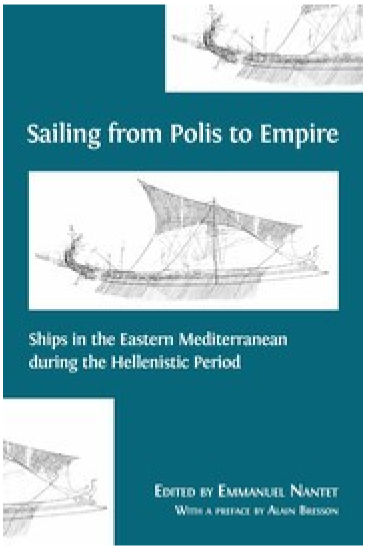
6. A Note on the Navigation Space of the Baris-Type Ships from Thonis-Heracleion

Belov, Alexander



Alexander Belov

Résumé

The available data on local boat-building techniques during the Late (664–332 BC) and Ptolemaic Periods (332–30 BC) of Ancient Egypt received a considerable boost from the more than sixty Ancient Egyptian ships that were found on the site of Thonis-Heracleion in 2000. Many of these ships seem to belong to the *baris*-type as described in Herodotus in his *Historia*. This chapter is an attempt to determine the space of navigation of these ships by examining the direct evidence derived from their construction, as well as indirect evidence drawn from the state of the ships' timbers and the results of reconstruction of their hulls, and of their propulsion and steering systems.

Texte intégral

- 1 Goddio 2007, 102–14.
- 2 For the latest information on Heracleion's topography see Goddio 2011; Fabre et al. 2013; Goddio et (...)
- 3 Term first proposed by Hirth (1978).
- 4 Yoyotte 2001; Fabre 2008.
- 5 Robinson and Goddio 2015.

1The site of Thonis-Heracleion is situated in the Bay of Abukir to the west of Alexandria, and it has been undergoing excavations by the European Institute for Underwater Archaeology (IEASM) since 1999.[1] The city had a rather complicated topography that abounded with peninsulas, canals and semi-enclosed areas of water. The passages between the sand dunes connected the coastal lagoon and the harbours of Heracleion with the Canopic branch of the Nile (Fig. 6.1).[2] The geographical situation of the city corresponds fairly well with the concept of a maritime gateway.[3] The city served as customs station for foreign ships going up the Nile and it was occupied already in the late eighth or early seventh century BC, though the second century BC was its golden age.4 In the Late Period the city controlled access to the Canopic branch of the Nile and was engaged in trade with Greece.5

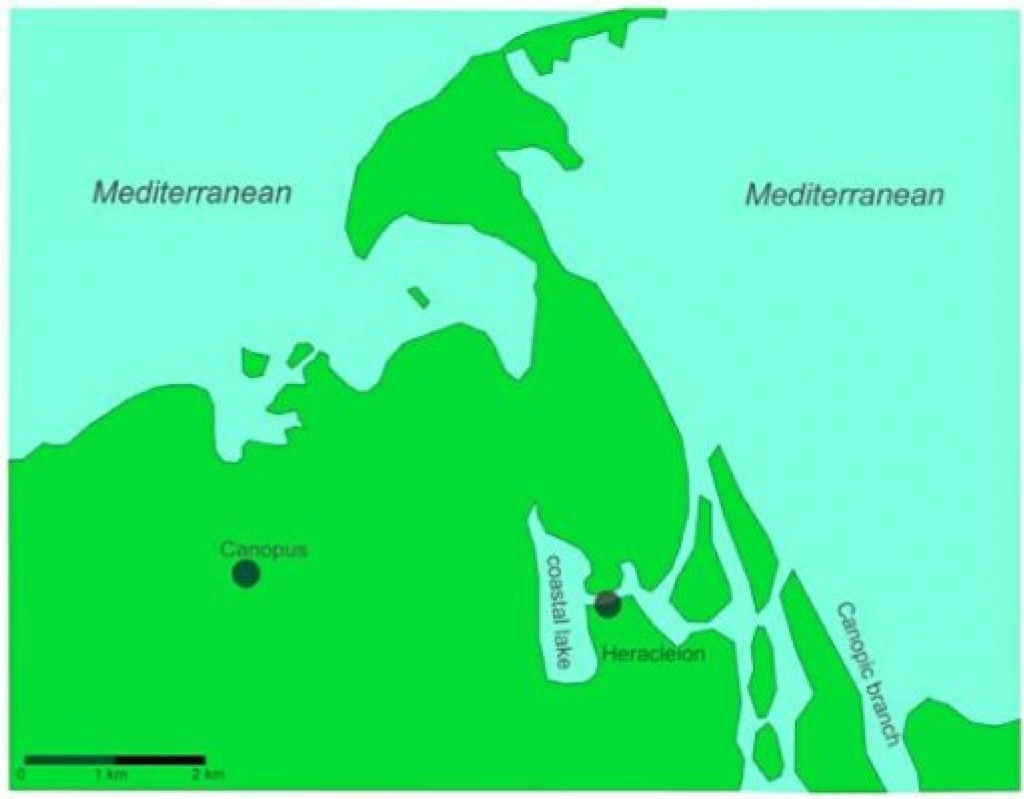


Figure 6.1 Simplified topography of the Canopic region (After Goddio 2007, 17, fig. 1.15.)

- 6 The actual number of ships probably exceeds one hundred. During the survey with a high-tech sub-bot (...)
- 7 Ships numbered 17, 43, 61 and 11.
- 8 Preliminary studies show that probably ships numbered 3, 8, 10, 17, 23, 43, 44, 45, 50, 51 and 63 b (...)
- 9 Belov 2014, 2015b, 2019.

2To this day, sixty-four shipwrecks have been discovered on the site of Thonis-Heracleion.6 Although only preliminary studies were carried out on the majority, several ships have been excavated.7 Numerous original features shared by many of these ships8 seem to bear witness to an archaeologically unattested constructional type, which finds parallels in Herodotus' description of a freighter (barge) called the *baris* (*Historiae* 2.96, c. 450 BC).9

6.1. Main Characteristics of the *Baris* as per Herodotus and New Archaeological Data

- 10 Casson 1971, 341, note 64.
- 11 Ibid.; Vinson 1994, 44–5; 1998, 252.
- 12 Ibid., 252–53.
- 13 Casson 1971, 340, note 60; 341, note 64; Vinson 1998, 254. Vinson cites two documents that might in (...)
- 14 Arnaud 2015b, 116.

3The Greek term *baris* (βᾶρις) probably originates in the Ancient Egyptian boat type called *br* (*byr*)10 that first appears in the Eighteenth Dynasty and refers to a sea-going craft.11 Demotic documents mentioning *br (byr)* are not numerous and contrary to hieroglyphic texts most of them probably refer to Nilotic cargo boats.12 Textual evidence from Greek papyri suggests that the *baris* was primarily a multipurpose freighter and transport vessel.13 Gradually replaced by other types, first of all probably by the *kerkouros*, the *baris* is last mentioned in the papyrus dated to 125 BC.14

- 15 Belov 2015a.

4The excavations of Ship 17 from Thonis-Heracleion helped to clarify several references from Herodotus' description that had previously been incomprehensible. Thus, the main features of the construction of the *baris* may be summarized in the following terms. The *baris* was a flat-bottomed freighter built from local acacias. A central keel-plank or a kind of proto-keel (Ship 17)15 did not project beneath the crescent-shaped hull. The planking of this ship consisted of short planks arranged like 'courses of bricks'. Long tenons reaching 2 m in length passed inside rectangular channels that were cut in the middle of the planks' edges, and were pegged to the planking at the extremities. At the same time, the tenons wedged the through-beams to the planking. The inner joints between the planks were sealed with papyrus. The boat was steered with an axial rudder that passed through an opening in the keel. The *baris* was a sailing ship, but according to Herodotus, it could only travel upstream with the help of a fresh breeze. Herodotus did not mention oars, and no traces of rowing arrangements were found on ships of this type from Heracleion. According to Herodotus, *barides* were built with quite a different carrying capacity and these ships were numerous on the Nile. Ship 17 would have been about 27–28 m long with a beam of 8 m that gives a length-to-width ratio of around 3: 4. The ship had a displacement of about 150 metric tonnes, a draft of 1.6 m and a tonnage of approximately 112 metric tonnes.

6.2. Navigation Area of the *Baris*-Type Ships

6.2.1. Written Sources

5As mentioned above, it seems that the term *baris* radically changed its meaning from the New Kingdom to the early Ptolemaic period, when, according to available documentation, the ship was primarily employed on the river. Thus, here again, the text of Herodotus, contemporary with the *baris*-type ships from Heracleion, appears to be the most important source for the current discussion.

- 16 Vinson 1998, 252.

6Herodotus' description of the *baris* comes sequentially after information on different aspects of life in the Delta, and it is logically linked to the description of Delta shipping in fragment 2.179.16 These observations give more weight to the arguments for the Delta origins of the *baris*, rather than an origin in the Nile valley.

- 17 Arnaud (2015a, 109) judiciously remarks that hauling is possible from a firm bank only, something d (...)
- 18 *Historiae* 2.96. A physical model developed during an interesting experiment carried out by Goyon in (...)
- 19 Cf. Casson 1965.

7According to Herodotus, the *baris* under sail could overpower the Nile's current only in case of a strong wind; otherwise, she was hauled from the bank.17 Herodotus also describes the original technique used by the Egyptians for steering the *baris* downstream with a help of a small raft and an anchor, their joint action straightening her course.18 Apparently the hauling of a ship upstream19 and a sophisticated technique for the descent both favoured the vessel's employment on the river.

8Book two of Herodotus contains another very important fragment related to this topic:

- 20 *Historiae* 2.179. Trans. Macaulay 1890. 'ἦν δὲ τὸ παλαιὸν μούνη Ναύκρατις ἐμπόριον καὶ ἄλλο οὐδὲν Αἰ (...)

> Now in old times Naucratis alone was an open trading- place, and no other place in Egypt: and if any one came to any other of the Nile mouths, he was compelled to swear that he came not thither of his own will, and when he had thus sworn his innocence he had to sail with his ship to the Canobic mouth, or if it were not possible to sail by reason of contrary winds, then he had to carry his cargo round the head of the Delta in boats ['*baris*' in the original text - AB] to Naucratis: thus highly was Naucratis privileged.20

9It is significant that Herodotus used different terms for the foreign seagoing vessel (ναῦς) and for the ships employed for local transportation (*baris*). This testimony confirms that the *barides* could operate beyond the Delta and thus belonged to a class of fluvio-maritime vessels. The following sections inquire whether this conclusion can be applied to the *barides* from Thonis-Heracleion.

6.2.2. Context of Ships from Thonis-Heracleion21

- 21 Different hypotheses regarding the origin of ships' accumulations (land reclamation or blockship ba (...)
- 22 Cataudella et al. 2015, 73, Table II. F. Goddio, personal communication.
- 23 Cooper 2011, 195; 2012, 61; 2012a.
- 24 See Robinson 2015, 213. Cooper (2012a, 26) cites the nineteenth-century sources according to which (...)

10It is important to underline the fact that the *baris* ships were quite numerous at Heracleion. It is still difficult to determine with precision the depth of the port facilities, but the coastal lagoons are quite shallow and usually about two to three meters deep. According to the recent Sediment Profile Imaging (SSPI) survey, the maximum depth in the ports of Heracleion did not exceed 4.5–5 m.22 Thus these ships with obviously shallow drafts were quite adapted to this environment. In addition, navigation on the Nile was highly seasonal23 and the smaller specimens of the *barides* seem to have been advantageous, as they could operate for a longer time than other types.24

- 25 See Nibbi 1991.
- 26 Calibrated date ^{14}C for wooden arms: 405 cal–208 cal BC. Dimensions: 75 x 50 x 18 cm.
- 27 Basch 1987, 66–67; Frost 1995. The destination of numerous huge anchors found in Heracleion could h (...)

11An interesting clue is offered by the anchors that were found in great numbers (more than 700) in the harbours of Heracleion. The anchors appear in different types but most of them are triangular stone composite anchors with two round front openings for wooden arms and one transverse opening for the cable.25 The majority of anchors are about 70–90 cm long and approaching a hundredweight. Some of these anchors were found on board the *barides* in a position relevant for mooring. This is certainly true in the case of Ship 43, which had a 100 kg anchor placed in vertical position at the bow.26 These anchors were probably handled with a help of tackles and a mast-derrick.27

- 28 Basch 1985, 1994; Zazzaro 2007, 2011; Zazzaro and Abd el-Maguid 2012; Tallet 2013, 2015.
- 29 Basch 1985, 457; 1994.

- 30 *mnit* or *ncyt* (Jones 1988, 198, n. 4, 199, n. 8).
- 31 *ḫrpw* (Jones 1988, 201, n. 12).
- 32 For more on the Ancient Egyptian iconography of mooring, see Doyle 1998, 220–35.
- 33 Frost 1970, 381.
- 34 Abd el-Maguid 2015.

12While there is a plenty of archaeological evidence of Ancient Egyptian anchors on board sea-going vessels,28 these were of no real use on the Nile.29 Instead, a wooden stake30 was driven into the muddy shore with a mallet,31 as shown by iconographical sources.32 Furthermore, there is no solid iconographical proof for the use of anchors on the Nilotic ships. However, it might have been that mooring techniques changed during the Late Period following the increase of maritime trade and fluvio-maritime traffic, for which the anchors were absolutely indispensable. Several 'elongated composite stone anchors'33 were discovered in a riverine environment in Egypt.34

- 35 Cooper 2012, 2012a.
- 36 *henet/hone* → T(hone) → Thonis. See Yoyotte 2001; 2013, 298–9, 307–8, 349–52. This specific geograph (...)
- 37 Goddio 2007, 111.
- 38 For more information about the geomorphology of coastal lagoons see Bird 1994. According to El-Wake (...)
- 39 Arnaud 2015b, 104–05.
- 40 Also known today as 'med mooring' or 'Tahitian mooring', this technique means that the vessel sets (...)
- 41 Ibid., 104.

13The Delta was a very particular region between the river and the sea, characterized by its unique navigational conditions and hazards35 caused by the varying geomorphology, geology, hydrology, and meteorology of this area. According to Yoyotte, the ancient name of the city — Thonis (Θῶνις in Ancient Greek sources) — originates in the indigenous name of the coastal lagoon (*henet/hone*) that existed there in Antiquity.36 The water of the lagoon was only slightly brackish and this is confirmed by numerous finds of the bones of Nile catfish (*Siluriformes*) and other fresh-water organisms.37 The sedimentology of a coastal lagoon is very different to that of a river and includes sediments ranging from coarse sand to silt and clay.38 Many hundreds of discoveries from Heracleion prove that this environment allowed regular employment of marine-type anchors. This is not surprising, taking into consideration the intense shipping and manoeuvring in the restricted harbour space, and the limited total length of wharfs. It seems that in the Ptolemaic period, the river was perceived as an extension of the sea.39 The structure of river administration followed the maritime model, as did mooring procedures in a *hormos*. These factors dictated the choice of the Mediterranean style of mooring40 and the employment of the marine variety of anchors that were also necessary for open mooring.41

14The acacia wood used as raw material, and many other features of indigenous shipbuilding, correspond well with etymological arguments and written sources testifying that the *baris* was undoubtedly a local type. These ships used anchors of a marine type as confirmed by Ship 43. However, this fact is not decisive as the anchors could have been used for mooring beyond the sandbar separating the estuary from the open sea, or only within its limits and in the harbours of Heracleion. In order to determine the navigational area of these ships, it is necessary to look closer at their construction.

6.2.3. Direct Evidence from Ships' Construction

- 42 Belov 2014.

- 43 Jones 1988, 164, n. 52.
- 44 Goedicke 1975, 95; Janssen 1975, 379.
- 45 Clark 1920, 49; Hornell 1943, 28.

15Many features of the *baris*-type ships indicate their river origins. The hull of the *baris* was constructed with very short planks. In the case of Ship 17, the average length of the planks was only 192 cm, while the segments of the proto-keel did not exceed 3 m in length.42 The proto-keel did not protrude, and that was an advantageous option for river navigation. The most ancient Egyptian term we know of referring to a keel or to a keel plank (*pipit*43) may mean a 'mud-kneader'.44 The same type of flat keel has been incorporated into the construction of the modern *nuggars* of the Upper Nile.45

- 46 Nilotic freighters *sekhet* and *satch* built by general Weni (*Wnj*) during the rule of Pepi I (Sixth Dy (...)

16All the elements of the ships' inner structure were characterized by a strong asymmetry and a roughness of execution. Thus, usually the beams were not horizontal, and were made of irregularly-shaped branches. All Ancient Egyptian sea-going vessels known from texts and from the archaeological record were built of imported wood, while the *barides* of Heracleion were built from local species of acacia which had been employed to construct river-faring boats since the Old Kingdom (2686–2160 BC).46

- 47 Timbers from Mersa Gawasis and Ayn Sukhna. See Ward and Zazzaro 2010; Pomey 2012a, 2012b. However, (...)
- 48 See Ward 2007; Pomey 2012a, 2012b.

17The joints of the planking of these ships were different from the double rows of the relatively small tenons and lashings mainly associated with the planking of Ancient Egyptian sea-going ships.47 Moreover, the tenons of the *baris* were pegged and that was never the case with the planking of sea-going ships, which employed free tenons to facilitate the assembly and disassembly of their hulls for transportation and storage.48 The vessels of Heracleion which have been studied so far were undecked.

18Thus, the constructional features of the *barides* seem to indicate that these ships were not really adapted for conditions on the open seas.

6.2.4. Reconstruction of the Hull: Supplementary Data

- 49 Belov 2019, chapter 3.1.
- 50 An iconographic parallel is provided by one of the ships depicted on the mosaic of Palestrina (c. 1 (...)
- 51 Belov 2015a, 206–07.

19The preliminary reconstruction of Ship 1749 suggests a crescent-shaped hull with considerable overhangs at both extremities.50 The overall length of the ship should have been about 27–28 m with a beam of 8 m. Its displacement was close to 150 tonnes, with a tonnage of about 113 tonnes.51 This was one of the largest *barides* known in Heracleion.

6.2.5. Longitudinal Structure

- 52 According to preliminary results of the modelling, this ratio was about 66 % in the case of Ship 17
- 53 Haldane 1993, 234–35; Vinson 1997.

- 54 A hogging truss was used in the construction of Egyptian sea-going ships at least until the New Kin (...)
- 55 J.-P. Olaberria 2015, personal communication. It seems that this function of the through-beams has (...)

20The short segments of the planking presented serious challenges for the longitudinal structure of the *baris*-type ships, as it seems that about only three-fifths of the overall length of their crescent-shaped hulls was supported by the water.[52] It is not yet clear how this problem was solved, although a bulwark might have played an important role in the longitudinal structure of Ancient Egyptian boats, to counterbalance the hogging of the hull.[53] No other means for maintaining the longitudinal strength of the hull have been discovered in the construction of the *barides*.[54] Hypothetically, the through-beams were capable of significantly reinforcing their longitudinal structure.[55]

6.2.6. Shallow Draft

- 56 Cooper (2012, 61) cites the late-nineteenth-century data according to which 'the Rashid mouth had a (...)

21Ship 17, being one of the largest specimens of the *baris* in Heracleion, would have a shallow draft of about 1.6 m that would have been a definite advantage for navigation on the river and within the shallow lagoons of the Delta, like those of Heracleion. The depth at the mouths of the Nile must have been inconsiderable too.[56]

- 57 Gaubert and Henein 2015.
- 58 Collet and Pomey 2015.
- 59 The dimensions of *lokkafa* of the lake Borollos described by Collet and Pomey has an overall length (...)
- 60 *BGU* 18.1 2740 dated to 87–86 BC. See Arnaud 2015a, 111.

22An interesting parallel is suggested by the Arab fishing boats of the Manzala[57] and Borollos[58] lakes. These boats, with a shallow draft, are perfectly adapted to traditional fishing inside a coastal lagoon.[59] The available documentation on a traditional ship from Lake Mareotis (*mariotike*)[60] does not contain any information about their construction, but these ships were probably shallow-draft as well.

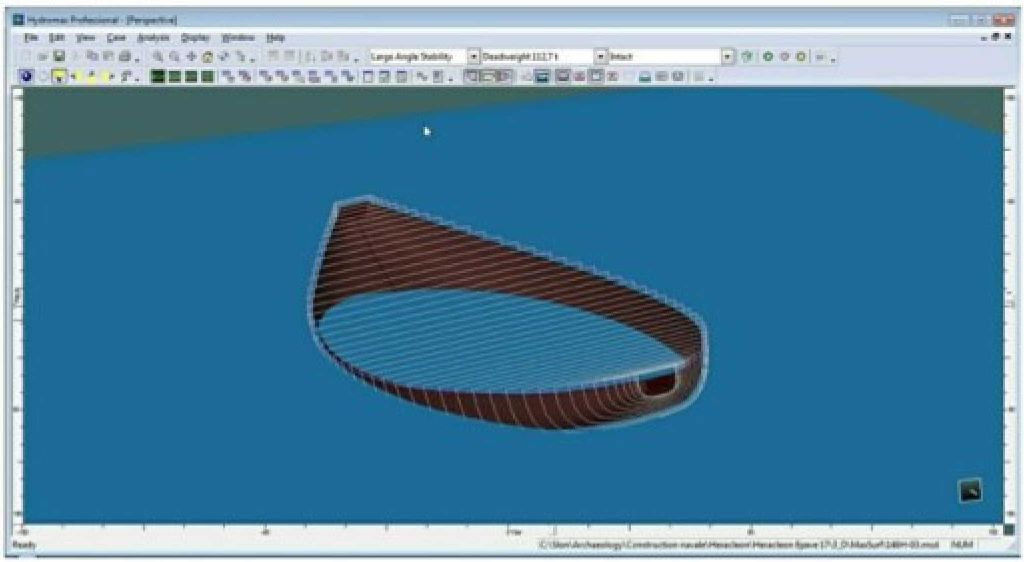


Figure 6.2 Starboard heel of 8 degrees of the hull of ship 17 from Thonis-Heracleion in *Formsys HydroMax*. Loadcase of 113 tons, freeboard of 0.64 m (A. Belov). CC BY 4.0.

6.2.7. Stability

- 61 In absence of a deck, this corresponds to the distance from the water to the upper edge of the hull
- 62 Difficulties of Nilotic navigation in medieval times are considered in works of Cooper 2008, 2011, (...)
- 63 See Cooper 2012, 61–62.
- 64 One of the ships represented on the Nile mosaic from Palestrina in Italy (ancient city of Praeneste (...)

23The estimated deadweight of Ship 17 of about 113 tonnes would have resulted in a free-board of 64 cm.61 The reconstruction of the hull suggests that the ship was very stable with the righting lever (GZ) being maximal at 57 degrees, but in reality the absence of a deck would not permit the heel to exceed 8 degrees (Fig. 6.2.). Apparently, this insufficient heel would only permit navigation on the Nile and in the estuary under good weather conditions.62 While modestly laden, the ship could probably sail along the coast, although, bearing in mind the strong currents and constant waves at the Nile's estuary,63 we can define the *barides* mentioned by Herodotus, in connection with the trans-shipment from the Eastern Delta, as decked vessels.64

- 65 Among recent publications: Arnaud 2015a, 106–08; 2015b, 8–10; Cooper 2012, 61–64; 2012a, 26; 2014, (...)

24The navigation on the Nile in Antiquity was highly seasonal,65 and therefore some of the voyages that would not be possible during the flood were possible during the period of low water, and *vice versa*.

6.2.8. Reconstruction of Steering and Propulsion Systems

- 66 Jones 1995, 39–40.
- 67 Pomey 2012b, 13; 2012c, 291.
- 68 A spare rudder was systematically included in the list of Ptolemaic affreightment contracts. Arnaud (...)

25The evidence for an axial rudder supports the conclusion that the ship's function was of a river or fluvio-maritime type. The first representations of the axial rudder in Egypt have been dated to the end of the Fifth (2494–2345 BC)66 or to the Sixth Dynasty (2345–2181 BC). This type of rudder was invariably characteristic of Nilotic ships. The boats of type II depicted on the rocks of Rod el-Air, which show parallels with the remains of the seagoing ships from Ayn Sukhna, are seemingly equipped with an axial rudder.67 However, Pomey notes that these boats were probably adapted to the sea while belonging to the Nilotic boat-building tradition, and that the navigation to the Sinai Peninsula would not have taken more than one day. Generally speaking, an axial rudder did not seem to be a good choice for a sea-going vessel.68

Figure 6.3 Mortise in the central segment K6 of the proto-keel of ship 17 viewed from above (Photo: C. Gerigk © Franck Goddio/Hilti Foundation).

- 69 Haldane 1996, 242.
- 70 Clarke 1920, 49: 'The stout beam or tree stem was to steady the short mast, which had a socket in t (...)
- 71 Goyon 1971, 22.
- 72 Cf Boreux 1925, 349.
- 73 Although the meteorology of the Delta was complicated and sometimes resulted in calms (Cooper 2012a (...)
- 74 Cf Casson 1965, 36–37, pl. 3, 5.

26The masts of Egyptians ships of the period under consideration were situated at the middle of the hull, a conclusion supported by the discovery of a mast-step notch 46 cm long, 13 cm wide and 5 cm deep within Ship 17 of Thonis-Heracleion (Fig. 6.3). Two large mortises in the central strake of the boat Mataria seem to correspond to the middle of the hull and to be related to the position of the mast.69 The construction of the boat of the Upper Nile *nuggar* may serve as an ethnographic parallel.70 It has been estimated that the relation between the height of the mast and the length of the hull in the majority of the Egyptian boats must have been close to 2: 3.71 If we accept this ratio, the height of the mast of Ship 17 of Thonis-Heracleion can be estimated at 17–18 m. Obviously, it would have been impossible to obtain a mast of this length from acacia wood, which, according to Herodotus, served as the raw material for its fabrication.72 Thus two hypotheses may be put forward: either the mast of the *baris* was considerably shorter than if obtained according to the above-mentioned ratio, or it was made from a different wood species. Taking into consideration the precision of Herodotus' descriptions so far, the initial hypothesis seems more convincing.73 In case the ship was unable to overcome the current, a mast must have been useful for attaching the tow line.74

Figure 6.4 Outer surface of ship 17's keel segment K6

(Photo: Author © Franck Goddio/Hilti Foundation).

6.2.9. The Particular Case of Ship 17 from Thonis-Heracleion

27The following arguments are based on evidence from Ship 17 only, and thus they cannot be conclusive. As we shall see, Ship 17 most likely never crossed the sandbar separating the estuary from the sea, but the information at our disposal is still too fragmentary to expand this conclusion on other *barides* from Heracleion.

6.2.10. Traces of Shipworms?

- 75 I would like to express my gratitude to Prof. David Blackman, who posed this question during the co (...)
- 76 *Teredo navalis* can temporarily tolerate salinity of 5 ‰. See Miller 1926, 17.

28No traces of shipworms were found on the outer surface of the keel, or on the planking of Ship 17 (Fig. 6.4), as in the case of the timbers of seagoing vessels from Mersa Gawasis and Ayn Sukhna.75 The shipworm *Teredo navalis* can thrive in brackish waters with a salinity as low as 9‰.76 It seems that Ship 17 was scuttled at the end of its economic life. Even if we forget about constructional limitations and suppose that she made regular sea voyages, this would inevitably result in at least partial infestation by shipworm.

- 77 Calculated for the period 1900 to 1959 (White, 1988).
- 78 Halim and Morcos 1995.
- 79 See charts in Hurst 1927, 447, Figs. 1–3.

29However, it is important to remember that the modern Nile with its regulated run-off radically differs from the ancient river. Thus, even after the construction of the Low Aswan Dam (1902–1933) the river carried approximately 84 km^3 of water in an average year.77 By 1969, the river had become almost completely auto-controlled and the volume of fresh water reaching the coastal zone dropped to 2.5–4 km^3 per year, in other words by twenty to thirty times less.78 During the peak of the flood the Nile's run-off was at least eight times higher than during the low water period.79 Only two of the Nile's branches remain today out of seven that existed during Herodotus' time. Without speculating about intricate paleoclimate models, it is sufficient to cite several modern salinity charts of the region. One can see that even today, the Nile considerably decreases the salinity of the surface layer in the vicinity of the Delta and this phenomenon must have been incomparably more pronounced in Antiquity (Fig. 6.5). It is difficult to calculate whether the salinity dropped to less than 9‰ and the scope of the resulting area of brackish water. This zone probably existed only when the Nile was flooding, and its area would have depended on the circulation pattern of the coastal waters. In conclusion, if ever Ship 17 crossed the sandbar separating the estuary from the coastal waters, she could have stayed there only for a limited period of time before being infested by shipworm.

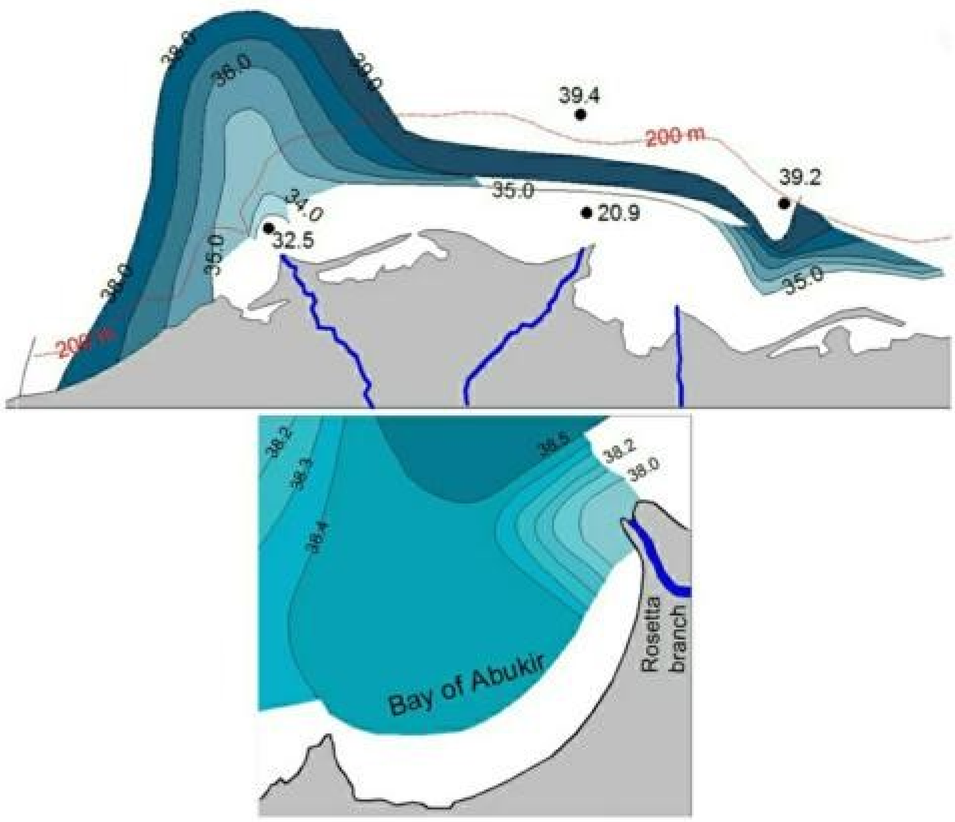


Figure 6.5 Salinity (‰) on the surface of the Mediterranean coast of Egypt in October 1982 and on the surface of the Bay of Abukir in March 1970 (Charts: Author, after Halim & Morcos 1995 [above] and El-Sharkawy & Sharaf el Din 1974 [below]).

6.2.11. Keel's Erosion?

30The outer surface of the keel and of the bottom planking of Ship 17 was not eroded at all, and thus there is a slight possibility that the boat was used in another environment than the Delta with its soft muddy banks.

6.3. Conclusions

- 80 For the association of this epithet — 'Les Portes de la Mer' — with Thonis see Yoyotte 1994, 683.
- 81 Yoyotte 1958, 427; 2001, 27.
- 82 Aramaic papyrus from Saqqara n. 26. Yoyotte 1994, 683; Briant and Descat 1998, 93–95.
- 83 Fabre and Goddio 2013, 70. Thonis-Heracleion is the most probable site of taxation for the ships me (...)

- 84 Westerdahl's theory (1992, 6–7) and its application to the mouths of the Nile is discussed by Coope (...)
- 85 Westerdahl 1998.
- 86 Boetto 2001, 2003, 2006, 2008.

31In the Late Period (664–332 BC), the city of Thonis-Heracleion, 'The Gates of the Sea',80 controlled access to Egypt, as well as supervising Greek ships in transit to Naucratis81 and Memphis;82 it therefore functioned as a customs station and *emporion*.83 The port commanded a strategic location at the mouth of one of the most important branches of the Ancient Nile, and perfectly fitted the category of a 'transit point' between 'transport zones' suggested by Westerdahl.84 The conditions of navigation radically changed at 'transit points', which are usually associated with market places, and this involved 'the reloading of cargo and the change of means of transport at a well-defined site [...] for an accompanying water or land transport in the new zone.'85 Flat-bottomed vessels from Ostia known as *naves caudicaria*, which were used for the trans-shipment of goods from the sea ports along the river Tiber, serve as a parallel (Fig. 6.6).86

Figure 6.6 Mosaic from the Square of Corporations in Ostia representing a scene of transshipment of goods from a sea-going vessel (right) to a riverine navis caudicaria (left) (Photo: I. Sailko, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=46365389).

- 87 Höckmann 2008–2009, 78–80, 82–83.
- 88 Pennigton and Thomas, in preparation; Thomas 2015.
- 89 Villing 2015, 231.
- 90 See note 79.
- 91 Thomas 2015, 253, Fig. 13.5.
- 92 Ibid., 252.
- 93 Tonnage: Steffy 1985, 100. Draft: Katzev 1981, 318.

32Höckmann argued that there had been regular trans-shipments of cargo from seagoing vessels to river-faring *barides* at Thonis-Heracleion.87 Villing expressed the opposite point of view; he relied on recent research,88 which suggested that the Canopic branch in Naucratis 'was wide and deep enough to accommodate Mediterranean seagoing ships all year round; trans-shipment at Thonis-Heracleion, as had sometimes been suspected, was thus not necessary'.89 It is difficult to agree with this conclusion. True enough, written sources90 are corroborated by several maritime finds from Naucratis.91 Thomas estimates the Canopic branch to be 5 m deep and circa 200 m wide near urban areas and concludes that ' [the] Canopic branch of the Nile was deep enough and navigable, likely all year round, for sea-going ships such as the Kyrenia'.92 However, we should note that the Kyrenia was a fourthcentury-BC Greek merchant ship of a very modest size. This 25-tonner's reconstructed length was about 13.86 m and she had a loaded draft of only 1.47 m.93 Apparently this ship would not have encountered serious problems in reaching Naucratis, even during the low-water season.

- 94 Nantet lists thirteen shipwrecks, with their deadweight tonnages and their loaded drafts. All of th (...)
- 95 Nantet 2016, 575–76. See also chapter 1 in this book.
- 96 Arnaud 2015b, 106–09, 112.

33Seagoing ships of considerable tonnage regularly came upriver to Naucratis, Memphis and even Thebes; thus, trans-shipment was not an obligation. Indeed, the loaded draft of the larger ships did not exceed the depth of the Canopic branch.94 Nantet shows that, in the Hellenistic period, large ships with tonnage exceeding 10,000 *artabs* (200–250 tonnes) and reaching as much as 18,000 *artabs* (about 400 tonnes), were numerous on the Nile.95 Arnaud notices that these ships, called *kerkouroi*, surely came from the sea and that they were more numerous in winter, from December to February, than during the high-water season.96 However, it is essential to remember that these ships operated from Alexandria and so did not need to enter the mouths of the Nile, a task that was sometimes difficult to do in earlier periods.

- 97 Morrison 1996, 345; Morrison et al. 2000, 156.

34The sources also tell us that military fleets were able to come upriver. One of the insurgencies during the first Persian domination (Twenty-seventh Dynasty, 525–404 BC) was supported by an Athenian fleet of 200 triremes that sailed up the Nile and seized the larger part of Memphis (Thucydides 1.104). This is not surprising, since these warships were relatively light and shallow-drafted. The replica of the Athenian trireme 'Olympias' had a draft of only 1.1 m.97

- 98 See note 80.
- 99 Höckmann, 110.
- 100 Briant and Descat 1998, 68. See also Nantet 2016, 575.
- 101 According to Wilson 2011 (39, note 27) 'ships of less than 75 tons were common throughout the Roman (...)

35Returning to the trade vessels of the Late Period, there is important evidence from the Persian era — the Ahiqar scroll98 — that contains a list of foreign ships that passed through an unnamed port on the Delta, most probably Thonis-Heracleion.99 There are two major groups of ships on the list: the 'small' ships had a tonnage of about 40 tonnes and the 'large' ones about 60 tonnes.100 Here again one is dealing with relatively small merchant ships that could easily come upriver on their own.101

- 102 Arnaud 2015b, 116.

36As far as the *barides* of Thonis-Heracleion were concerned, their construction strongly indicates a river origin of this type, which probably had a fluvio-maritime designation.102 If the assumption of the hull's form from Ship 17 is correct, they were well-adapted to navigation within the estuary but were not particularly seaworthy.

- 103 Robinson 2015, 222, 291, note 51.

37It has been suggested that these ships could have belonged to the temple fleet.103 Several possibilities can be proposed for their use: either they were involved in the trans-shipment of goods from the larger seagoing vessels that could not enter Thonis-Heracleion because of their considerable draft, or they transported goods from Heracleion up the river, or, finally, both. The absence of a deck would have been a definite advantage for rapid trans-shipment.

- 104 Cf Höckmann 2008–2009, 83; Villing 2015, 231.
- 105 Cooper 2012a, 26. 'The warming land often generated land breezes that cancelled out the prevailing (...)

38In my opinion, the question of trans-shipment at Heracleion is not as unambiguous as it is sometimes assumed to be.104 There are too many parameters involved for us to be certain: the tonnage of the ship, the nature of her cargo, seasonality and meteorological conditions, etc. Some of the seagoing ships continued their journey upriver on their own while others needed trans-shipment to the river-faring craft. It was only the question of tonnage and draft: as evidenced by Herodotus (2.179, see above) it was sometimes difficult to navigate around the Delta due to the contrary winds. On the other hand, the Delta often had calm waters, and that could also have necessitated trans-shipment.105

Bibliographie

Bibliography

Literary Sources

Achilles Tatius, *Leucippe and Clitophon*.

Diodorus Siculus, *Bibliotheca Historica*.

Heliodorus, *Aethiopica*.

Herodotus, *Historiae*.

Thucydides, *History of the Peloponnesian War*.

Secondary Sources

Abd el-Maguid, M. 2015. 'An Elongated Composite Stone Anchor from Matariya.' In *Alexandria Under the Mediterranean. Archaeological Studies in Memory of Honor Frost*, edited by G. Soukiassian, 125–36. Etudes Alexandrines 36. Alexandria: Centre d'Études Alexandrines.

Arnaud, P. 2012. 'La mer, vecteur des mobilités grecques.' In *Mobilités grecques*, edited by L. Capdetrey, 89–135. Scripta Antiqua 46. Bordeaux: Ausonius.

Arnaud, P. 2015a. 'Navires et navigation commerciale sur la mer et sur le "Grand fleuve" à l'époque des Ptolémées.' In *Entre Nil et mers. La navigation en Égypte ancienne*, edited by B. Argémi and P. Tallet, 105–122. *Nehet* 3

Arnaud, P. 2015b. 'La batellerie de fret nilotique d'après la documentation papyrologique (300 av. J.-C.–400 apr. J.-C.).' In *La batellerie Egyptienne. Archéologie, histoire, ethnographie*, edited by P. Pomey, 99–150. Études Alexandrines 34. Paris: Centre d'Études Alexandrines.

Basch, L. 1985. 'Anchors in Egypt.' *Mariners Mirroir* 71: 453–67.

Basch, L. 1987. *Le musée imaginaire de la marine antique*. Athens: Institut Hellénique pour la Préservation de la Tradition Nautique.

Basch, L. 1994. 'Some Remarks on the Use of Stone Anchors and Pierced Stones in Egypt.' *International Journal of Nautical Archaeology* 23 (3): 219–27.

Belov, A. 2014. 'ANew Type of Construction Evidenced by Ship 17 of Heracleion-Thonis.' *International Journal of Nautical Archaeology* 43 (2): 314–29. https://doi.org/10.1111/1095-9270.12060

Belov, A. 2015a. 'Did Ancient Egyptian Ships have Keels? The Evidence of Thonis-Heracleion Ship 17.' *International Journal of Nautical Archaeology* 44 (1): 74–80. https://doi.org/10.1111/1095-9270.12078

Belov, A. 2015b. 'Archaeological Evidence for the Egyptian *baris* (Herodotus, II.96).' In *Thonis-Heracleion in Context: The Maritime Economy of the Egyptian Late Period*, edited by D. Robinson and F. Goddio, 195–210. Oxford Center for Maritime Archaeology Monographs 8. Oxford: Oxford Center for Maritime Archaeology.

Belov, A. 2019. 'Ship 17: A Late Period Egyptian Ship from Thonis-Heracleion.' In *Oxford Centre for Maritime Archaeology Monograph 10*. Oxford: Oxford Centre for Maritime Archaeology.

Bird, E. C. F. 1994. 'Physical Setting and Geomorphology of Coastal Lagoons.' In *Coastal Lagoon Processes*, edited by B. Kjerfve, 9–39. Elsevier Oceanography Series 60. Amsterdam, London, New York and Tokyo: Elsevier.

Boreux, C. 1925. *Etudes de nautique égyptienne: l'art de la navigation en Egypte jusqu'à la fin de l'ancien Empire*. Cairo: Institut français d'archéologie orientale.

Casson, L. 1965. 'Harbour and River Boats of Ancient Rome.' *Journal of Roman Studies* 55: 31–9.

Casson, L. 1971. *Ships and Seamanship in Ancient World*. Princeton: Princeton University Press.

Cataudella, S., D. Crosetti, and F. Massa, eds. 2015. *Mediterranean Coastal Lagoons. Sustainable Management and Interactions among Aquaculture, Capture Fisheries and the Environment*, *Studies and Reviews* 95. Rome: Food and Agriculture Organization of the United Nations. General Fisheries Commission for the Mediterranean.

Clarke, S. 1920. 'Nile Boats and Other Matters.' *Ancient Egypt*, 2–50.

Collet, R., and P. Pomey. 2015. 'Les voiles de Borollos.' In *La batellerie Egyptienne. Archéologie, histoire, ethnographie*, edited by P. Pomey, 299–314. Etudes Alexandrines 34. Paris: Centre d'Études Alexandrines.

Cooper, J. P. 2008. 'The Medieval Nile: Route, Navigation and Landscape in Islamic Egypt.' PhD diss., University of Southampton.

Cooper, J.P. 2011. 'No Easy Option: Nile Versus Red Sea in Ancient and Medieval North-South Navigation.' In *Maritime Technology in the Ancient Economy: Ship-Design and Navigation*, edited by W. V. Harris and K. Iara, 189–210. *Journal of Roman Archaeology* Suppl 84.

Cooper, J. P. 2012. ''Fear God; Fear the Bogaze': The Nile Mouths and the Navigational Landscape of the Medieval Nile Delta, Egypt.'*Al-Masaq: Islam and the Medieval Mediterranean* 24 (1): 53–73. https://doi.org/10.1080/09503110.2012.655584

Cooper, J. P. 2012a. 'Nile Navigation: Towing All Day, Punting for Hours.' *Egyptian Archaeology* 41: 25–27.

Cooper, J. P. 2014. *The Medieval Nile: Route, Navigation, and Landscape in Islamic Egypt*. Cairo: The American University in Cairo Press. https://doi.org/10.5743/cairo

/9789774166143.001.0001

Darnell, J. C. 1992. 'The Kbn.wt vessels of the Late Period.' In *Life in a Multicultural Society: Egypt from Cambyses to Constantine and Beyond*, edited by J. H. Johnson, 67–89. Studies in Ancient Oriental Civilization 51. Chicago: Oriental Institute of the University of Chicago.

Doyle, N. 1998. 'Iconography and Interpretation of Ancient Egyptian Watercraft.' M.A. diss., Texas A & M University.

El-Sharkawy, S. H., and S. H. Sharaf el Din. 1974. 'Hydrographic Structure and Circulation Pattern of Abu Kir Bay Near Alexandria, Egypt.' *Bulletin of the Institute of Oceanography and Fisheries, Egypt* 4: 461–71.

El-Wakeel, S. K., and S. D. Wahby. 1970. 'Bottom Sediments of Lake Manzalah, Egypt: Notes.' *Journal of Sedimentary Petrology* 40 (1): 480–96.

Fabre, D. 2008. 'Heracleion-Thonis: Customs Station and Emporion.' In *Egypt's Sunken Treasures. Catalogue of the Exhibition in Madrid*, edited by F. Goddio and M. Clauss, 219–25. Munich, Berlin, London and New York: Prestel.

Fabre, D. 2015. 'The Ships of Thonis-Heracleion in Context.' In *Thonis-Heracleion in Context: The Maritime Economy of the Egyptian Late Period*, edited by D. Robinson and F. Goddio, 175–94. Oxford: Oxford Center for Maritime Archaeology.

Fabre, D. and Belov, A. 2012. 'The Shipwrecks of Heracleion-Thonis: An Overview.' In *Achievements and Problems of Modern Egyptology. Proceedings of the International Conference*. 29 September–4 October 2009, Moscow, edited by G. A. Belova, 107–18. Moscow: Russian Academy of Sciences.

Fabre, D. and F. Goddio. 2013. 'Thonis-Heracleion, Emporion of Egypt, Recent Discoveries and Research Perspectives: The Shipwrecks.' *Journal of Ancient Egyptian Interconnections* 5 (1): 68–75.

Frost, H. 1970. 'Bronze Age Stone Anchors from the Eastern Mediterranean.' *The Mariner's Mirror* 56: 377–94.

Frost, H. 1985. 'The Kition Anchors.' In *Kition V: The Pre-Phoenician Levels*, edited by V. Karageorghis and M. Demas, 295–306. Nicosia: Department of Antiquities.

Frost, H. 1995. 'Where Did Bronze Age Ships Keep their Stone Anchors?' In *TROPIS III. 3nd International Symposium on Ship Construction in Antiquity. Proceedings*, edited by H. Tzalas, 225–29. Athens: Hellenic Institute for the Preservation of Nautical Tradition.

Gaubert, C., and N. H. Henein. 2015. 'Le bateau du lac Manzala.' In *La batellerie Egyptienne. Archéologie, histoire, ethnographie*, edited by P. Pomey, 285–98. Etudes Alexandrines 34. Alexandrie, Centre d'Études Alexandrines.

Goedicke, H. 1975. *The Report of Wenamun*. Baltimore and London: Johns Hopkins University Press.

Goddio, F. 2007. *The Topography and the Excavation of Heracleion-Thonis and East Canopus (1996–2006). Vol. 1, Underwater Archaeology in the Canopic Region in Egypt*. Oxford: Oxford University Press for the British Academy.

Goddio, F. 2011. 'Heracleion-Thonis and Alexandria, Two Ancient Egyptian Emporia.' In *Maritime Archaeology and Ancient Trade in the Mediterranean*, edited by D. Robinson, 121–38. Oxford Center for Maritime Archaeology Monograph 6. Oxford: Oxford Center for Maritime Archaeology.

Goddio, F., D. Robinson, and D. Fabre. 2015. 'The Life-cycle of the Harbour of Thonis-Heracleion: The Interaction of the Environment, Politics and Trading Networks on the Maritime Space of Egypt's Northwestern Delta.' In *Harbours and Maritime Networks as Complex Adaptive Systems*, edited by J. Preiser-Kapeller and F. Daim, 25–39. Mainz: Verlag des Römisch-Germanischen Zentralmuseums.

Goddio, F. 2015. 'The Sacred Topography of Thonis-Heracleion.' In *Thonis-Heracleion in Context: The Maritime Economy of the Egyptian Late Period*, edited by D. Robinson and F. Goddio, 15–54. Oxford: Oxford Center for Maritime Archaeology.

Goyon, G. 1971. 'Les navires de transport de la chaussée monumentale d'Ounas.' *Bulletin de l'institut français d'archéologie orientale* 69: 11–41.

Haldane, C. W. 1993. 'Ancient Egyptian Hull Construction.' PhD diss., Texas A&M.

Haldane, C. W. 1996. 'Ancient Egyptian Hull Construction.' In *TROPIS IV. Proceedings of the 4th International Symposium on Ship Construction in Antiquity*, edited by H. Tzalas. Athens.

Halim, Y., and S. A. Morcos. 1995. 'The Impact of the Nile and the Suez Canal on the Living Marine Resources of the Egyptian Mediterranean Waters (1958–1986).' In *Effects of Riverine Inputs on Coastal Ecosystems and Fisheries Resources*. FAO Fisheries Technical Paper, 19–50. Rome: Food and Agriculture Organization of the United Nations.

Hirth, K.G. 1978. 'Interregional Trade and the Formation of Prehistoric Gateway Communities.' *American Antiquity* 43: 35–45.

Höckmann, O. 2008–2009. 'Griechischer Seeverkehr mit dem archaischen Naukratis in Agypten.' *Talanta* 40–41: 73–135.

Hornell, J. 1943. 'The Sailing Ship in Ancient Egypt.' *Antiquity* 17: 27–41.

Hurst, H. E. 1927. 'Progress in the Study of the Hydrology of the Nile in the Last Twenty Years.' *The Geographical Journal* 70 (5): 440–58.

Janssen, J. 1975. *Commodity Prices from the Ramesside Period*. Leiden: E. J. Brill.

Jones, D. 1988. *A Glossary of Ancient Egyptian Nautical Titles and Terms*. London & New York: Kegan Paul International.

Jones, D. 1995. *Egyptian Bookshelf: Boats*. London: British Museum.

Katzev, M. L. 1981. 'The Reconstruction of the Kyrenia Ship, 1972–1975.' *National Geographic Society Research Reports* 13: 315–28.

Le Père, J. M. 1822. 'Mémoire sur le canal.' In *Description de l'Égypte: ou, Recueil des observations et des recherches qui ont été faites en Egypte pendant l'expédition de l'armée française, publié par les ordres de Sa Majesté l'empereur Napoléon le Grand*, edited by J. Jollios, 236–39. Paris: Imprimerie Impériale.

Macaulay, G. C. 1890. *The History of Herodotus*. London: Macmillan.

Miller, R. C. 1926. 'Ecological Relations of Marine Wood-Boring Organisms in San Francisco Bay.' *Ecology* 7 (3): 247–54.

Morrison, J. S. 1996. *Greek and Roman Oared Warships 399–30 BC*. Oxford: Oxbow Books.

Morrison, J. S., J. F. Coates, and N. B. Rankov. 2000. *The Athenian Trireme. The*

History and Reconstruction of an Ancient Greek Warship. 2nd ed. Cambridge: Cambridge University Press.

Nantet, E. 2016. *Phortia. Le tonnage des navires de commerce en Méditerranée du VIIIe siècle av. l'ère chrétienne au VIIe siècle de l'ère chrétienne*. Rennes: Presses Universitaires de Rennes.

Nibbi, A. 1991. 'Five Stone Anchors from Alexandria.' *International Journal of Nautical Archaeology and Underwater Exploration* 20: 185–94.

Pennington, B., and I. R. Thomas. In preparation. 'Palaeo-Landscape Reconstruction at Naukratis and the Canopic Branch of the Nile.'

Pomey, P. 2012a. 'Ship Remains at Ayn Soukhna.' In *The Red Sea in Pharaonic Times: Recent Discoveries Along the Red Sea Coast. Proceedings of the Colloquium Held in Cairo/Ayn Sukhna 11–12 January 2009*, edited by P. Tallet, 235–44. Cairo: Institut Français d'Archéologie Orientale.

Pomey, P. 2012b. 'The Pharaonic Ship Remains of Ayn Sukhna.' In *Between Continents: Proceedings of the Twelfth Symposium on Boat and Ship Archaeology* (ISBSA 12 — Istanbul 2009), edited by N. Günsenin: 7–15. Istanbul: Ege Yayınları.

Pomey, P. 2012c. 'Les graffiti navals de la zone minière du Sud-Sinaï (Rod al-Air, Gebel al-Hazbar, Ouadi Shella/Ouadi Boudra).' In *La zone minière pharaonique du Sud-Sinaï- I. Catalogue complémentaire des inscriptions du Sinaï*, edited by P. Tallet. MIFAO 130. Cairo: Institut Français d'Archéologie Orientale.

Pomey, P. 2015. 'La batellerie nilotique gréco-romaine d'après la mosaïque de Palestrina.' *La batellerie Egyptienne. Archéologie, histoire, ethnographie*, edited by P. Pomey 151–73. Alexandria: Centre d'Études Alexandrines.

Porten, B., and A. Yardeni. 1993. *Textbook of Aramaic Documents from Ancient Egypt. 3. Literature, Accounts, Lists*. Jerusalem: Hebrew University.

Robinson, D., and F. Goddio, eds. 2015. *Thonis-Heracleion in Context: The Maritime Economy of the Egyptian Late Period*. Oxford Centre for Maritime Archaeology 8. Oxford: Oxford Centre for Maritime Archaeology.

Robinson, D. 2015. 'Ship 43 and the Formation of the Ship Graveyard in the Central Basin at Thonis-Heracleion.' In *Thonis-Heracleion in Context: The Maritime Economy of the Egyptian Late Period* edited by D. Robinson and F. Goddio, 211–27. Oxford: Oxford Center for Maritime Archaeology.

Robinson, D. 2018. 'The Depositional Contexts of the Ships from Thonis-Heracleion, Egypt.' *International Journal of Nautical Archaeology* 47 (2): 325–36, https://doi.org/10.1111/1095-9270.12321

Rogers, E. M. 1996. 'An Analysis of Tomb Reliefs Depicting Boat Construction from the Old Kingdom Period in Egypt.' PhD diss., Texas A & M University.

Somaglino, C. 2015. 'La navigation sur le Nil. Quelques réflexions autour de l'ouvrage de J. P. Cooper, The Medieval Nile. Route, Navigation, and Landscape in Islamic Egypt, Le Caire — New York, 2014.' In *Entre Nil et mers. La navigation en Égypte ancienne*, edited by B. Argémi and P. Tallet, 123–61. *Nehet* 3. Paris: Centre de recherches égyptologiques de la Sorbonne.

Steffy, J. R. 1985. 'The Kyrenia Ship: An Interim Report on its Hull Construction.' *American Journal of Archaeology* 89 (1): 71–101.

Tallet, P. 2013. 'The Wadi el-Jarf site: A Harbor of Khufu on the Red Sea.' *Journal of*

Ancient Egyptian Interconnections 5 (1): 76–84.

Tallet, P. 2015. 'Les 'ports intermittents' de la mer Rouge à l'époque pharaonique: caractéristiques et chronologie.' In *Entre Nil et mers. La navigation en Égypte ancienne*, edited by B. Argémi and P. Tallet, 31–72. *Nehet* 3. Paris: Centre de recherches égyptologiques de la Sorbonne.

Thomas, I. R. 2015. 'Naukratis, "Mistress of ships", In Context.' In *Thonis-Heracleion in Context: The Maritime Economy of the Egyptian Late Period*, edited by D. Robinson and F. Goddio, 247–65. Oxford Centre for Maritime Archaeology, Monograph 8. Oxford: Oxford Centre for Maritime Archaeology.

Thompson, D. 1983. 'Nile Grain Transports under the Ptolemies.' In *Trade in the Ancient Economy*, edited by P. Garnsey, K. Hopkins, and C.R. Whittaker, 64–75. Berkeley and Los Angeles: University of California Press.

Tzalas, H. 1999. 'Were the Pyramidal Stone-Weights of Zea Used as Anchors?' In *TROPIS V — 5th International Symposium on Ship Construction in Antiquity*, edited by H. Tzalas, 429–54. Athens: Hellenic Institute for the Preservation of Nautical Tradition.

Villing, A. 2015. 'Egyptian-Greek Exchange in the Late Period: The View from Nokradj-Naukratis.' In *Thonis-Heracleion in Context: The Maritime Economy of the Egyptian Late Period*, edited by D. Robinson and F. Goddio. Oxford: Oxford Center for Maritime Archaeology.

Vinson, S. 1994. *Egyptian Boats and Ships*. Buckinghamshire: Shire Publications.

Vinson, S. 1997. 'On *hry.t* 'Bulwark', in P. Anastasi IV, 7/9–8/7.' *Zeitschriff fur Agyptische Sprache* 124 (2): 156–62.

Vinson, S. 1998. 'Remarks on Herodotus' Description of Egyptian Boat Construction (II, 96).' *Studien zur Altägyptischen Kultur* 26: 251–60.

Ward, C. 2004. 'Boatbuilding in Ancient Egypt.' In *The Philosophy of Shipbuilding. Conceptual Approaches to the Study of Wooden Ships*, edited by F. Hocker and C. Ward, 12–24. College Station: Texas A & M University Press.

Ward., C. 2007. 'Ship-Timbers: Description and Preliminary Analysis.' In *Harbor of the Pharaohs to the Land of Punt*, edited by K. A. Bard, 135–50. Naples: Università degli Studi di Napoli 'L'Orientale.'

Ward, C., and Zazzaro, C. 2010. 'Evidence for Pharaonic Seagoing Ships at Mersa/Wadi Gawasis, Egypt.' *International Journal of Nautical Archaeology* 39 (1): 27–44. https://doi.org/10.1111/j.1095-9270.2009.00229.x

Wehausen, J. V. 1988. 'The Colossi of Memnon and Egyptian Barges.'*International Journal of Nautical Archaeology and Underwater Exploration* 17 (4): 295–310.

Westerdahl, C. 1992. 'The Maritime Cultural Landscape.' *International Journal of Nautical Archaeology and Underwater Exploration* 21 (1): 5–14.

Westerdahl, C. 1998. 'The Maritime Cultural Landscape: On the Concept of the Traditional Zones of Transport Geography.' https://www.abc.se/m10354/publ/cult-land.htm

Wilson, A. 2011. 'Developments in Mediterranean Shipping and Maritime Trade from the Hellenistic Period to AD 1000.' In *Maritime Archaeology and Ancient Trade in the Mediterranean*, edited by D. Robinson, 33–60. Oxford Center for Maritime Archaeology Monograph 6. Oxford: Oxford Centre for Maritime Archaeology.

White, G. F. 1988. 'The Environmental Effects of the High Dam at Aswan.' *Environment* 30: 5–40.

Yoyotte, J. 1958. 'Notes de toponymie égyptienne.'In *Festschrift zum 80. Geburtstag von Professor Dr. Hermann Junker, Mitteilungen des Deutschen Archäologischen Instituts, Abteilung Kairo* 16: 414–30. Wiesbaden: Otto Harrassowitz.

Yoyotte, J. 1994. 'Les contacts entre Egyptiens et Grecs (VIeI–IIe s. av.J.-C.): Naucratis, ville égyptienne.' *Annuaire du Collège de France. Résumé des cours et travaux* (1992–1993, 1993–1994): 679–92.

Yoyotte, J. 2001. 'Le second affichage du décret de l'an 2 de Nekhtnebef et la découverte de Thônis-Héracleion.' *Egypte, Afrique & Orient* 24: 24–34.

Yoyotte, J. 2013. *Histoire, géographie et religion de l'Egypte ancienne: Opera Selecta*. Leuven: Peeters Publishers.

Zazzaro, C. 2007. 'Ship Blades, Anchors and Pierced Stones.' In *Harbour of the Pharaohs to the Land of Punt*, edited by K.A. Bard and and R. Fattovich, 150– 60. Naples: Università di Napoli 'L'Orientale'.

Zazzaro, C. 2011. 'Les ancres de Mersa Gawasis.' *Egypte, Afrique & Orient* 64 (2): 13–20.

Zazzaro, C., and M. Abd el-Maguid. 2012. 'Ancient Egyptian Stone Anchors from Mersa Gawasis.' In *The Red Sea in Pharaonic Times: Recent Discoveries along the Red Sea Coast. Proceedings of the Colloquium held in Cairo/Ayn Sukhna 11–12 January 2009*, edited. by P. Tallet, 87–103. BIFAO 155. Cairo: IFAO.

Notes

1 Goddio 2007, 102–14.

2 For the latest information on Heracleion's topography see Goddio 2011; Fabre et al. 2013; Goddio et al. 2015; Goddio 2015.

3 Term first proposed by Hirth (1978).

4 Yoyotte 2001; Fabre 2008.

5 Robinson and Goddio 2015.

6 The actual number of ships probably exceeds one hundred. During the survey with a high-tech sub-bottom profiler in autumn 2016, many dozens more were discovered, some of them five meters under the clay (F. Goddio, personal communication). These ships are remarkably well preserved. For the origins of this vast assemblage of ancient vessels, see Robinson 2018.

7 Ships numbered 17, 43, 61 and 11.

8 Preliminary studies show that probably ships numbered 3, 8, 10, 17, 23, 43, 44, 45, 50, 51 and 63 belong to a *baris* type. In this author's opinion, that may well be the case for the majority of ships preserved on the site of Thonis-Heracleion.

9 Belov 2014, 2015b, 2019.

10 Casson 1971, 341, note 64.

11 Ibid.; Vinson 1994, 44–5; 1998, 252.

12 Ibid., 252–53.

13 Casson 1971, 340, note 60; 341, note 64; Vinson 1998, 254. Vinson cites two documents that might indicate a military use for *br* ships (Vinson 1998, 253). According to line 12 of the Rosetta Stone (196 BC) the defensive fleet of Ptolemy V contained νῆες (ships) in the Greek text that correspond to the hieroglyphic *kbn.wt* and to the Demotic *byry*. Darnell (1992, 72–73, notes 21 and 54) suggests a parallel between these ships and those employed by Rameses III (1184–1153 BC) to defend the Delta against the Sea Peoples. Another example is the Roman *P. Krall* 14/8 mentioning *br* ships as part of a naval fleet. In papyrus *W.Chr*. 11 A (123 BC) a *baris* transports soldiers (See Arnaud 2015b, 116). The employment of freighters during a war for purposes such as transporting the troops or as auxiliary fighting units is quite obvious and does not require further comment.

14 Arnaud 2015b, 116.

15 Belov 2015a.

16 Vinson 1998, 252.

17 Arnaud (2015a, 109) judiciously remarks that hauling is possible from a firm bank only, something difficult to achieve on a river with an ever-changing hydrological regime.

18 *Historiae* 2.96. A physical model developed during an interesting experiment carried out by Goyon in collaboration with the Central Hydraulic Laboratory of France proved the efficiency of the technique described by Herodotus. See Goyon 1971, 38–41, annex 1. Mathematical manipulations proposed in a subsequent publication by Wehausen et al. (1988) fully confirm the results of the modelling.

19 Cf. Casson 1965.

20 *Historiae* 2.179. Trans. Macaulay 1890. 'ἦν δὲ τὸ παλαιὸν μούνη Ναύκρατις ἐμπόριον καὶ ἄλλο οὐδὲν Αἰγύπτου· εἰ δέ τις ἐς τῶν τι ἄλλο στομάτων τοῦ Νείλου ἀπίκοιτο, χρῆν ὀμόσαι μὴ μὲν ἑκόντα ἐλθεῖν, ἀπομόσαντα δὲ τῇ νηὶ αὐτῇ πλέειν ἐς τὸ Κανωβικόν· ἢ εἰ μή γε οἷά τε εἴη πρὸς ἀνέμους ἀντίους πλέειν, τὰ φορτία ἔδεε περιάγειν ἐν βάρισι περὶ τὸ Δέλτα, μέχρι οὗ ἀπίκοιτο ἐς Ναύκρατιν. οὕτω μὲν δὴ Ναύκρατις ἐτετίμητο.' Herodotus does not mention Thonis. The hypothesis dealing with this omission can be found in Höckmann 2008–2009, 115, 124.

21 Different hypotheses regarding the origin of ships' accumulations (land reclamation or blockship barrier) may be found in Robinson 2015. Cultural, socio-economic and geopolitical contexts are considered in Fabre 2015.

22 Cataudella et al. 2015, 73, Table II. F. Goddio, personal communication.

23 Cooper 2011, 195; 2012, 61; 2012a.

24 See Robinson 2015, 213. Cooper (2012a, 26) cites the nineteenth-century sources according to which the ships with deadweight of 60 tonnes were not able to navigate in the Delta during five months of the year.

25 See Nibbi 1991.

26 Calibrated date ^{14}C for wooden arms: 405 cal–208 cal BC. Dimensions: 75 x 50 x 18 cm.

27 Basch 1987, 66–67; Frost 1995. The destination of numerous huge anchors found in Heracleion could have been different. For example, the largest among two anchors found at the bows of Ship 51 (?) weights 630 kg (!) (calibrated date ^{14}C for wooden

arms: 396 cal–198 cal BC. Dimensions: Anchor 1 — 106 x 80 x 26 cm; Anchor 2 — 154 x 94 x 30 cm). The hull of this ship was only partially preserved but several parameters of its planking indicate that the length of the ship did not exceed 20–25 m, so it was not of extraordinary size. Thus, it might have been that the largest anchors of Heracleion were used as mooring anchors. This idea was introduced by several members of the jury for my PhD thesis on 31 January 2014 (P. Arnaud, P. Pomey, F. Goddio). The same hypothesis had already been proposed for the pyramidal stone anchors from Zea (see Tzalas 1999). Bronze Age stone anchors weighing 850 and even 1350 kg were found in Kition (see Frost 1985).

28 Basch 1985, 1994; Zazzaro 2007, 2011; Zazzaro and Abd el-Maguid 2012; Tallet 2013, 2015.

29 Basch 1985, 457; 1994.

30 *mnit* or *ncyt* (Jones 1988, 198, n. 4, 199, n. 8).

31 *ḫrpw* (Jones 1988, 201, n. 12).

32 For more on the Ancient Egyptian iconography of mooring, see Doyle 1998, 220–35.

33 Frost 1970, 381.

34 Abd el-Maguid 2015.

35 Cooper 2012, 2012a.

36 *henet/hone* → T(hone) → Thonis. See Yoyotte 2001; 2013, 298–9, 307–8, 349–52. This specific geography is described in classical sources: Heliodorus, *Aethiopica* 5; Achilles Tatius, *Leucippe and Clitophon* 4.12.7–8; Diodorus Siculus, *Bibliotheca Historica* 1.31.2–5. For discussion see Fabre 2015, 180–84.

37 Goddio 2007, 111.

38 For more information about the geomorphology of coastal lagoons see Bird 1994. According to El-Wakeel and Wahby (1970) 'the predominant type of sediment covering the bottom of the lake [Manzalah — A.B.] is the complex type sand-silt-clay followed in abundance by the clayey sand and silty clay. There is a basinward increase in grain size of sediments.'

39 Arnaud 2015b, 104–05.

40 Also known today as 'med mooring' or 'Tahitian mooring', this technique means that the vessel sets a temporary anchor off the pier and then approaches it at a perpendicular angle. The vessel then runs two lines to the pier.

41 Ibid., 104.

42 Belov 2014.

43 Jones 1988, 164, n. 52.

44 Goedicke 1975, 95; Janssen 1975, 379.

45 Clark 1920, 49; Hornell 1943, 28.

46 Nilotic freighters *sekhet* and *satch* built by general Weni (*Wnj*) during the rule of Pepi I (Sixth Dynasty, 2345–2181 BC). According to the text they were 32 m long. Together with tamarisk, acacia wood was identified as the construction material of the freighter boats from Lisht (Middle Kingdom, c. 1950 BC). See Ward 2004, 15.

Traditional boats of the Upper Nile are still built of *Acacia nilotica* (See note 29). Acacia also dominates as the constructional material for the ships of Thonis-Heracleion. Preliminary xylological analysis showed that, among 63 shipwrecks, about 80 % have planking made of acacia. See Fabre and Belov 2012, 109–10. Ship 17 of Thonis-Heracleion was entirely built of acacia. See Belov 2014.

47 Timbers from Mersa Gawasis and Ayn Sukhna. See Ward and Zazzaro 2010; Pomey 2012a, 2012b. However, double rows of mortises were equally attested in planks from Lisht that belonged to a river-going freighter. See Haldane 1993, 237.

48 See Ward 2007; Pomey 2012a, 2012b.

49 Belov 2019, chapter 3.1.

50 An iconographic parallel is provided by one of the ships depicted on the mosaic of Palestrina (c. 125 BC), which was recently identified as a *baris* by Pomey (2015, 164–66).

51 Belov 2015a, 206–07.

52 According to preliminary results of the modelling, this ratio was about 66 % in the case of Ship 17.

53 Haldane 1993, 234–35; Vinson 1997.

54 A hogging truss was used in the construction of Egyptian sea-going ships at least until the New Kingdom (exemplified by the sea-going vessels of the Punt expedition launched by Queen Hatshepsut, Eighteenth Dynasty, 1473–1458 BC). However, there is no evidence that a hogging truss was employed on ships from Heracleion. On the other hand it remains a possibility that a rope truss was employed during the *constructional* phase to pre-stress the hull against the hogging. Although this element disappears from the iconographic record after the Old Kingdom, Egyptians probably continued to use it for larger vessels (see Rogers 1996, 99–104). Ship 17 had a kind of proto-keel that protruded inside the hull (see Belov 2015a) but as it was composed of short segments, it could hardly increase the longitudinal stiffness of the hull to any great degree.

55 J.-P. Olaberria 2015, personal communication. It seems that this function of the through-beams has not yet become the subject of a detailed study.

56 Cooper (2012, 61) cites the late-nineteenth-century data according to which ‘the Rashid mouth had a maximum draught of 2.1 m, and the Dumyāt mouth just 1.8 m, compared with 6 m just upstream’.

57 Gaubert and Henein 2015.

58 Collet and Pomey 2015.

59 The dimensions of *lokkafa* of the lake Borollos described by Collet and Pomey has an overall length of 14.5 m, a beam of 5.5 m and a shallow draft of 0.6 m. The boat carries a lateen sail with a windage of 130 m^2. The average depth of the lake is 1–1.5 m and rarely reaches 2 m.

60 *BGU* 18.1 2740 dated to 87–86 BC. See Arnaud 2015a, 111.

61 In absence of a deck, this corresponds to the distance from the water to the upper edge of the hull.

62 Difficulties of Nilotic navigation in medieval times are considered in works of Cooper 2008, 2011, 2012, 2012a, 2014 and are corroborated by Ancient Egyptian

sources (see Somaglino 2015). Arnaud (2015b, 104, note 14) cites Roman and Late Roman Nilotic contracts with clauses forbidding to navigate at night and in bad weather. Diodorus Siculus (*Bibliotheca Historica* 1.31.2–5) describes the danger of approaching the low coast of Egypt. One should not underestimate complicated navigation in the so-called *boghâz* of which there exist following description left by one of the participants of Napoleon's expedition (1798–1801): 'In Egypt the narrow and perilous straits between the branches of the Nile and the sea are called *boghâz*. These straits are closed by the sands that accumulate due to the confrontation of the high seas with the current of the river. These sandbanks vary depending on the seasons and the winds, so that those bars that are ordinarily found in the mouths of the Nile often change their position, and require the mariners to seek the services of a pilot, who could indicate to them a passage or a channel in the mouth of the river; but this continual surveillance of a pilot is not always sufficient to prevent accidents.' Le Père 1822, 236.

63 See Cooper 2012, 61–62.

64 One of the ships represented on the Nile mosaic from Palestrina in Italy (ancient city of Praeneste) dated to c. 125 BC was recently identified as an example of the *baris* type (Pomey 2015, 164–66). This ship had a large cabin aft of the mast and was probably decked.

65 Among recent publications: Arnaud 2015a, 106–08; 2015b, 8–10; Cooper 2012, 61–64; 2012a, 26; 2014, chapter 7; Somaglino 2015, 127–37.

66 Jones 1995, 39–40.

67 Pomey 2012b, 13; 2012c, 291.

68 A spare rudder was systematically included in the list of Ptolemaic affreightment contracts. Arnaud 2012, 95–96. Fabre (2015, 184, note 47) provides interesting parallels with the axial rudders of the junks.

69 Haldane 1996, 242.

70 Clarke 1920, 49: 'The stout beam or tree stem was to steady the short mast, which had a socket in the keel and a strap or other form of stay to secure it to the beam.'

71 Goyon 1971, 22.

72 Cf Boreux 1925, 349.

73 Although the meteorology of the Delta was complicated and sometimes resulted in calms (Cooper 2012a, 26), the wind was often favourable for vessels going upriver. According to Arnaud (2015b, 107) the period from December to February was a good time for large ships to sail upstream. The words of Herodotus that a *baris* could not sail upstream unless with a *fresh breeze* may be a slight hint concerning the height of the mast. A short mast would permit hoisting a sail of modest size only and this could explain the difficulty of the ship sailing upstream while being heavily loaded and beating against the strong current.

74 Cf Casson 1965, 36–37, pl. 3, 5.

75 I would like to express my gratitude to Prof. David Blackman, who posed this question during the conference 'Heracleion in context' in Oxford in March 2013.

76 *Teredo navalis* can temporarily tolerate salinity of 5 ‰. See Miller 1926, 17.

77 Calculated for the period 1900 to 1959 (White, 1988).

78 Halim and Morcos 1995.

79 See charts in Hurst 1927, 447, Figs. 1–3.

80 For the association of this epithet — 'Les Portes de la Mer' — with Thonis see Yoyotte 1994, 683.

81 Yoyotte 1958, 427; 2001, 27.

82 Aramaic papyrus from Saqqara n. 26. Yoyotte 1994, 683; Briant and Descat 1998, 93–95.

83 Fabre and Goddio 2013, 70. Thonis-Heracleion is the most probable site of taxation for the ships mentioned on the Papyrus palimpsest from Elephantine (Ahiqar scroll, TAD C 3.7, 473–402 BC). See Briant and Descat 1998, 92. The papyrus contains customs registers belonging to thirty-six Ionian and Phoenician ships that came to Egypt in the period from March to December. See Porten and Yardeni 1993.

84 Westerdahl's theory (1992, 6–7) and its application to the mouths of the Nile is discussed by Cooper (2012, 70–71).

85 Westerdahl 1998.

86 Boetto 2001, 2003, 2006, 2008.

87 Höckmann 2008–2009, 78–80, 82–83.

88 Pennigton and Thomas, in preparation; Thomas 2015.

89 Villing 2015, 231.

90 See note 79.

91 Thomas 2015, 253, Fig. 13.5.

92 Ibid., 252.

93 Tonnage: Steffy 1985, 100. Draft: Katzev 1981, 318.

94 Nantet lists thirteen shipwrecks, with their deadweight tonnages and their loaded drafts. All of them could have sailed on the Canopic branch. Even the Madrague de Giens shipwreck, with a deadweight tonnage of 402.5 tonnes and a loaded draft of 3.75 m, could have sailed there. Nantet 2016, 226, Table 47.

95 Nantet 2016, 575–76. See also chapter 1 in this book.

96 Arnaud 2015b, 106–09, 112.

97 Morrison 1996, 345; Morrison et al. 2000, 156.

98 See note 80.

99 Höckmann, 110.

100 Briant and Descat 1998, 68. See also Nantet 2016, 575.

101 According to Wilson 2011 (39, note 27) 'ships of less than 75 tons were common throughout the Roman period as they were before and afterwards' [the long ton of 1016 kg is used — AB].

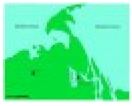
102 Arnaud 2015b, 116.

103 Robinson 2015, 222, 291, note 51.

104 Cf Höckmann 2008–2009, 83; Villing 2015, 231.

105 Cooper 2012a, 26. 'The warming land often generated land breezes that cancelled out the prevailing northwesterlies blowing in off the Mediterranean Sea, resulting in frequent calms that left Nile boats facing a strong current with no supporting wind. Even when the sea breezes broke through, Delta channels were not always oriented in a way that enabled navigators to take advantage of them. The combined result of all these factors was hard labour for Nile navigators.'

Table des illustrations

	**Légende**	Figure 6.1 Simplified topography of the Canopic region (After Goddio 2007, 17, fig. 1.15.)
	URL	http://books.openedition.org/obp/docannexe/image/14399/img-1.jpg
	Fichier	image/jpeg, 17k
	**Légende**	Figure 6.2 Starboard heel of 8 degrees of the hull of ship 17 from Thonis-Heracleion in *Formsys HydroMax*. Loadcase of 113 tons, freeboard of 0.64 m (A. Belov). CC BY 4.0.
	URL	http://books.openedition.org/obp/docannexe/image/14399/img-2.jpg
	Fichier	image/jpeg, 24k
	**Légende**	Figure 6.3 Mortise in the central segment K6 of the proto-keel of ship 17 viewed from above (Photo: C. Gerigk © Franck Goddio/Hilti Foundation).
	URL	http://books.openedition.org/obp/docannexe/image/14399/img-3.jpg
	Fichier	image/jpeg, 22k
	**Légende**	Figure 6.4 Outer surface of ship 17's keel segment K6
	Crédits	(Photo: Author © Franck Goddio/Hilti Foundation).
	URL	http://books.openedition.org/obp/docannexe/image/14399/img-4.jpg
	Fichier	image/jpeg, 25k
	**Légende**	Figure 6.5 Salinity (‰) on the surface of the Mediterranean coast of Egypt in October 1982 and on the surface of the Bay of Abukir in March 1970 (Charts: Author, after Halim & Morcos 1995 [above] and El-Sharkawy & Sharaf el Din 1974 [below]).
	URL	http://books.openedition.org/obp/docannexe/image/14399/img-5.jpg
	Fichier	image/jpeg, 20k
	**Légende**	Figure 6.6 Mosaic from the Square of Corporations in Ostia representing a scene of transshipment of goods from a sea-going vessel (right) to a riverine navis caudicaria (left)

		(Photo: I. Sailko, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=46365389).
	URL	http://books.openedition.org/obp/docannexe/image/14399/img-6.jpg
	Fichier	image/jpeg, 59k

Auteur

Centre for Egyptological Studies of the Russian Academy of Sciences, Moscow.