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## **Ships and harbours of the Hellenistic and Roman Mediterranean: a new approach**

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### **Abstract**

Harbours have been some of the most important centres of trade and exchange, as well as of interaction between different people and cultures. They are, nevertheless, primarily built to accommodate and serve ships, an aspect rather poorly examined by scholarship and research. This paper will present a new approach on the study of the harbours of the Hellenistic and Roman Mediterranean based on the examination of their configuration vis-à-vis their capacity to accommodate certain numbers and types of ships. This approach aims in introducing a new methodology that can be applied in further sites and time periods.

### **Key words**

*Hellenistic and Roman Harbours; Mediterranean; Aegean sea; Delos ships; draft; capacity; anchoring; beaching; docking.*

## **Preface**

This paper is based on the author's on-going PhD study at the University of Birmingham under the title "The construction, use and evolution of late Hellenistic and Roman harbours of the Aegean". The author would like to thank his supervisors, Henry Chapman, Gareth Sears and Mantha Zarmakoupi for their feedback, support and help in the development and progress of this study.

## **Introduction**

Ancient harbours are amongst the most important and intriguing anthropogenic structures. And this is mainly due to their key role as centres of commercial and cultural exchanges and human interaction, especially during eras of intensified sea trade like the Hellenistic and Roman period and in geographical areas where the sea played a major role in every aspect of human life like the Mediterranean. Harbours have a complex nature that unifies a series of functions: they operate as gateways to hinterland, nodal points in commercial networks and monumental maritime facades of cities and states, as well as autonomous spaces and distinct settlements that serve the people related with the sea in a variety of ways (Delano Smith 1979: 327; Karmon 1985; Rickman 1985; Rogers 2013; Bouras 2016; Reger 2016: 14).

But whatever their role is, harbours are built, organised and operated under a very specific principle: to sufficiently shelter and serve ships and their cargoes, as well as crews and passengers. And this is a principle essentially connecting the world of harbours with that of ships and seamanship and defining their role within contemporary commercial networks. As we will see this aspect of harbour operation has not yet been sufficiently explored in scholarship and there is great potential in a new approach that connects harbours with the number, type and tonnage of the ships they had to accommodate, as well as the cargoes these ships carried and the role they played to the harbours' development.

## **Hellenistic and Roman Harbours of the Mediterranean: an overview**

There are few other periods in the history of Europe that can be considered more dynamic than the Hellenistic and Roman one (Rostovtzeff 1941: v; Grant 1990: ix). This period was marked by significant developments, especially in the economic sector (Archibald 2005: 1), which peaked thanks to the gradual unification of the Mediterranean world that started under Alexander the Great and was completed with the Roman Empire. This unification made mobility and exchange some of the major characteristic of the period (Paterson 1998: 150; Wilson 2011: 39; Temin 2013: 2); especially during

the Roman Imperial years, the sheer volume of trade, often served by new, larger and technologically improved ship types, grew to unprecedented levels (Casson 1974: 121-2). This intensification of sea trade naturally brought new demands on contemporary harbours. These had to serve a rising number and growing tonnage of ships, as well as an equally high amount of commercial activities and larger populations (Casson 1971: 366-7; Oleson and Hohlfelder 2011: 814-6). Many were hence transformed into “models of really clever and efficient planning and artistic creations of a high order, beautifully laid out and adorned with imposing buildings and decorative sculptures” (Rostovtzeff 1941: 1042). A new important technology also appeared in harbour construction, with the introduction of the use of hydraulic concrete by the Romans, which were to succeed (but not entirely replace) the older, “Greek” technique of ashlar construction on rubble foundations (Casson 1971: 367-8; Oleson 1988: 148; Rickman 1996: 285). The harbours of the period were thus some of the most dynamic, busy and important centres of commerce and seamanship, as well as “*facades maritimes*” and gateways of cities, states and regions (Horden and Purcell 2000: 392) and this makes their study extremely important.

### **A methodological gap**

For more than a century, ancient harbours have been approached and studied in various ways and literature on them amounts an impressive number of studies (for general overviews of the relative scholarship see Blackman 1982: 85-90 and Oleson and Hohlfelder 2011: 810). More recent studies have contributed greatly to the knowledge of ancient Mediterranean harbours, especially of the Hellenistic and Roman period, developing various new methodologies and approaches: these included the meticulous examination of commercial networks and of the seminal role harbours played in them, both in the wider area of the Mediterranean (Wilson et al. 2013; Preiser-Kapeller and Daim 2015) as well as in more specific regions (Bouras 2008; 2016; Schörle 2011; Leidwanger 2013). The complex relationship of harbours with their urban or rural hinterlands has been studied too, especially in well-researched sites like Ostia/Portus (Brandt 2005; Boetto 2010; Keay 2013; Boetto 2016) and Delos (Karvonis 2008; Karvonis and Malmay 2009; 2012; Zarmakoupi 2013; 2018). Finally, interdisciplinary approaches combining archaeological and geophysical research were employed in sites like Portus, Miletus and Ephesus (Keay et al. 2014; Brückner et al. 2014; Delile et al. 2015), successfully recreating the original environment of harbours and their evolution.

Despite the importance of all these studies, the relationship between ships, cargoes and harbours in a more explicitly functional, “down-to-earth” way has been largely neglected, with few exceptions: Johannès Pâris in his pioneering study on the harbours of Delos (1916) tried to consider the capacity of these harbours to accommodate a certain number of ships, but he lacked accurate and sufficient data

on both the harbour's configuration as well as on the ships of the period; a similar effort was made by Alexandros Papageorgiou-Venetas in his 1981 study of the urban environment of Hellenistic and Roman Delos, but he also did not consider bathymetric and ship draft data adequately. Giulia Boetto was the only scholar who properly introduced ship typology and size/tonnage into her discussion over the operation of Roman Portus and Ostia (2010; 2016). By taking advantage of the improved knowledge on ancient ship configuration and operation she proposed a division of the two harbours and their river and canal network into specific zones different types of ships could use and where different kinds of cargoes could be handled. Boetto's thorough approach showed the potential of studying harbour vis-à-vis ships by combining data from both fields. The scholar, however, did not include bathymetric data in her calculations, nor did she consider the possibility of alternative methods of using harbours beyond docking and many questions were left unanswered. A more inclusive and more quantitative methodology is thus necessary for the proper understanding of the complex relationship of harbours with ships.

### **Ships and harbours: a complicated relationship**

The first step towards understanding the relationship between ships and harbours is the thorough examination of the ships that would have used these harbours during a given time period, in our case the Hellenistic and Roman one. The typology of the ships of this period (this mostly refers to merchantmen, which are most likely to use commercial harbours and survive in the archaeological archive better than galleys) has been extensively studied and discussed in a series of publications (Casson 1971: 171-2; Parker 1992: 89; Jurišić 2000; Boetto 2010: T.1; Nantet 2016), largely based on direct information from shipwreck finds (Figure 1). Thanks to this data substantial evidence have been accumulated on issues such as size and draft, which are very important for the navigation and handling of ships within harbours (Boetto 2010: 121, T.1; Nantet 2016: T.47). The basic typology of ships of the period, including their tonnage, size and draft, is seen in Table 1.

Several important points relevant to the relationship between harbours and ships have appeared through the study of the ships of the period: ships were quite variable both in terms of size and tonnage, as well as cargo, and no specific, "average" type of merchantman seems to have ever existed. Despite a general tendency for ships to become larger towards the end of the Roman Republican Period (e.g. the "myriophoroi" 10,000-amphorae carriers of the early-1<sup>st</sup> century BCE; Wallinga 1964: 3-5; Wilson 2011: 39) what becomes evident through the scrutiny of the evidence is that these, along with other merchantmen of great tonnage (even up to 1,200 tons like the *Isis* "mega-freighter" described by Lucian in the 2<sup>nd</sup> century CE; Casson 1971: 186-8; Houston 1987) operated side-by-side with a

multitude of smaller ships, supplementing each other and serving different trade networks (Tchernia 2011: 87-8; Nantet 2016: 122-3). To these ships one should add the large number of small-capacity lighters, service boats, tugboats and ferries that operated in an around every harbour of the period, especially the one related with canal networks and rivers like Alexandria and Portus (Casson 1965; Khalil 2010; Boetto 2010). Despite, however, the number of smaller ships operating in ancient harbours, their size, tonnage, as well as draft were small and had a limited impact on the configuration and operation of harbours; they could either use shallower areas and beaches or their cargo value was small and would not require any substantial investments in the configuration of the harbours they frequented.

Another important aspect of the seamanship and the ships of the period is the ability to deploy alternative methods of using harbours beyond docking. **Although a common practice today, docking in antiquity appears to have been a much less popular choice for mariners.** Before the introduction of the hydraulic concrete by the Romans in the second half of the 1<sup>st</sup> century BCE (Brandon et al. 2014: 233-5) most docks and other harbour works were erected on rubble foundations (Rickman 1996; Blackman 2008, 643-7; Wilson 2011: 46-7). Ships of greater tonnage could not approach such structures due to the inclination of the foundation. Wooden piers would have solved the problem, but they appear to have been scarce, as their use is documented in very few sites (Marseille; Hesnard 1994: 209) and in highly stylised Roman frescoes (Votruba 2017: Fig.8), whereas they are totally absent from written sources. Nevertheless, even when the hydraulic concrete was introduced, this did not affect the configuration of every harbour in the Mediterranean, since its application was costly (its basic material, the pozzolana pumice, was imported from Campania) and technically complex. Thus many areas remained untouched from this new technology (Brandon et al. 2014: 233-4, Fig.3.2; Nakas 2019). The merchantmen of the period were, however, well outfitted and quite advanced and could employ alternative methods easily. Anchoring in the open and using lighters and beaching were the main ones, practices widely employed also by vernacular ships in recent years and even today (Houston 1988: 560-1; Votruba 2017: Figs.5 -6). **Anchoring was commonly employed throughout the Greco-Roman world,** as seen through written evidence, whereas ships carried enough anchors of various kinds and sizes (Votruba 2014); **regular beaching and draft-beaching** on the other hand was ideal for smaller vessels, lighters and light galleys (Votruba 2017: 26), but more complicated for larger ships, especially when loaded. The common **use of lifeboats as tugboats and lighters,** sounding leads and multiple sails of various types and sizes (the *artemon* foresail had become a usual feature in ships by the 1<sup>st</sup> century CE; Arnaud 2011: 152) would have allowed ships to approach and use harbours easily, and, more importantly, adapt to any harbour and coastal environment they would encounter during their travels,

equipped with harbour works or not (Casson 1971: 248-9; Whitewright 2011: 8; Wilson 2011: 45-6; Nakas 2019).

The second step for the implementation of this new approach to harbour studies concerns the in-depth scrutiny of harbours themselves. And this aims basically in the recreation of the original form harbours had during the period studied. The geological changes and mainly the steady rise of the sea level in the Mediterranean, but also local subsidence, uplift, siltation, earthquakes as well as recent interventions are what have basically given Mediterranean harbours the image they have today (usually submerged; Marriner and Morhange 2007). The implications emerging from this study concern the variability of harbour spaces and the difficulty in establishing their original size and, mostly, depth, a feature that greatly influences their ability to accommodate ships. Thorough geophysical research is required for the most accurate and inclusive recreation of ancient harbour environment. Geophysical data is not, however, available in all sites, whereas others, due to their dynamic character, are ever-changing and various scenarios can be suggested concerning their original configuration.

Having created a reliable reconstruction of the harbour researched we can import the data on ships collected in order to check out the capacity of the harbour, as well as the possible methods that could be employed for its use by mariners and reach some useful and solid conclusions. This will be demonstrated below in the case study harbour of Delos.

### **The case study of Delos**

Delos was the port-of-trade *par excellence* of the Hellenistic and early Roman Mediterranean (Lawall 2005: 214). The city developed from a small settlement around the sanctuary into one of the main centres of retail trade and seamanship and witnessed a unique and unprecedented urban development from the early 3<sup>rd</sup> century BCE and until its destruction and decline in 88/67 BCE (Hatzfeld 1919, 34, 36; Green 1990, 384-5; Rauh 1993). The significance of Delos as a religious, cultural and commercial centre triggered the beginning of large-scale excavations (since 1872) and other studies (for a general overview of the scholarship on ancient Delos see Bruneau and Ducat 2005 and Zarmakoupi 2015), which have also included the geomorphology and archaeology of the local harbours (Pâris 1916; Duchêne et al. 2001; Zarmakoupi and Athanasoula 2018). These studies have offered adequate data to allow for a satisfactory reconstruction of the ancient city and its harbours.

Delos is located at the centre of the Aegean, with the Cyclades “dancing” around the sacred island of Apollo, according to Callimachus’ description (*Del.*300-1; Constantacopoulou 2007: 25-6), conveniently situated on the main sea routes crossing the archipelago (Pâris 1916: 7; Bouras 2016:

216-8, Fig.1). It is an arid, small, elongated island with no substantial natural harbours, despite the fragmentation of its coasts, which are generally rocky, apart from the centre of its western shore where a series of sandy beaches is to be found (Figure 2). Natural siltation is minimal and apart from the regular sea-level rise (2-2.5 m since the late Hellenistic period; Desruelles et al. 2004; Dalongeville et al. 2007) the coastal landscape has not been heavily disturbed by other natural factors (Hejl et al. 2002: 54-5). Large parts of the Main Harbour have unfortunately been covered by excavation debris and the modern jetty that serves the island today (Zarmakoupi and Athanasoula 2018: 93).

Lacking a big natural harbour or anchorage, Delos was served by a series of smaller ones dispersed along its coasts (Figure 2). The Main Harbour (often referred to as the “Sacred Harbour”, although the term is not attested in any ancient source) was located at the centre of the island’s western coast (Figure 3); it gave direct access to the sanctuary as well as to two of the main markets of the island (the agora of the Competaliasts to the south and the agora of Theophrastos to the north) and was protected from the prevailing northern and north-western winds by the impressive rubble “Great Mole” (the whole structure measures c. 200 x 100 m). The ancient harbour was relatively small (1,500-2,000 m<sup>2</sup>), very shallow (maximum 1-2 m) and heavily affected by siltation from the sea, since the mole created a vortex phenomenon, which recycled both sea as well as land sediments, greatly contributing to its transformation into a sea-side swamp (Desruelles et al. 2007: Fig.5). No dredging was documented in antiquity, but even if this had occurred it would have made little difference since the crystalline basement rock is to be found just underneath the surface sediments (Desruelles and Hasenohr 2018: 42). Towards the south the Merchant Harbour stretched for nearly 600 metres along the shallow, sandy coast, up to the Asklepieion peninsula (Figure 4). The whole harbour covered an area of approximately 7,000 m<sup>2</sup>. The beach opened to a series of warehouses or shops, lined up on the shore, along with a narrow stone-paved quay (Malmay & Karvonis 2016: 176). Although no harbour works were erected there, the area was protected from the prevailing northern winds by the “Great Mole”, as well as the two Rematiaris islets. Its small depth along the sandy coast also depleted waves thanks to the refraction principle (Beresford 2013: 31-3). To the north of the Main Harbour the Skardanas bay was also used as a harbour, as the semi-submerged remains of a quay and a commercial building indicate (Duchêne et al. 2001: Pl.LVIII-LXIII, Plans VII-VIII; Zarmakoupi & Athanasoula 2017). The harbour was relatively small (1,000 m<sup>2</sup>) and much deeper than the other ones (Figure 5); it was, nevertheless, exposed to the winds and currents, facing west/northwest, unprotected by any natural or human-made feature. Finally the island’s east coast, that was generally rocky and exposed and inhabited only at the area of the stadium, was served by the harbour of Gournas. This accommodated ships coming from the east (Zarmakoupi 2018: 37), and operated also as the local harbour of the Stadium District (Figure 6).



The harbour was deep but totally unprotected and a unique feature was the construction of an ashlar quay along the shore (Zarmakoupi and Athanasoula 2018: 98, Fig.10).

Considering the original form of the harbours of Delos and relating it with the size and draft of contemporary ships we can reach the following conclusions considering the harbours' capacity and operation. The Main Harbour had no capacity whatsoever to accommodate any ship with a draft of more than 1 m, and that not close to its shores, which were even shallower (Figures 3 and 7). Although theoretically there would have been enough space for more than 100 small and very small capacity ships, it is highly unlikely that anything above 50 such ships could be accommodated there, leaving enough space for movement and anchoring. These ships would have also been unable to dock on the quays at the harbour's southern part, since these were ashlar structures built on dry land and a strip of sand or rubble divided them from the sea (Figure 7). The Merchant Harbour, had an improved capacity, thanks to its size and depth, but could still not accommodate any ships of large capacity (Figures 4 and 8). It is estimated that 20 ships of medium, 40 ships of small and at least 100 ships of very small capacity could use the harbour. As in the Main Harbour, no actual docks existed there, quays being actually retaining walls supporting a narrow paved road separated from the sea by a wide beach (Malmay and Karvonis 2016: Fig.5). The Merchant Harbour did, however, open to a wider area, conventionally called Southern Anchorage, located to the south of the Great Rematiaris islet, a deep and relatively protected area, that has been used as an anchorage in recent years and is still used today by sailing ships (Figure 2; Gallois 1910: Figs.26, 28-31, 38). The anchorage covered an area of approximately 23,000 m<sup>2</sup>, offering plenty of space and depth for the accommodation and movement of ships of every capacity: it is estimated that at least 38 ships of great, 85 ships of medium, 130 ships of small and about 500 ships of very small capacity could use the area. Skardanas was a small but rather deep bay, allowing for the simultaneous accommodation of 2-3 ships of great, 10 ships of medium, 10 ships of small and 20 ships of very small capacity (Figure 9). As in the Main and Merchant Harbours no remains of any actual docks have been preserved at Skardanas bay and it is highly probable that it had a similar configuration with the Merchant Harbour, with quays separated by a beach at its middle. Finally Gournas was a rather deep harbour and was equipped with what appears to have been a 50 m-long ashlar dock, founded in rather deep water (5-7 m) that allowed the docking of ships of large capacity too (Figure 10; Papageorgiou-Venetis 1981: Fig.85; Zarmakoupi and Athanasoula 2018: Fig.1). It is estimated that 4 ships of great, 6 ships of medium, 10 ships of small and 12 ships of very small capacity could use the harbour.

What becomes evident from the examination of the capacity of the Delian harbours, as well as the implications of the movement and accommodation of various ships is **the inability of any ship to dock**

on any harbour structure of the island, with the possible exception of the Gournas small dock (wooden piers in Delos are not documented in written sources or archaeological finds). Harbour works were in general surprisingly poor for such an important harbour city, limited to the “Great Mole”, the Gournas quay and the line of quays/retaining walls along the waterfront, which, however, could not function as proper docks. Furthermore, the Main Harbour, as well as large part of the Merchant Harbour was practically inapproachable by ships of medium and large capacity, which would have to use Skardanas and Gournas, which were the least protected areas for anchoring or the Southern Anchorage. Although the later was relatively well protected by the Great Rematiaris islet, it still remained exposed to any abrupt change of wind, something not at all uncommon in the Aegean (Arnaud 2005: 16-23).

Beaching would have been easy on the long, sandy beaches of the island’s western coast, but that would have mostly considered ships of very small capacity and galleys, since larger ships would have to be empty of their cargoes and would require substantial manpower and supports to be hauled on land. Draft beaching could have been a solution, but the draft of medium and large capacity ships, when loaded (Table 1), would have prevented porters from approaching them, due to the depth of the water. The operation of a shipyard, a slipway and a capstan, attested by inscriptions on the island during the 3<sup>rd</sup> century BCE (Homolle 1882: 67; Vélissaropoulos 1980: 215) confirm the importance of the practice but most likely refer to ship maintenance and not to a general practice for the accommodation of large numbers of ships.

It appears that the best solution for ships visiting the busy island would have been to cast their anchors in the open and use lighters for the loading/unloading of merchandise. Despite the dangers such a practice entails, mainly the possibility of ships losing their cables, drifting and crushing on the shores, it was a rather convenient method for using the local harbours. It allowed great numbers of ships of all types to visit the island without entering enclosed basins, where movement would have been difficult and affected by siltation, as it happened in the Main Harbour. The operation of multiple harbours around the island and in a short distance to each other also allowed ships to use each according to their provenance, the climatic conditions, lack of space or according to the urban district they had to serve (Zarmakoupi 2018: 37-8). Such use of the harbours of Delos was directly related to the commercial operation of the whole city. Notwithstanding the volume of commercial traffic handled in the busy harbour city during the Late Hellenistic period, the city operated predominantly as a retail centre: relatively small parts of cargoes (especially of bulk victuals) were actually transported on the island, which could cover large part of its needs through local production and imports from nearby islands (Reger 1994: 99-101). It is thus not surprising that the storage infrastructure of the city was equally limited as its harbour works (Duchêne 1993: 125; Zarmakoupi 2013: §7). This operation of the island

as an *entrepôt* from which trade was administered and cargoes transhipped or diverted would perfectly agree with the lack of substantial infrastructure and the employment of **short-term anchoring of merchantmen around it.**

The study of the harbours of Hellenistic Delos through the eyes of the mariners who used them, paints a complex and very interesting picture: as the city grew rapidly thanks to its commercial development, Delians took advantage of every single bay, beach and anchorage to facilitate sea traffic (Zarmakoupi 2018: 36-8). Little was, however, invested into any harbour works, that being protective moles and quays or dredging operations. **The “Great Mole” of the Main Harbour was rather unnecessary, since the harbour was very shallow and was most likely connected with the protection of ceremonial galleys** that would have used the harbour regularly (Figure 7; the demarcated “galley cove” operated there, as indicated by a boundary stone inscription; Dûchene et al. 2001: 153-4). The harbours of Delos were, quite like the unfortified, “boundless” city itself, open to the outer sea and ships could easily move around them, taking advantage of any favourable condition and making good use of space. The nature of these largely exposed harbours, must have forced merchantmen to lie at anchor and use lighters. Despite the potential dangers of this method, it kept ships away from the hazards of the rocky or sandy shores and allowed them to move easily around the island and leave without much trouble when their cargoes were sold. The development of Delos into “the common market of Greece” (Paus.8.33.2), a thriving retail centre and a unique cosmopolitan city, proves that the harbours, despite their “simplicity” adequately fulfilled their role and contemporary mariners had all the skill and equipment to use them with safety.

## **Conclusions**

Approaching ancient harbours through their relationship with the ships they were built to shelter and serve provides new and very useful data on their operation and development. More importantly, this data is strictly measurable and accurate and can create compound scenarios on the operation of harbours in connection to ships and cargoes. As seen the in case study of Delos, the employment of this method shows the ingenuity and resourcefulness of the mariners of the period, as well as the complexity of contemporary harbours, which did not always have to be deep, large and equipped with substantial harbour works to fulfil their role on the one hand as ship havens and on the other as commercial centres. By applying this approach to more harbours of the period, but also of other periods and regions, can be a very useful tool for the better understanding of harbours and their role in the development of contemporary economy, trade and seamanship.

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## Tables

Categories	Name/shipwreck	Capacity (t)	Length (m)	Beam (m)	Height from keel to deck (m)	Draft (m)	Area covered (m <sup>2</sup> )
<b>Exceptionally large cargo ships</b>	<i>'Syracosa'</i> <i>'Isis'</i>	1,200-1,700	53	14	7	4.5	742 m <sup>2</sup>
<b>Large cargo ships (myriophoroi)</b> 10,000 amphorae 50,000 <i>modii</i> 350-500 tons	<i>Madrague de Giens</i> <i>Albenga</i>	350-390	40	9-12	4.5	3.5-4	280-600 m <sup>2</sup>
<b>Large capacity</b> 5,000 amphorae 150-350 tons	<i>Antikythera</i> <i>Punta del Francese</i> <i>Antirhodos</i> <i>Saint-Tropez</i> <i>Mahdia</i> <i>Spargi</i> <i>Marzamemi</i> <i>Torre Sgarrata I</i>	170-350	21-40	8-14	3.5-5	2-4	
<b>Medium capacity</b> 3,000 amphorae 20,000 <i>modii</i> 75-150 tons	<i>Bourse de</i> <i>Titan</i> <i>Marseille</i> <i>Pisa A</i> <i>Kizilburun</i> <i>St. Gervais 3</i> <i>Porto Nuovo</i>	80-150	15-30	4-9	2-3	1.5-2	125-270 m <sup>2</sup>
<b>Small capacity</b> 1,000 amphorae 10,000 <i>modii</i> 15-75 tons	<i>Apollonia</i> <i>Ladispoli</i> <i>Ashkelon Roman</i> <i>Laurons 2</i> <i>Carry-le-Rouet</i> <i>Margarina</i> <i>Cavalière</i> <i>Marseillan Beauséjour</i> <i>Chretienne C</i> <i>Meloria C</i> <i>Conque de Salins</i> <i>Miladou</i> <i>Diano Marina</i> <i>Naples A</i> <i>Dramont A &amp; I</i> <i>Ouest Giraglia 2</i> <i>Fiumicino 1 &amp; 2</i> <i>Pisa (Hellenistic ship)</i> <i>Grado I</i> <i>Planier III</i> <i>Grand Congloué B</i> <i>Port-Vendres I</i> <i>Grand Ribaud D</i> <i>Serçe Limanı</i> <i>Izmetište</i> <i>Tre Senghe</i> <i>Kyrenia</i> <i>La Giraglia</i>	20-80	12-24	3.3-6	1-2.5	1.5-2.5	70-175 m <sup>2</sup>
<b>Very small capacity</b> (less than 15 tons)	<i>Herculaneum</i> <i>Ostia, Isola Sacra I</i> <i>Kinneret</i> <i>Pisa B, C &amp; F</i> <i>Naples B &amp; C</i> <i>Toulon 1 &amp; 2</i>	4-10	6.3-13	2-5	0.4-0.8	0.5-1.2	16-63 m <sup>2</sup>

Table 1: A comparative table of the dimensions and tonnage of various ships of the Hellenistic and Roman period of the Mediterranean, based on shipwreck finds and written evidence.

## Figures

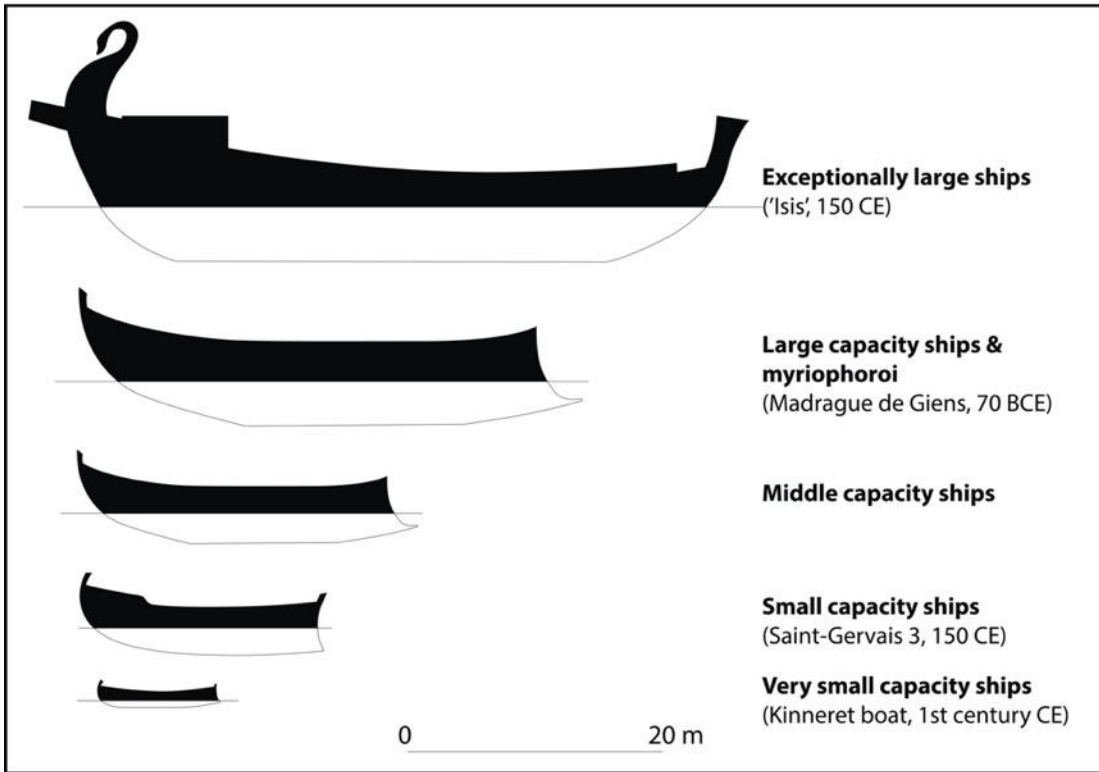


Figure 1. Comparative profiles of various Mediterranean ships of the Hellenistic and Roman period (drawing by the author).

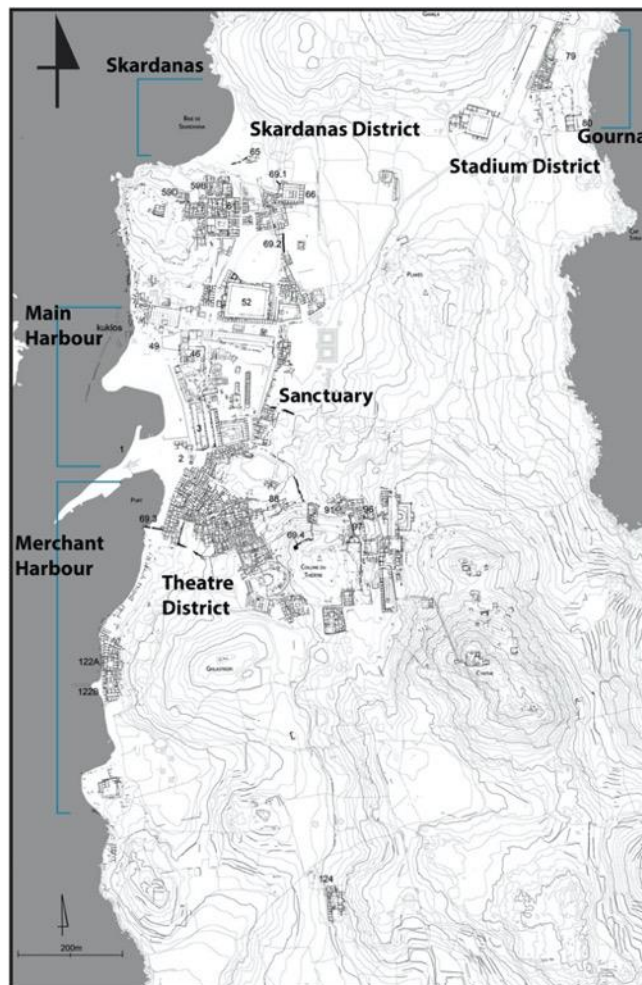
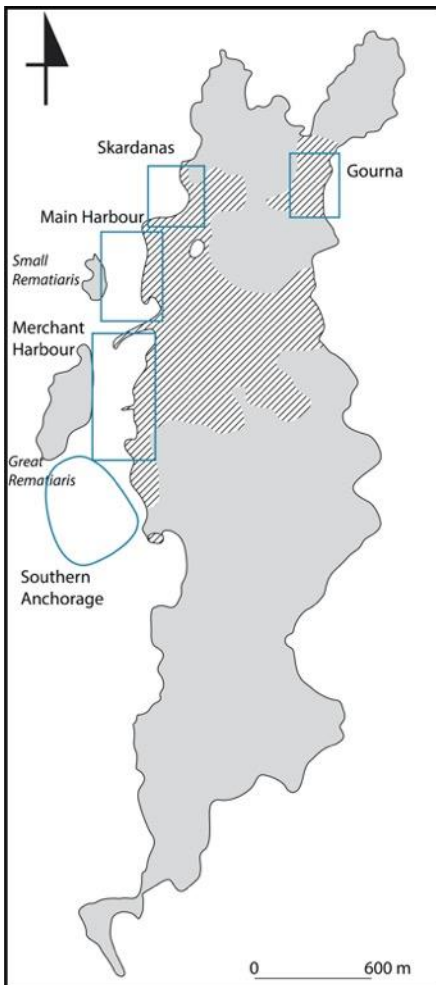


Figure 2. Left: general plan of Delos with the various harbours and anchorages of the island indicated. Right: plan of the ancient city of Delos with various harbours and sites mentioned in the text indicated (drawings by the author; for the plan on the right the map published by Moretti et al. 2015: Pl.5 has been used).

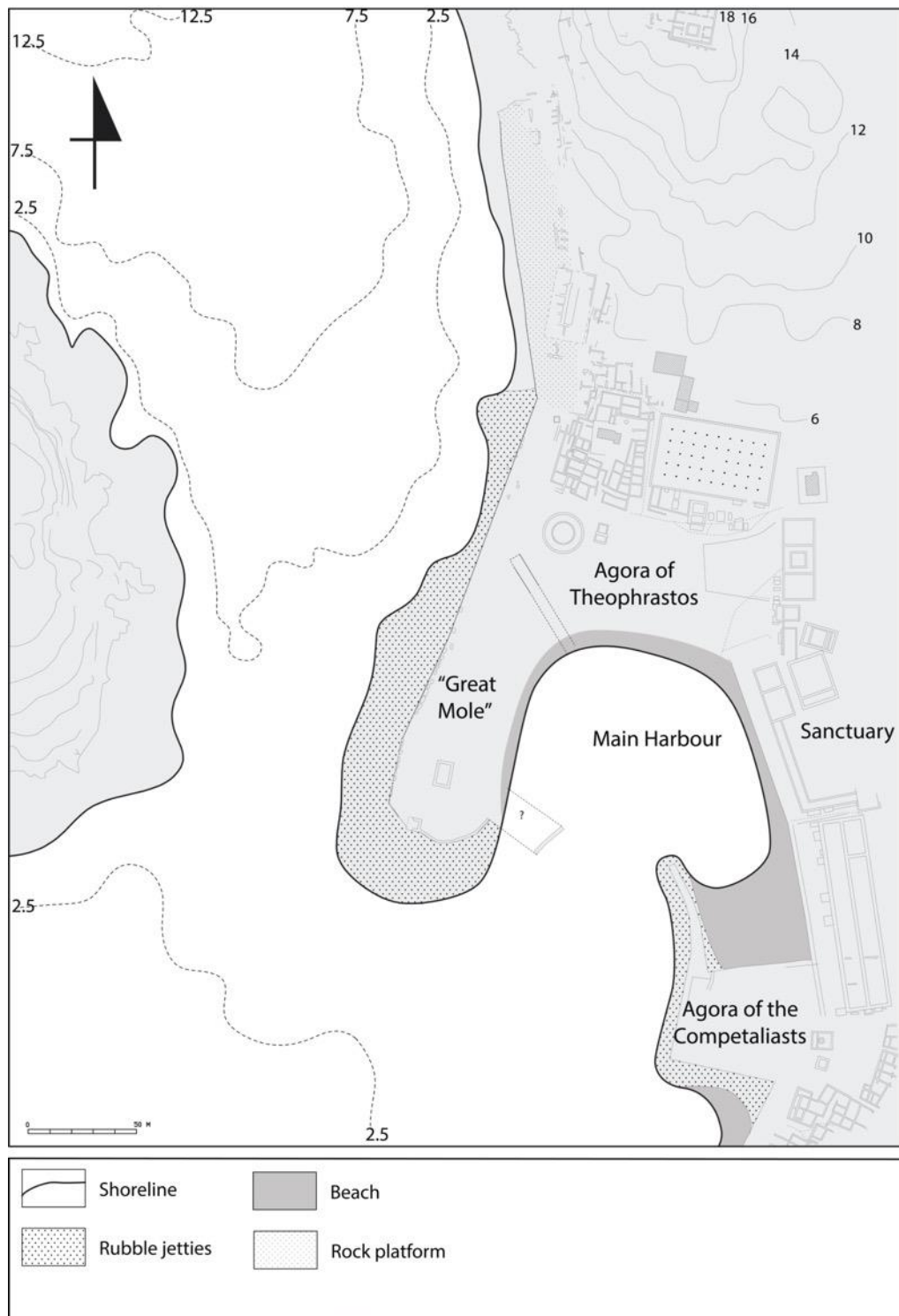


Figure 3. Delos' Main Harbour as it would have been during the late Hellenistic Period (drawing by the author; bathymetry is based on the plans published by Pâris 1916: Pl.1-IV; the ancient remains on the coast are based on Moretti et al. 2015: Fig.5 and on the survey by Dardinier, published in Duchêne et al. 2001: Doc.I-VIII).



Figure 4. Delos' Merchant Harbour as it would have been during the late Hellenistic Period (drawing by the author; bathymetry is based on the plans published by Pâris 1916: Pl.1-IV; the ancient remains on the coast are based on Moretti et al. 2015: Fig.5).

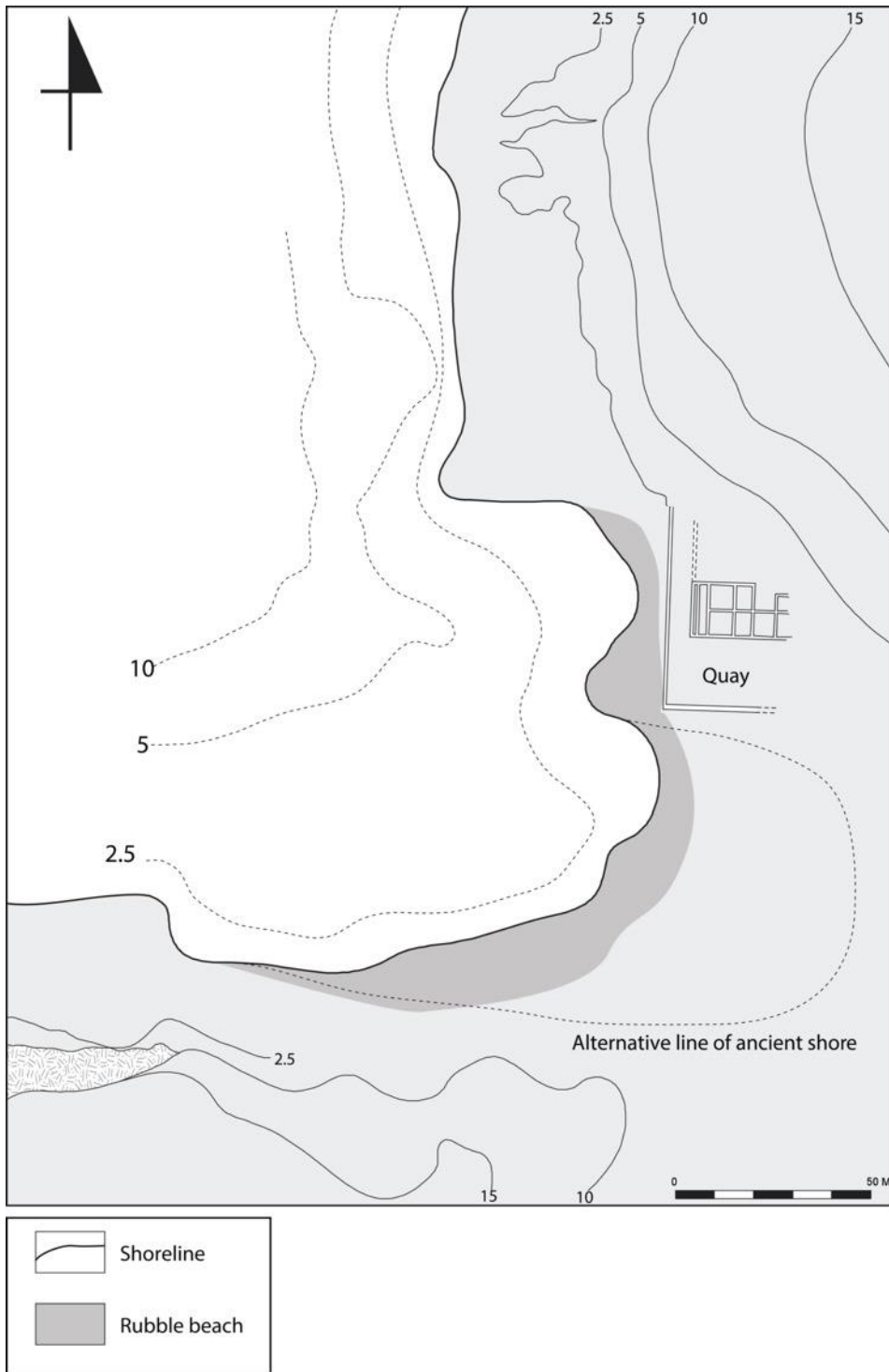


Figure 5. Delos' Skardanas harbour as it would have been during the late Hellenistic Period (drawing by the author based on the plans published by Papageorgiou-Venetas 1981: Fig.84 and by Duchêne et al. 2001: Plans VII-VIII).

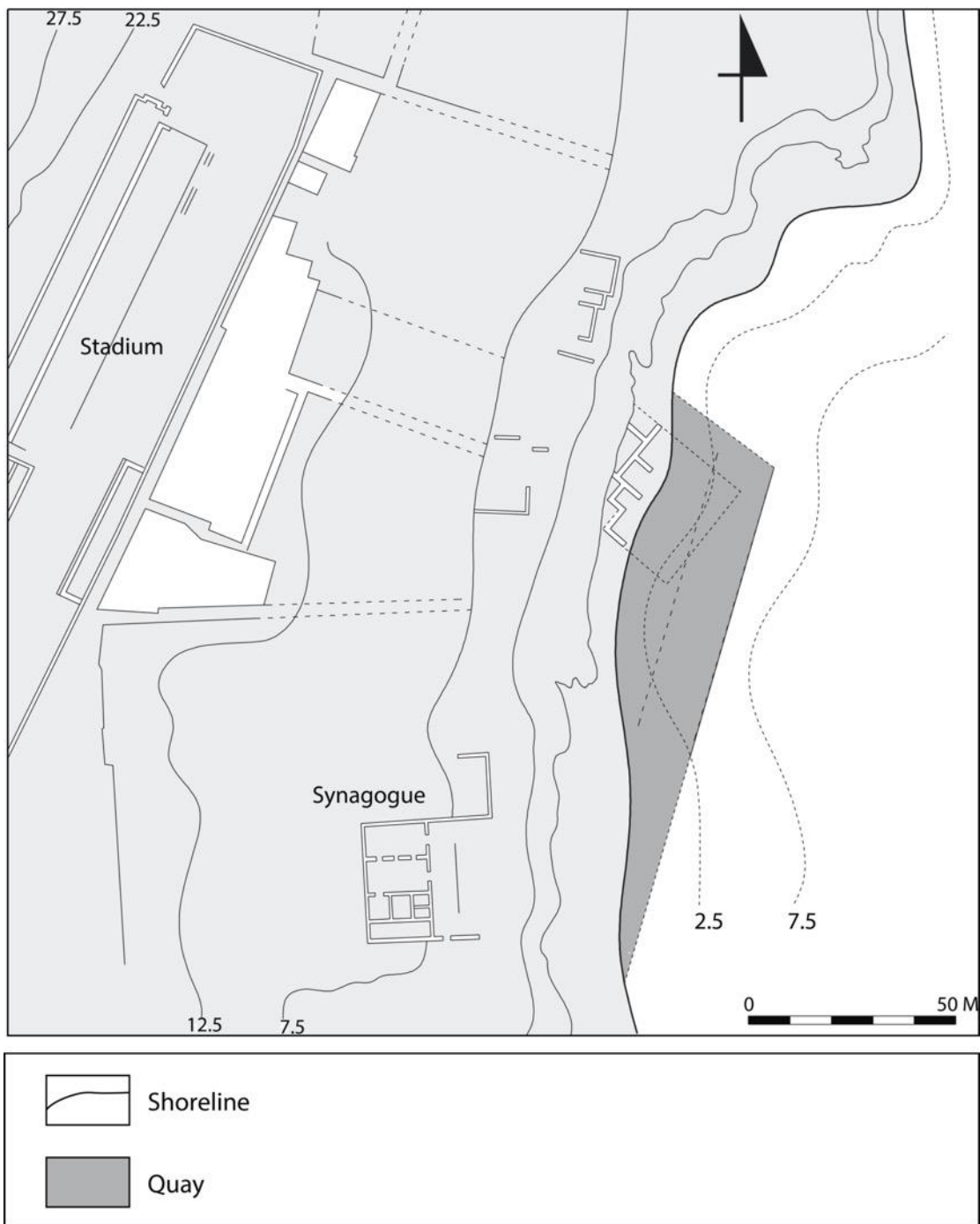


Figure 6. Delos' Gourná harbour as it would have been during the late Hellenistic Period (drawing by the author based on the plans published by Papageorgiou-Venetas 1981: Fig.85 and by Zarmakoupi 2015: Fig.132).

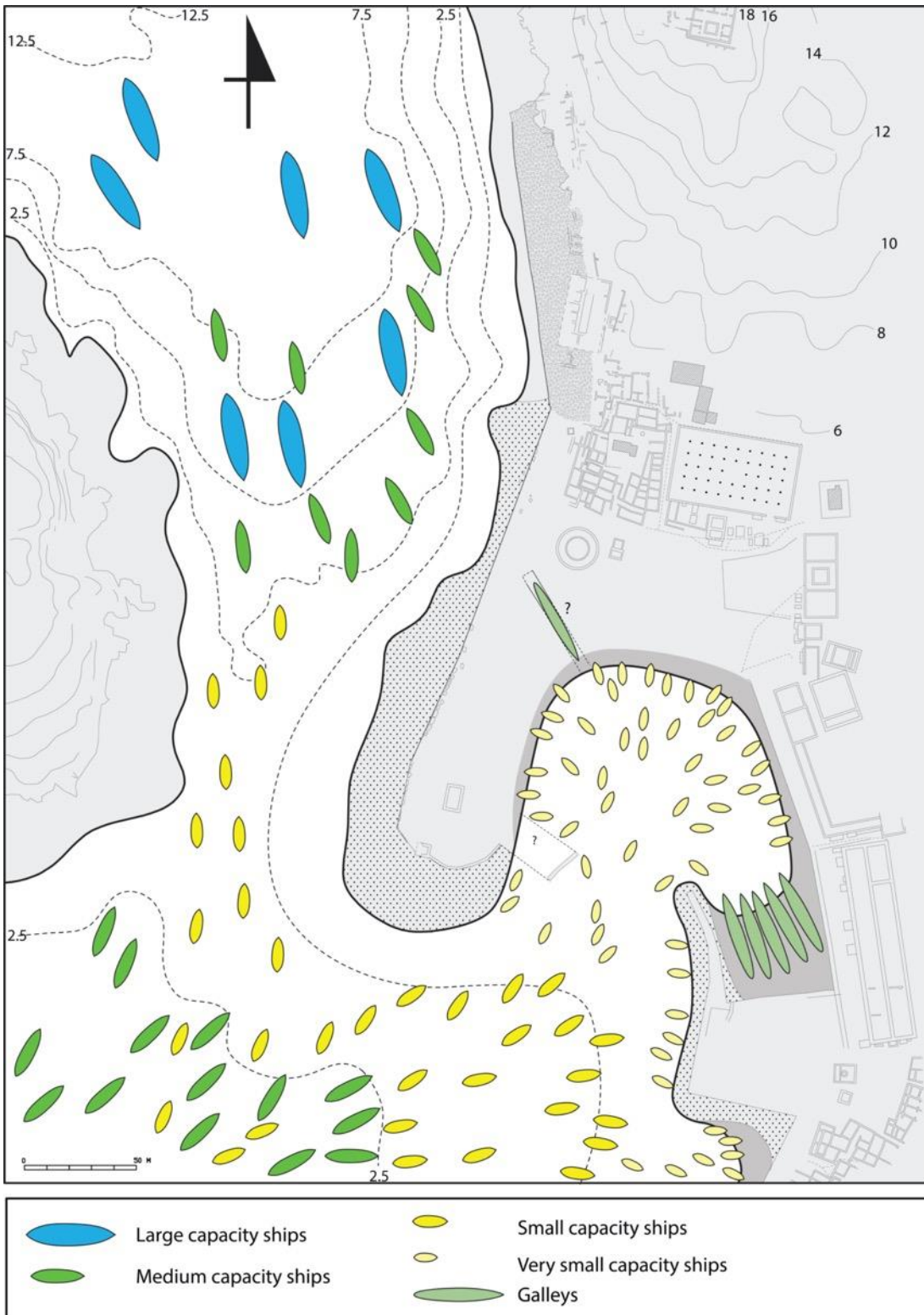


Figure 7. Reconstruction of the use of Delos' Main Harbour according to the draft (left) and the estimated number (right) of ships and the harbour's depth (drawing by the author).

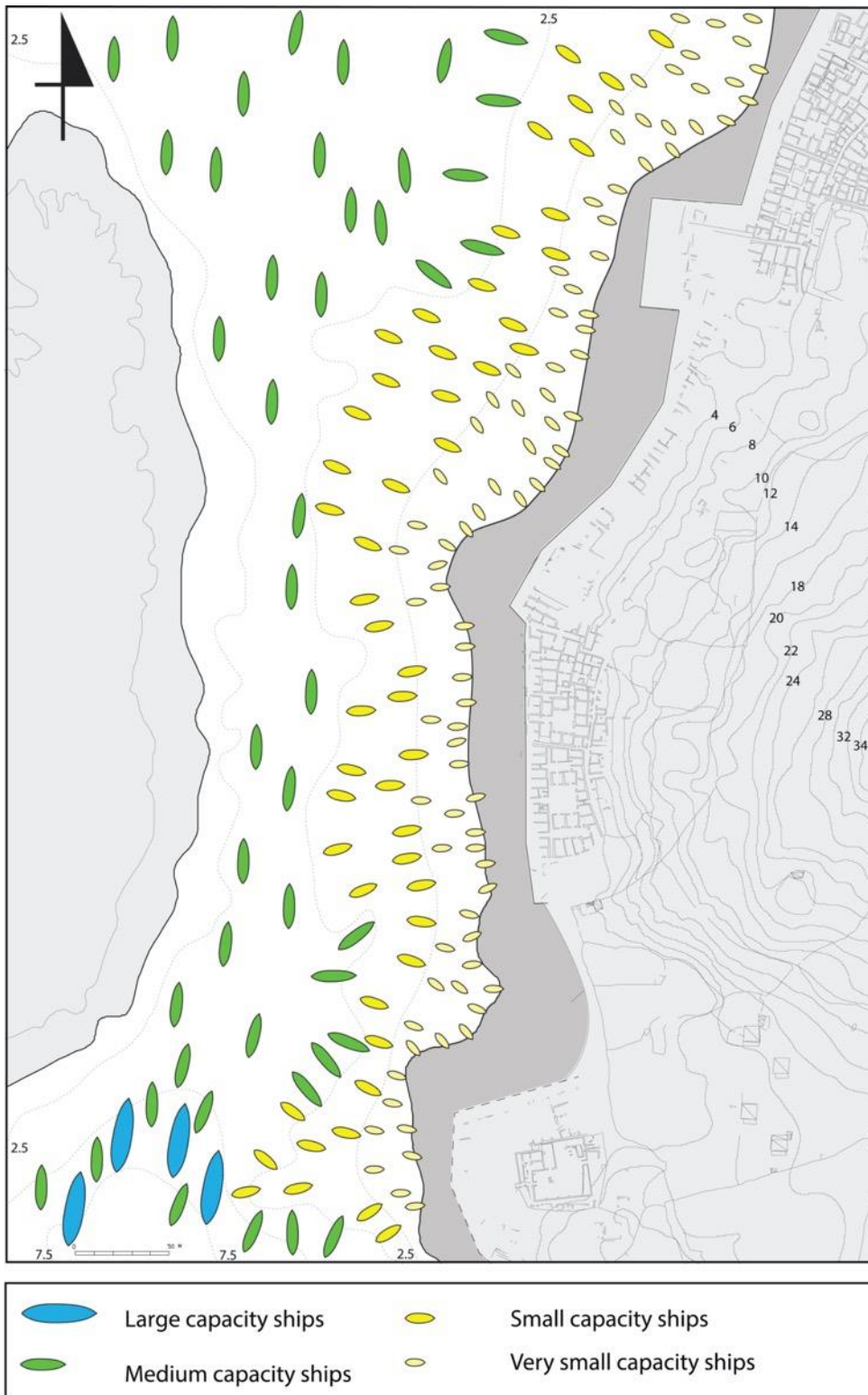


Figure 8. Reconstruction of the use of Delos' Merchant Harbour according to the draft (left) and the estimated number (right) of ships and the harbour's depth (drawing by the author).



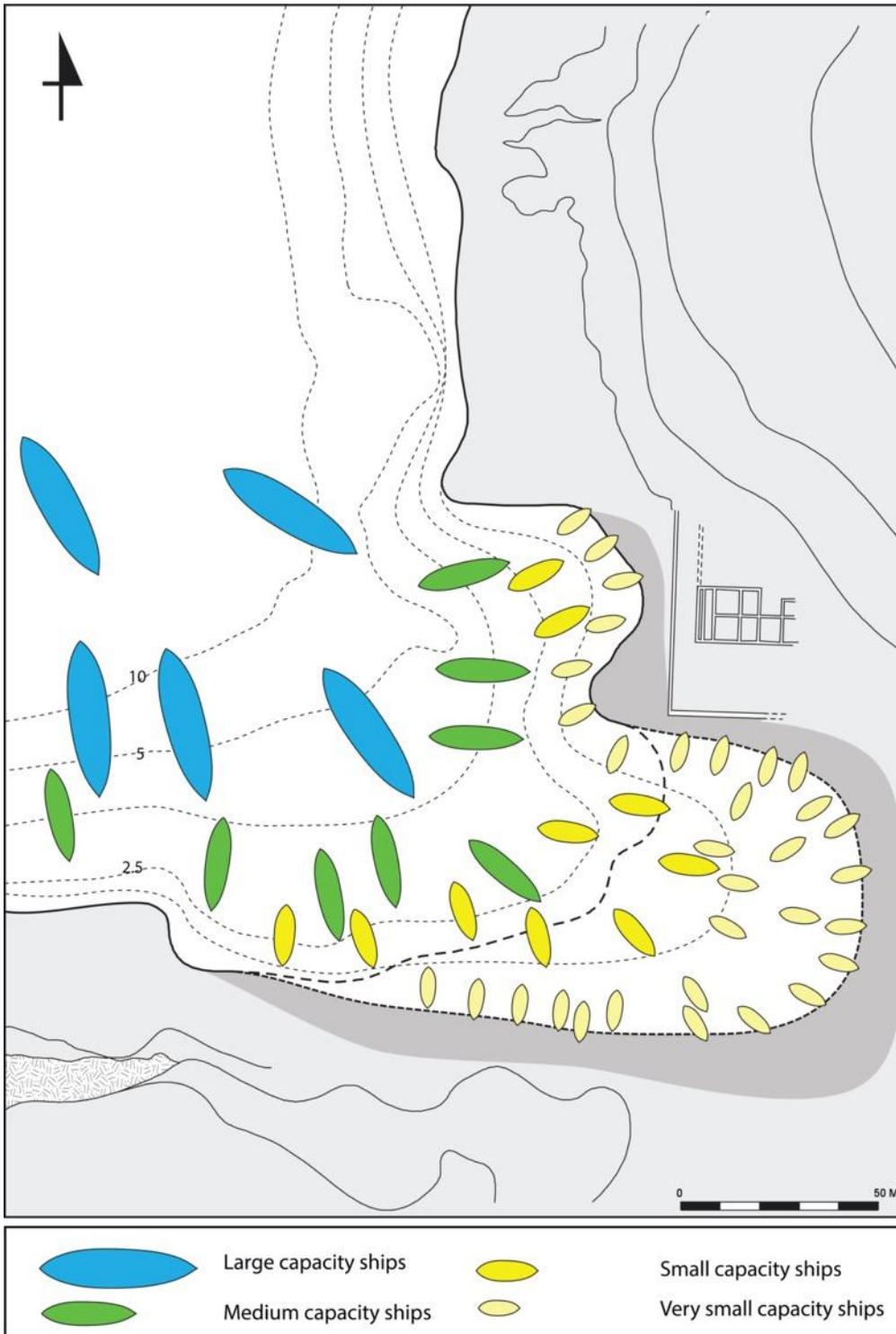


Figure 9. Reconstruction of the use of Delos' Skardanas harbour according to the draft (left) and the estimated number (right) of ships and the harbour's depth (drawing by the author).



Figure 10. Reconstruction of the use of Delos' Gourná harbour according to the draft (left) and the estimated number (right) of ships and the harbour's depth (drawing by the author).