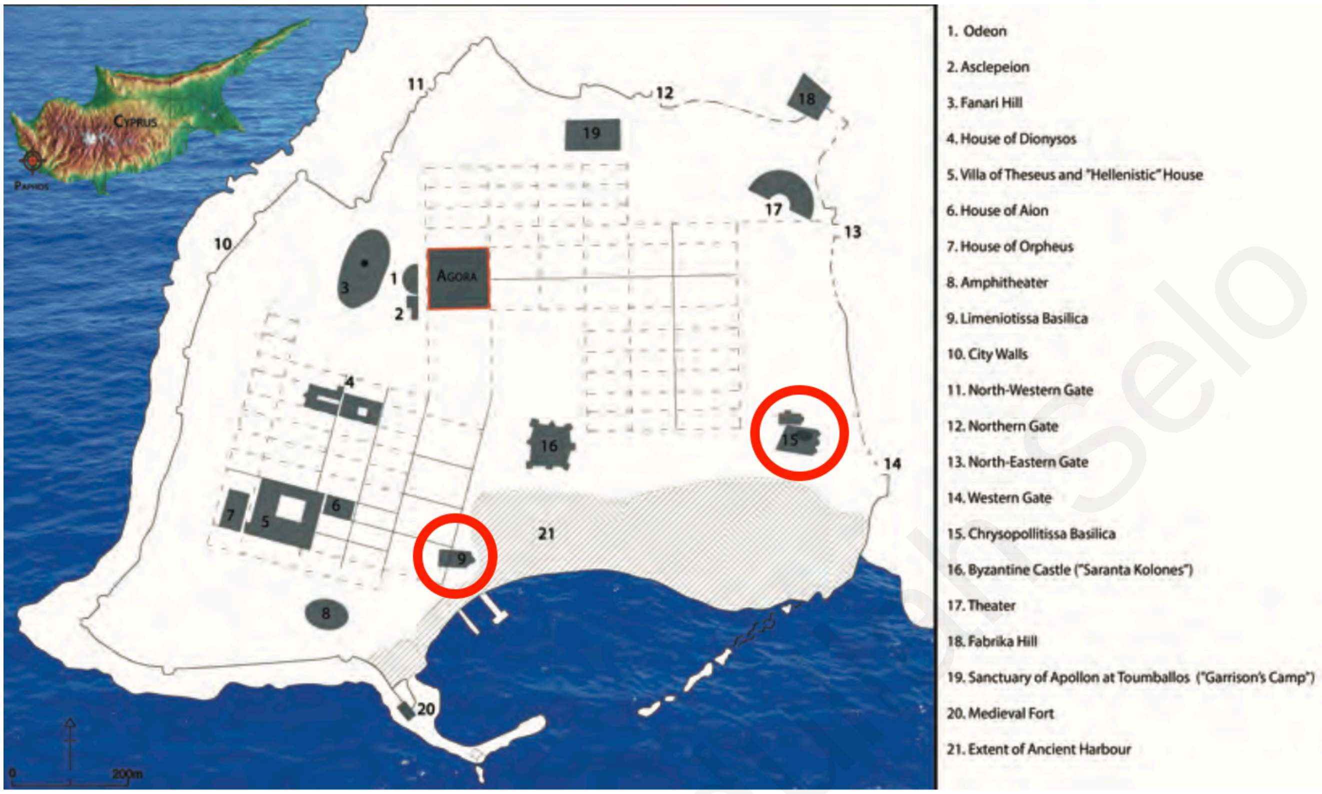


Figure. 21. *Map of Paphos showing the location of Limeniotissa Basilica as number (9), and Chrysopolitissa Basilica number (15), (Misžk and Wladyka, 2016, 2).*

1.3: Transport Amphora Production and Horrea.

According to Preiser (2015, 1-2), the term "port town" refers to the crucial relationship between the port and its surrounding community, including the port infrastructure and facilities that support maritime activities. The dynamics of the port's commercial activity shaped the social life of the community while also provided the populace with a source of income. In antiquity, ports' facilities typically included industries of a range of goods, shops and warehouses. The coastal settlements in the Eastern Empire extended or built new production facilities at ports, and even increased in the 5th century as a result of the commercial demand (Kingsley, et al., 2000, 1-10; Pieri, 2012, 29-31). The remarkable exchange between the selected ports and the rest of the Eastern Mediterranean region testifies the large scale of production and the port network (Kingsley, et al., 2000, 2-5; Pieri, 2012, 27-40).

In the ports under study, a remarkable number of port facilities such as production centers, warehouses, and shops were built during the Late Roman period. It appears that the most common type of maritime industry in the region was the production of transport amphorae. This is because amphora was the best transportation container for food-stuff especially by the sea until the 12^{th} century (Peakcock and Williams, 1986, 2 and 29-32; Parker, 1992, 31-33). The quantity of amphora production discovered in the region suggests that they were most likely manufactured in multiple centers (Demesticha and Michaelides, 1994, 289; Pieri, 2012, 27-35).

The discovery of amphorae workshops in Patara (Appendix 1, no 3) and Elaiussa Sebaste (Appendix 1) demonstrates the amount of contribution in the region for this sector (Borgia and Iacomi, 2010, 1029-1035; Dündar, 2015, 199-210). Kilns are considered as one component of a manufacturing site, which separates them from other facilities. Aside from the ones covered in this research, there may be more kilns and manufacturing sites in each study case's rural region that contributed to the necessities of the area. Patara had seven Late Roman kilns, which is the greatest concentration in the research region thus far. Five of them were located in the city's northeastern outskirts, between the cemetery church and the Günlük rock-cut tomb **(Fig. 22).** Another kiln was found in the palaestra of the Harbour Bath, as well as one in the Tepecik Necropolis south of the city. These manufacture sites produced various artifacts, like amphorae, pots, red slip wares, roof tiles and bricks (Dündar, 2015, 204-208). Moving along the Cilician coast, the remains of a kiln were discovered about 100 m from the Soli-Pompeopolis harbour's long-western breakwater **(Fig. 23).** This kiln had manufactured LRA 1 and 1B from the 5th to the 7th century (Autret, 2010, 203-206; Yagci and Kaya, 2011, 64). It is unknown if there were additional kilns. However, if it only had the discovered kiln, this means that it was not a large production center (Autret, et al, 2010, 203-206; Yagci and Kaya, 2011, 64). While it seems more as a significant market for the area's productions with the discovery of a distinct colonnaded street **(Fig. 24),** (Appendix 1, no 5), which is surprisingly large at 450 m long and 14.50 m wide (Yagci and Kaya, 2011, 63; Yagci and Yigitpasa, 2017, 114-118; Burns, 2017, 189). This type of street appears to be a common feature of Late Roman period in the Eastern Mediterranean, as seen in Patara (Appendix 1, no 4), and Caesarea (Appendix 1, no 2).

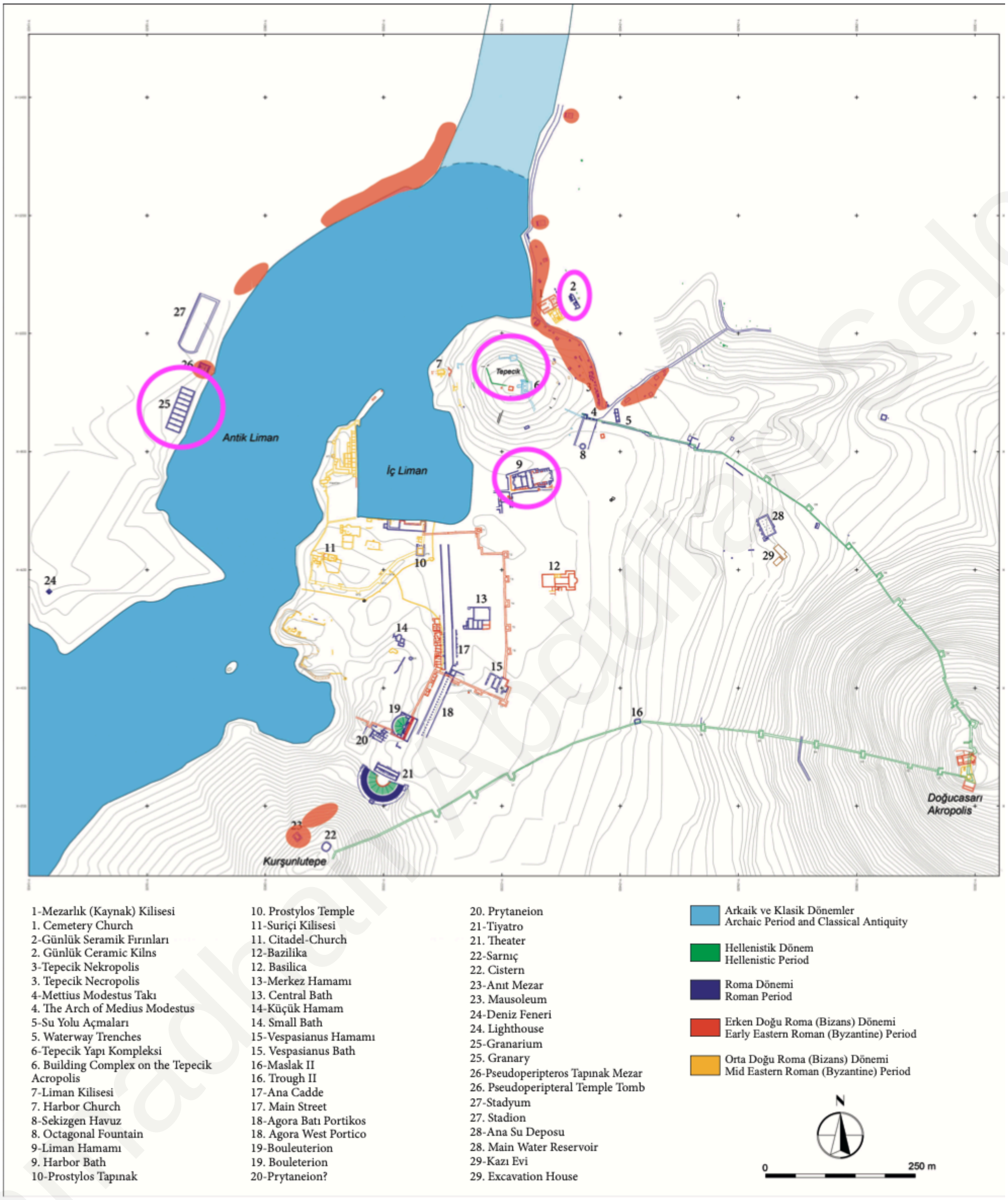


Figure. 22. *Map demonstrating the location of kilns and horrea (number 25) in Patara (Kocak, 2019, 74).*

Figure. 23. *A map of Soli-Pompeiopolis showing location of kiln site and colonnaded street (Autret, 2010, 204).*

In Elaiussa Sebaste, a production complex was discovered between the city's southern terrace and the Byzantine palace **(Fig. 11. no. 10),** (Appendix 1, no 6). The location of this complex and its associated kilns was likely determined by its near proximity to the harbour. From the south, the complex was connected to the quay by a sloping ramp about 3 m wide. This production center was known for its active manufacture of LRA1 and domestic pottery; particularly renowned for LR1 production from the second half of the 4th century and reached its zenith in the 5th century (Ferrazzoli and Ricci, 2009, 37; Ebolese, et al., 2018, 326). Cyprus in general, and Paphos in particular, had strong economic and traditional ties with the aforementioned territory (Demesticha, 2003, 474). Paphos, like other sites, produced amphora during the Late Roman period. An amphora workshop with one kiln in Kato-Paphos was located next to the Hellenistic and Roman cemetery, east of the city, 300 m outside of the ancient walls **(Fig. 24),** (Appendix 1, no 3) produced LRA1 and, presumably, LRA 13 (Demesticha and Michaelides, 1994, 290-291; Demesticha, 2003, 470-474). These production centers remained in operation until around the middle of the 7th century.

Figure.24. *A photograph of the kiln in Kato-Paphos* (Demesticha and Michaelides, 1994).

In order to store the manufactured, imported and exported production, warehouses or *horrea* in Latin, were necessary. Certainly, *horrea* as a main port facility, were directly linked to the maritime shipping. They were constructed either on the breakwater directly or in the vicinity of the harbours. Although, the function of the *horrea* was to store goods, it was also to keep them in good condition for a longer time. Roman *horrea* have been found in several designs: with a square or rectangular, courtyard, corridors and vaults, or in some cases a mixed design was utilized (Patrich, 1996, 146-150; Rickman, 1971, 1-5 and 216).

Throughout the Late Roman Empire, the *horrea* was associated with Roman civic and military Annona as a temporary storehouse of grain from Egypt to Constantinople. There was an urgent need for *horrea* in places where huge quantities of local produce and imported military supplies were collected, and such facilities must have been a priority in the state and army's building agenda (Cavalier, 2007, 53-54; Erdkamp, 2016, 13-14; Howard, 2013, 865; Kocak, 2019, 76; McCormick, 2001, 101-104; Panella, 1993, 641-642; Rizos, 2013, 659 and 689; Winter, 1996, 127). This point of view is supported by the number of Late Roman transport amphorae found in the Eastern Mediterranean and the Mediterranean region in general that was transported mainly by Annona (Karagiorgou 2001, 149-156). The *horrea* of Caesarea (Appendix 1, no 2) and Patara (Appendix 1, no 4) are examined here as case studies. Rizos (2015, 288-290) discussed the once Hadriani *horrea* in Patara that were built in 119 CE. They consisted of a large rectangular complex situated in the north of the lighthouse, west of the channel **(Fig. 22, no 25 and Fig. 25).**

This complex composed of eight rectangular *horrea* of similar size and height of roughly 8 m (Cavalier, 2007, 53-54; Kocak, 2019, 76). Rizos (2015, 288-293) argues that, in addition storing grain as a layover station from Egypt to Constantinople, this *horrea* housed olive oil and wine throughout the Late Roman period.

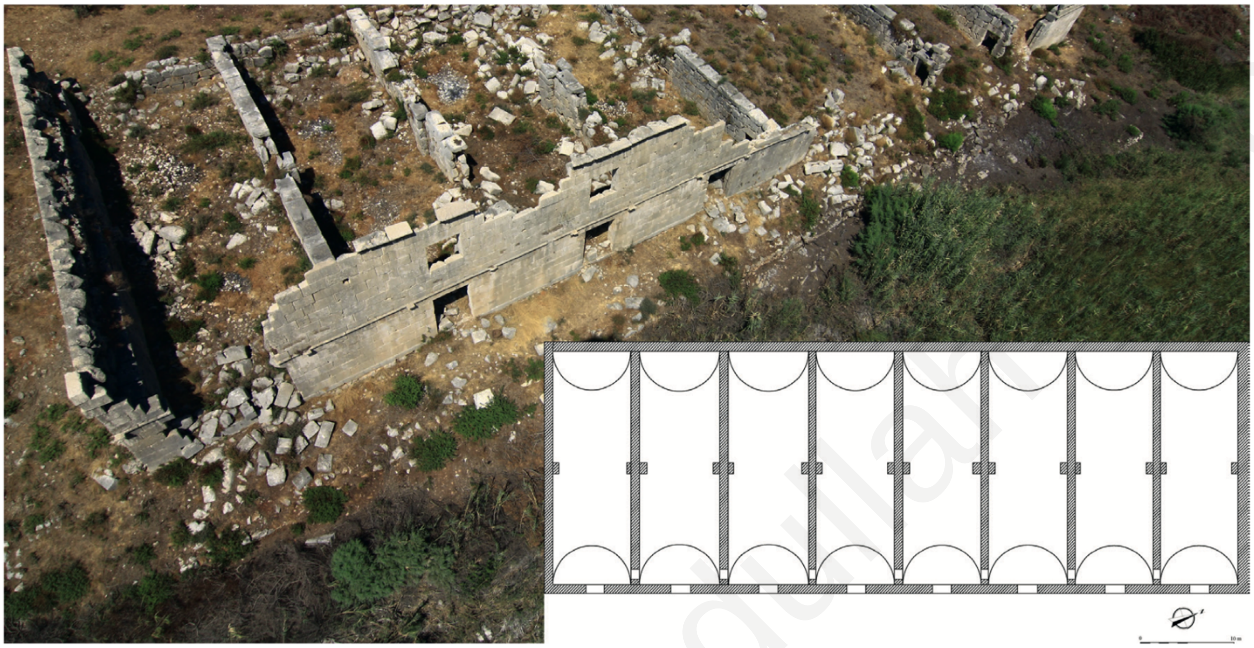


Figure. 25. *A plan of Patara's horrea (Kocak, 2019, 75).*

In Caesarea, several types of *horrea* were discovered in different locations **(Fig. 26).** A Late Roman *horrea* building with two rows of six vaulted *cellae* flanked by a large stairway stood against the western façade of Herodian temple **(Fig. 27).** They were established in 300 CE, perhaps to store the *annona* or military supplies during the wars with Persia. However, their connection to the financial system suggests that they were used until the 6th century (Rizos, 2015, 294-295). On the northern side of the inner harbour, a large complex of *horrea* dated to the Late Roman period was unearthed between 1993 and 1998 excavation season **(Fig. 28).** This *horrea* was in direct communication with the quay of the port because of their close proximity to it (Patrich, 1996, 150-168; 1999, 73-74; Rizos, 2015, 294; Uzi 'Ad and Gendelman, 2018, 2). It consisted of three aisled hangers, indicating a completely distinct warehouse; an oblong rectangular structure, which was split lengthwise into three hallways, the central one for entrance, and the side ones for smaller storage rooms. Moreover, the four-vaulted substructure of the procurator's praetorium **(Fig. 29),** which was constructed in 77/78 CE, throughout the Late Roman era, parts of this structure were repaired and utilised for many other purposes besides storing goods; including the conversion of vault 11 into a chapel, vault 12 into an oven, and the palace of the rulers of the new province of Palaestina Prima. Additionally, *horrea* that were most likely privately owned were discovered near the insulae of the 6th century domus south of the praetorium. Rows of cells with subterranean silos that were well-separated from one another and renowned for serving commercial purposes

(Levine, 1975, 37; Cavalier, 2007, 53-54; Rizos, 2015, 294-296). Patrich (1996, 168), argued local elites invested in these warehouses for their benefit. In general, the *horrea* in Caesarea seem larger than in Patara. While in Patara they are higher and different shapes than Caesarea. The floor of one vault in Caesarea was decorated with mosaic, but such a feature has not been found in Patara. Also, the *horrea* of Patara were linked to each other with a 1.3 m wide door while in Caesarea seems they were separated (Levine, 1975, 37; Cavalier, 2007, 53-54: Kocak, 2019, 76).

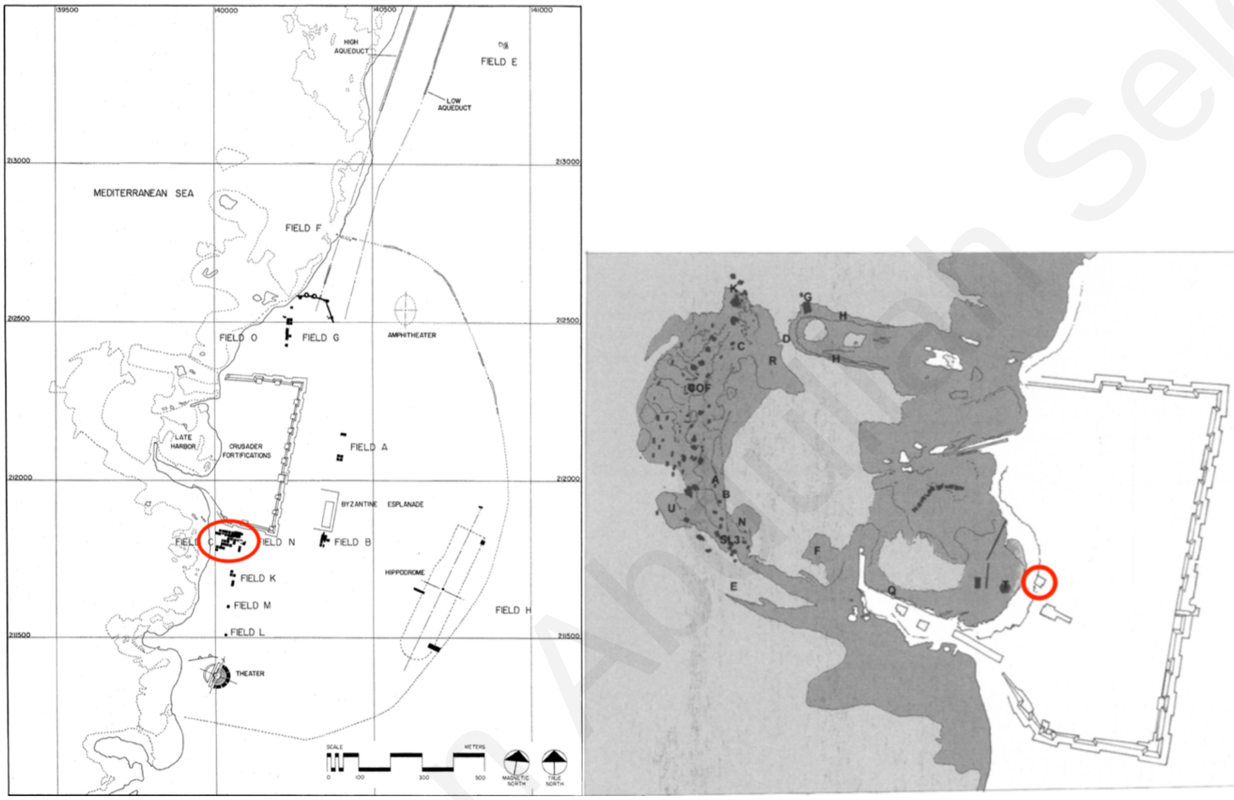


Figure. 26. *Caesarea maps demonstrating horrea's locations (Right map from Blakely, 1988, 36 – Left map Brandon, 2008, 247).*

Figure. 27. *A plan of the inner Harbour horrea of Caesarea in front of Herodian temple (Rizos, 2015, 294).*

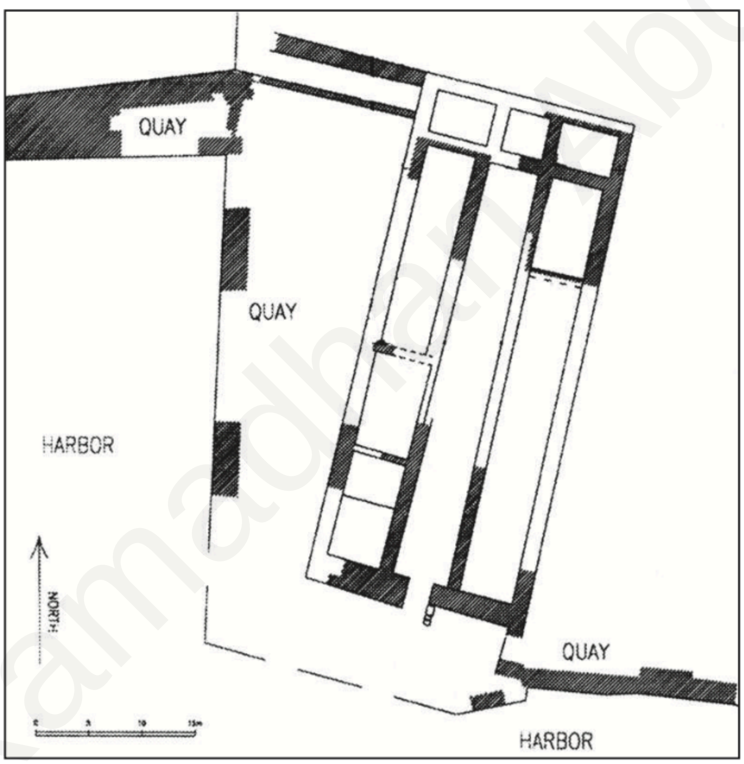


Figure. 28. *A plan of the northern large complex of horrea in Caesarea (Rizos, 2015, 294).*

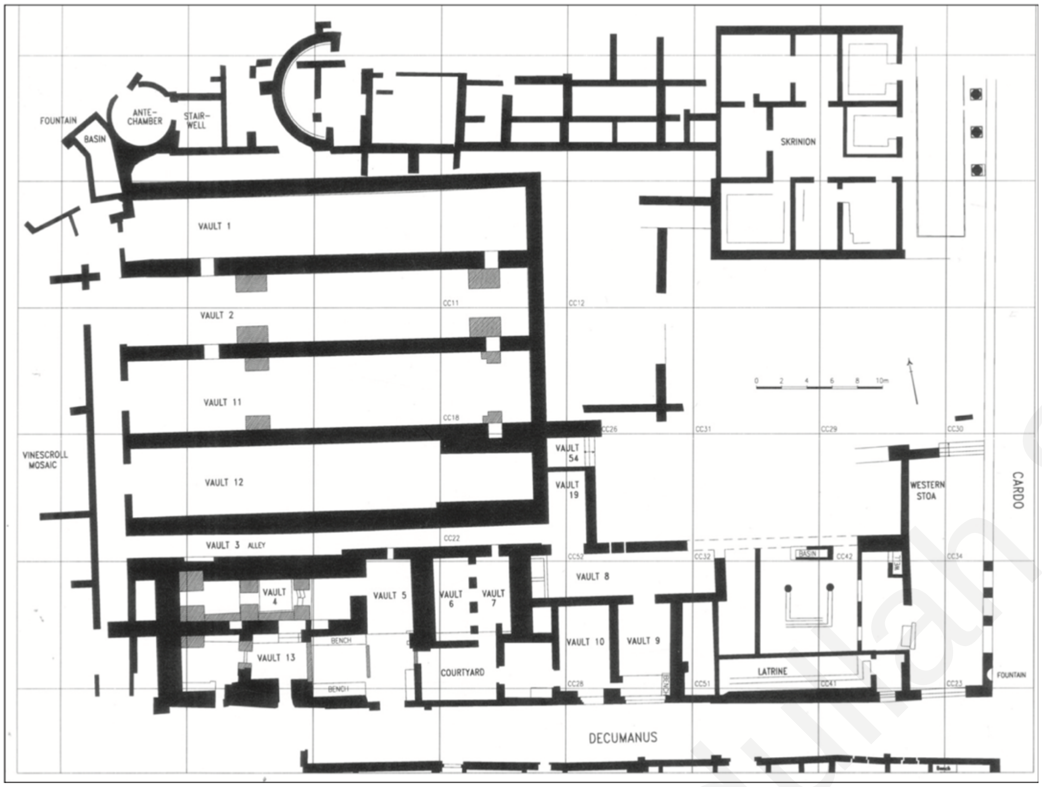


Figure. 29. *A plan of the praetorium, known as the Mithraeum Horrea in Caesarea (Rizos, 2015, 295).*

Chapter 2: Port Construction: the use of cement.

Roman engineers' ingenuity in port technology was evident in the production of materials and their placement in the field. The production of hydraulic concrete was composed of large irregular stone or tuff aggregate put in a mortar of lime and sand-like volcanic ash containing chemically reactive aluminosilicates, nowadays known as pozzolanic hydraulic concrete or mortar (Oleson, 1988, 147-157; Hohlfelder, 1997, 379; Blackman, 2008, 644-645). This composition enabled the builders to produce large concrete blocks, which aided in the construction of port structures and facilities. This technology has significantly improved building quality, design, and sustainability to the point where structures could persist and remain intact in seawater for centuries; this is due to the tenacity and longevity of hydraulic concrete materials (Brandon, 1996, 27-35; Stanislao, et al., 2011, 472-480; Wilson, 2011, 47). Vitruvius in his account (5.12.3) argue the practical issues of materials placement on the field: *Next, in the designated spot, formwork enclosed by stout posts and tie beams is to be let down into the water and fixed firmly in position. Then the area within it at the bottom, below the water, is to be levelled and cleared out, [working] from a platform of small cross-beams. The building is to be carried on there with a mixture of aggregate and mortar, as described above, until the space left for the structure within the form has been filled.*

Of course, it would be helpful to know what the "designated place" was supposed to look like and how the forms were supposed to be "put up" there. The builders were aware that the cement requires time to cure in the underwater environment, while it was difficult to place this material in the water. In this order, to prevent the concrete mix from separating and weakening, wooden caissons were used to transport the concrete all the way to the bottom (Brandon, 1996, 34). Divers were most likely present at the time, but building as much as possible on land would have been the simplest strategy. Possibly wooden caissons would be constructed on the ground before being placed in their final position. Despite the fact that no boards or beams remained, fragments of wood were discovered in Caesarea's port with usage of mortise and tenon joints (Brandon, 1996, 34; Hohlfelder, et al, 2007, 410; Votruba, 2007, 328-329). Three different methods of wooden caisson were used in Caesarea's port to allow the hydraulic concrete to settle in the marine environment. Furthermore, these wooden caissons provided additional protection for the port structure (Brandon, 1996, 28-29; Raban, 1998, 227-243; Hohfelder, et al., 2007, 410-411). The first method involves either hammering vertical boards with no bottom into the sea floor and then supporting them with internal and exterior cross beams, or doing it backwards by installing the cross beams first and then connecting the planks to them. Therefore, the caisson was filled with concrete to set and cure **(Fig. 30)**, (Joseph, et al., 2004, 125). The second method included the construction of a floating caisson (around .11 x 15 x 4 m) that was designed by shipwrights probably on land and floated into place, then filled with a hydraulic concrete and aggregate admixture and submerged gently into the seafloor **(Fig. 31)**, (Holum, et al., 1992, 84; Joseph, et al., 2004, 124; Brandon et al., 2014, 212). The third method is similar to the second, a caisson was built with on the shore with horizontal planks joined by mortise and tenon and pulled into position (Oleson, et al., 2004, 206).

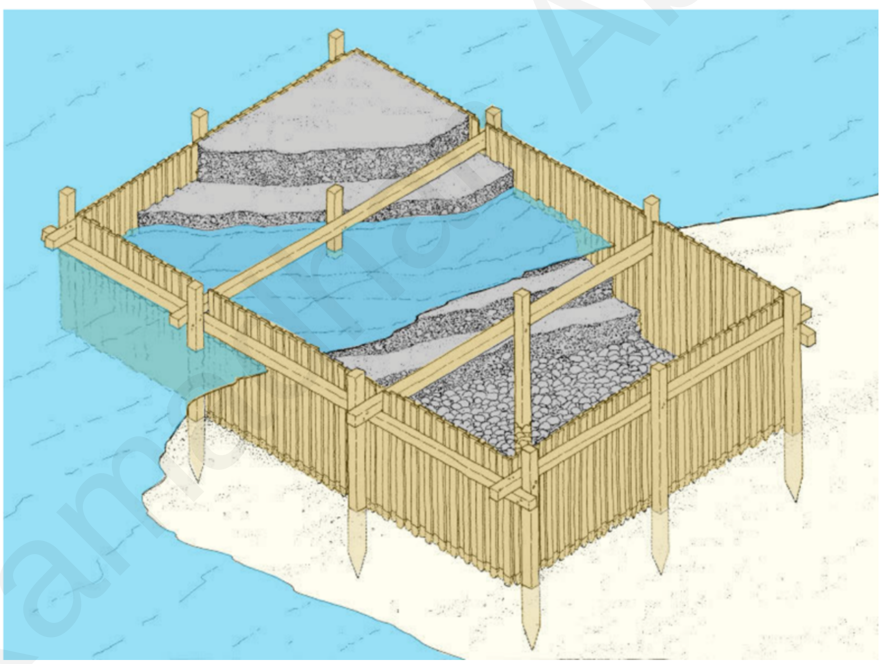


Figure. 30. *A hypothetical reconstruction of the first type of wooden caisson used in Caesarea's port (Brandon, 1996, 31).*

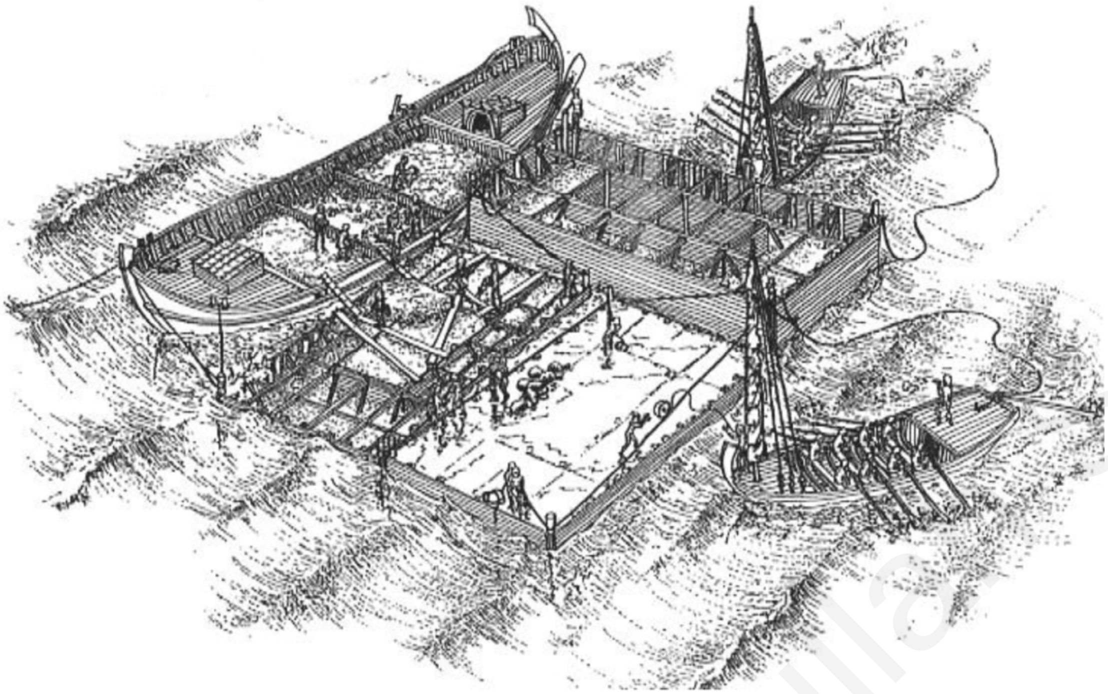


Figure. 31. *A hypothetical reconstruction of floating caissons filled by concrete (Brandon, 1996, 37).*

In Paphos, instead of wooden caissons, the double vertical walls technique was employed and during Roman repairs, they were filled with rubbles and concrete (Leonard, et al., 1998, 156; Misžk and Waldyka, 2016, 9-16). Similarly, at Pompeiopolis, both breakwaters were originally surrounded on the inside and outside by two stone walls **(Fig. 32)** that were around 2-3 m thick (possibly thicker in the lower half), sitting on top of a layer of debris. These barriers created the space for a breakwater\mole with sizable boxes that would later be filled with concrete. The top surface of the stones of the upper layer, were fastened to one another to keep them together **(Fig. 32).** Using this method, allowed builders to design a distinctive basin form that has been successfully maintained through time (Vann, 1994, 533; Brandon, et al., 2010, 391-394; Oleson, 2014, 517). This style of wall for breakwaters was built in the 4th century in Seleucia Pieria, 120 m long, with five m ashlar headers (Pamir, 2014, 178-190).

Figure. 32. *The ashlar wall that containing marine concrete at Soli-Pompeiopolis breakwater/mole. The surface stones were fastened to each other (Oleson, 2014, 517).*

In Alexandria, large blocks containing pozzolana were discovered in the third basin of the Portus Magnus suggesting that it was likely installed during the Roman or Late Roman period (Goddio and Darwish, 1998, 37). Initially, the archaeologist believed that these blocks did not consist of pozzolana, but this belief was later changed by Oleson (et al., 2014, 222). The presence of pine wood under the 3 to 4 cm thick blocks, as well as vertical and inclined beams held in mortar, is an important finding in these blocks, which are similar to Caesarian techniques. These characteristics suggest that they were molded into wooden caissons and floated to the desired location.

Chapter 3: The Capacity of the Ports.

The ports of the Late Roman period had to accommodate an increasing number of large ships while also maintaining a high ratio of maritime activities and people (Casson 1971, 366-367; Oleson and Hohlfelder, 2011, 814-816). There has been very little research on the topic of port capacity. Schörle (2011, 95) argued: *The area of a harbour has to be used as a proxy, since area data are much more widely available. While there is no simple relationship between area and docking space, generally a larger area will have more docking space around its edges, more space for jetties, and will have a larger sheltered anchorage space for ships waiting to dock. So, area is a reasonable proxy for this general analysis.*

De Graauw (1998, 53-58) computed the general layout of three basins of Alexandria's Magnus Portus port and approximated its capacity, using the sizes of Ptolemy II vessels. Furthermore, Goddio (2008, 38) calculated the same basin to be around 2,260,000 sqm, with a total length of quay estimated to be 12,380 m. Keay (2012, 44) measured Portus of Ostia at around 234,000 sqm and estimated its quay to be 13,890 m. In addition, Oleson (1988, 152) measured the outer basin of Caesarea at 200,000 sqm, while Sharvit (et al., 2022, 2) measured its inner basin at 37,500 sqm. As well as, Schörle (2011, 95–97), and Wilson (et al., 2012, 382-384), applied and improved those techniques in a related investigation and provided important data on the capacity of various Mediterranean ports, as can be seen in **Fig. 33 and 34.**

Site	Harbour area (ha)	Wharfage length (m)	Reference
Portus (total)	234	*c.* 13,890	Keay 2011 (Chapter 2, n. 65); Morelli *et al*. in press.
Claudian basin	*c.* 200	2,860	Wharfage figure includes various canals.
Trajanic hexagon	33.3	2,100	
darsena	1.08		
Alexandria, Portus Magnus	> 226	12,380	Calculated from plan in Goddio and Fabre 2008: 38.
Puteoli (total)	67.9		Calculated from plan in Brandon *et al*. 2008: 376 fig. 1.
Puteoli (Portus Iulius)	53.9		Calculated from plan in Brandon *et al*. 2008: 376 fig. 1.
Puteoli (Portus Baianus)	14		Calculated from plan in Brandon *et al*. 2008: 376 fig. 1.
Antium	25-30		Felici 1995: 61.
Ephesus	*c.* 18–24		Calculated from Google Earth.
Caesarea Maritima (outer basin)	20		Oleson 1988: 152.
Hadrumetum	20		Bartoccini 1958: 12.
Centumcellae	14	No more than 2000	Calculated from plan in Caruso *et al.* 1991.
Carthage (circular and rectangular harbours)	14		Romanelli 1925: 92.
Terracina	11		Calculated from plan in De Rossi 1980: 100, fig. 25.
Lepcis Magna	10.2	1200	Bartoccini 1958: 12–13.
Torre Astura	7.8		Calculated from Marzano 2007: 49, fig. 5.
Kenchreae (Corinth)	3		Kingsley 2004: 140.
Cosa	2.5		Gazda 1987: 75.
Giglio Porto	*c.* 2		Calculated from plan in Ciampoltrini and Rendini 2004: 138, fig. 6.[a]
La Mattonara	1.24		Calculated from plan in Higginbotham 1997: 94, fig. 18.
Villa port at San Simone	0.84		Degrassi 1955: 136.
Ventotene (Pandateria)	0.7		Franco 1996: 297.

a The units of the scale bar of this plan are not specified and the plan has clearly been greatly reduced from the stated 1:20000 scale; checking against Google Earth indicates that the scale bar must represent 30 m in 2 m and 10 m units.

32 Tacitus *Annales* 15.18.2.

33 Cf. Goddio, this volume (Chapter Seven); Fabre and Goddio 2010: fig. 5.1.

Figure. 33. *The table provided by Schörle (2011, 96), which demonstrate the dimensions of harbour area and wharfage (quay) of several Mediterranean ports.*

Site	Harbour area (ha)	Wharfage length (m)	Reference
Portus (total)	234	c. 13,890	Keay (Chapter 2: n. 64); Morelli, Marinucci and Arnoldus-Huyzendveld 2011
Claudian basin	c. 200	c. 2,860	Wharfage figure includes various canals
Trajanic hexagon	33.3	2,100	Keay (Chapter 2, this volume)
Darsena	1.08		
Alexandria, Portus Magnus	>226	12,380	Calculated from plan in Goddio and Fabre 2008: 38
Puteoli (total)	67.9		Calculated from plan in Brandon, Hohlfelder and Oleson 2008: 376 fig. 1
Portus Iulius	53.9		Calculated from plan in Brandon, Hohlfelder and Oleson 2008: 376 fig. 1
Portus Baianus	14		Calculated from plan in Brandon, Hohlfelder and Oleson 2008: 376 fig. 1
Antium	25–30		Felici 1995: 61
Ephesus	c. 18–24		Calculated from Google Earth
Caesarea Maritima (outer basin)	20		Oleson 1988: 152
Hadrumetum	20		Bartoccini 1958: 12
Centumcellae	14	No more than 2,000	Calculated from plan in Caruso, Gallavotti and Aiello 1991
Carthage (circular and rectangular harbours)	14		Romanelli 1925: 92
Terracina	11		Calculated from plan in De Rossi 1980: 100, fig. 25
Lepcis Magna	10.2	1,200	Bartoccini 1958: 12–13
Torre Astura	7.8		Calculated from Marzano 2007: 49, fig. 5
Kenchreae (Corinth)	3		Kingsley 2004: 140
Cosa	2.5		Gazda 1987: 75
Giglio Porto	c. 2		Calculated from plan in Ciampoltrini and Rendini 2004: 138 fig. 6*
La Mattonara	1.24		Calculated from plan in Higginbotham 1997: 94 fig. 18
Villa port at San Simone	0.84		Degrassi 1955: 136
Ventotene (Pandateria)	0.7		Franco 1996: 297

*The units of the scale bar of this plan are not specified and the plan has clearly been greatly reduced from the stated 1:20,000 scale; checking against Google Earth indicates that the scale bar must represent 30 m in 2 m and 10 m units.

Figure. 34. *The table provided by Wilson (et al., 2012, 281), which demonstrate the dimensions of harbour area and wharfage (quay) of the ports along the Italian coast from Cosa to the bay of` Naples.*

The basins of Magnus Portus of Alexandria **(Fig. 35)**, are at the top of the list, much larger than the other case studies **(Table. 2).** Undoubtedly such a space provided more room for large ships to manoeuvre to or from the quays. The Paphos basin, which comprised of two internal bays (Daszewski, 1981, 333-334; Hohlfelder, 1995, 195; Veikou, 2015, 42; Mišžk and Wadyka, 2016, 9-13), appears smaller than Caesarea, but significantly larger than Soli-Pomeopolis **(Fig. 3)**, both basins of Elaiussa Sebaste **(Fig. 4)** and Patara **(Fig. 1).**

Table. 2. *The basin area of ports.*

Port	Basin area - sqm
Magnus Portus of Alexandria	2,260.000
Caesarea	237,000
Paphos	173,100
Soli-Pompeiopolis	52,217
Elaiussa Sebaste	South – 49,612 North – 28,237
Patara	24,908

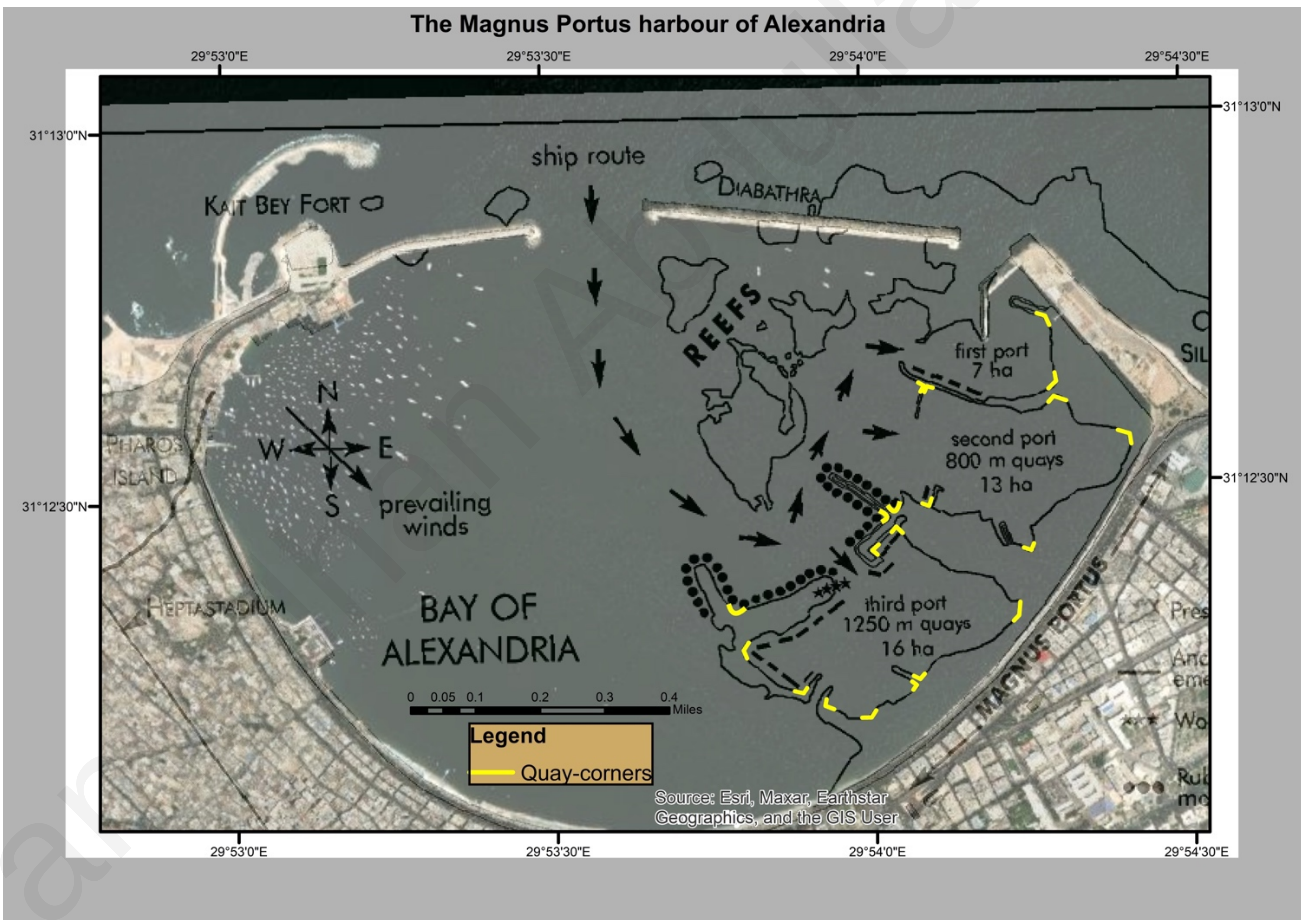


Figure. 35. *The structure of Magnus Portus of Alexandria: quay corners are highlighted in yellow (map from de Graauw, 2022a, 16 – made up in GIS).*

Schörle (2011, 95) and Wilson (et al., 2012, 382-383) suggested that the length of the quay is the greatest indication for determining the number of ships that could dock on it. Hereby, the length of the quay is divided by the amount of space required for a ship to moor perpendicular to the quay as a Mediterranean tradition of mooring ships: on its bow or stern, plus additional space for clearance between ships and the corners of the quay. The alignment of eleven cargo shipwrecks sunk in Olbia's port due to a natural catastrophe while moored parallel to one another on the port's quay in the 5th century CE, attests to this method of mooring in the Late Roman period (D'Oriano and Riccardi, 2004, 89). Blackman (2008, 651-653) referring to this docking tradition, argued that a column separated each block for a ship to moor in the quay, as those uncovered on Caesarea's eastern quay (Raban, 1996, 660).

As quays are either totally vanished or severely fragmented, as was mentioned in the preceding chapter, it is challenging to estimate the exact quay size in order to determine the ports' actual capacity. Nonetheless, the inner edge of the breakwater and the basin was commonly used as a quay. Since the internal layout line of each basin plan is readily accessible, it is measured in this study as an approximation of the quay size. No statistics are available for any of the other ports included in this study, with the exception of Alexandria, whose capacity has already been estimated by de Graauw (1998, 53-58). The moles and jetties that stretched into the harbour's basin of Alexandria's Magnus Portus were discovered by Goddio's (1998, 5-50) team during their underwater investigation. These structures offered protection and increased the length of the accessible quay, which is around 12,380 m.

In this study, GIS is used to estimate the internal layout line of Caesarea, Elaiussa Sebaste, Patara, Soli-Pompeiopolis, and Paphos **(Table. 3).** GIS also offers the opportunity to digitize a polygon or a polyline and compute its area by georeferencing a port plan (with a known scale) in the global map.

Table.3. *The size of the port's basins, breakwaters and the estimated size of quays, all values measured in GIS.*

Ports	**Basin Area-sqm**	**Estimated Quay-m**	**Breakwater/mole-m**
Alexandria (Portus Magnus)	2,260,000 (Goddio, 2008, 38).	12,380	--------
Caesarea	Outer basin 200,000 (Oleson, 1988,152). Inner basin 37,500 (Sharvit, et al., 2022, 2).	2,073	southern 480 northern 280 (Hohlfelder, et al., 1983, 137-140; Oleson, et al., 1984, 286-289).
Paphos	173,100	1882	western 400 eastern 280 (Daszewski, 1981, 330; 1987, 134 n. 39).

Soli-Pompeopolis	52,217	981	320 (Vann, 1994, 530-531).
Elaiussa Sebaste (southern harbour)	49,612	752	------
Elaiussa Sebaste (northern harbour)	28,237	557	29
Patara	24,908	540	77

Sizes of Late Roman shipwrecks from the Mediterranean basin are also calculated in order to compute how many of them could be moored at a quay **(Table. 4)**. A total of 16 shipwrecks that were examined, nine ships have a length between 10 and 20 m, four have a length between 20 and 30 m, and the remaining were less than 10 m long. However, the ship's width is more essential for this study. The width of the majority of 8 shipwrecks assessed here were in beam of 5 m, and 4 are between 7 to 10, while 4 of them are less than 5 m **(Table. 4).** In this research, a ship with a beam of 7.50 m is referred to as "large" and a ship with a beam of 5 m is referred to as "medium" size ship **(Table. 5).** The beam of 7.5 m reflects the average size of a large ship among the study cases such as Port Vendres and Dor 2006. Whereas the 5 m beam refers to a medium-sized ship such as Tantura A, Yani Kapi 27 and Port Berteau 2. As McCormick (2001, 94-96) argued that in general the size of Late Roman ships was not large in comparison with previous periods. The most common ship could carry under 75 tons of cargo.

Table.4. *Mediterranean Late Roman ships and their dimensions.*

Shipwrecks	**Date (century CE)**	**Shape**	**(Estimated) Length (m)**	**(Estimated) Width (m)**	**Type**	**Reference**
Yani kapi 34	5th	Wine-glass	7.60	2.09	Cargo ship	Kocabas, 2015, 21-22.
Yani kapi 17	7th to 8th	Flat bottom	8.20	2.25	Cargo ship	Kocabas, 2015, 23.
Yani kapi 3	5th to 6th	Flat bottom	9.12	2.28	Cargo ship	Kocabas and Kocabas¸ 2008, 152–163.
Yani kapi 11	7th	Wine-glass	11.25	3.75	Cargo ship	Ingram, 2018
Tantura A	End of 5th – beginning of 6th	Flat bottom	12	4	…………	Wachsmann, 1997; Navri, at el., 2013.

Yani kapi 27	7th to 8th	Wine-glass	12	4.30	Cargo ship	Türkmenog˘lu, 2013, 414–422.
Port Berteau 2	End of the 6th – beginning of the 7th	Flat bottom	14.3	4.8	…………	Pomey, et al., 2012, 263-264.
Yani kapi 35	5th	Wine-glass	15	5.20	Cargo ship	Kocabas, 2015, 23-24.
Yassıada 1	7th	Wine-glass	20.52	5.2	Cargo ship	Pomey, et al., 2012, 266-268. Bass and van Doorninck, 1982.
Tantura F	Mid 7th to the end of 8th	flat bottom	15.7	5.2	Fishing vessel	Barkai and Kahanov, 2007. Pomey, et al., 2012, 269-270.
Dor 2001/1	6th	Flat bottom	16.9	5.4	Cargo coaster	Pomey et al., 2012, 260-262.
Fiumicino 1	End of the 4th or beginning of the 5th	Flat bottom	17.18	5.6	Caudicarig – fluvial craft	Pomey et al., 2012, 253-255.
Port-Vendres 1	5th	Flat bottom	18–20	7.5	Barge	Pomey et al, 2012, 255-256.
Dor 2006	End of 6th – beginning of 7th	Flat bottom	25	7.5	Cargo ship	Barkanm, et al., 2013; Navri, et al., 2013.
Yassiada 2	4th	Wine-glass	20	8	Cargo ship	Pomey, et al., 2012
Pantano Longarini	Early 7th	Wine-glass	31.5	10.25	Coastal barge	Kampbell, 2007. Pomey, et al., 2012, 268-269.

Table. 5. *The length and width of Late Roman shipwrecks.*

Shipwrecks	(estimated) Length (m)	Average Length	(estimated) Width	Average beam	No of Ships	
Yani kapi 34	7.6		2.09			
Yani kapi 17	8.2		2.25			
Yani kapi 3	9.12		2.28			
Yani kapi 11	11.25	9.0425	3.75	2.5925	4	Boats
Tantura A	12		4			
Yani kapi 27	12		4.3			
Port Berteau 2	14.3		4.8			
Yani kapi 35	15		5.2			
Yassıada 1	20.52		5.2			
Tantura F	15.7		5.2			
Dor 2001/1	16.9		5.4			
Fiumicino 1	17.18	15.45	5.6	4.9625	8	Mid-size merchament
Yassiada 2	20		8			
Port-Vendres 1	19		7.5			Barge
Dor 2006	25		7.5	7.66666667	3	Large merchantmen
Pantano Longarini	31.5	23.875	10.25		1	Barge
					16	

Thus, each block on the port's quay could house a number of large or medium ships with a 4 m clearance between pairs of ships in each side. Wilson (et al., 2012, 383) provided 4 m clearance for 5m-beam ships and Testaguzza (1970, 162-163) for 9m-beam ships provided 5 m clearance space into consideration while calculating the capacity of several Roman ports. They did not specify why such a space was provided between two ships, but it was most likely to provide adequate distance to prevent a collision between ships in the event of sea movements. Such space was also required for a ship to comfortably arrive and depart (maneuver), embark and debark. To support this idea, Nakas (2020, 4-6) argue about the complicated relationship between ships and harbours, indicating that such a distance between two ships was critical for all maritime operations on the port. Furthermore, to avoid interference between ships at the corners of the quay where two rows of ships meet, 15 m is subtracted for each corner in the quays as an average size of a ship length among the study cases. The following formula gives the minimum number of ships per quay, since in reality the corner space could have been also utilised:

Net quay length – (number of corners x interference space for corners) ÷ (ship width + interference space between ships) = number of the ships that a quay could accommodate.

This is illustrated in **(Fig. 35)** and the following maps and drawings which offer a hypothetical representation of a port with its estimated capacity:

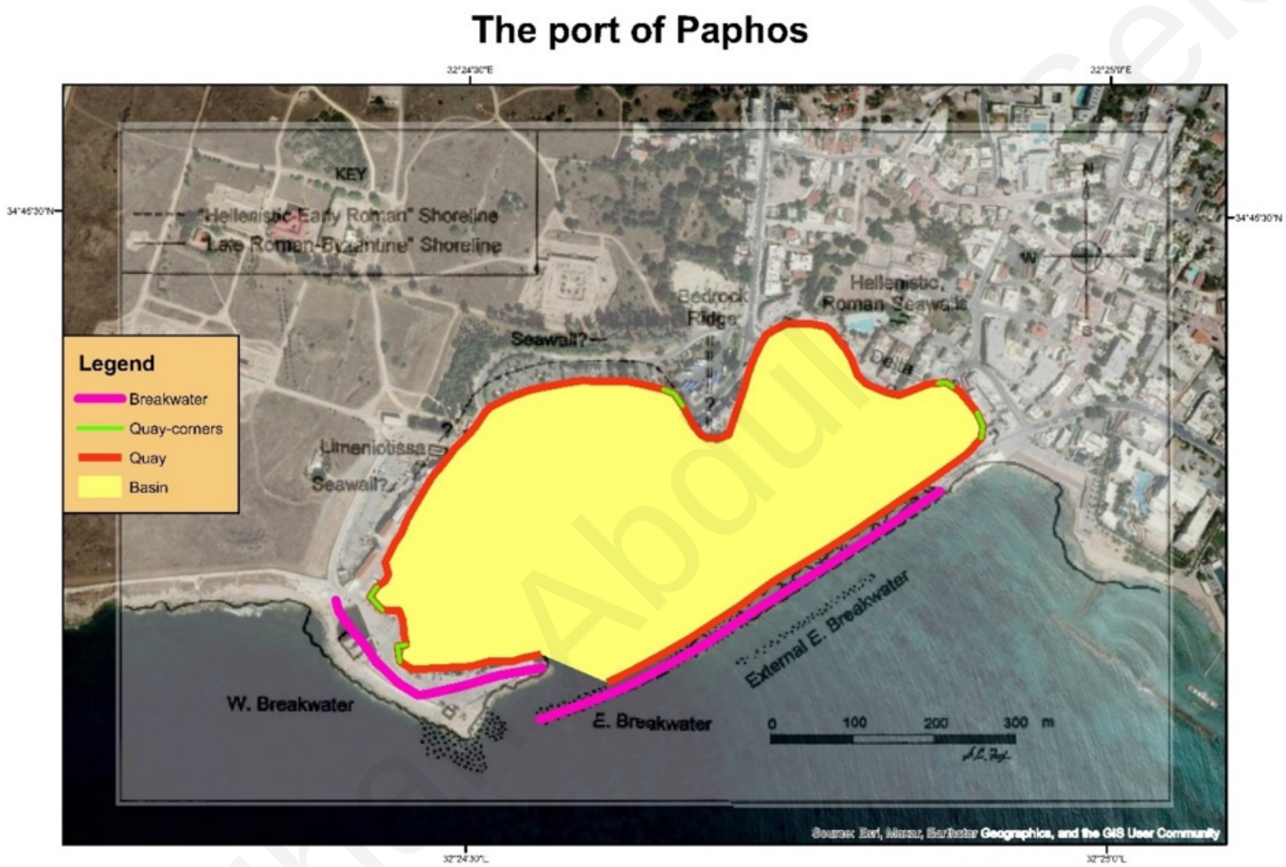


Figure. 36. *The map of Paphos's port: yellow is basin, red is estimated quay, green is corners and purple is breakwaters (map from leonard, et al., 1998, 151 - made up in GIS).*

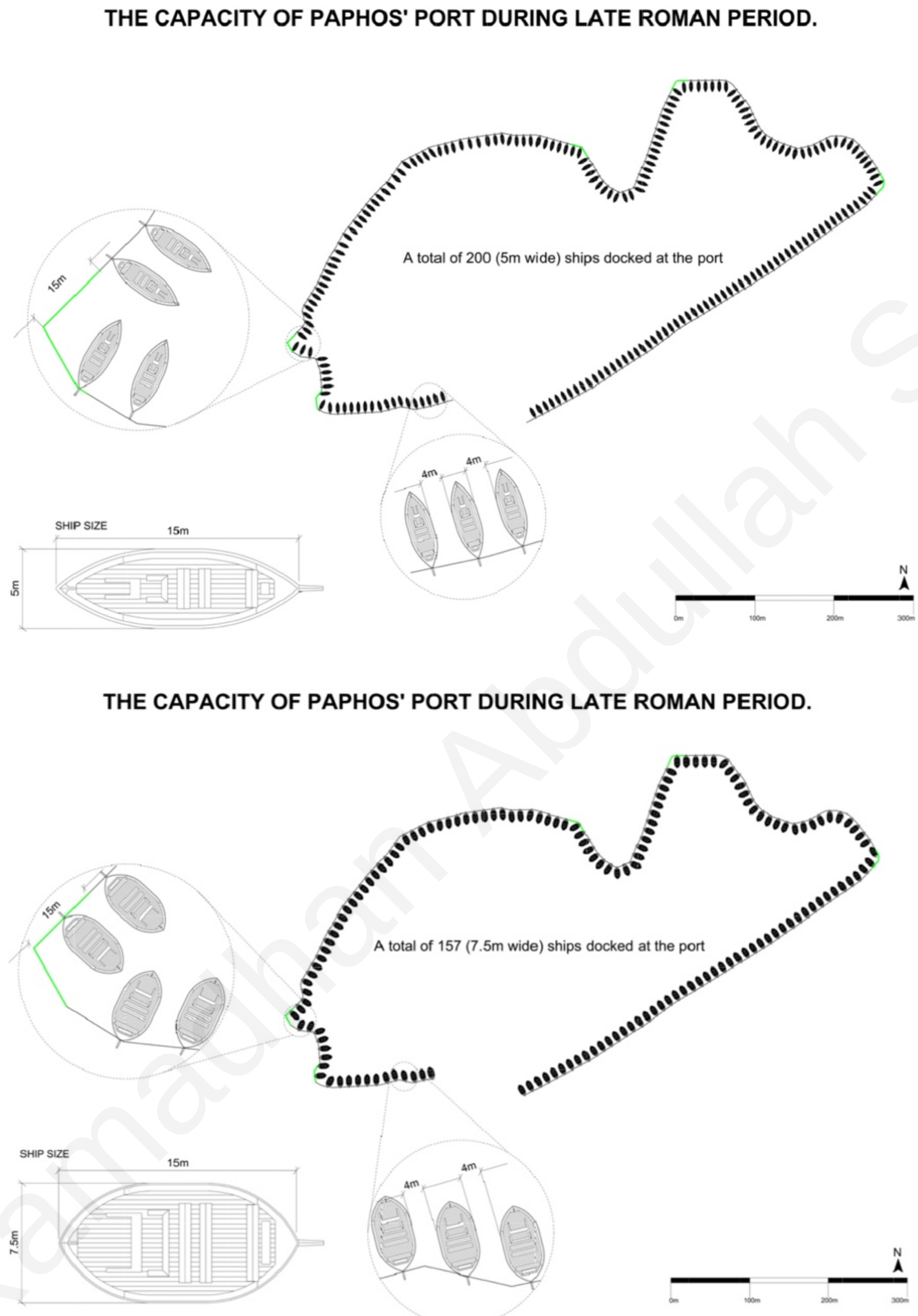


Figure. 37. *A hypothetical drawing as a conventional estimation for the capacity of Paphos's port: Top drawing is for medium ship of 5 m wide. Bottom drawing is for 7.5 m wide large ship (made by AutoCad).*

Figure. 38. *The map of Soli-Pompeiopolis's port: yellow is basin, red is breakwaters, purple is estimated quay and green is corners (map from Brandon, et al., 2010, 393 – made up in GIS).*

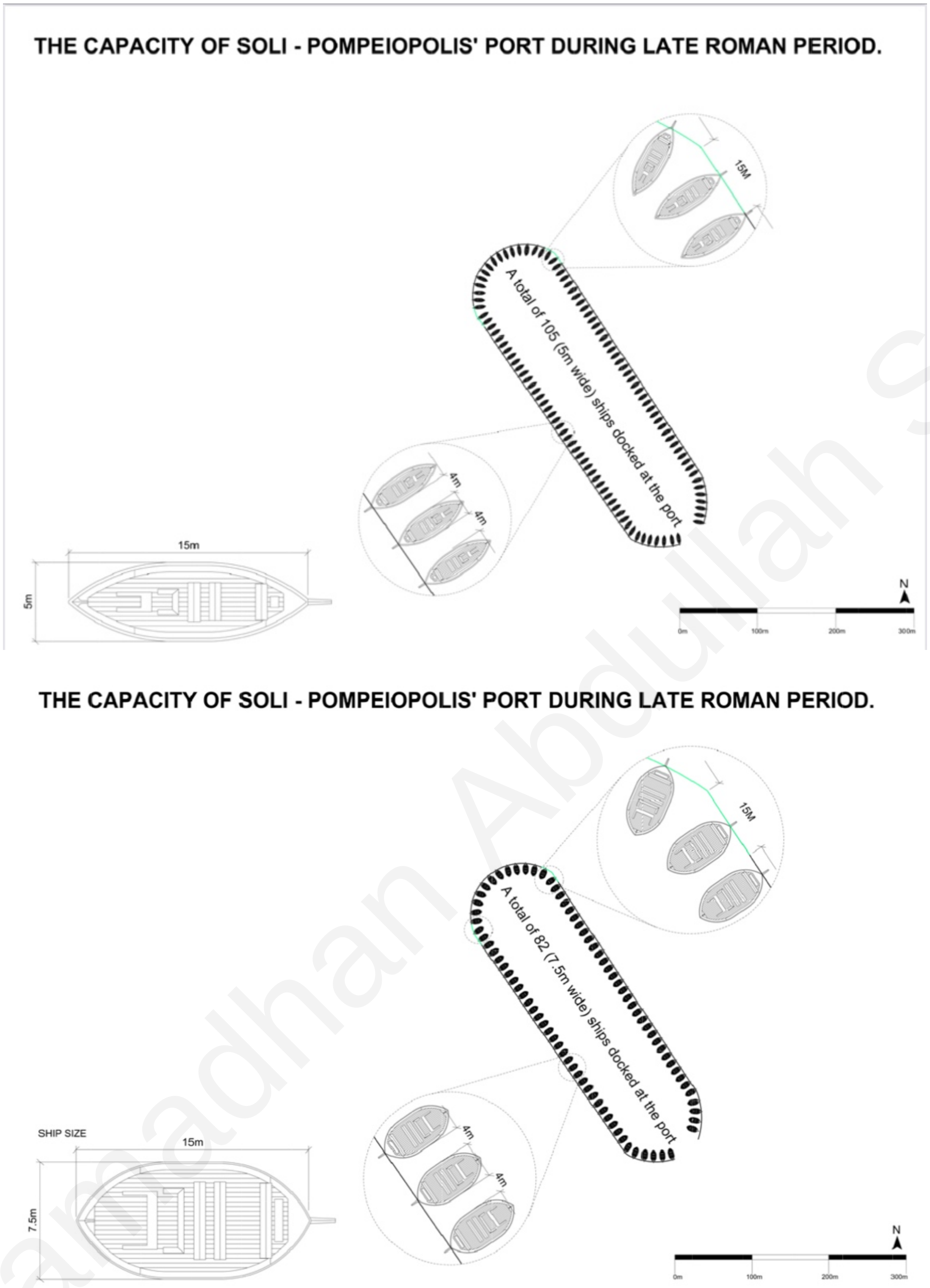


Figure. 39. *A hypothetical drawing as a conventional estimation for the capacity of Soli-Pompeiopolis's port: Top drawing is for medium ship of 5 m wide. Bottom drawing is for 7.5 m wide large ship (made by AutoCad).*

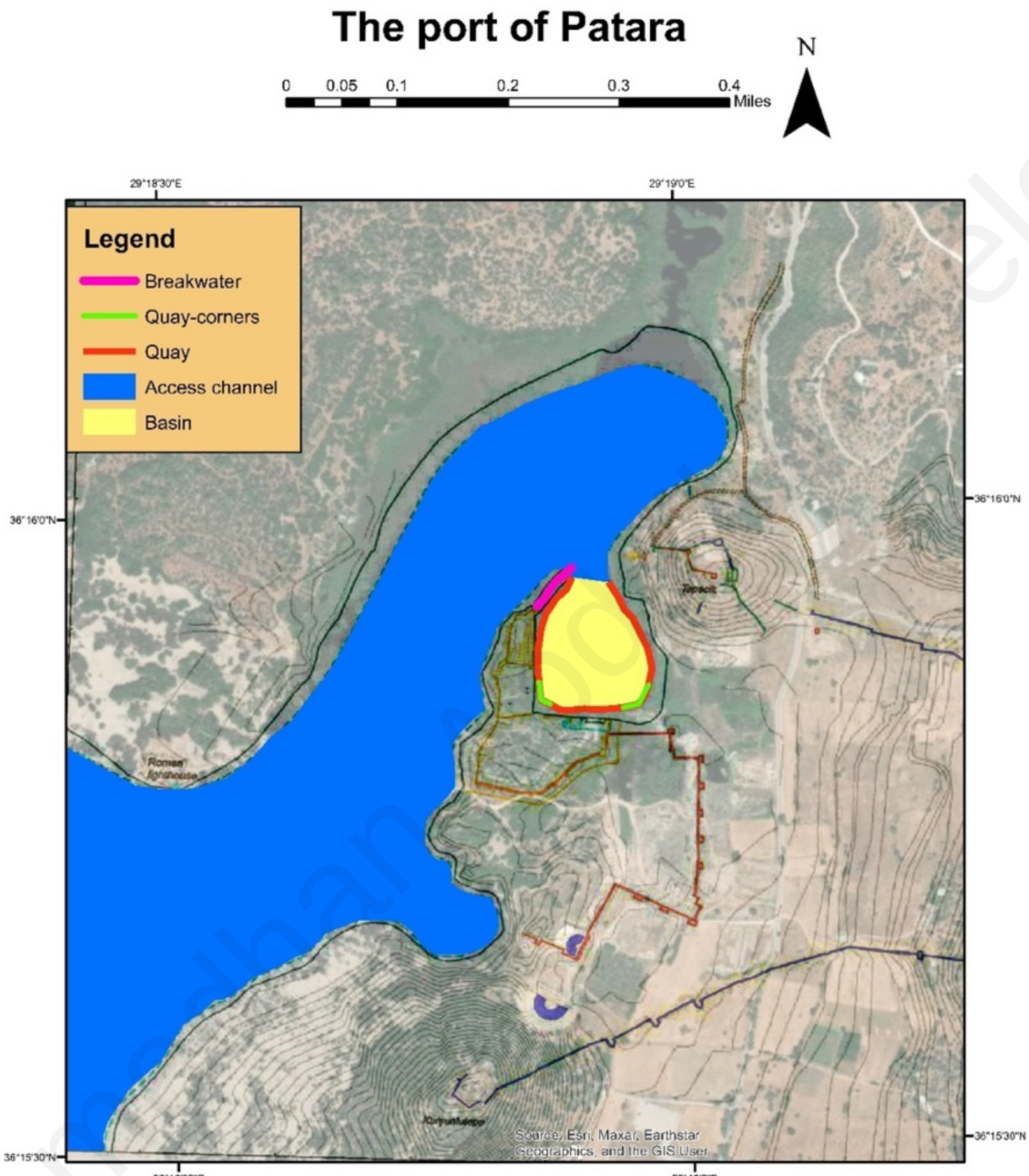
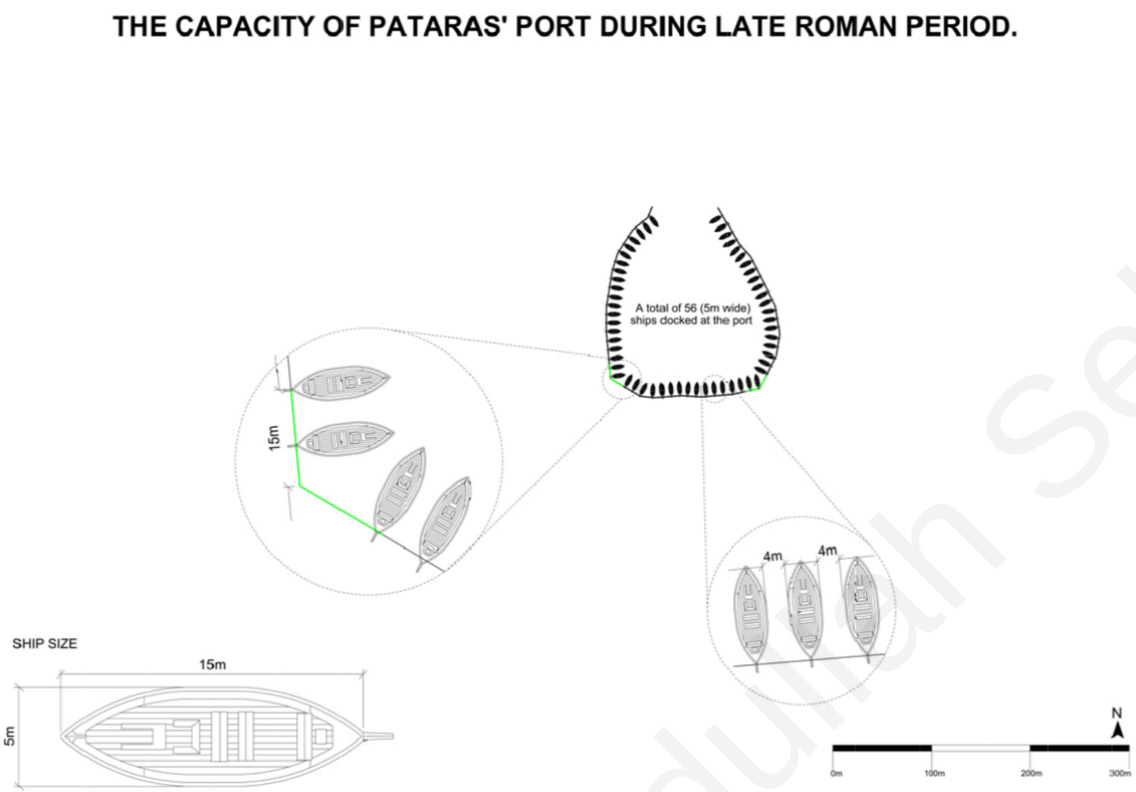


Figure. 40. *The map of Patara's port: yellow is basin, red is estimated quay, green is corners and purple is breakwater (map from Kocak, 2019, 74 – made up in GIS).*



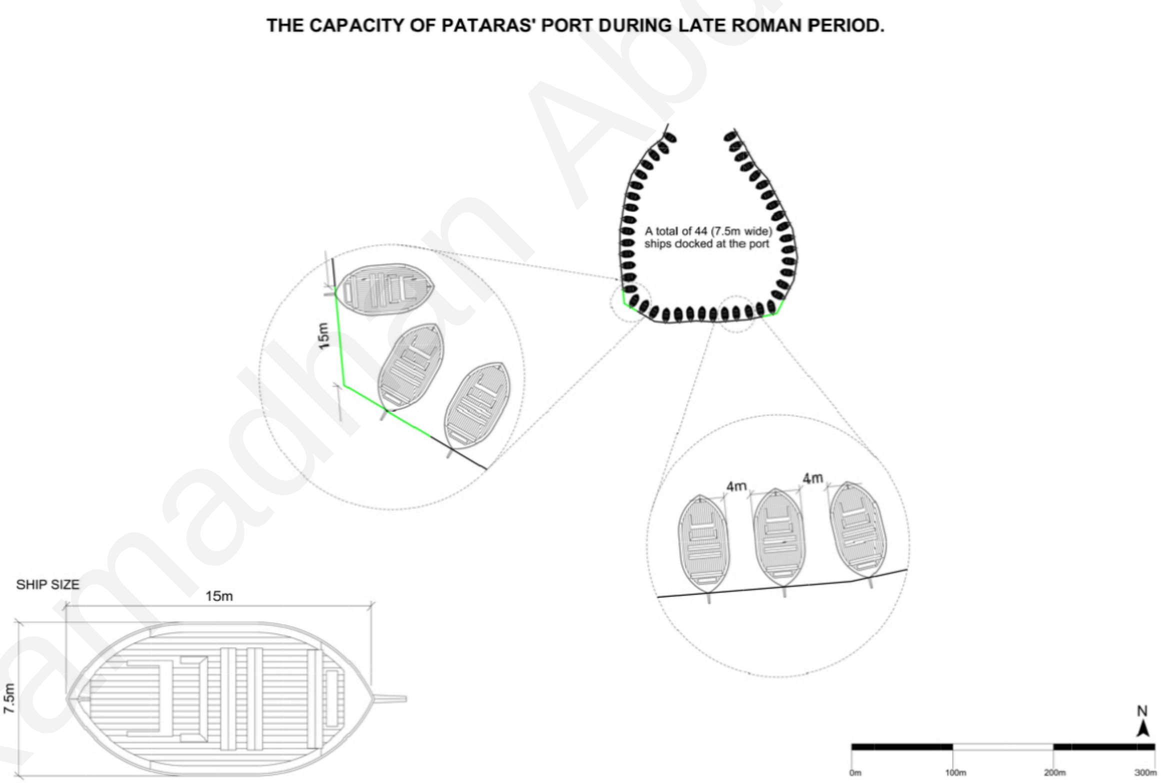


Figure. 41. *A hypothetical drawing as a conventional estimation for the capacity of Patara's port: Top drawing is for medium ship of 5 m wide. Bottom drawing is for 7.5 m wide large ship (made by AutoCad).*

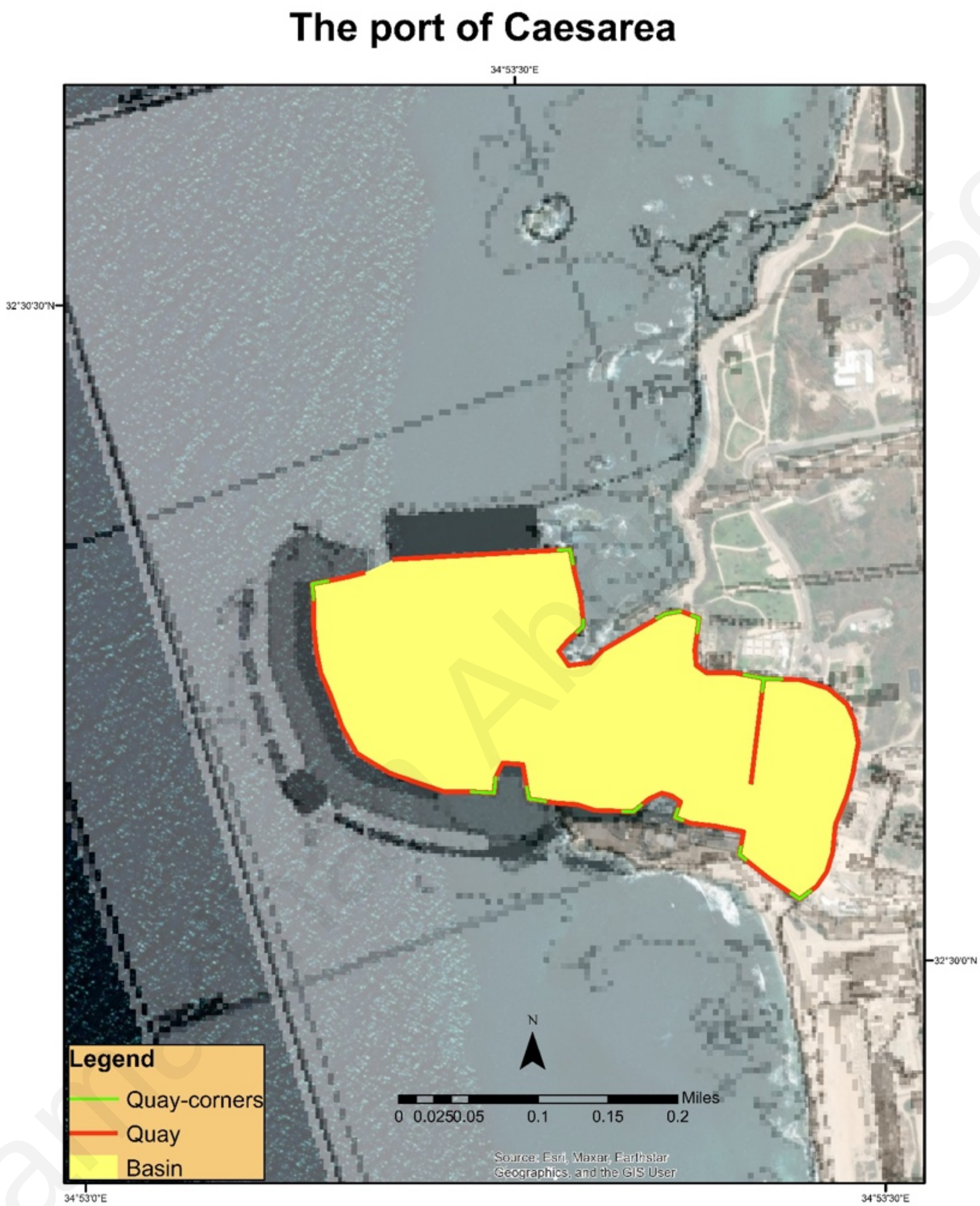


Figure. 42. *The map of Caesarea's port: yellow is basin, red is estimated quay and green is corners (map from Blakely, 1988, 36; Rogers, 2013, 186 – made up in GIS).*

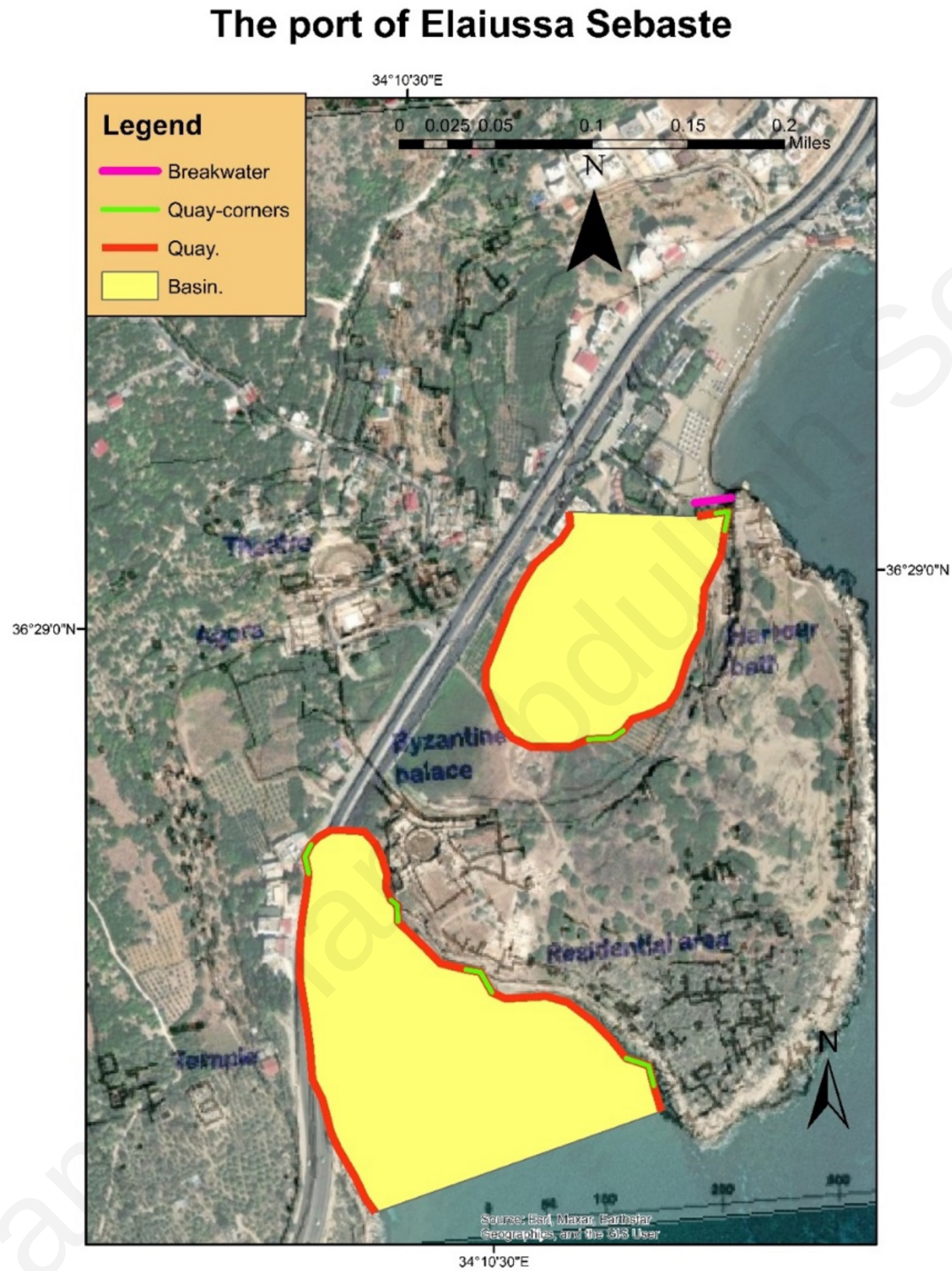


Figure. 43. The map of Elaiussa Sebaste's port: *yellow is basin, red is estimated quay, green is corners and purple is breakwater (map from Borgia, 2021, 2 – made up in GIS).*

Therefore, in **(Table. 6)** the capacity of each port is estimated as the number of large and mid-sized merchantmen that a quay would host such in the same time. Certainly, there were more factors that may have affected or changed the capacity of ports, such the addition of mooring space by wooden piers (Schörle, 2011, 102) or shallow beaches for smaller ships (Rickman, 1985, 111; Houston,1988, 560-564; McCormick, 2001, 419-421). Apart from these, the management of the port and its facilities may have further effects on the port's traffic. For instance, the subdivision of a port's main basin into smaller embayments and the allocation of each to a certain maritime activity depended on the ship's design; the port maintenance and loading and unloading processes also could impact the maritime traffic of ports (Casson, 1996, 369-370). Warehouses as its main facility, manufacturing centres, and marketplaces would further attract commercial activities to the area. For example, the *horrea* of Patara and Caesarea offered room for keeping goods for an extended period of time (Appendix 1, no 2 and 4). The colonnaded streets of Soli-Pomeiopolis (Appendix 1, no 5), Patara (Appendix 1, no 4) and other shop streets in Caesarea (Appendix 1, no 2) enhanced the volume of commerce in their respective ports. However, the investigated ports may not have been necessarily used in the same way throughout the Late Roman period; this is a hypothetical attempt done here to attain some main approaches in the capacity aspect for ports. This study gathered and provided some significant methodologies and data for future work in the maritime activities, economy, and social interests of ports studies.

Table.6. *The calculation of quays, ships, corners of the quays and the interference space between ships moored in the quay.*

Port	**Quay length (m)**	**Number corner-gaps**	**Calculation of corner-gaps (15m as interference space for angles on the quay)**	**Clear quay length (total length minus corner-gap length)**	**Number of large merchantmen (clear quay length minus – average beam (7.5m) + interspace 4m)**	**Number of Mid-size merchantmen (clear quay length minus – average beam (5m) + interspace 4m)**
Alexandria (Portus Magnus)	12,380	20	20x15=300	12,380-300= 12,080	= 1,050	= 1,342
Caesarea	2,073	13	13x15=195	2,073-195= 1,878	= 163	= 208
Paphos	1,882	5	5x15=75	1882-75= 1807	= 157	= 200
Soli-Pompeopolis	981	2	2x15=30	981-30= 951	= 82	= 105
Elaiussa Sebaste (southern harbour)	752	4	4x15=60	752-60= 692	= 60	= 76

Elaiussa Sebaste (northern harbour)	557	2	2x15=30	557-30= 527	= 45	= 58
Patara	540	2	2x15=30	540-30= 510	= 44	= 56

Chapter 4: Discussion.

4.1. Port Capacity.

Among all examined ports Alexandria stands out. A number of smaller breakwaters, jetties, reefs, and quays separated the three inner harbour basins in its eastern port (Appendix 1, no 1). This special structural element was only found in Alexandria (Goddio and Darwish, 1998, 6-52). Some of the main basins of these ports were separated to smaller inner embayments for further security, to evenly disperse the ships and allow for comfortable loading and unloading. On top of that, each embayment or sometimes a harbour was specified for a particular maritime activity. According to Oleson (2014, 511-513), allocating each basin to a distinct sort of activity was influenced by the types of the ships. For example, a military ship had a totally different design than a cargo or fishing ship. Therefore, the anchorage of each basin was formed according to the ships it hosted in order to maximize the utilised area. In Alexandria, the eastern harbour was dedicated to royal purposes, while the western harbour was devoted more to commercial activities. Ships might be moved from one harbour to another, if necessary, by cutting canals in the Heptastadium to provide room for other ships (de Graauw, 2022a, 15). Another example is Caesarea, where the inner basin was most likely a military or royal shelter, while the intermediate basin was used for other maritime activities (Strauss, 2006, 64). According to Anonymous Stadiasmos or Periplus Maris Magni (297), probably written in the 4th century CE, the enclosed basin of Paphos was comprised of three internally separated embayments. Leonard (et al., 1998, 155-156) believed that Paphos had only two internal bays, with the third located outside the breakwater. These basins were most likely split into two parts: western basin for military usage and eastern basin for commercial activities (Leonard, et al., 1998, 142; Vitas, 2010, 271-272). Daszewski (1981, 333-334), on the other hand, believes it is improbable that a basin was exploited for military objectives during the Roman period. Whereas Hohlfelder (1995, 195) suggests three potential applications for the Paphos basins: an international emporium, a local commerce facility, and a shipyard. At, Elaiussa Sebaste, it seems that each harbour had only one basin (Melis, et al., 2015, 567; Schneider, 1999, 35). It is unknown whether they had specific purposes, however, it is argued that due to siltation events in the northern basin, nearly all maritime activities were relocated to the southern harbour during Late Antiquity (Melis, et al., 2015, 580-581; Tempesta, et al., 2020, 40-45).

According to the evidence so far, independent quays structures are scarce. Perhaps the inner side of the port's breakwaters was often used as a quay and the inner (land) edge of the basin could also accommodate ships (Blackman, 2008, 649). For instance, in Alexandria (Appendix 1, no 1), the quays were independently constructed and attached to the breakwaters. Meanwhile, the small moles which shaped three internal harbours in the main basin of Magnus Portus harbour were hosting ships (Goddio and Darwish, 1998, 15-51; Goddio and fabre, 2014, 89-95). In addition, the Heptastadium bay according to de Graauw (2022b, 18), was serving maritime needs. Tempesta (et al., 2020, 42) stated that the moles along the southern and eastern banks of the northern harbour and the northern bank of the southern harbour of Elaiussa Sebaste were utilized as quays. The one at the southern harbour, in particular, was linked to the warehouse complex, implying that ships were loaded and unloaded there from products held in the warehouses. In Caesarea, ruins of vaulter chambers, a series of towers, and a large promenade for ship cargoes were discovered above the port's L-shaped breakwater (Oleson, et al., 1984, 286-289; Oleson, 1988, 152; Hohlfelder, et al, 1983, 137-140; Yadin, et al, 1975, 16-17). In comparison to Rickman's (1971, 123-147) description of Portus similar structures, these buildings might be designed as storage. Therefore, their presence right over the breakwater suggests that ships were also embarking and disembarking from there. The western well-preserved Pompeiopolis breakwater/mole demonstrates that the seawall linked to its inner part, which was designed to form the breakwater, provided a suitable area for ships to dock (Brandon, et al., 2010, 391-392; Oniz, 2018, 2). Moreover, the 10 m long Late Roman seawall erected beside the 150 m long Hellenistic seawall on the eastern side of the Paphos basin (Leonard, et al., 1998, 146) was most likely used to call ships **(Fig. 44).**

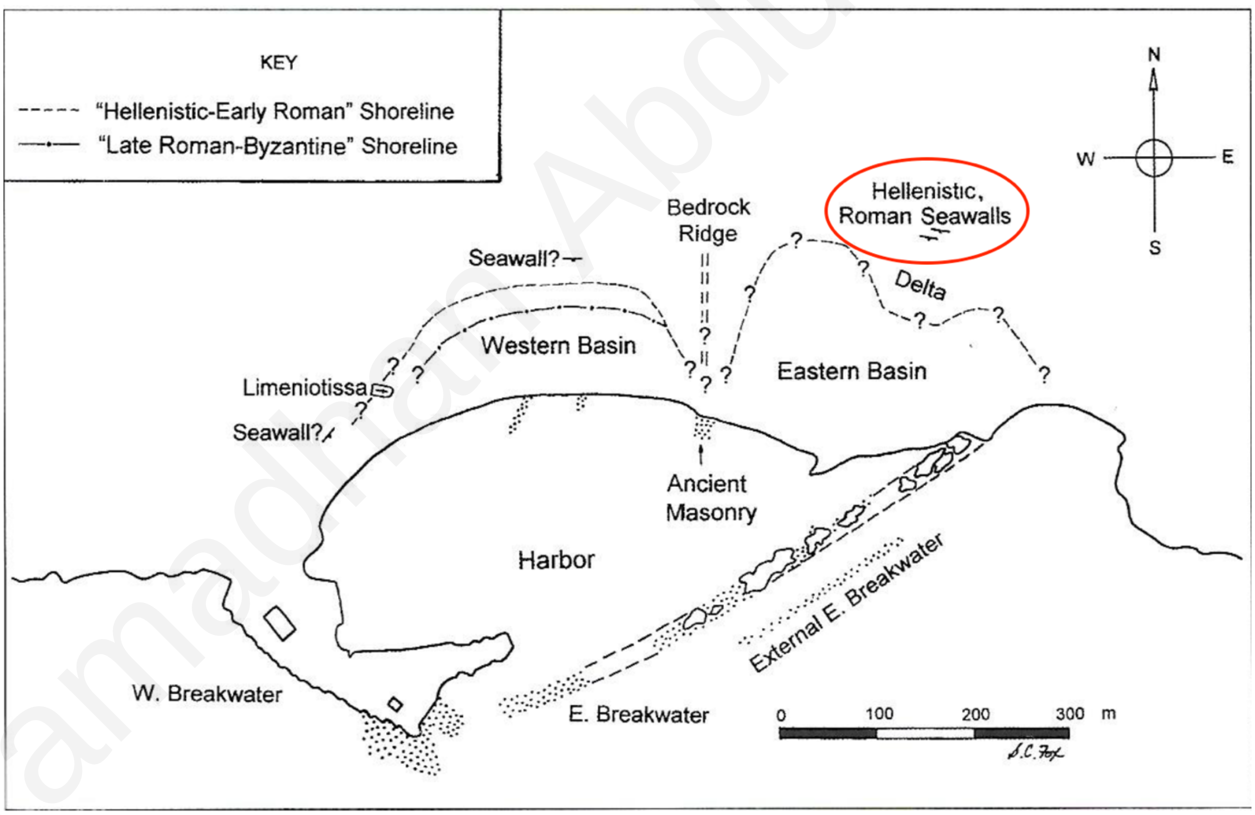


Figure. 44. *The possible Late Roman seawalls in the eastern part of Paphos port (Leonard, et al., 1998, 151).*

Another alternative for ships to dock in a port would be the use of wooden piers, although their usage is only attested in a few places (Hesnard, 1994, 209) and in highly stylized Roman frescos (Votruba, 2017, 20). Blackman (2008, 650) claims that the amount of quay increased after the Roman Empire placed piers on the port basin, as evidenced by the north and south breakwaters of Caesarea port (Oleson, et al., 1984, 291-292), and three inner harbours of Alexandria's Portus Magnus (Goddio and Darwish, 1998, 5-15; Fabre and Goddio, 2010, 59-65). Or possibly ships were loaded and unloaded by regular beaching and draft-beaching through the shallows possibly outside of the port, which was ideal for smaller ships (Rickman, 1985, 111; McCormick, 2001, 419-421; Votruba, 2017, 9 and 26).

There were other considerations that influenced the capacity of a port. For example, when the Late Roman engineers repaired and improved their port infrastructure (discussed below), it encouraged more ships to dock there, which in turn most probably increased the port's capacity. For instance, in the case of Caesarea's port, after Anastasius I (485–518) renovated its structure, attracted maritime activities and increased its capacity. This can be obviously recognized in this part of Procopius of Gaza's account: *But, thanks to your good will, the city is rejuvenated and receives ships with good courage and is full of the necessities* (Procopius Gazaeus Panegyricus in Imperatorem Anastasium, P.G. lxxxvii, Part, 3, 2817).

For comparison, **Table 6** demonstrates, as expected and as de Graauw (2022b, 18-22) concluded in his first attempt to estimate Portus Magnus capacity, that Alexandria is one of the largest in the Mediterranean Sea and most likely the largest in the Eastern Mediterranean region, with the capacity to host a large number of activities during Roman periods. After Alexandria, Caesarea appears to have the second-highest capacity, during the Late Roman period, while it was the most important pilgrimage destination and commercial center in Judea and the Eastern Mediterranean region. It is worth noting that Paphos and Caesarea are comparable in terms of capacity. The description of Caesarea and Paphos beside each other by Ammianus Marcellinus (XIV., 8, 10-11.; XIV., 8, 14-15—9, 1) may indicate that they were equivalent to each other in maritime activities in the Eastern Mediterranean as they were the main ports for Judea and Cyprus during the 4th century and onwards. Thus, Paphos was the closest Cypriot port to north Africa and Aegean Sea, therefore, sea route connectivity required such port infrastructure and capacity to facilitate trade between these economic and social centres (Leonard, 2005, 343-346; Vitas, 2010, 264).

Even though in the previous chapter Pompeiopolis was characterized as a commercial-market port more than a producer-industrial site (Yagci and Kaya, 2011, 63; Burns, 2017, 189) in contrast with Patara and Elaiussa Sebaste. It seems that it was also the largest in capacity among them. Surprisingly, Patara and Elaiussa Sebaste which were main production sites and economic centres for their territories throughout Late Romar period (Borgia and Iacomi, 2010, 1035-1049; Dündar, 2015, 204-208; Tempesta, et al, 2020, 46) were relatively smaller than Pompeiopolis. However, both harbours of Elaiussa Sebaste demonstrate larger capacity than Patara.

The management of the embarkation and disembarkation process of cargo, passengers, as well as storing goods within warehouses (Rickman, 1988, 262) could also influence the capacity of the port. As Coesentino (2021, 1) accounted, a ship before sailing from one port to another, it had to be in a suitable place to load its consignment: the essential part was the main cargo, then the secondary cargo and the belongings of the ship crew (Opdebeeck, 2005, 11). According to Rizos (2015, 290-291), the inscription on the *horrea* at Myra's port, which is quite near Patara, said that whenever products were unloaded at *horrea* or put into ships, were always measured and weighted for quality control and to ensure that the commodities arrived safely. This legislation was most likely also enacted in Patara. Nevertheless, it is probable that the storage arrangement directly on the port mole and on the adjacent areas of the port affected the management of its capacity. For instance, the remains of a wide promenade for ships and a vaulter-chambers above the southern L-shaped breakwater of Caesarea, as well as large Late Roman *horrea* complexes located on the vicinity of the inner harbour. The presence of warehouses on the moles may imply that in order to expedite the traffic of the trade, either exported goods were first stored there before being loaded into the ship's cargo or imported goods were first stored there and then transported to the large main complexes of *horrea*.

4.2. Port use and re-use.

None of the six examined ports were constructed during the Late Roman period, and it seems that not even one new port was established in the whole Eastern Mediterranean region. This raises a crucial point in this research. All studied ports were built before the 4th century. While from the 4th century onwards, the eastern Empire received the majority of maritime activities (Leidwanger, 2020, 211-212), because the western side declined (Ermatinger, 1959, 55-65; Bowman, et al., 2005, 437-487; Ward, 2005, 5-10). In addition, the construction technology and techniques were supposed to be even more advanced during Late Roman period, since they had been extensively used before. There are several plausible answers to this question. It is possible that the empire's needs might have been covered by the existed ports in the Eastern Mediterranean, although better facilities were still needed **(Table. 7).** In this regard, according to what is mentioned in the first chapter, the regional governments and elites invested to the variety of port facilities and related buildings, including industrial zones, warehouses, shops, and even churches. This relates to the socioeconomic concerns and maritime communities as well as the technological capacity and environmental circumstances of the sites. Some of these facilities were newly constructed such as the *horrea* structures located in the western of Herodian temple and others in the northern of the inner harbour of Caesarea. The industrial center at Elaiussa Sebaste, several kilns in Patara, one in Pompeiopolis and one in Paphos. Moreover, existed facilities were adapted to respond to the new needs such as the *horrea* complex in Patara the colonnaded street in Pompeiopolis and Caesarea.

Table.7. *Investment in port facilities and related buildings in the six Late Roman ports.*

Port	**Church**	**Workshop**	**Shop**	**Wearhouse**
Alexandria	2	**N/A**	**N/A**	**N\A**
Caesarea	1	**N/A**	1 street	3 *horrea*
Paphos	3	1 amphora kiln	**………….**	**………….**
Soli-Pompeopolis	1	1 amphora kiln	1 street	**………….**
Patara	3	7 kilns	1 street	One large *horrea* complex
Elaiussa Sebaste	4	6 kilns	**…………**	…………..

Religious structures had a significant role, acting as both a navigational point and a spiritual destination for pilgrims and other travellers. Their significant sizes implies that their respective ports were functioning successfully, serving the Late Roman maritime community. It appears that at all the study sites new churches were erected, except in Pompeiopolis, while so far merely a chapel has been uncovered. The octagonal church of Caesarea is considered as the largest among the study sites (Appendix 1, no 2). The construction of such a massive church was due to the position of Caesarea as the main layover of the Holy Land and possibly reflected the wealth of the city (Shalev, 2015, 235-240). In Patara (Appendix 1, no 4), the large 5th century basilica so-called Harbour church dictate the importance of the port's traffic as a station and the religious position of the city for the pilgrimage and other visitors (Peschlow, 2017, 282-284; Sahin, 2019, 332-335; Ercan, 2020, 11). At Paphos (Appendix 1, no 3), the seven aisled Ayia Kyriaki Chrysopolitissa was dominating the coast, where beside the other basilica of the city called Panayia Limeniotissa, accompanied olive oil production facilities which directly involved them with the port trade activities (Keane, 2021, 7). The size of Elaiussa Sebaste's churches were drastically small compared to abovementioned sites (Appendix 1, no 6).

Late Roman engineers maintained their port structures in the Eastern Mediterranean until at least the 6th and 7th century. For instance, the harbour of Tyre underwent substantial dredging in the 5th century (Marriner and Morhange, 2006, 164-168). In Paphos, an attempt in Late Roman period was made to construct a hard surface, above the low-lying area in the northwest of the basin, maybe to cover a swampy area. As well as, a 10 m long seawall was built in the eastern part of the harbour throughout Late Roman period, most probably to protect the basin from sea actions and accommodate ships (Leonard, et al, 1998, 146-152). The Late Roman remnants of a rectangular building connected to a circular tower directly above Patara's breakwater indicates the existence of a defensive wall that was likely constructed to protect and safeguard the inner harbour (Bruer and Kunze, 2010, 79-101; Brengel, et al., 2014, 290-294; Kocak, 2019, 79-80). Concerning Elaiussa Sebaste, while the port had two distinct harbours, throughout the Late Roman period practically all maritime activity was transferred to the southern harbour as the northern one was silted up (Tempesta, et al., 2020, 40-45). This suggests that the southern basin may have been adequate for the empire's needs, which is why the northern basin was disregarded with no attempt to repair it. In Caesarea, port repair efforts were taken more seriously. First, 68% of the excavated coins date to Late Antiquity and only 12% to earlier centuries, on one hand indicates the prosperity of port during that period and on the other hand, the gap between the periods suggests that the port seafloor was likely cleaned and scraped in the early 4th century in an effort to renovate or build the port structure (Lampinen, 1992, 169). However, there is no physical evidence of this. Later, Anastasius I (485–518) financed the renovation of the port of Caesarea extensively around the beginning of the 6th century (Hohlfelder, 1988a, 58; Patrich, 2011, 99; Oleson, et al., 1984, 294-295). In particular, Procopius of Gaza, an actual witness who visited Caesarea at the beginning of the 6th century, possibly after the earthquake of 502 CE, recorded this renovation project in his accounts. As seen in the following letter to Anastasius I (Hohlfelder, 2000, 44):

Since the port of the city named after Caesar had fallen into bad condition in the course of time and was open to every threat of the sea, and no longer in fact deserved to be classed as a port but retained from its former fortune merely the name - you did not overlook her need and her constant laments over the ships which frequently, escaping the sea, were wrecked in the harbour. Those who awaited the cargoes suffered pitifully, seeing the destruction of those things of which they were in need, and seeing it without being able to help. But, thanks to your good will, the city is rejuvenated and receives ships with good courage and is full of the necessities (Procopius Gazaeus Panegyricus in Imperatorem Anastasium, P.G. lxxxvii, Part, 3, 2817).

This account describes how the port was abandoned for a while following its devastation, but was later revitalized by Anastasius I and attracted nautical activities from the region. It also states that they had the appropriate staff and equipment to accomplish the project. In this perspective, Raban (1998, 254-255) describes how the Late Roman engineers were aware of restoration methods. For instance, the rampart technique was primarily utilized in the inner half of the buried northern breakwater, the sluice gate-channel, and the lighthouse site at the point of Caesarea's southern breakwater in order to withstand wave height and offer a conducive environment for workers to repair it. Another important aspect is that Procopius' descriptions suggest that the project was supported financially by the emperor (Levine, 1975, 17-18). Hohlfelder (1997, 374) presented additional evidence to support this claim by stating that wealthier people were invited to donate to the waterfront installation as a conspicuous representation of their civic duty in the case that government financing was insufficient. This suggests that supplying funding for religious constructions was discretionary, although it was obligatory for ports. Moreover, this indicates the inability of the State to offer enough financial support for the port's maintenance. Considering the economy of the Empires was largely focused on supporting their military demands in the Levant and the Balkans, both of which were threatened by enemies. Constructing a new port would have required a larger budget, which would have been difficult to get at the time. In addition, the Late Roman rule and the control of enemies in some territories of the Empire (which required taxes from people), as well as natural disasters, political events, and social changes, had a substantial impact on the region's economy and security.

4.3. Harbour engineering.

Another question is whether or not Late Roman harbour engineers continued to employ the building technologies and techniques of the past, or they used different methods (Hohlfelder, et al., 1983, 133-134; Oleson, 1988, 147-157). The passage of Procopius of Caesarea is the most authentic source about the skills of Late Roman engineers' in constructing ports in the Mediterranean basin: *There too be skillfully contrived a sheltered harbour which had not existed before. Finding a shore which lay open to the winds from two directions and to the beating of the waves, be converted it into a refuge for voyages in the following way. He prepared great numbers of what are called "chests" or cribs, of huge size, and threw them out for a great distance from the shore along oblique lines on either side of the harbour, and by constantly setting a layer of other chest in regular courses upon those underneath he erected two very long walls, which lay at an angle to each other on the opposite sides of the harbour, rising from their foundations deep in the water up to the surface on which the ships float. Then upon these walls he threw rough-cut stones, which are pounded by the surf and beat back the force of the waves; and even when a severe storm comes down in winter, the whole space between the walls remains cam, a single entrance being left between the breakwaters for the ships to enter the harbour* (De Aedifictis, 1.11.18-20).

Procopius witnessed the construction of two Late Roman ports on Constantinople's Bosporus. He illustrated the techniques used to build breakwaters from the beach into the open sea to produce an enclosed basin. Hohelfelder (1997, 368-375) interpreted this passage in depth. In comparison to Caesarea, where a foundation of rubble or random blocks was formed to sustain the breakwater's structure, Hohelfelder revealed that Procopius' assertion in setting boxes on the structure's foundation testifies that the engineers were aware of the fatal problems of cement structures built on a sandy or muddy sea floor. On the other hand, the fact that Procopius mentions later on his account (1.11.22) that wooden caissons were utilized in Greece's Anthedon port in the 6th century CE, demonstrates that certain building methods were still in use or advanced with the expansion of their knowledge (Belke, 2022, 223-230; de Graauw, 2022a, 6). For example, in Theodosian harbourr at Yenikapi in Constantinople, instead of usual rectangular shaped wooden caisson, a pentagonal shape was employed for its southernmost structure (Ginalis and Kydonaksi, 2021, 35). Nonetheless, Procopius does not specify whether the concrete, whose usage is inferred, was hydraulic or not. Ousterhout (1999, 133-134) argued that after the 4^{th} century, Roman engineers may have relied only on crushed potsherds, lime made from argillaceous limestone, or pulvis instead of concrete. In this regard, Gertwagen (1988, 150-151) mentioned that, despite the use of wooden caissons in the renovation of Caesarea's port, hydraulic concrete was not used; instead, the caissons were filled with non-hydraulic mortared rubble, which spilled out when the wooden caissons rotted and fell apart, causing the breakwater to collapse. In the 6th-century Justinianic port of Anthedon, the champers of its northern breakwater and southern quay were filled with a mixture of rubble, mortar, and coarse ceramic (Schlager, et al., 1968, 44-49; Ginalis, 2022, 87-89 and 97-99). Even in the 9th century, when the Muslims repaired Akko port, the caissons were filled with non-hydraulic mortared rubble (Gertwagen, 1988, 150-151). In addition, for a double-walled quay structure at Late Roman Patara, large slabs of limestone were used. Little stones were placed between the joints of the larger blocks in order to provide, as much as feasible, a horizontal sitting space for the top row of larger blocks. Although the mortar filler of the double-walled structure consists mostly of crushed stones, relatively big fragments of amorphous limestone were also utilized (Bruer and Kunze, 2010, 72-73; Dündar and Kocak, 2021, 138). Hence, it appears that hydraulic concrete was not used as the primary material in the Late Roman era. Most probably, because pozzolana was imported from Puteoli near Naples to the Eastern Mediterranean (Oleson and Branton, 1992, 57-58), and it is likely that, with the collapse of the Western Roman Empire in the 4th century, maritime connections between the Eastern and Western Empire were affected (Panella, 1993, 641-642; McCormick, 2001, 101-104). The concrete material mainly was transferred to the Eastern Mediterranean by the *annona* going from Alexandria to Rome (Hohlfelder, 1999, 158-159). After the 4th and even more in the 5th century, Rome was receiving *annona* from Africa (Erdkamp, 2016, 13-14) while the Eastern Empire was directly conetcted to Constantinople. In addition, the distance from Puteoli to the Eastern Mediterranean necessitates a lengthy trip; for instance, the distance from Puteoli to Caesarea was over 1000 nautical miles **(Fig. 45).** Such a long voyage was expensive, as was the concrete material. The estimated amount of volcanic ash necessary to build a harbour at Caesarea was the equivalent of at least 44 grain shiploads from Alexandria weighing 400 tones each (Hohlfelder, 1999, 258-259; Votruba, 2007, 327; Brandon, et al., 2014, 233-234). This suggests that establishing a port in the Eastern Mediterranean during the Late Roman period needed a lot of such trips to import enough construction materials. That is why, in Late Roman era alternative materials were employed instead of hydraulic concrete.

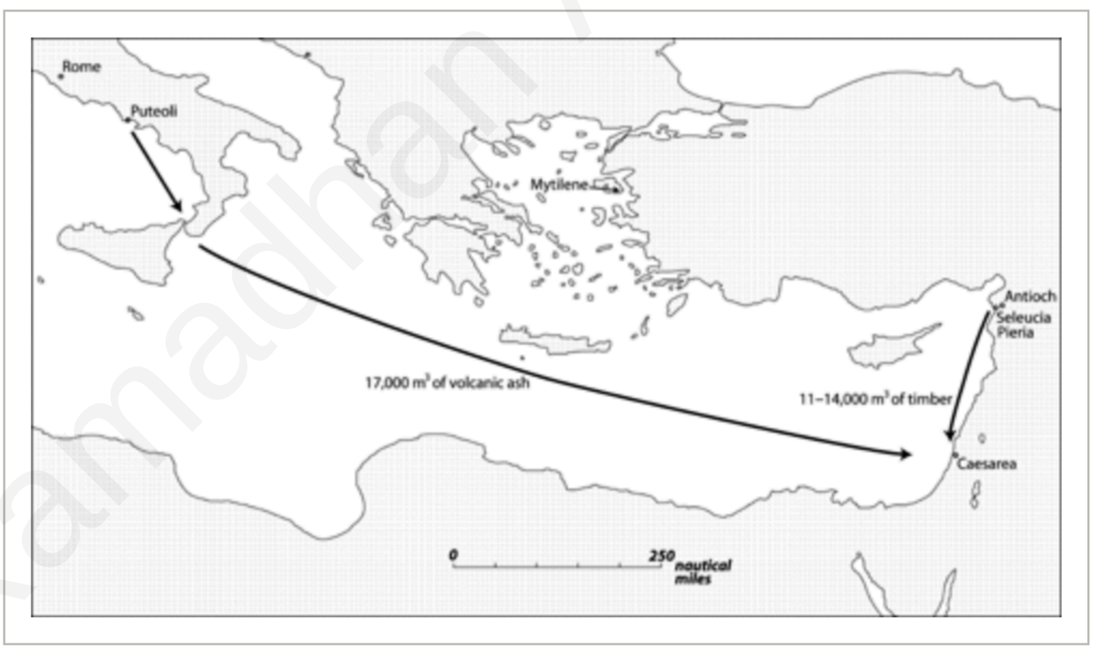


Figure. 45. *A map shows the suggested areas from where the materials for Caesarea's breakwater were acquired, from Puteoli-Naples o Caesarea* (Votruba, 2007, 327).

According to de Graauw (2022b, 178), with the development of concrete in building port structures, lighthouses were built directly on the port's breakwater and became a physical and inseparable component of its structure. Therefore, some scholars consider a lighthouse tower like a main part of the port structure, for example, in Caesarea **(Fig. 8),** (Appendix 1, no 2), Paphos **(Fig. 10),** (Appendix 1, no 3), and Pompeiopolis **(Fig. 9),** (Appendix 1, no 5). While some others, consider it to be a port facility, such as those in Alexandria **(Fig. 6),** (Appendix 1, no 1), Patara **(Fig. 7)**, (Appendix 1, no 4), and Elaiusa Sebaste **(Fig. 11, no 7),** (Appendix 1, no 6). Due to the Eastern Roman empire's precarious situation, when at war with Sassanids and Arabs (Kaegi, 2003, 256-300; Bowman, 2005, 437-487; Ward, 2005, 5-10), lighthouse towers probably functioned as a guard tower to safeguard the port and its settlement. For example, Eusebius of Caesarea's account, written in the 4th century, reflects the tower's function at Caesarea's port entrance, as a guiding and guarding towers "*From afar they raise their voices like torches, and they cry out, as from some lofty and conspicuous watchtower, admonishing us where to walk and how to direct the course of our work steadily and safely*" (Eusebius, Book I, Chapter I, 4). The terms *"Torches and watch-tower"* in his text depict the lighthouses of Caesarea and indicate their existence throughout the Late Roman period on the one hand, and its role as a monitoring tower on the other. Furthermore, when Alexandria was conquered by Muslims in the 7th century, Al-Masoudi later in his book (Mourouj Al-Dahab, 947 CE, Chapter 1, 232), accounted for the Arabs' descriptions of Alexandria at the time *"and on top of it he placed statues of copper and others … among them is a statue pointing with its hand at the sea if the enemy get close to it in a manner of one night, and if it is close and it is possible to see it by sight due to the close distance, a huge sound is heard from that statue that can be heard from two or three miles away, so the people of the city know that the enemy has approached them, and they look at it with their eyes".* This account demonstrates that the Pharos of Alexandria most likely served as a guard tower during wartime. The discovery of a Late Roman circular-shaped tower remains at the entrance of Patara's inner harbour, attached to a rectangular wall that served as a defensive barrier. It might be the second lighthouse of Patara while an inscription revealed that two lighthouses were serving navigation aids (Iskan, et al., 2008, 110). According to Kocak (2019, 74-82) and Dündar and Kocak (2021, 130-135), one objective of this tower was safeguarding. This raises a hypothesis that perhaps other lighthouses in the Eastern Mediterranean were used in Late Roman era to protect the ports and their settlements during war times.

Chapter 5: Conclusion.

The six case studies demonstrate different characteristics in their structures with some common features. The basin of a port basically consisted of breakwaters and quay walls, which are the most fundamental elements of harbourwork. Three distinct basin layouts were identified among the six study cases: a closed internal basin connected to the open sea by a long channel, an open layout enclosed by two breakwaters, and a layout of separated bays by an isthmus that provided two independent harbours.

The advent of hydraulic concrete during the Roman Empire had a significant impact on port construction techniques and designs. It enabled engineers to construct large and complex structures in the water. Concrete's toughness and longevity preserved many parts of these structures even to nowadays. The ports examined in this study, demonstrate the advanced construction techniques and technology. However, it appears that certain Roman techniques were probably kept in use during the Late Roman period, some were developed, and such hydraulic concrete probably was not used in constructing or repairing works, instead, other alternative materials were utilised. Alexandria and Caesarea's ports, as two major commercial centers in the Eastern Mediterranean region, as well as other ports, were adapted to the Empire's new economic realities with their existed structures.

Taken together, however, the materials analyzed in this study indicate that the Late Roman ports had a great capacity and waterfronts were busy with an intensive maritime traffic. The difference in capacity between these ports clarifies each port's position within the region in general and in each area in particular. Although, during Late Roman period, it appears that new ports were not constructed, the existing once were more likely capable of regional and international commerce with accommodating significant numbers of ships: the ports of Ceasarea, Paphos and Soli-Pompeiopolis, for instance, could accommodate around 513 medium size merchantmen and 402 large once. Nevertheless, it seems that during this period new facilities were constructed, or existed once were adapted to meet the demands of the maritime community. The investment in port facilities and related buildings in the Late Roman period most probably increased the port's capacity on the one hand and indicates that during this period ports operated effectively on the other.

Moreover, the discoveries of workshops for the manufacture of transport amphorae, warehouses for storing production for longer period and shops for trade in the vicinities of the ports, testify that from the 4th and 5th century onwards, Eastern Empire's economy was developed around maritime commercial activities. Therefore, these urban waterfronts with flourishing maritime activities were an essential factor for the development of their settlements into major trade centers. The construction of monumental church structures, further supports this idea. However, it does not only embody the progress of urbanization, but also reveals the importance role of religion in that time and the connection of the ecclesiastical authorities with the economic system of the province.

Appendix 1. Catalogue of the Ports.

1. Alexandria:

Short history:

The Port of Alexandria is located on the western edge of the Nile Delta on Egypt's northern shore (Goiran, et al., 2018, 1). According to Strabo (17. 1.2-4, 1. 6-8.), the founding of Alexandria began with Alexander the Great's arrival in Egypt (332-331 BC). At the time, the only suitable port in the area was on Pharos Island; to link the island to the mainland, a causeway (Heptastadium) was constructed which provided two separated harbours. It was illuminated by Alexandria's Pharos Lighthouse. Each harbour was assigned a distinct name: to the west was the harbour of Eunostos, which was used for commercial purposes, and to the east was the harbour of Magnus, that was utilized for royal activities (de Graauw, 2022b, 14). Kibtos, which means "box," was afterwards built as a third harbour (Belov, 2014, 2). Strabo (17. 1. 4-8.) identifies Alexandria as the greatest port in Egypt and maybe in the Mediterranean region. Alexandria became one of the largest commerce centres in the Eastern Mediterranean particularly and the whole Mediterranean Sea in general, within the dominion of Rome and subsequently Constantinople (after the transitional phases). Pottery takes a vital position of Roman and Late Roman archaeological enquiry, along with the rich agricultural land of the area. They affirm the maritime transportation of Alexandria from and to the Mediterranean Sea (Shaw, 2004, 419-421-432).

In the early Late Roman period, Alexandria became notable for religious strife caused by the conflict between pagan, Jewish, and Christian faiths when Christianity spread (Kaplow, 2005, 1-5; Kristensen, 2010, 158-167). The city has increasingly become a battleground for warring faiths. This situation had an impact on Alexandria, which had become gradually impoverished both financially and culturally (Mostafa, et al., 1990, 23; Shaw, 2004, 431-432; Kristensen, 2010, 158-167; Dokras, 2020, 7-8). However, Alexandria as the main port for transporting grains by Annona to Rome, in the 5th century, it was directly contacting with Constantinople (Panella, 1993, 641-642; Hohlfelder, 1999, 158-159; McCormick, 2001. 101-104). In the 7th century, Alexandria ceased to be Egypt's capital, and Fustat took its place. By the 8th century, the majority of the port structure had already been submerged (Goiran, et al., 2018, 226-229; Dokras, 2020, 2-3).

Port structure:

Basin layout: it comprised of two separated harbours within an island connected to the mainland via a central isthmus (Jondet, 1916; Goddio and Darwish, 1998, 15-51; 2014, 89-95; McKenzie, 2003, 36; Fabre and Goddio, 2010, 53-65).

Breakwaters:

Western harbour: the large breakwater, recorded by Jondet (1916, 14), is a breakwater in the northwestern harbour of Alexandria with a total length of more than 2300 m and a width of 60 to 80 m. Engineers at the period took advantage of the Abu Bakar (now El Aramil) reef to build such a large structure of limestone blocks (McKenzie, 2003, 39-41; Belov, 2014, 8-12), over two mounds 40 to 60 m apart (de Graauw, 2022b, 25).

Eastern harbour: Goddio's (1998) team discovered the eastern harbour's submerged structure, which included three internal harbours. Its western arm, whose housed Alexandria's lighthouse-Pharos, is an eastern promontory of Pharos Island, which surrounded the harbour's entrance and served as a breakwater. The eastern side is protected by Cape Lucias, a 450-meter natural extension that also served as a breakwater for the main basin, particularly the first inner harbour (Goddio, et al., 1998, 16-17; McKenzie, 2003, 36; Gkikaki and Lemi, 2014, 154). The first harbour which is known as the inner harbour was surrounded by a 250 m long jetty in its south-west side which separate it with the second harbour. A limestone block mole with 110 m length and 20 m width divided this harbour into two basins. From the other side, Cape Lochias protected these two basins. A 350-meter-long and 150-meter-wide peninsula lay between the second and third harbours, acted as a breakwater. There was a 40-meter-long and 6-meter-wide limestone jetty on the peninsula's southernmost tip. Another to the north was 50 m long and 7 m wide, with a 12 m expansion at the head. There was also a 180-meter-long and 18-meter-wide breakwater on the peninsula's northern tip with a large L-shaped breakwater stretched to the southwest at the same spot, with 90 m in length and 25 m in width. Additionally, near the southeastern extremity of the peninsula, a three-branched island lay with a length of 350 m and a width of 70 m. Along with the peninsula, they created the third and most significant harbour in the Magnus Port basin **(Fig. 34),** (Goddio, et al., 1998, 15-51; 2014, 89-95; Fabre and Goddio, 2010, 55-65).

Quay: along the submerged quays of Portus Magnus (Goddio and Darwish, 1998, 15-51; 2014, 89-95; McKenzie, 2003, 36) a considerably preserved quay with the length of 160 m was discovered at around 1.30 m depth of the entrance of the western port. It was filled with blocks and quarry stones. It is evidenced that Alexandria had more quays in both harbours, but there are not sufficient materials to be studied here (Mostafa, et al., 1990, 38).

Lighthouse: around 299 BC, Ptolemy I selected the western edge of the entrance to the Great Harbour (the eastern end of Pharos Island) for building a lighthouse, which was finished during the reign of his son Ptolemy II "Philadelphus" in 279 BC. (Jondet, 1916, 47-50; Bernand, 1966, 31-32; Goddio, 1998, 12; Strauss, 2006, 60; McKenzie, 2007, 38-41; Kassem, 2011, 276; Belov, 2014, 5; Trethewey, 2016, 2). It resists for around 1500 years (Dessandier, et al., 2008, 16). A mosaic from the church of Qasr in Libya dating to the first half of the fourth century indicates that it was still standing throughout the Late Roman era (Cowell, 2014, 86). It remained in use throughout the 7th century until its upper portion was destroyed in the early 8th century during the battle with Muslims (Abouseif, 2006, 2; Kassem, 2011, 277). This unique structure was built by Sostrates of Cnidus out of white marble or limestone to shine in the sunlight. He reinforced its construction with lead mortar to make it more resistant to the region's frequent seismic threats (Talfourd, 1903, 247-248; McKenzie, 2007, 42; Chica, 2014, 61). In the Qait Bey site, some of these materials' remnants are dispersed at sea floor (Yoyotte, 1998, 214; McKenzie, 2007, 43-44). Its bottom floor was rectangular or square, around 30 x 30 m, while its upper floor tapered down to 25 m (Jondet, 1916, 80-83; McKenzie, 2007,42). The middle as an octagonal central section was about 20 m long and 30 m in height. The fire was put in an open cupola in the top portion, which was a circular cylinder about 10 m high, and a large, mysteriously curved mirror was used to reflect the fire's light into a beam (Jondet, 1916, 80-83; McKenzie, 2007,42; Kassem, 2011, 276-277; Dokras, 2020, 11). This allowed sailors to detect a dominant fire burning from the structure's summit from up to 50 kilometres distant during the darkness of the night. There was a statue of the sea deity Poseidon or Zeus standing on the top of the last floor, towering at a height of five metres (McKenzie, 2007, 41-42; Jordan, 2014, 45).

Churches:

Two churches were discovered outside of the pagan temple that were constructed around the beginning of the 4th century CE. Sozomen mentions just the Acadia church, which is positioned at the bottom of the great staircase leading up to the Serapeum (Eccl Hist: 7.15). The second is the Martyrium, which was eventually renamed Saint John and was erected on the city's highest point near the temple, serving as a prominent beacon for mariners (Rowe and Rees, 1957, 503-504).

Port facilities:

Maritime industries: not found yet.

Shops: not found yet.

Warehouses: not found yet.

2. Caesarea:

Short history:

The remains of the remarkable settlement and submerged port of Caesarea are situated about 2 km away south of Modern Caesarea in Israel's coast of Mediterranean Sea. Caesarea was conquered by Romans in the 1st century BCE. Herod the Great, king of Judaea, around 22–10/9 BCE, built an artificial concrete port over the remains of the Hellenistic Straton's Tower (Duane, 1983, 61-65; Joseph, et al., 2004, 122-124; Brandon, 2008, 245; Patrich, 2011, 6-13). In honour of Caesar Augustus, it was named Sebastos. Hence, it functioned as the primary port and capital of the king's kingdom (Patrich, 2011, 91). Caesarea retained its status as the capital of the Roman Judea-Syria-Palestine provinces and the seat of the country's financial prosecutors at the beginning of the Late Roman Empire. Moreover, urbanisation and society progressed rapidly. As long as it maintained its position as the provincial capital of the Empire, this prosperity persisted (Patrich, 2011, 93-95-117-120; Ratzlaff, et al., 2017, 141-143). In addition to the Samaritan revolts, the prosperity of the city and its port decreased as this county was divided into smaller provinces throughout the 4th to early 5th centuries. An inscription discovered in 1993 on the northwest end of the breakwater suggested that this portion of the port's structure was already submerged by the end of the 1st century (Patrich, 2011, 92-99), and the inner harbour was also filled with sediment (Raban, 1996, 628-643). This situation seems to have persisted until the late 5th to early 6th century CE, according to Procopius of Gaza (Procopius of Gaza, Panagyr. Anast. 19, PG 87: 2817), Anastasius I 491-518 extensively renovated the port structure and revived it to maritime activities.

Notwithstanding these facts, Caesarea's port was at the time the largest concrete structure in the Mediterranean Sea. The sophisticated hydraulic concrete Roman harbour-technology enabled specialists to construct large breakwater and other structural components (Joseph, et al., 2004, 122-124; Brandon, 2008, 245). According to inscriptions dating from the third to the 7th centuries CE, the port provided a variety of work opportunities for the people and became a source of diverse incomes for the empire (Lehmann and Holum, 2000, 112–14, inscr. no. 109; Patrich, 2011, 76). The archaeological records, including as coins, inscriptions, pottery, and so on, demonstrate the city's maritime prosperity as a cosmopolitan metropolis (Patrich, 2011, 91-95). Towards the end of the Late Roman Empire, Caesarea saw a rapid fall as a result of Muslim invasion after a six-year siege in 634 CE and conquered it in 640 CE (Patrich, 2011, 158-160)

Port structure:

Basin layout: it comprised of an inner and an outer basin, surrounded by two substantial breakwaters (Hohlfelder, et al., 1983, 137-140; Oleson, et al., 1984, 286-289; Raban, 1998, 246; Strauss, 2006, 64)

Breakwaters: It had two breakwaters, the southern T-shaped breakwater with an extension of a supr and the northern breakwater stretched straight from the mainland that created a single entrance (Levine, 1975, 16; Raban, 1998, 246). The T-shaped one enclosed the main basin from south to west, around 480 metres long, its width size differs from one place to another; at its beginning, it was 40 m wide, the fallen part differs in the western fall from 60-70 m at the edge of the arc (Levine, 1975, 16-17; Hohlfelder, et al., 1983, 137-140; Oleson, et al., 1984, 286-289; Oleson, 1988, 152). Afterwards it expands significantly, reached a size of between 150 and 180 m close to the breakwater's head. Whereas the northern breakwater was smaller, about 280 m long and 60 m wide (Levine, 1975, 16-17; Hohlfelder, et al., 1983, 137-140; Oleson, 1988, 152).

Quay: Caesarea's quays were characterised by Josephus (JA) XV.) as being broad, curved, and encircling the port basin. According to the findings of the 1980–1983 C.A.H.E. P excavation season (Oleson et al., 1984, 291-292), the southern breakwater's curve is occasionally traced by a single course of regular ashlar blocks measuring 1.8 m by 0.7 m by 0.6 m. This quay's upper course looks to have been demolished or reused. It has not been confirmed that this occurred in the Late Roman period or in later times. Galili (et al., 2021, 8-10) emphasised two Roman quays in the center basin that are still in use nowadays.

Lighthouse: in order to facilitate the port's marine trade, two towers known as "twin towers" were built just above the tip of the breakwaters (Oleson, et al., 1984, 294-296; Vann, 1991, 127-139; Blackman, 2008, 644). Josephus (JA, 10.334-336; XV, 9, 6) described their position and named "Dursus" Caesar's son-in-law. A Tessera made of silver, lead and clay from the 2nd century was also uncovered, depicted the twin towers-lighthouses crowned by sculptures and dominating the port's mouth. That agreed with Josephus' description (Raban, 1998, 218-219). Roller (1998, 134) interpreted the formation of these towers as an imitation of the Alexandria lighthouse, evidence that the twin towers on Caesarea's breakwaters were proper lighthouses. According to Oleson (et al., 1984, 294), the eastern tower was 4 m long, 3 m wide, and 4 m high. If they were yoked, they may have been the same size.

Churches:

Emperor Zeno erected a large octagonal church measuring 50 x 50 m on the city's highest point. It featured a large octagonal core with a diameter of 20m and walls of around 22m. It was also surrounded by an octagonal sidewalk and covered by a large dome with an inner circle diameter of 37.50 m and walls of 39 m (Holum, et al., 1988, 188; 2004, 192-195; Shalev, 2015, 235-240).

Port facilities:

Maritime industries: not found yet.

Shops: a Late Roman street with shops on each side was located to the north of the Caesarea complex (Uzi 'Ad and Gendelman, 2018, 37).

Warehouses: In Caesarea, several types of Late Roman *horrea* were situated in different locations. A Late Roman *horrea* building with two rows of six vaulted *cellae* flanked by a large stairway stood against the western façade of Herodian temple (Rizos, 2015, 294-295). On the northern side of the inner harbour, a large complex of *horrea* was erected and due to its proximity to the port, was in direct communication with the quay (Patrich, 1996, 150-168; 1999, 73-74; Rizos, 2015, 294; Uzi 'Ad and Gendelman, 2018, 2). Moreover, the four-vaulted substructure of the procurator's praetorium which was constructed in 77/78 CE. Throughout the Late Roman era, parts of this structure were repaired and utilised for many purposes, including the conversion of vault 11 into a chapel, vault 12 into an oven, and the palace of the rulers of the new province of Palaestina Prima. Additionally, *horrea* that were most likely privately owned were located near the insulae of the opulent 6th century domus south of the praetorium. Architecturally was made up of rows of cells with subterranean silos that were well-separated from one another and renowned for being commercial (Levine, 1975, 37; Cavalier, 2007, 53-54; Rizos, 2015, 294-296).

3. Paphos:

Short history:

The port of Nea-Paphos is situated about 14 km southwest of the Palaipaphos promontory on the south-western coast of Cyprus (Leonard, 2005, 584-591; Miszk and Wadyka, 2016, 1). After the Roman Empire annexed Cyprus in 58 BC, Paphos remained one of the island's religious and political centres until the end of the Late Roman period (Mikocka, 2018, 129). Paphos obtained a significance position in the area as one of the main ports on Cyprus (Leonard, et al., 1998, 142; Coesentino, 2013; Miszk and Wadyka, 2016; Iacovou, 2019, 204). Paphos's history was marred by earthquakes. A major earthquake ruined Paphos and its harbour in the 4th century CE. Thus, information about the ensuing years is scarce, however, Late Roman finds uncovered in the harbour zone might indicate that the port was functioning properly which means the port was repaired after the devastation (Maier and Karageorghis, 1984, 250–251; Leonard, et al., 1998, 142-143; Marangou, 2002, 246-249; Leonard, 2005, 587-588: Mikocka, 2018, 120-130).

The construction of large churches (Maier and Karageorghis, 1984, 192-194; Barker, 2016, 147) and an amphora production kiln (Demesticha and Michaelides, 1994, 290-291; Demesticha, 2003, 470-471) supports the idea that the port and the city recovered during the Late Roman period. The lawyer and historian of the Christian Church Sozomen (Ecclesiastical History (Book V), Chapter 10) noted the port of Paphos when describing the voyage of St. Hilarion from Gaza to Paphos. This statement indicates that its harbour was still in function, probably until Arab raids in the 7th century. Eventually, siltation has entirely diminished it.

Port structure:

Basin layout: it was enclosed by two breakwaters/moles (Hohlfelder and Leonard, 1994, 51; Leonard, et al., 1998, 146-147; Wladyka, 2019, 52)

Breakwaters: The port's eastern breakwater was proposed to be 400 m long and 5 to 10 m wide (Daszewski, 1981, 174). After the discovery of a mound of submerged debris on the western end of the entrance, it added roughly 94 m in length and 18 m in breadth to the breakwater, which totaled nearly 600 m in length. The western breakwater was 210 m long, with a further 50 to 70 m spur, making it 270 to 280 m long and 20 to 25 m wide. Nowadays it has been covered by the later structures (Daszewski, 1981, 331; 1987, 174 n. 39; Hohlfelder and Leonard, 1994, 51-59; 1995, 197-199).

Quay: the traces of a structure were uncovered on the bedrock ridge that divided the enclosed basin into two smaller bays. It has been suggested that it was a Late Roman quay structure (Leonard, et al., 1998, 145-156).

Lighthouse: the remains of a colonnaded structure were located in the port's eastern breakwater and are thought to belong to a lighthouse structure (Hohlfelder, 1995, 200; Vitas, 2010, 273-276).

Churches:

The large basilica of Ayia Kyriaki Chrysopolitissa is located near the theatre in the eastern part of the harbour. The materials from the ruin of the theatre were re-employed in its construction. It was a seven-aisled structure 38 m wide and 53 m long. In the sixth century, bishop Sergio decreased the number of aisles from seven to five. A three-aisled basilica with a semicircular apse, named Panayia Limeniotissa, which translates to "Our Lady of the Port," was constructed a short distance north of the port, dominating the cityscape as seen from the sea. It was the residence of the bishops of Paphos from the late 4th to the 7th centuries (Athanasios and Papantoniou, 2017, 273; Kyriakou, 2019, 50-52; Maier and Karageorghis, 1984, 192-194; Barker, 2016, 147). In addition, a third church was built between these two churches, where the "Saranda Kolones" castle is located (Hayes, 2003, 449).

Port facilities:

Maritime industries: an amphora workshop was located at Kato-Paphos near to the Hellenistic and Roman cemetery, 300 metres east of the city's ancient walls. Due to the construction of a modern hotel directly above the site, only a kiln that produced LRA 1 and possibly LRA 13 on a smaller scale (Demesticha and Michaelides, 1994, 290-291; Demesticha, 2003, 470-474).

Shops: not found yet.

Wearhouse: not found yet.

4. Patara:

Short history:

Patara was one of the biggest and most secure ports on the coast of ancient Lycia in southern Anatolian coast (Dündar, 2013, 142; Peschlow, 2017, 280). Apollo, according to Strabo (14.2.29), founded Patara in 278/277 BCE. as a major port city with an official harbour that fostered nautical operations. Patara was occupied by the Lycians, an Anatolian civilization, until 43 CE, when the Romans conquered it and made it the administrative hub of the area, left their imprint on this thriving port (Ozturk, 2020, 8; Reitzenstein, 2016, 53-55). Due to the significance of this city, Romans embellished it with magnificent and exquisite public buildings. Its imperial lighthouses (Iskan, et al., 2008, 91-100) and Hadrian's enormous granary (Cavalier, 2007, 57; Rizos, 2015, 288-290), in addition to production centres (Dündar, 2015, 204-208), indicate that the port maintained an important strategic position on the sea routes during late antiquity, particularly in the Eastern Mediterranean region (Foss, 1994, 14-15). Moreover, the development of local and international commerce through its port contributed to the city's thriving economy, while its government contributed to urbanism via the construction of new churches and monasteries (Foss, 1994, 1-2; Peschlow, 2017, 282-284; Sahin, 2019, 332-335; Ercan, 2020, 11). Thereupon, the settlement flanked the hill towards the south and west directions (Peschlow, 2017, 280-281).

In addition, in Late Antiquity the Eastern Empire's borders were threatened. The discovery of Late Roman-era defensive buildings atop Patara's inner harbour breakwater indicates that the harbour was fortified to protect the city. Especially, the erection of a tower-shaped structure that likely served as a guard tower reinforces this idea (Kocak, 2019, 74-82). Eventually, In the late 14th century CE, the harbour was abandoned due to silt accumulation carried by the Xanthos River (about 5 km west of the port's bay) and turned into a marsh. Due to the decline of the harbour, the settlement was also abandoned about the middle of the 15th century (Dündar and Kocak, 2021, 127-128).

Port structure:

<u>Basin layout:</u> Patara possessed a complex closed layout design, with a long inner access canal connecting the central harbour basin to the open sea. A breakwater enclosed the central harbour,

which stretched from the basin's western edge and leaned towards the east (Dündar and Kocak, 2021, 128-130).

Breakwater: the measurements of Patara's breakwater have not been published yet. In this study, GIS is used to measure the breakwater which appears to have around 77 m in length (Kocak, 2019, 74-82; Dündar and Kocak, 2021, 130-135).

Quay: a Late Roman quay wall approximately 40 m northeast of the edge of the promontory was uncovered by Bruer and Kunze (2010, 72). It is preserved in a space of 7,5 m in length, 2,4 m in width, and 2 m in height (Dündar and Kocak, 2021, 138).

Lighthouse: during the reign of Emperor Nero (54–68 CE), the Patara lighthouse known as Torino was constructed in 64–65 CE (Iskan, et al., 2008, 91-94-111). Iskan I, the director of Patara's Excavation, is now working on the replica of this lighthouse. The rock that served as its foundation is made up of a 27 m square podium (Kocak, 2019, 73). The harbour was seen from this podium's eastern side. A round-shaped tower with two interlocking cylinder components holding an elevated stairway above the podium. A third cylinder, 6 m in diameter, was formed of double shells of slightly curved blocks. A second compact cylinder with a diameter of 1.2 m was raised in the centre of the lighthouse. (Iskan, et al., 2008, 92).

Churches:

Four churches were constructed in the city during the Late Roman period. The earliest church, known as Grave, or Cemetery and Spring church, was situated on the ancient road that leads from the south to the city, between Tepecik in the west and the slope of Günlük Tepe in the east. The second is 30 m long and 15 m broad, and was located on Doucasar Hill in the city's east. A large basilica, 60 m long and 40 m broad, was also built outside the city wall in the 5th century. It was considered the city's most important church and was dedicated to Saint. Nicholas. The fourth church, called Harbour Church, was located on the western slope of Tepecik Hill, flanked the harbour bay (Peschlow, 2017, 282-284; Sahin, 332-335; Ercan, 2020, 11).

Port facilities:

Maritime industries: during the Late Roman era, seven circular or oval-shaped kilns with domed fire chambers were built. The ruins of five of them, known as the "Keramaikos" of Patara and dating from the third to sixth centuries, located in the northeast corner of the city, between the Cemetery Church and the Günlük rock-cut tomb. They are built in U-shapes with stone walls on three sides measuring 21 x 12 m. Another kiln at the Harbour Bath's palaestra specialised in amphorae and other big pots. A kiln, distinct from the one described above, may be found south of the city at the Tepecik Necropolis, built of stone and with its fire chamber dug straight into the bedrock (however at the end of the 4th century it was converted into a bothros). Together with the kilns, a ceramic manufacturing facility was constructed on the northern slope of the Tepecik Acropolis between the 5th and 7th centuries (Dündar, 2015, 204-208).

Shops: a colonnaded street connected the Agora in front of the Bouloutrion to the inner harbour, where the remains of stores are still standing (Burns, 2017, 1-2; Ercan, 2018, 81; Lavan, 2020, 34-40).

Wearhouse: a large rectangular complex 70 m long and 27 m wide from south to north located west of the city's southern point. It was composed of eight juxtapositions of rectangular *horrea* of similar size and height of roughly 8 m. There were, however, no signs of a floor. These *horrea* are joined together by a 1.3 m wide and a 2 m wide and 8 m high door on its eastern long side, which goes into each of the eight rooms (Cavalier, 2007, 53-54; Kocak, 2019, 76).

5. Soli – Pompeiopolis:

Short history:

Soli-Pompeiopolis was an ancient Anatolian port city on Anatolia's southern coast, with the remains of its harbour and settlement located 11 kilometres west of Mersin modern city. During the Graeco-Roman period, its strategic location on the Cilician plain between Cilicia Pedias and Cilicia Tracheae assisted its role as a regional commercial and military centre (Novak, et al., 2017, 155; Novak and Rutishauser, 2017, 134-140). Pompeiopolis was established by Achaeans and Rhodians from Lindos, according to Strabo (14.5.8). The fact that Chrysippos, the Stoic philosopher, Philemon, the comic poet, and Aratos, the composer of the Phainomena in poetry, all resided in the city attests to the city's significance at the time. When Pompey, the Roman general of Asia Minor, arrived in the city in 68 BC, the city thrived. He named it Pompeiopolis and used the harbour as a base for his navy to fight the Cilician pirates (Morrell, 2017, 57-95). The Roman Emperor Antoninus Pius visited to the city in the middle of the second century CE and provided financial sin order to build a distinctive artificial concrete structure for the port. This became a significant source for the development of the city and income for the inhabitants. The discovery of an imperial coin collection at the location, which is inscribed with harbour figures and maritime activities from the reign of Antoninus Pius 143–145 AD, shows proof that the Pompiopolis harbour served the empire effectively after it was built and imposed as a significant landmark for the region (Boyce, 1958, 67-72). The importance of its port is also noted in the Stadiasmus Maris Magni periplus (165-171-311), which was written in Greek in the second half of the third century CE: *when a straight line with a slight south-eastern wind is followed, there's a distance of 500 stadia from the Pyramos River to Soloi, 150 stadia from Zephyrion*. In addition, the port's commercial activity was facilitated by the large colonnaded street that surrounded it, especially during the Late Roman era when the empire's emphasis was concentrated on the Eastern Mediterranean area (Yagci and Kaya, 2011, 63; Burns, 2017, 189; Yagci and Yigitpasa, 2017, 114-118). A mosaic with fish figures, seashells, and various sizes of bronze fishing rods on the southern end of the western portico of the street, facing the harbour denotes the presence of a fisherman's store (Yildirim, 2017, 78). The government supported religious activities in the majority of the eastern towns of the Roman Empire, and in the late Roman period, Pompeiopolis became a Christian bishopric. Eventually, the harbour became unusable due to the invasion of alluvium and sand carried by the Lyparis Stream. After, the city's destruction by a powerful earthquake in 527 CE, it was abandoned, then, the city and the harbour lost some of its significance (Oniz, 2018, 1), up until the arrival of Muslim forces in 904 CE (Brandon, et al., 2010, 390-191).

Port structure:

Basin layout: it consisted of two parallel breakwaters with bent ends, provides an entrance to the inner basin (Oleson, 1988, 147-155; 2004, 219; Brandon, et al., 2010, 393).

Breakwaters: Its two identical breakwaters were roughly 320 m in length and 23 m in width and were spaced 180 m apart. Despite the fact that just 160 m of the western breakwater remain, it is much better preserved than the eastern one. Vann (1994, 530-531) had difficulty deciding its measurements; just 140 m of its length were documented and the rest has disappeared. Both arms' landward halves are covered with silt and sand. The eastern arm's seaward side is more damaged than the western one. This is due to the fact that the western arm was erected on a reef, which supported it, but the eastern arm was constructed on sand and likely could not withstand the ocean environment (Brandon, et al., 2010, 391; Oniz, 2018, 2).

Quay: not found yet.

Lighthouse: The lighthouse was built on the western end of the breakwater. It is only depicted on a coin of Antoninus Pius' reign, which lasted from 138 to 161 CE. Aside for this piece of information, there isn't much more known about it (Boyce, 1958, 68; Vann, 1994, 530).

Churches:

Only a chapel is detected (Yagci and Kaya, 2011, 103-105).

Port facilities:

Maritime industries: One kiln is detected (Autret, 2010, 203-206; Yagci and Kaya, 2011, 64).

Shops: a colonnaded commercial-market street, 450 m long and 14.50 m wide, flanked Pompeopolis' main road and led to the harbour (Yagci and Kaya, 2011, 63; Burns, 2017, 189; Yagci and Yigitpasa 2017, 114-118). It had 200 columns and served as a connection between the city's northern entrance and the harbour's basin. Numerous businesses, such as the litrina shops on the east portico of the street, displayed renovation evidence on their flooring and functional adjustments (perhaps after the earthquake of 525 CE). Nonetheless, the use of lead pipes for the water system, as opposed to terracotta pipes in the past, paints a vivid picture of the Late Roman contribution to the city and the significant position of the market for harbour traffic (Boyce, 1958, 67-76; Yagci, 2010, 71; 2016, 512-513; Yagci and Kaya, 2011, 63).

Warehouses: not detected.

6. Elaiussa Sebaste:

Short history:

Elaiussa Sebaste's or Elaeousa Sebaste's ruin is situated in the ancient Cilicia region, roughly 55 kilometres from Mersin province on Anatolia's southern shore (Borgia, 2021, 1). The word of Elaiussa (Ελαιούσα), was derived from the Greek term (Elaion - ἔλαιον), which means oil, because its hinterland is a rich agricultural area, particularly for olive trees. Therefore, the inhabitants had a history of manufacturing olive oil, which was the driving factor behind the economic activity of its harbour (Schneider, 2008). Elaiussa was founded between the end of the 2nd and the beginning of the 1st centuries BC on a little island connected to the mainland by a small isthmus in the Mediterranean Sea. It is now nearly completely submerged under the sand (Melis, et al., 2015, 566-572; Tempesta, et al., 2020, 39). Strabo (14.5.6.) and Josephus (JA, 16.4.6), both stated that during Archelaus' reign, Elaiussa was annexed to the Cappadocia region (36 BC – 17 CE). He moved his seat to the settlement and named it "Sebaste" in honour of the emperor. Sebaste was passing through difficulties at the time due to the pirate attacks in the area. Archelaus moved there to eliminate them and control the area's coastline (Panichi, 2005, 202-208), which was of relevant importance to the Empire's control of the Eastern Mediterranean Sea.

Christianity had an important role in the Ealiussa throughout the Late Roman Empire and became a religious centre in the area. From the sixth century forward, the empire contributed to religious structures, mainly churches (Gough, 1954, 54-59; Schneider, 1999, 43-47). It may also be seen in various coinages that portray religious symbols, such as a cross (Schneider, 1999, 319-325). The Agora zone on Elaiussa's mainland was known as the momentous quarter, and it was assigned for religious activities during the 5th and 6th centuries (Schneider, 2008, 17). The port's location inside two independent harbours, northern and southern basins, afforded it a significant presence in the district's maritime route network, connected it to other Cilician coastal cities and agricultural interior villages, as well as other ports in the Mediterranean region (Tempesta, et al., 2020, 39-42). The discovery of an industrial zone with amphora manufacture, for example, suggests that it was a significant Roman maritime city in the region for exporting wine and olive oil (Polosa, 2008, 167-17; Borgia et al., 2010, 1035-1049; Tempesta et al., 2020, 46). Nevertheless, throughout the Late Roman Empire, its northern port silted up and marine activities were relocated to the southern basin. Therefore, it maintained its position until the end of the Late Roman Empire, when in the 2nd half of the 7th century, Arab invasion commenced in the area and earthquakes caused its final abandonment (Melis, et al., 2015, 566; Borgia, 2017, 296-298; 2021, 1).

Port structure:

Basin layout: it comprised of two separated harbours within an island connected to the mainland via a central isthmus (Schneider, 1999; 2003; 2008; Tempesta, et al., 2020, 40-45).

Breakwaters:

Southern harbour: on the northern bank of the southern harbour, the remains of a trapezoidal-shaped breakwater made of limestone, mortar, and concrete were discovered. Tempesta (et al., 2020, 42) suggested that there may be a second breakwater around the harbor's basin. There is currently no more information available on these breakwaters.

Northern harbour: on the southern side of the port's entrance, along its isthmus, the remnants of a 4th century CE breakwater were discovered. GIS is employed to determine its size, which seems about 24 m long and 17 m wide (Pipere, 2019, 386-389; Tempesta, et al., 2020, 40-45).

Quay: Tempesta (et al., 2020, 40-45) suggested that its breakwater served as a quay.

Lighthouse: The lighthouse or guide tower, as previously estimated, was located on the north-western tip of the promontory (Tempesta, et al., 2020, 43-44). A similar structure was uncovered near the end of the eastern breakwater of the northern harbour, although it has not yet been excavated (Polosa, 2019, 174).

Churches:

Four churches were built in the city during Late Roman times. One was 11.35 x 7.30 m and was situated at the southeast end of the pagan temple, which was on at the southernmost tip of a low headland facing the harbour (Gough, 1954, 54-59). A basilica situated on the east side of the island right on the steep rocky outcrop. It was 8.55 m wide, but the remnants of the priest's pew and a chamber make the church 20.50 m broad in total. On the southernmost edge of the island was a 7.30-m-high apse of a second basilica's fragmented building. In addition, on the highest point of the island, the third basilica was directed to the northeast next to a thermal bath that dates back to the 5th century (Hild and Hellenkemper, 1986, 69-71).

Port facilities:

Maritime industries: A production complex consisted of six kilns built on the southern terrace of the industrial area, between this region and the Byzantine palace, as well as close to the south-western necropolis and the mouth of Kuru Paşa Deresi. They are made up of two rows of eight mud brick pillars (Ferrazzoli and Ricci, 2009, 37; Borgia et al., 2010, 1035-1049; Ebolese et al., 2018, 326; Tempesta et al., 2020, 46). The complex also comprised artisan facilities, raw material storage, and a clay settling pool in addition to these kilns (Ferrazzoli and Ricci, 2009, 37; Ebolese, et al., 2018, 326).

Shops: not found yet.

Warehouses: not found yet.

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