AND THE EARTH IS JOYOUS...
И ЗЕМЛЯ В ЛИКОВАНИИ...

Essays in Honour of Galina A. Belova
Сборник статей в честь Г. А. Беловой

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Сборник статей в честь основателя Центра египтологических исследований РАН Г. А. Беловой, под руководством которой проводятся российские археологические исследования в Египте. В книгу вошли работы отечественных и зарубежных ученых, посвященные истории, археологии и культуре Египта и античного мира.

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CONTENTS/ СОДЕРЖАНИЕ

Alexander A. Belov *

NAVIGATION WITHIN THE GREAT HARBOR OF GRECO-ROMAN ALEXANDRIA

The author summarizes results of studies (including underwater) that were carried out in Alexandria within the last 10 years and compares them with the works of classical authors. A. A. Belov describes the structure of the Great Harbor, history of the port and the arrangement of its operation, and studies climatic and other factors that had an impact on the harbor's location and courses of the ships calling at the Great Harbor and leaving it.

Keywords: Alexandria, Rhakotis, Great Harbor, navigation, trade and military ships, Pharos lighthouse, underwater archaeological studies, classical authors.

Μητέρι χαίριν

Neither the Centre for Egyptological Studies, nor its branch in Cairo, with its team of excellent Egyptologists and collection of fine individuals, would ever have existed if it were not for the inexhaustible energy of Galina Belova. And we would never have these inimitable adventures that we call expeditions. Our foreign colleagues would hardly believe how difficult it was to push through such a project in Russia in the 1990s. Galina succeeded in taking the lead on bureaucratic hurdles long believed to be impassable, in confronting the indifference and greed of officials and in standing firm against the threats from the dignitaries of the time who did not differ much from bandits. Family life was not any easier for her either, and under strong pressure she had to bring up two children under conditions when hunger and cold were the daily reality of academics. However, enough of sad stories of the past. Galina managed to keep her energy and optimism through all these hardships and to remain an open, merry and attractive person who gives us not only an example of a true researcher but, what is more important, of a real human being.

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INTRODUCTION

Today the Eastern Port of Alexandria with its total surface of 600 ha accommodates just a flotilla of fishing vessels of modest size and several dozen yachts. All the intense maritime traffic has long gone to the Western Port, which has the necessary handling infrastructures. Thus the remains of the structures of the Great Harbor (Μέγας λιμήν, *Magnus portus*) are well preserved and continue to provide precious information about the functioning of this famous port and its role in the development of the city. This paper proposes some ideas concerning the navigation within this port in Greco-Roman times.

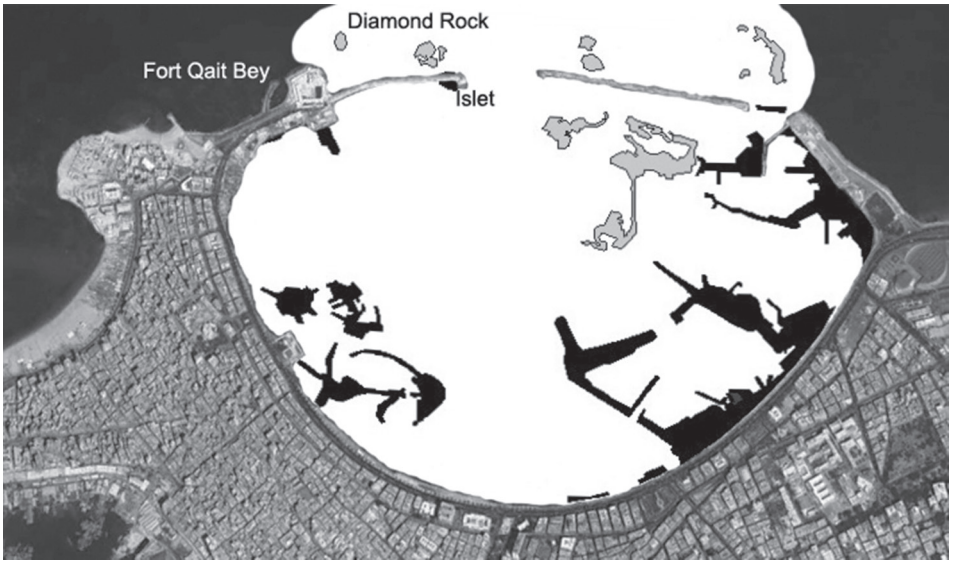

Figure 1. Submerged remains of the ancient Great Harbour of Alexandria inside modern Eastern Port of the city. Port structures that were situated above the sea level in Antiquity are shown in black while those below it (including natural reefs) are grey-colored. Figure by the author with the submerged structures shown after FABRE, GODDIO, 2010. P. 53, fig.5.1

The European Institute of Underwater Archaeology (IEASM) has been applying up-to-date techniques of underwater archaeological research in the Eastern Port of Alexandria since 1992 [1]. These techniques, which have included bathymetric, side-scan sonar, multibeam and magnetometric surveys, have made it possible to plot with high accuracy the submerged port structures of the Great Harbor of Alexandria. Discovered structures consist of well-founded breakwaters and piers of various orientation and length that divide the harbor into several basins. In recent years, the general image of the submerged structures has been further improved, especially in the western part of the harbor (Figure 1). Judging by the bench marks on the reefs and taking into consideration the basic principles

[1] GODDIO, 1995.

for this type of installation, it has been possible to establish that the sea level has risen by at least 7,5 m since antiquity [2]. However, this figure can change from one area of the port to another.

The village of Rhakotis existed in dynastic times on the site of the future Alexandria while the island of Pharos was known to Greek sailors at least starting from the 8th century BC [3] (*Hom. Od.* 4.354–369). Some structures of the Great Port date back to the dynastic period [4].

Strabo, who stayed in Alexandria in the 20s of the 1st century BC, begins the description of Alexandria with the ports of the city and especially praises the sophisticated design of the Great Harbor (*Strabo Geogr.* 17.1.6). Indeed, ancient builders took advantage of the coastline that offered the best conditions for creating a port on the Mediterranean coast of Egypt [5]. An opportunity to construct a double port that was less dependent on wind direction also followed the traditional preferences of the ancients [6].

Considering the main ports of Alexandria known from the classical sources, one can notice the advantageous position of the Great Harbor. It was situated in the central and the richest part of the city, in direct proximity to the imperial residences and major public buildings (*Strabo Geogr.* 17.1.6–9). This was not the case of the western port of Eunostos (Εὐνόστος λιμήν, meaning "Harbor of Good Return") with the adjoining port of Kibotos (Κιβωτός, "Box"). According to Strabo, the city soon came to end farther west from Eunostos, where an extensive necropolis began (*Strabo Geogr.* 17.1.10). The port on Lake Mareotis (λιμήν λιμναῖος) had trading value par excellence (*Strabo Geogr.* 17.1.7) in spite of the fact that sometimes a navy could have been accommodated there (*Philo Flac.* 92).

Literary sources describe military conflicts that took place in the Great Port. Here Caesar had burnt 50 quadriremes and quinqueremes as well as another 22 vessels during the Alexandrian War of 48–47 BC (*Caes. Bel. civ.* 3.111–112). The further development of this war included numerous naval encounters. Later, Octavian's fleet entered the Great Harbor in 30 BC after his glorious victory at Cape Actium (*Plut. Ant.* 76.1–11). The shipyards around the Great Harbor

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[2] Goddio, 2011. P. 130; Goiran, Carbonel, 2014. The contribution of the eustatic sea level rise in the region of Alexandria is estimated to be in the range of 1,0 to 1,5 m, while that due to land subsidence, which is the major factor in flooding, contributes 5–6 m over the last 2 000 years. See Franco, 1996.

[3] Nibbi, 1983.

[4] Stanley, Landau, 2010. P. 48–49; Goddio, Fabre, 2010. P. 65.

[5] The Mediterranean coast of Egypt is very low, while the region of the Nile Delta in antiquity was a real labyrinth of secondary channels and shallow lagoons, situated between the main branches of the river. The recently discovered city of Thonis-Heracleion was the primary Egyptian port, customs station and emporion on the Mediterranean starting from the 8th century BC (see Goddio, 2007; Fabre, Goddio, 2013). The topography of the city is very complicated and is characterized by many islands, channels and inner basins.

[6] Robert, 1960.

in Strabo's description obviously surpassed in size those of the port of Kibotos (*Strabo Geogr.* 17.1.9–10). At the same time, this port was of primary trade significance that reached its peak in the Roman imperial period [7]. Thus, the Great Harbor of Alexandria had a paramount trade, military and political value both for the city and for the country as a whole.

The primary analysis of the port installations of Megas Limen according to new archaeological evidence has been done in a monograph that was published in 1998 [8]. The organization of the discovered port structures has been explained from the point of view of modern marine engineering, taking into account the technical possibilities of the time. The arrangement of the outer breakwaters, the moles that separate three major harbors within the port's inner structure, as well as supplementary moles and piers proved to follow a well-conceived strategy that made optimal use of the site's natural features. Certain aspects of navigation within the port have been considered in subsequent publications [9]. However, while the topography of the submerged ancient port is now established, there are still some unresolved questions concerning the operation of the port.

Wind

The definition of prevailing winds is very important for any port as, apart from wind-induced swell, major currents also frequently depend on wind direction.

It is known from textual sources that navigation in the Mediterranean officially occurred during the period from May 27 to September 14 (*Veget. Epit.* 4.32). Though these limits were not strictly respected [10]. it would not be incorrect to consider this period as a time when the majority of the sea voyages were carried out. Figure 2 shows the percentage of wind in cardinals in summer months according to the data of the meteorological station in Alexandria from 1973 to 1992 [11].

As follows from the chart below, the northwesterly wind dominates throughout the period of the "open sea". These are so-called Etesian winds (ετέσιαι: "annual", "periodic"), which arise in summer between the high-pressure area over the Balkans and the low-pressure area over Asia Minor (*Diod. Hist.* 17.52.2; *Strabo Geogr.* 17.7). Around Alexandria the northwest wind blows 75 percent of the time in summer and thus it is this direction that is most significant for the port. The basins of Megas Limen were indeed constructed under the lee of Pharos Island and of the submerged reefs that are situated northwest of the port. Apart from the artificial piers that protected the port from the wind from this dominating direction, there is also a group of numerous piers designed

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[7] Rougé, 1966. P. 38.

[8] Goddio, Darwish, 1998; De Graauw, 1998.

[9] Goddio, Yoyotte, 2008. P. 273; Goddio, Fabre, 2010 P. 65–67; Goddio, 2011. P. 130–134.

[10] Arnaud, 2012.

[11] De Graauw, 1998. P. 57–58.

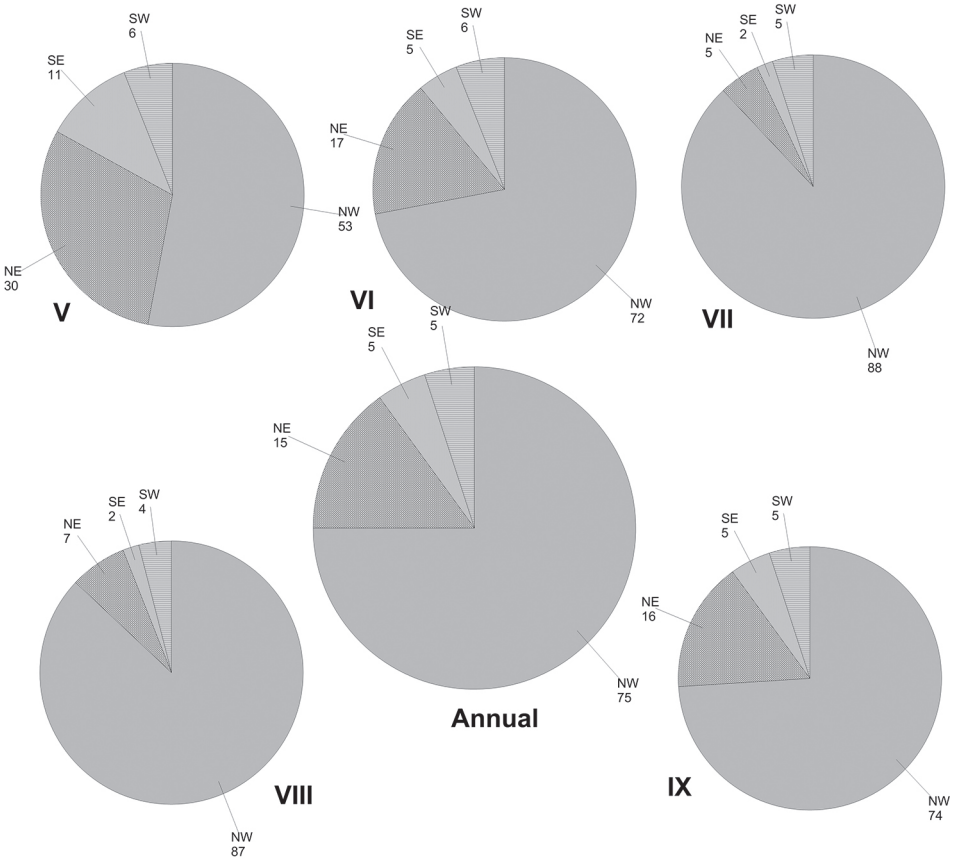

Figure 2. Monthly percentage of wind in cardinals during the period from May to September in the region of Alexandria averaged for 20 years (1973–1992)

to shield it from the northeast in complete correspondence with the second prevailing wind direction.

Today, weak eastern currents with a speed of 0,1–0,7 knots prevail in this area [12]. At the same time, the construction of Heptastadium, which connected the island of Pharos to the mainland, should have significantly changed the character of circulation within the port. According to a modeling approach, this effect was rather favorable for the Great Harbor, slowing down the silting rate [13].

Position of the Pharos Lighthouse

Because the Egyptian coast is so low, the right course for Alexandria had to be signaled from a long distance. On the other hand, numerous reefs complicated the approaches to the port and obstructed the channel itself. According

[12] Goddio, Darwish, 1998. P. 6.

[13] Millet, Goiran, 2007.

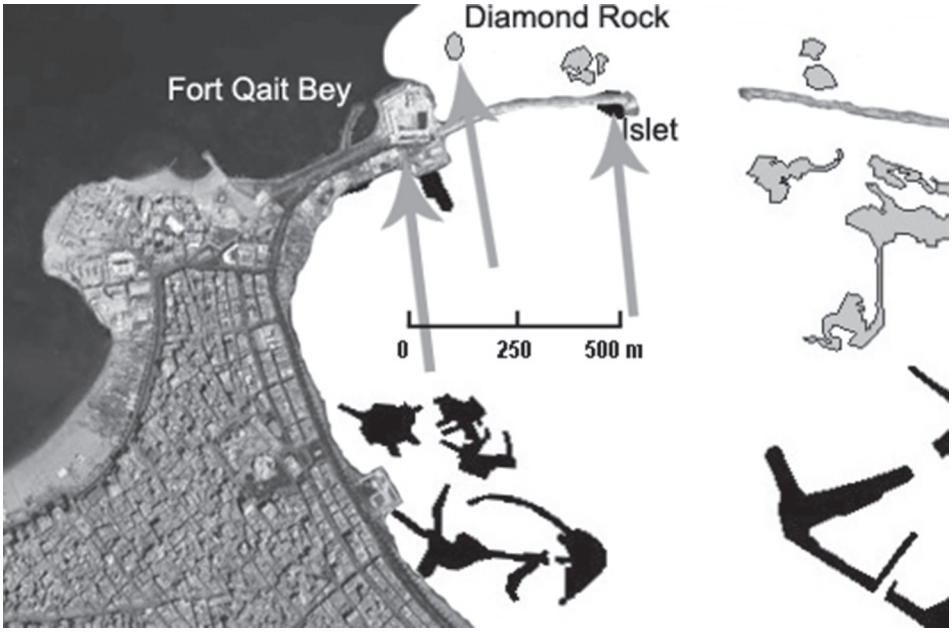

Figure 3. Location of the Lighthouse as per different hypotheses

to Strabo, some of the reefs were on the surface while the others were submerged, and thus were even more dangerous for navigation (*Strabo Geogr.* 17.1.6). Thus the position of the Pharos Lighthouse is of primary importance, and this question has been repeatedly raised in the literature [14]. Several different locations have been proposed for the lighthouse: the site of the medieval fort Qait Bey (end of the 15th century AD), the site of the submerged reef called "Diamond Rock" located east-northeast from Qait Bey and, finally, the site on the submerged islets close to the modern main entrance to the harbor (Figure 3).

After the charting of the ancient remains of the Great Harbor was accomplished, it was possible to reconsider the information of ancient authors on the relative position of the harbor's entry, the lighthouse and some other topographical features of the city [15].

Although there is no lack of descriptions of the Great Harbor [16], the most precise one undoubtedly belongs to Strabo. According to him, the site of the lighthouse was located on the rock at the extremity of the Pharos Island, and this rock was surrounded by water (*Strabo Geogr.* 17.1.6) [17]. A description by Achilles

[14] JONDET, 1912. P. 14; JONDET, 1916. P. 47–50; BERNAND, 1966. P. 31–32; FROST, 1975; BERNAND, 1995. P. 48–51; GRIMAL, EMPEREUR, 1997; EMPEREUR, 1998a. P. 64–87; EMPEREUR, 1998b; GODDIO, DARWISH, 1998. P. 12; EMPEREUR, 1999. P. 25–29.

[15] GODDIO, DARWISH, 1998. P. 15–16.

[16] BERNAND, 1998.

[17] ἔστι δὲ καὶ αὐτὸ τὸ τῆς νησῖδος ἄκρον πέτρα περίκλυστος.

Tatius (2nd century AD), who was born in Alexandria, contains such expressions as "*structure . . . in the middle of the sea*" and "*building . . . suspended above the surface* [of the waters]" (*Ach. Tat.* 5.6). Moreover, in this evidence the extremity of the island of Pharos and the position of the lighthouse are not mixed together (*Ach. Tat.* 5.6) [18].

In the Islamic period, Pharos was visited by many travelers [19]. One of them, who saw the lighthouse in 985 AD, wrote that it was connected to the land by a narrow road firmly built on the rocks. More information is to be found in an interesting testimonial by Aboul Haggag Youssef Ibn Mohammed el-Balawi el-Andaloussi, who visited the lighthouse in 1166 and left a detailed description of this event [20]. At the time of his visit, the lighthouse had already been repaired many times, but it was still functioning. According to Aboul Haggag, the lighthouse was located on a small island connected to the mainland by a dike [21]. The dike was only 1,60 m above sea level and it was inundated in case of bad weather [22]. Finally, there is a crucial testimonial by the chronicler of Sultan Qaitbey, who mentioned that in June 1477 the ruler arrived in Alexandria and ordered the construction of a fort on the foundations of Pharos that had been completely destroyed a century before.

Strabo says that the lighthouse was built at the extremity of Pharos Island, but there is no contradiction with the evidence of medieval travelers because in the geographical sense the dike would "unify" the site of the lighthouse with the island of Pharos [23]. The dike in question can be observed on many marine charts and maps of the city dating from the 17th to the 20th century (Figure 4).

During the underwater research of the Centre des Études Alexandrines, more than 3500 blocks occupying 2,25 ha of the sea bottom to the northeast of the Qait Bey fort were discovered [24]. Some of the blocs of red Aswan granite more than 11 m long probably formed the monumental doorway in the Doric

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[18] "*After this [sightseeing of the lighthouse] he took us to his house, which was on the shore at the extremity of the island*".

[19] Palacios, 1933.

[20] Toussoun, 1936. The reliability of Aboul Haggag's report was much criticized, and it is true that the dimensions suggested by him for separate levels of the lighthouse are inaccurate (Empereur, 1998b. P. 82). At the same time, his general description of the site might better reflect the reality.

[21] Obviously it is not the island of Pharos the author describes, as even at modern sea level its length would exceed 3 600 meters. Moreover, by the 12th century the island of Pharos must have already been transformed into the peninsula following the sedimentation of the two harbors. See Hesse, 1998. P. 27. The Mosque of Abd el-Kader el-Gilani was built on the coast projection in 953. In the 10th century it was possible to walk along the 20-meters-wide beach that had been formed on the west side of Heptastadium. The lands from the two sides of Heptastadium were asymmetrical. See Hesse, 2002. P. 234.

[22] We must bear in mind that by the 12th century AD, considerable sea transgression must have already occurred, and this also must be the reason why the platform of Pharos was partially underwater. An Arab traveler who visited the lighthouse in 1227 reported that it was accessible only by sea (Palacios, 1933). The lighthouse was completely destroyed by an earthquake on August 8, 1303.

[23] Arguments in favor of a probable location of the lighthouse on a small island can be found in Fraser, 1972. Note 98.

[24] Empereur, 1999. P. 27.

Figure 4. Fragment of a map of Alexandria and of East Harbour by E. Napier (1841). Note the "Causeway" leading from the mainland to the "Pharos castle" (bottom right corner)

style. Two colossi, attributed to Ptolemy II and Arsinoe II, are of the utmost importance for the localization of the lighthouse.

Thus the arguments in favor of the site of Qait Bey are very convincing. At the same time, it is necessary to take into consideration observations of another nature. During an underwater survey of the Great Harbor, numerous lines of wave erosion were discovered on many submerged reefs. The depth of these lines varies within 6,5–7,0 m [25]. A theoretical elevation of about 7 m would co siderably change the appearance of the area around Qait Bey. A line of reefs to the northwest of the modern coast of Anfoushi would transform into the steep coast while the water area of the bay of Anfoushi becomes *terra firma* of the island of Pharos.

[25] GODDIO, DARWISH, 1998. P. 12.

Figure 5. Space view of a fragment of the Alexandrian coast with a part of the East port, the Anfoushi region and the Fort Qait-Bey. © 2014 Cnes/Spot Image, Image © 2014 DigitalGlobe

A bathymetric chart or even a space photograph can serve as a good illustration for this (Figure 5).

Accordingly, the fort of Qait Bey would no longer be situated on the extremity of the island, but rather, far from the shoreline. Observations and measurements made by G. Jondet proved that the plateau of Qait Bey continued 200 m northeast from the wall of the fort, and the upper surface of the plateau was only 70 cm under water [26]. It has already been noted that the ancient peninsula of Lochias on the east of the harbor extended much farther west than today [27]. and the rock Pharillion charted in the *Description d'Égypte* could not have marked the ancient peninsula's end. The same conclusion must apply to the fort of Qait Bey, which is located just on the other side of the harbor.

In light of the above arguments, I would posit the location of the lighthouse some 200 meters northeast of the fort of Qait Bey that would correspond to the extremity of Pharos Island in antiquity (Figure 6).

To conclude this section, we must mention a port whose period is being analyzed. Obviously one cannot consider the Great Harbor as a complex of permanent installations but rather as a mobile system that constantly changed over time depending on natural, economic and political factors. For the moment it is not easy even to date the appearance of the first port installations. According to the wood remains discovered on the island of Antirhodos, the first port facilities had appeared in pre-Ptolemaic times [28]. Over time new breakwaters and piers

[26] Jondet, 1912. P. 48.

[27] Saint-Genis, 1818. P. 52–54.

[28] Goddio, Yoyotte, 2008. P. 65. There is evidence of occupation of the site of Rhakotis as early as the Old Kingdom. See Véron, Goiran, 2006.

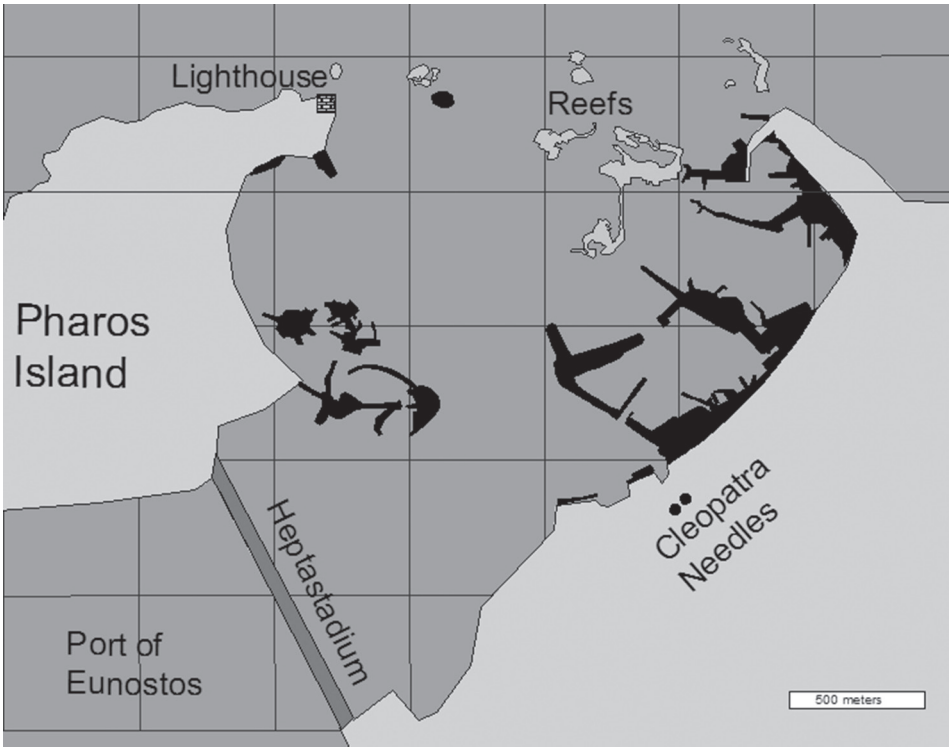

Figure 6. Reconstruction of the ancient topography of the Great Harbour including the submerged reefs and port structures discovered. After FABRE, GODDIO, 2010. P. 53

appeared while some others turned to ruins. Some parts of the harbor were subject to silting, and special efforts must have been undertaken to counteract this process [29]. However, this paper proposes only some general ideas on the navigation within the Great Harbor, so I consider a well-organized harbor of Hellenistic times that included all major port structures according to the current research.

The major factors that are necessary to analyze the maneuvers of an ancient ship calling at the Great Harbor include dominating wind direction, currents, navigation signs (lighthouse, alignments, cairns), natural hazards (reefs) and the topography of the port itself.

ANCHORAGE OF THE SHIPS ON THE ROADS OF THE GREAT HARBOR

Most likely, the proper roads of the Great Harbor began under the shelter of the island of Pharos. The French engineer Gaston Jondet, who was studying the remains of the port of Eunostos at the beginning of the 20th century, has stated this point of view as follows [30]:

[29] For example, the slipway for the ships (*diolkos*) is recorded after 1 AD probably due to silting of the two passages in the Heptastadium. See FRASER, 1961.

[30] JONDET, 1916. P. 6–7.

> *Before the construction of Heptastadium, which connected Pharos Island with the littoral, western and eastern ports, there were freely communicated and formed the roads of Alexandria that were completely protected by a line of reefs and the area of considerable depths that lies in parallel to the coastline to the southwest from Pharos to Cape Agami and to the northeast to Cape Silsileh at an average distance of about 2500 meters* [31].

The anchorage seaward from Pharos was risky, and it seems possible to assume that whenever possible, it was avoided. The coast was alee and abounded with reefs (*Strabo Geogr*. 17.1.6; *Ios. ant. Iud.* 4.612*)*, and the inhabitants of the island were reputed to be "pirates" who, according to Caesar, did not shun plundering any ships that touched the coast there (*Caes. Bel. civ.* 3.112). However, Flavius Josephus (37–95 AD) writes that the light of the lighthouse warned the seamen to put down anchor at some distance and wait until the end of the night before daring to enter the port (*Ios. ant. Iud.* 4.613). There existed other circumstances that could prevent a skipper from entering the basin of the Great Harbor immediately. Among them were unfavorable weather conditions [32], the channel being closed by chains (*Lucan*. 10.53–60), or even reasons of secrecy (*Philo. Flac.* 27–28, 109–111). However, it seems that in most cases, pilots tried to proceed under the protection of Pharos Island as soon as possible, and in fact, this space was considered to be part of the port's roads. A few ancient anchors have been found on the submerged reef that is parallel to the coast of the Ras el-Tin peninsula (the ancient island of Pharos) at a distance of about 1 km and depth of 10–20 m [33]. On the contrary, the remains of several shipwrecks that were discovered by the Centre des Études Alexandrines to the north of Fort Qait-Bey testify to the dangers that were in store for seamen who lingered in order to enter the port [34].

Ships' entry into the harbor basin

Strabo (20–26 BC) and Flavius Josephus (37–95 AD) noted that for an arriving ship, the island of Pharos with the lighthouse was on the right-hand side, that is, to the west (*Strabo Geogr.* 17.1.9; *Ios. ant. Iud.* 4.612*)*, while the submerged reefs and Cape Lochias were on the other side, that is, to the east. It should be remembered that in antiquity the Lochias Peninsula provided a natural protection for the harbor from the northeast, and it was much more prominent and wider than

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[31] The construction of Heptastadium in fact changed nothing in this sense except that now each port possessed its own proper roads.

[32] Caesar's auxiliary fleet misguided by the east wind was anchored near the Cape of Agami (the ancient cape *Chersonesus*), and the author of the *Alexandrian War* wrote that *the coast is very convenient for anchorage* (*Ceas. Bel. civ.* 9).

[33] The remains of only two ancient anchors have been discovered so far, at a depth of 18 m during the reconnaissance of this area. However, Greek-type limestone stock from a wooden anchor (t.a.q. 4th century BC) is estimated to weigh 320 kg, suggesting that it belonged to a vessel of considerable size. See Belova et al., 2014. P. 8.

[34] Empereur, 1999. P. 29; Empereur, 2002.

today [35]. The ancient breakwater of Cape Lochias probably did not exist in Strabo's time as he speaks only of a natural barrier; however, the breakwater is mentioned by Flavius Josephus.[36] The narrowness of the entrance to the Great Harbor is documented by Caesar, Strabo and Flavius Josephus. All these authors speak only of one entry channel leading to the Great Harbor (*Caes. Bel.* civ 3.112; *Strabo Geogr*. 17.1.6; *Ios. ant. Iud.* 4.612–615*)*. According to Pliny the Elder (23–79 AD), there were three main passages to the port of Alexandria — Steganus, Posideum and Taurus (*Plin. Nat. hist.* 5, 34.128). However, it is necessary to note that we do not know whether Pliny meant the passes to the Great Harbor only or to both major ports of Alexandria divided by Heptastadium [37]. Nevertheless, it seems that there were at least two major channels leading to the Great Harbor (Figure 7).

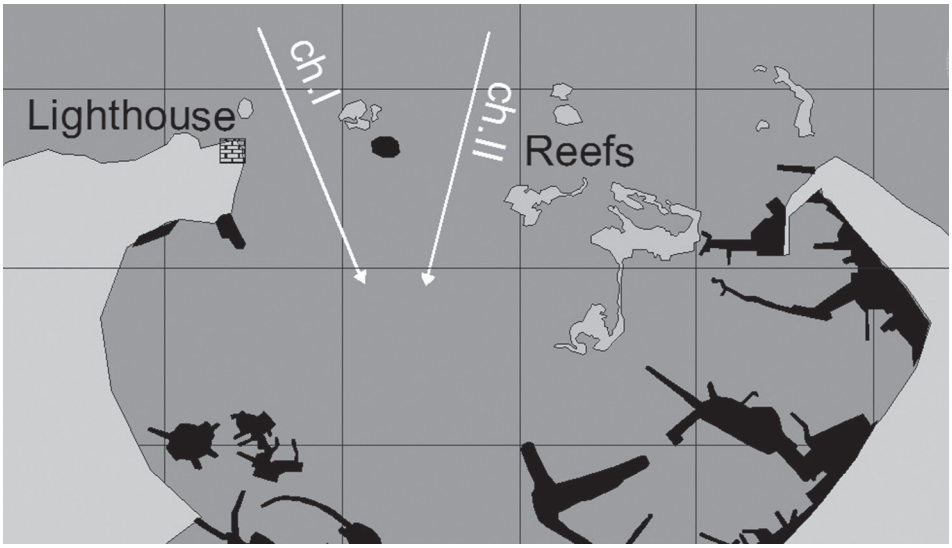

Figure 7. Hypothetic position of the channels leading to the Great Harbour in Antiquity

The first one was situated between the lighthouse and the central islet where the remains of some constructions were discovered by G. Jondet [38]. It seems appropriate to recall here the meaning of the Greek word *στεγανός*, which was used in Latin by Pliny for the name of one of the passes. It means "closed", "tightly

[35] Modern topographic data (GODDIO, FABRE, 2010. P. 55) proves the ideas expressed in SAINT-GENIS, 1818. P. 52–54 and FRASER, 1972. P. 23.

[36] FRASER, 1972. Note 141.

[37] This idea has been proposed by SAINT-GENIS, 1818. P. 2, 26, 31–32 and criticized in FRASER, 1972. Note 136. Fraser emphasizes that Pliny in his narrative speaks about the lighthouse that in any case was of no use for entering the western harbor. This argument does not seem to be decisive because Pliny's description is very general and is not based on personal observation.

[38] JONDET, 1916. P. 50.

closed" and even "impenetrable". The same sense of complicated access resonates in another name of the pass — *scopulus* (*lat.* "rock") — a name that most often had been applied to the reefs [39]. Access to the harbor was not easy, and Flavius Josephus (37–95 AD) describes the entry channel as follows:

> *The port of Alexandria is difficult for ships to approach even in peace-time, the entrance being narrow and diverted by submerged rocks which preclude direct passage* (*Ios. ant. Iud.* 4.612) [40].

Indeed, the bathymetric chart shows many submerged reefs in a passage between Pharos Island and the central islet; the width of the channel itself would not exceed 170 m. It would be difficult enough to pass through the channel without changing the course of the ship. Flavius Josephus continues his description of the entry channel:

> *Around this island immense walls have been reared by human hands; and the sea dashing against these and breaking around the piers opposite renders this passage rough and ingress through the strait perilous. The harbor inside is, however, perfectly safe and is thirty furlongs in length* (*Ios. ant. Iud.* 4.612).

This narrative perfectly reflects the position of the narrow channel in the direction of dominating wind and swell. The refraction of the waves causes the appearance of irregular swell ("broken water", "chopped waves") that is potentially dangerous for navigation. On the other hand, the surface current must have helped the ship to pass through the channel. It would have been convenient to enter the Harbor by Channel I with a tailwind or on a broad reach on starboard tack. Under good weather conditions, the ship could continue sailing to the central part of the harbor. In case of a strong gale or unfavorable, wind the skipper could considerably reduce sail by means of brails [41]. While running downwind it was possible to take in the sail completely and to continue the course by windage of the hull only. Vessels with the two masts could have left the sail only on the ront one — artemon. This would reduce the speed of the ship while ensuring good maneuverability.

Channel II between the central islet and the reefs to the east was slightly wider than the first one. It coincides with the modern entrance to the Eastern Port and corresponds to a pronounced depression in underwater relief.[42] At the same time, this channel was less advantageous in case of dominating wind direction. While Channel II was quite easy to pass on broad reach, it was harder on beam reach because the space was limited and the reefs so close alee [43].

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[39] Botti, 1897. P. 58.

[40] Trans. Thackeray, 1957; "crooked run"—καμπτόμενος δρόμον.

[41] Casson, 1995. P. 270.

[42] Goddio, Darwish, 1998. P. 15–16.

[43] It seems appropriate to cite here the following fragment by Philo (13–50 AD): "*For many a time and to many has it happened that they have crossed wide spaces of navigable waters and passed a long voyage in safety escorted by favorable breezes, and then in the harbor itself have suddenly been shipwrecked just when they were on the point to cast anchor*" (*Philo De Som*., II, 143), trans. Colson, 1958.

The descriptions of the voyages that have reached us in peripli that start to appear in the 4th century BC are usually restricted to an enumeration of the great landmarks and distances and do not go into detail on the particularities of entry into the specific ports. In any case, these documents were not intended to be used by the people of the sea [44]. However, there is no doubt that knowledge of the coast and of the specific features of each port was the foundation of an ancient mariner's mastery [45]. When calling at complicated ports like Alexandria, skippers must have regularly used alignments that made it possible to choose the right bearing. There were a lot of remarkable and high buildings in Alexandria that could have served as reference points. For example, the height of two obelisks surnamed "The Needles of Cleopatra", erected in 13 BC at the entrance of the Caesareum, amounted to 21 m [46]. This temple was situated in the central part of the harbor close to the shore. A line from the entrance of the harbor to one of the obelisks would cross the central part of the island of Antirhodos with a royal palace on it (*Strabo Geogr.* 17.1.9) [47] (Figure 8). At the same time, the cult of Octavian Augustus was especially venerated in Caesareum by seamen and therefore such alignment would have held additional symbolic significance (*Philo De leg*. 151).

There is no doubt that there existed a number of other alignments. For example, the temple of Serapis was situated on a hill approximately 1 km from the shore. The obelisks installed in front of this temple (*Hist. Al.* 33) would have been visible from the sea even before the construction of Diocletian's column in 298 AD. In modern times the latter appears on a number of marine charts, for example, on the chart of the New Port compiled in 1738 by the captain of the Danish Navy, F. L. Norden [48]. Together with the old tower situated closer to the coast, this column forms an alignment that marks the reef at the entrance to the port.

Interesting information concerning the port's entry can be found in the epigram of Poseidippos of Pella (3rd century BC) devoted to Ptolemy I Soter that contains the following fragment:

> *And the sailor might run to the very Bull's Horn, yet he would not miss, in sailing hither, O Proteus, his target, Zeus Soter* [49].

P. M. Fraser believed that the Bull's Horn (Ταύρου κέρας) is a noted rock at the entrance of the Great Harbor since Pliny mentions the channel called *Taurus* [50]. However, the results of recent topographical surveys make it possible to suggest another hypothesis.[51] Let us take a look at a small islet just in the cent-

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[44] ARNAUD 2012. P. 118.

[45] ARNAUD, 2012. P. 118.

[46] For the position of the obelisks, see GODDIO, DARWISH, 1998. P. 10; EMPEREUR, 1998a. P. 112–118; ARNAUD, 2002.

[47] The palace on Antirodos Island.

[48] GODDIO, DARWISH, 1998. P. 19 (Figure 4).

[49] Trans. FRASER, 1972. P. 18.

[50] FRASER, 1972. P. 18.

[51] GODDIO, FABRE, 2010. P. 61.

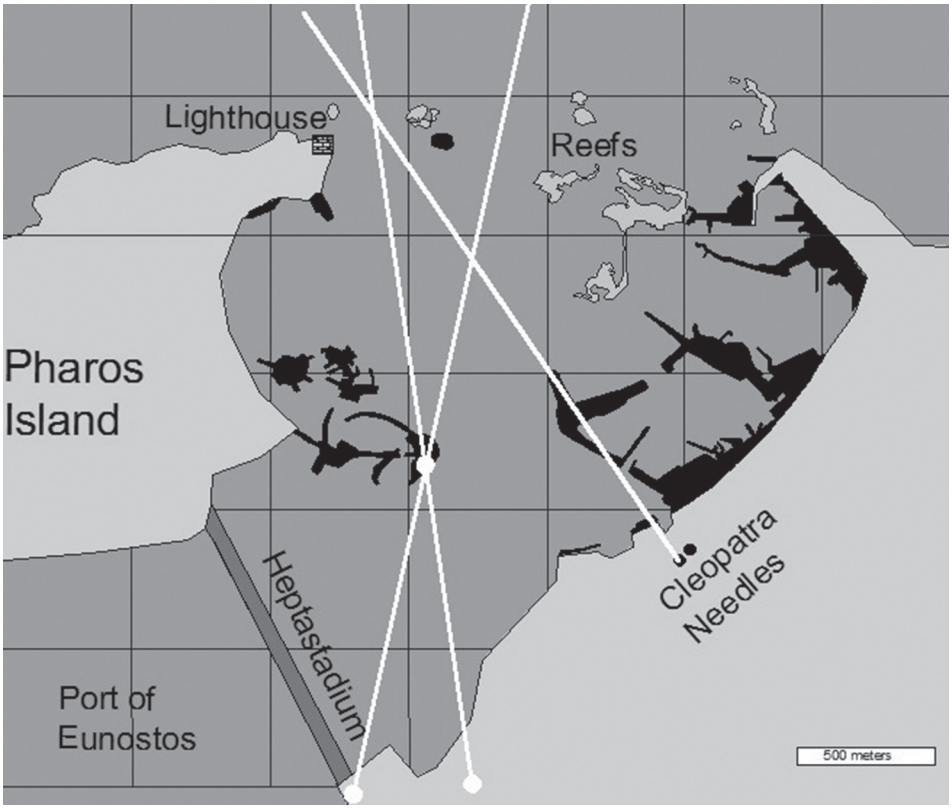

Figure 8. Possible alignments marking the entrance to the Great Harbour

er of the ancient water area of the harbor (see Figure 9, number 4). This islet, now submerged, is remarkable for the curved breakwater that is impressively long. It is difficult to deny that the islet with the breakwater resembles a profile of a horned bull's head. At the same time, the breakwater is situated directly opposite to the hypothetic channels leading to the harbor. In fact, this mole was constructed to protect the small port to the south of the swell of the open sea. A landmark installed on the breakwater or on the islet itself should have been clearly visible from the sea. The primary task of the lighthouse was to show the entrance to Alexandria at a great distance but, because of its dimensions, Pharos was not efficient for entering the harbor. It seems more probable that another reference point could have been erected or chosen somewhere farther along the coast, for example, at the base of the Heptastadium as shown on Figure 8.

The Harbors of Magnus Portus

Before we continue the discussion of navigation within the ancient port, it is necessary to give a short description of its basins (Figure 9).

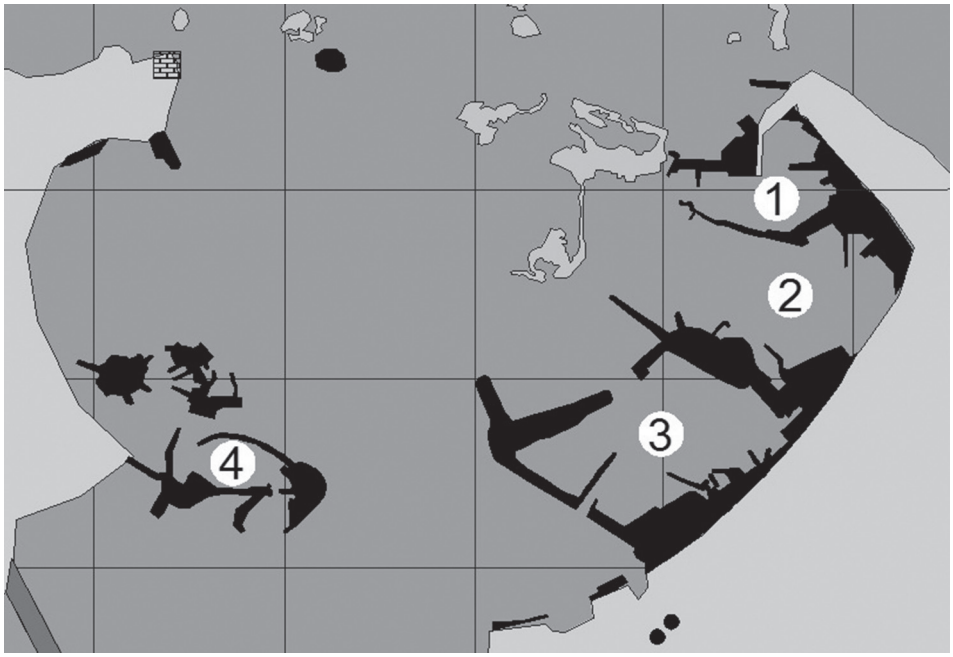

Figure 9. Major basins of the Great Harbour

The Royal Port of the Galleys, "*dug into the rock*" (*Strabo Geogr*. 17.1.9) (harbor 1), was located to the west of Cape Lochias [52]. The water area of this harbor does not exceed 5 ha. The entrance to the harbor was very narrow and, thus, easy to close with chains.

Harbor 2 farther to the south had an area of about 15 ha. It seems that the reefs to the northwest protected both of these harbors from the swell. An access to Harbor 2 had been restricted too by means of a breakwater of considerable length anchored on the peninsula and stretched in the direction of the reefs nearby. Remains of the masonry have been discovered on the central reef on the other side of the channel. The narrow passage between the reef and the breakwater was probably closed by chain. This harbor has been identified as a military port [53].

Farther southwest along the coast was a third harbor. It had a considerable area of 16 ha and was closed on one side by the peninsula of the Poseidium and on the other side by the island of Antirhodos. A mole protrudes from the Poseidium toward the eastern tip of Antirhodos. A secondary inner port was situated under the lee of Antirhodos Island. Its southern part was separated by a long and narrow dike. According to Strabo, that was a small royal port (*Strabo Geogr*. 17.1.9). A secondary passage between this dike and the mole protruding from the ancient coast had a double function. On the one hand, it provided an alter-

[52] GODDIO, FABRE, 2010. P. 55.
[53] GODDIO, 2011. P 130.

native exit in case of strong northerly or northwesterly winds, and on the other, it supported water circulation in the port preventing the port from silting up [54]. The reefs situated to the north broke the swell coming from the open sea, and the mole at the northwestern tip of Antirhodos Island protected the port from the reflected waves formed in the western part of the Great Harbor. Numerous piers of this central port were most likely used for the trade ships.

An intricate system of peers and dikes that was discovered in the western part of the Megas Limen may correspond to the region of small trading ports and shipyards (*Strabo Geogr.* 17.1.9) [55].

Navigation within the port's basin

Now it is possible to consider the most probable maneuvers for the ancient ship navigating within the Great Harbor.

Maneuvers of calling at the harbors of Megas limen. The fastest and most logical course for gaining access to the harbors of Megas limen must have been the direct trajectory toward the passage between the central reef and the island of Antirhodos (Figure 10, A1). The distance from the central point of Channel I to the entrance of the third, second and first harbors was 1300, 1600, and 1900 m respectively. However, in case of strong wind, direct access to these harbors would become risky. In this case it would be preferable to put the helm starboard after passing through the channel and to resume the course under the protection of Pharos Island (Figure 10, A2). Here the strength of the wind and swell was less and the ship could continue sailing the southeastern course toward the narrow 20-meters passage between the island of Antirhodos and the shore.

In both cases the crew had enough time to take in sail on the approaches to the third harbor [56]. A square-rigged vessel of the time could furl the sail rather quickly by means of brails that ran to the deck, and thus just a few crew members could complete this operation [57].

Another probable tack can be suggested toward the newly discovered port structures in the western part of the harbor (Figure 10, A3). Some remains in the northwest of the Eastern Port probably correspond to the quays that belong to the submerged coast of the island of Pharos. Complicated structures on the southern part of the island include several well-protected ports of modest size.

Finally, it is worth considering another important itinerary toward the passages that existed in Heptastadium (*Strabo Geogr.* 17.1.6) (Figure 10, A4). It is well known that the entrance to the western port of Eunostos was possible via nar-

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[54] Goddio, 2011. P. 130.

[55] See Goddio, 2011. P. 132–133.

[56] Calms are quite frequent in the Mediterranean in summer. Therefore, all vessels, even the larger cargo ships destined for long-range voyages, were equipped with oars. Rowing was also indispensable while calling at tricky ports like that of Alexandria. See Casson, 1995. P. 65, 157.

[57] Casson, 1995. P. 68.

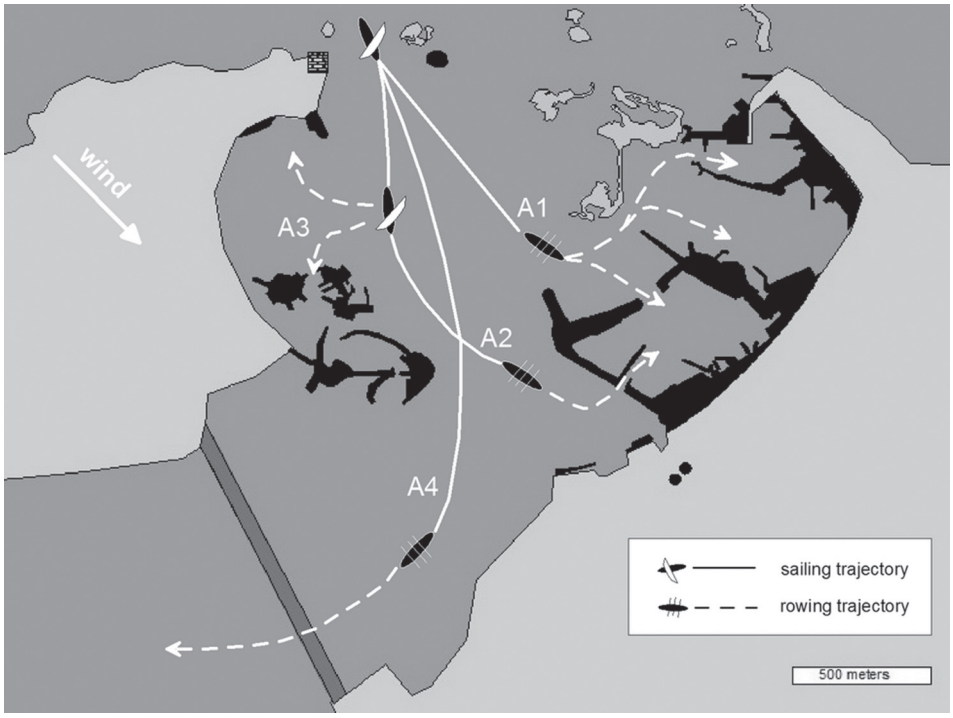

Figure 10. Hypothetic courses of preference for the ships calling to the harbours of Megas Limen and to the port of Eunostos

row channels among the reefs that were not easy to pass (*Strabo Geogr.* 17.1.6) [58]. In Roman times, there were shallows in the port's basin (*Caes. b. Al.* 14). Under certain conditions like bad visibility or high swell, it might have been safer to enter the inner roads of the Great Harbor first and to pass to the port of Eunostos through the passages in the Heptastadium. In any case, the goods that were destined for shipping to the inner parts of the country must have been constantly channeled from Portus Magnus to the Port of Eunostos, which was connected to Lake Mareotis and the Nile.

Because of its low speed and stability, a sea breeze can be efficient for entering a harbor [59]. In Alexandria, the direction of the sea breeze generally corresponds to that of the dominating wind direction from the northwest [60]. The regular character of the Alexandrian breeze was noted by Gaston Jondet, who perfectly understood the importance of this factor for the port's design [61].

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[58] JONDET, 1916. P. 8–9.

[59] The breeze is the wind that arises on a regular basis in all coastal areas due to the difference in day heating and night cooling of the neighboring surfaces of sea and land. The sea breeze blows in the afternoon and blows from sea to land. The coastal breeze, on the contrary, blows at night from land toward the sea.

[60] In fact, the Etesian wind is the same breeze in its origin but is just taken on a much larger scale.

[61] JONDET, 1916. P. 12.

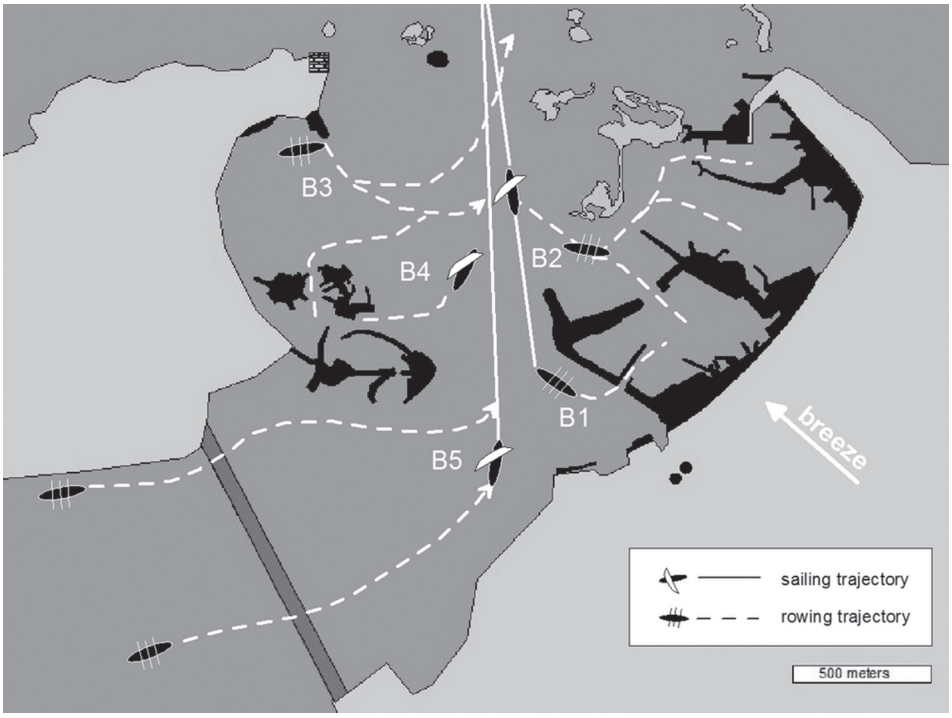

Figure 11. Possible courses of ships leaving the Great Harbour with the coastal breeze

Leaving the port. The tides being negligible in the Mediterranean, there was no danger of "missing one's tide". Therefore, it was the wind that acquired great importance for a ship leaving the Great Harbor. A ship could rely exclusively on rowing, of course, but that was possible only in case of relatively weak northerly winds or the winds from the shore (coastal breeze). As for a sufficiently brisk wind (approximately more than 5 points on the Beaufort scale) of the dominating direction from the northwest, it hardly left any chance of leaving the port by rowing.

A coastal breeze was the most advantageous wind for a ship leaving the harbor. Besides its favorable direction that is perpendicular to the shore, it is very stable and not too strong. At the same time, the influence of the coastal breeze can sometimes extend up to 20 km from the coast. To make good use of the coastal breeze while leaving the Great Harbor, the ship should have rowed first to the open water area in the central part of the port and, after putting sail, moved straight ahead toward the channel using the lighthouse as a reference point (Figure 11, B1–B5). Putting sail before passing through the channel seems to be appropriate in all these cases except when sailing from the port near the south-eastern extremity of Pharos (Figure 11, B3). Probably in this case it was safer and easier to put sail after passing through the channel.

It was a more difficult business to leave the harbor under sail with the usual northwesterly wind blowing, and it was ultimately impossible if this wind was brisk

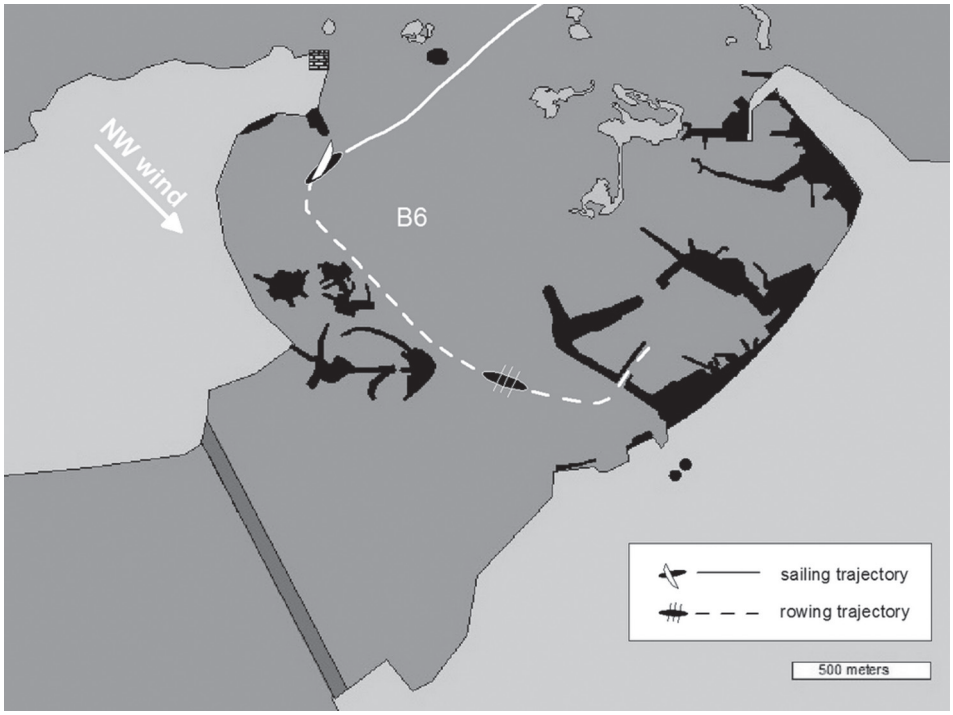

Figure 12. Possible track of leaving the harbour under sail in case of moderate NW wind

enough. Caesar himself experienced the fact that Etesian winds could prevent ships from leaving Alexandria (*Caes. Bel. civ.* 3.107). The question of whether or not the ships of the classical period were able to beat against the wind has been repeatedly raised in the literature [62]. Written sources indicate without any ambiguity that this kind of sailing was well known to the ancients. Of course, the angle of windward sailing was not high, surely less than 60 degrees to the wind [63], so it was used when it appeared to be more efficient than rowing, chiefly during long separate tacks [64]. However, windward sailing in the limited space of the harbor seems improbable. A ship approaching alee the island of Pharos near Heptastadium theoretically would have been able to leave the harbor by Channel II while sailing on a beam reach on port tack (Figure 12, B6). At the same time, it is necessary to remember that the ship actually had to be directed closer to a wind because of the considerable drift of ancient vessels. Moreover, an error or an uncontrollable fall off the maneuver could end in catastrophe on leeward reefs. At the same time, moderate weather conditions would render this maneuver quite acceptable.

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[62] TILLEY, 1994; CASSON, 1995. P. 273, 464; ROBERTS, 1995; WACHSMANN, 1998. P. 253; WHITEWRIGHT, STARKEY, 2007; PALMER, 2009; WHITEWRIGHT, 2011.

[63] ROBERTS, 1995. P. 312–313. A figure of 70–80 degrees to the true wind seems more convincing See ARNAUD, 2012. P. 115.

[64] ROBERTS, 1995. P. 312.

Mooring of ships in the Great Harbor

Let us compare the dimensions of the three major harbors of Megas Limen with some of the largest Mediterranean ports of antiquity (Table 1) [65].

Port	Dimensions (м)	Water area (ha)	Wharfage length (m)
Pireus-Kantaros	1000×500	50	
Carthage	500×300	15	
Portus		234	c. 13 890
Caesarea Maritima		20	
Lepsis Magna		10,2	1200
Alexandria (total)		**>226**	**12 380**
Harbour 1 (Royal)	350×200	7	
Harbour 2	600×300	15	
Harbour 3 (Antirhodos)	550×400	16	

Table 1. Dimensions of the selected ancient ports

It has already been noted above that the Great Harbor must have been the most logical choice for the disposition of the navy in Greco-Roman times. Thus the water areas of the three harbors of Megas Limen, as well as the length of their piers, were quite sufficient for the mooring of the large fleet of both trade and military vessels. However, several ideas can be offered concerning the most probable site for a constant disposition of the navy.

Some part of the navy, probably elite military units and the king's personal fleet of luxury boats, could have been accommodated in the royal harbor (Figure 9, port N1). However, its modest size and extremely narrow entry passage did not satisfy the requirements for a permanent military port. Between the two other harbors, it is the second one (N2) that had an advantage of a single entry channel that was well under control. This conclusion is proved by the existence of an important breakwater at the northwestern tip of the peninsula. It seems that one of the objectives that was assigned to this 180-meters-long construction was to constrict the entry channel. To this effect, two walls and a small dike were discovered on the central reef on the other side of the channel [66]. These remains probably correspond to the structure responsible for closing the entry with a chain.

At the same time, the third harbor also could have been used from time to time for the disposition of the navy. This conclusion can be illustrated by the events of the Alexandrian War of 48–47 BC. According to Caesar, immediately after his arrival in the city, he was accommodated in the part of the royal palace that was joined by the theater that "*was attached to the house which took the place*

[65] Graaw, 1998; Schörle, 2011.

[66] Goddio, Darwish, 1998. P. 14

of a citadel, and had approaches to the port and to the other docks" (*Caes. Bel. civ*. 3.112) .[67] In this defensive position Caesar had been forced to burn his own fleet consisting of 50 large ships (quadriremes and quinqueremes) and 22 smaller ships (*Caes. Bel. civ*. 3.111). A portion of the vessels that he had burned was beached. Caesar had been surrounded and he did not have many soldiers, and thus both the port and the shipyards were probably not far away from Caesar's position (*Caes. Bel. civ.* 3.111). At the same time, the location of the theater is attested to by Strabo. He says that before the island of Antirhodos there was an artificial harbor and the theater was over it (*Strabo Geogr.* 17.1.9) [68]. Therefore, it can be suggested that the theater, which is mentioned more than once in the sources, was situated in the vicinity of the third harbor, and it may have been in this harbor that Caesar's fleet was moored and beached.

Here another question arises in connection with the storage of military ships during peacetime and in winter. Lead sheathing was used in antiquity as protection against shipworms and also for enhancing the watertightness of the hull of merchant ships. Thus, merchant ships could rest in the water during the whole period of navigation [69]. However, this was not true for military galleys lacking lead sheathing because of its weight and subsequent loss of speed [70]. The normal life for a seagoing ship, according to the sources, was around 20–26 years; this was achieved chiefly by regular beaching of the ships (ἀνέλκειν) and by keeping them in the shipsheds (νεώσοικοι) in winter [71]. Shipworm (*Teredo navalis*) could significantly decrease the lifetime of the ship. Apart from this, the ship's weight could increase by at least 15 percent as a result of a constant stay in the water [72]. Ancient naval commanders tried by all means to avoid this [73]. Therefore, the shipsheds that were usually incorporated in a standard naval base (τὰ νεώρια, *navalia*) must have existed in Alexandria.[74]

In his description of Alexandria, Strabo uses the word τὰ νεώρια twice (*Strabo Geogr.* 17.1.9–10). First he mentions shipyards in his description of the monuments near the third harbor. After that, while moving from east to west, he describes the temple of Caesar, then the emporium with the warehouses (ἀποστάσεις), and, finally, τὰ νεώρια extending to Heptastadium. According to him, there were shipyards in the port of Kibotos as well — that is, on the west-

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[67] Trans. PESKETT, 1996.

[68] Next he describes the position of the Posidium and Timonium. The submerged island of Antirhodos and the peninsula with the platform of Timonium were discovered during topographic surveys, and their position corresponds well with Strabo's description. See GODDIO, FABRE, 2010. P. 55.

[69] However, merchant ships were also sometimes hauled out inside the port. See BLACKMAN, 1995.

[70] STEINMAYER, MACINTOSH, 1996.

[71] MORRISON, 1996. P. 355–356.

[72] Tests carried out by the US Navy proved that wood infested with shipworm is destroyed within a period of 2–7 years. See STEINMAYER, MACINTOSH, 1996. P. 106.

[73] *Hdt*. 7.59.3; *Xen. Hell.* 1.5.10; *Thuc*. 7.12.3, 7.60–72; *Polib*. 1.51.7, 1.51.9.

[74] CASSON, 1995. P. 363–365.

ern side of Heptastadium. This is proved by the events of the Alexandrian War as Caesar's adversaries prepared their fleet in the inner part of the port of Eunostos (*Caes. b. Al*. 13). We have a rather precise idea of the position of the Caesareum thanks to the "Needles of Cleopatra," and thus it is possible to estimate the distance used by the emporium, the warehouses and the shipyards at approximately 1300 meters. To cite Strabo, the shipyards were "extending to Heptastadium"; therefore, they were long enough and occupied the major part of this space. It seems quite probable that the main shipsheds for winter storage of the ships might have been situated somewhere around here.

The shipsheds are best known from the Athenian port of Zea (Pireus) [75]. They were constructed to house the triremes and looked like stone slips partially cut in bedrock and partially constructed from blocks of the same local stone [76]. The slip for a ship was around 37 m long and 3 m wide, not counting its underwater part. The roof was supported by the columns that also served to hold the ship's hull on the slip [77].

According to Herodotus, the Greeks who were settled near the town of Bubastis in the Delta by the pharaoh of the 26th Dynasty, Psamtik I (664–610 BC), had the slips (ὁλκός) for their ships (*Hdt*. 2.154). Later, Necho II (610–595 BC) built slips for his war galleys on the coast of the Red Sea (*Hdt*., 2.159).

So-called places for drying (ψύκτραι) were discovered near Syracuse on Cyprus and on some islands in the Aegean.[78] They are represented by rows in the bedrock of parallel grooves that are 40–50 m long, 80–90 cm wide and 40–50 cm deep situated on shallow places, hidden from the waves. Obviously this is a simpler type of ship storage, but its application in Alexandria seems less probable as it does not correspond to the care of the Ptolemies in the creation of their navy. Alexandria stands on Pleistocene sandstone bedrock, and the construction of shipsheds of this type or another should not have presented any particular difficulties.

Unfortunately, until now no archaeological evidence has been found to prove the existence of the shipsheds in Alexandria. Although possible traces of the shipsheds must have been destroyed during the construction of the modern embankment, one can still hope to uncover some remains of facilities of this kind in the submerged part of the city in the western part of the Eastern Port.

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[75] The evidence for the shipsheds is exhaustive and includes remains from Rome, Carthage, Syracuse, Crete, Rhodes, Kos, Dor, Apollonia, Thurii, Oeniadae, Sunium and other harbor cities. See Blackman, 1982; Blackman, 1987; Blackman, 2003.

[76] Casson, 1995. P. 363–365.

[77] Coates, 2002.

[78] Auffray, 2002.

CONCLUSIONS

More than ten years of archaeological surveys of the Great Harbor of Alexandria have completely changed the conception of the ancient topography of the port area of the city. The remains of ancient port structures show the high level of the port's organization and correspond to the descriptions by ancient authors. This new archaeological data makes it possible to consider general aspects of navigation within the Great Harbor. The most probable courses of the ships calling at the Great Harbor and leaving it under sail or oars have been considered while taking into account ancient sources, hydro-meteorological factors and the performance of the rigging of the time. An important role of the alignments for the navigation within the harbor is underlined, and some possible reference points are proposed. In the absence of archaeological proof, some thoughts are developed on the probable disposition of the navy and on the location of the shipsheds for winter storage in Greco-Roman times.

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СУДОХОДСТВО В БОЛЬШОЙ ГАВАНИ АЛЕКСАНДРИИ В ГРЕКО-РИМСКИЙ ПЕРИОД

А. А. Белов обобщает результаты исследований, в том числе подводно-археологических, проводившихся в Александрии на протяжении последнего десятилетия, и сопоставляет их со сведениями, содержащимися в произведениях античных авторов. В статье описывается устройство Большой гавани, история порта, особенности организации его работы, рассматриваются климатические и иные факторы, которые повлияли на местонахождение гавани и маршруты судов.

Ключевые слова: Александрия, Ракотис, Большая гавань, судоходство, торговые и военные корабли, Фаросский маяк, подводно-археологические исследования, античные авторы.