

# *The Earliest Maritime Voyaging in the Mediterranean: View from Sea\**

**Archaeology gives us proofs of prehistoric people's presence on islands and seacoasts; natural sciences give us information on the conditions of early maritime voyaging. The concrete designs of the earliest vessels from before the third millennium BC are still unknown. We can hypothetically list the possible concepts or we can create model solutions. Two experimental voyages in dug-out canoes called the Monoxylon Expeditions took place in the Mediterranean in 1995 and 1998. We do not need to presume that dug-out canoes were the only type of vessel used, but we can presume that they are the vessel most suitable due to their characteristics. The aim of this article is to take a look at the finds in the Mediterranean from the eras of Mesolithic/Epipalaeolithic and Pre-Pottery Neolithic (PPN)/Neolithic utilising experience from the mentioned voyages. Such approach could be called 'view from sea'. It uses results of a hands-on approach to view new facts or views concerning the earliest maritime voyaging.**

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The results of the Monoxylon Expeditions (see **boxes 1–4**) got into specialised literature selectively and with delay (Broodbank 2006, 209; Zilhão 2014, 187–188; Vigne 2013; Howitt-Marshall – Runnels 2016). They were more extensively used only by Jean-Denis Vigne (Vigne 2014; Vigne et al. 2013). Even the more often used results (Broodbank 2006; Farr 2010; Ammerman 2010; Sampson 2014; McGrail 2010)

of an attempt with a papyrus ship (Tzalas 1989; 1995) deserve more attention.

The hypothesis on the importance of dug-out boats for the earliest maritime voyaging in the Mediterranean (Tichý 1992; 1994) was based on the evidence of woods on the Mediterranean coast (Butzer 1970), the find of a dug-out boat on the former sea coast in Northern Europe (Andersen 1986), and the tradition of longboats, probably made from wood, at the beginning of the Bronze Age in the Eastern Mediterranean (Broodbank 1989) and evidence of polished stone axes in the Neolithic. The find of the Neolithic dug-out canoe in the Bracciano lake (Fugazzola Delpino – Mineo 1995; Fugazzola Delpino 1995) possibly used to transport obsidian from the Lipari Islands makes the hypothesis more probable. The possible use of dug-out boats in earliest maritime voyaging is an alternative to the hypothesis of reed boats use to carry obsidian suggested by Harry Tzalas (1989; 1995). In the context of ground-breaking finds of Late Dryas gatherers (Ammerman 2010; 2011; 2013; 2014) and farmers from PPN A and PPN B (Vigne et al 2013; Vigne 2013) in Cyprus, possible contacts of Mesolithic populations in the Aegean Sea (Sampson 2014; Efstratiou 2013) and 'pioneering' settlements with 'maritime knowledge package' on the west coast of Turkey (Horejs et al. 2015) the question becomes topical: Is it possible to relate reed boats only to gatherers and dug-out boat to farmers? Is a reed boat suitable for the transport needs of farmers? It is necessary, especially with important discussions on the character of cargo (Zilhão 2014; Vigne et al. 2013) to respect technological possibilities of gatherers and farmers to build one or other type of boat. Seán McGrail (2010, 104, Tab. 8.1) suggests that a plank boat could not have been built before the arrival of Neolithic technologies. Similarly, the

building of a dug-out boat needs polished stone axes or at least large knapped axes. Fire is not enough to shape a large boat. The current finds presume contemporality of gatherers and farmers which leads to the appearance of a view (Nowicki 2014, 48) that there was no obvious functional difference between the types of vessels in Mesolithic/Epipalaeolithic and Neolithic. Comparison of their characteristics is therefore very important. The views presented here or in earlier works (Tichý 2000; 2001) do not push the dug-out boat as the only or prevalent type. They can be considered as a type that lead to the tradition of wooden boats in the Mediterranean. That means that tradition which was basis for the later maritime developments.

## *What was the Earliest Maritime Voyaging*

The categorisation of islands in the Aegean Sea created by Cyprian Broodbank (1999) suggests that this region was suitable for early maritime voyaging because of the islands configuration. Maritime travel started in the eastern Mediterranean during the cold climate of late Dryas, when the gatherers inhabited Cyprus (Broodbank 2006; Ammerman 2010; 2013). It is possible that people reacted intensively as in Levant where they switched to agriculture or extensively with sea voyages looking for sources on new coasts (Ammerman 2010, 88). On the Greek mainland and Aegean Islands there is little evidence of farming earlier than 9000 years ago (Ammerman 2013, 9). From the seventh millennium BC many stylistic and technological parallels of material culture reminds us that Greece was colonised via maritime processes coming from Levant and the southern Turkish coast (Perlès 2001; 2005). On the Aegean Islands the Mesolithic settlements from the eighth millennium BC using sheep husbandry were identified.

\*Dedicated to Harry Tzalas, not just for his brave deed

The sheep had to be transported there via Cyprus from Levant (Sampson 2014). The presence of pigs on these islands is also mentioned as they are not indigenous (Efstratiou 2013, 209–210).

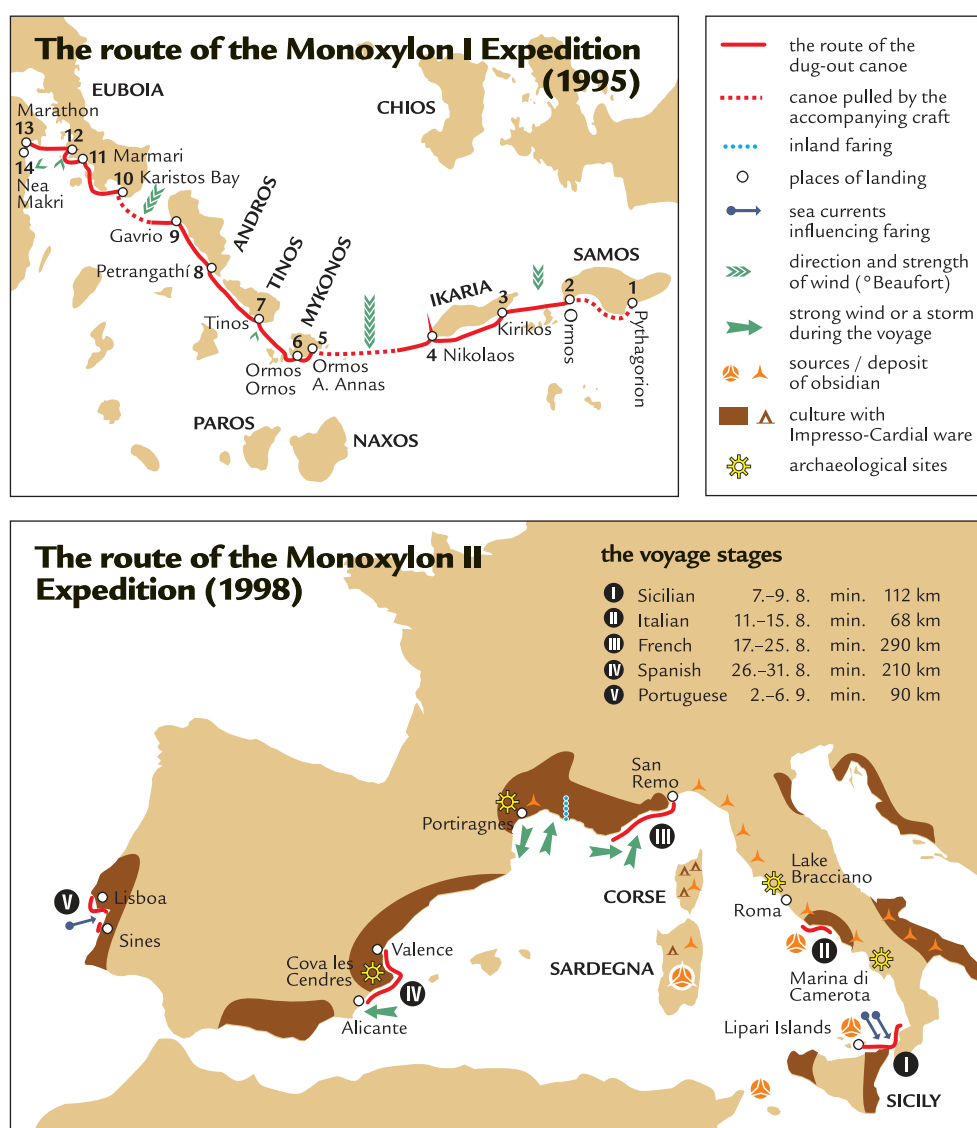
The Neolithic is the era of the most intensive island colonisation (Farr 2010, 184). The analysis of the Mediterranean islands showed that in the Neolithic they preferred to colonise islands visible from the mainland. In the Pre-Neolithic the more remote islands were visited for raw materials and in the Bronze Age for trade. In the earliest maritime voyaging the distances of up to 50 km were easily attainable (Dawson 2010, 205, 210). How does that fit with the development of vessels? It is possible that even in the Neolithic a voyage of 100 km was risky and therefore used only to get to the sources of obsidian (although even here it was possible to cut the distances by using chains of islands as stepping stones). The common distance in colonisation of islands and coasts was 60 km, that means a day long trip with live cargo. It is possible that the difference in the use of navigation between the eastern and western Mediterranean was social. The east had more developed hierarchy and greater population density (Zilhão 2014, 196), it could be characterised by stronger pressure to realise maritime voyages even without obvious innovations in vessels construction.

C. Broodbank (2010, 250) lists the changes in the Late Dryas as first maritime revolution, with the second only in the third millennium BC. The period between 5500 to 3500 BC he considers a period without changes. That does not mean that a development of a dug-out boat (or any other vessel) stopped for such a long time. Just the opposite, the above mentioned evidence of longboat depictions in the Early Bronze Age (Broodbank 1989, 327; 2000, 98, Fig. 23) shows that development of a long and slim ship continued. A dug-out boat, documented for very early periods by finds in North Greece (Marangou 1997; 2001) and especially Slovenia (Erić 1993–1994), could be a base for construction of a future vessel. It is possible that because of the lack of large trees they started

to use planks (Broodbank 2010, 253) either to heighten the sides of the dug log or to develop a truly plank boat.

There is other evidence that the vessels from the Epipaleolithic/Mesolithic/Neolithic periods could have been simple and that crossing distances was difficult. Albert J. Ammerman (2011) pointed out the 'paradox' between the speed of agricultural colonisation of Cyprus and Southern Italy. The colonisation of Southern Italy followed some 2000 years later, that would mean speed 0.75 km in a year. Why is the spread of agriculture to Crete so slow (about 1000 years later than Cyprus)? And from Crete to the mainland? Is it truly the low speed of vessels, which, based on the circulation of obsidian, carried out voyages 60 to

100 km long? Not even the spread of obsidian supports the idea of long distance voyages. Obsidian from Melos did not travel to Italy, obsidian from the sources in the Tyrrhenian Sea is not found in Greece or in the Aegean. The percentage of obsidian decreases with distance from source, which would suggest only short voyages (Ammerman 2014, 218). The speed of agriculture spreading from Southern Italy to Portugal though increased. From Central Italy it took only just above six generations to Portugal, that means an average speed of 5 to 10 km per year (Zilhão 2001). The reason for the speed increase could be the fact (apart from those named by Zilhão 2001) that in the Western Mediterranean Neolithic culture could spread via coastal voyaging along its Northern coast.



■ Fig. 1 The route of Monoxyton I Expedition and the route of Monoxyton II Expedition.



■ Fig. 2 Three meters of the dug-out canoe were made with a stone axe.

### Recent experimental maritime voyages

The experimental voyages of the two basic types of vessels – the Expedition Papyrella in 1988 and the Expeditions Monoxyton in years 1995 and 1998 (Fig. 1) are helpful in assessment of earliest maritime voyaging. The aim of all the expeditions was to test the given vessel in the conditions they would have been used in and to find out their navigational capabilities including transport capacity. We would like to compare the conditions and results because views have been presented that the maritime conditions in the Aegean Sea did not allow for a use of canoe while Papyrella of a suitable size would have been more effective (Sampson 2014, 68). Or a simple statement that early vessels were made from reed (Farr 2010, 183).

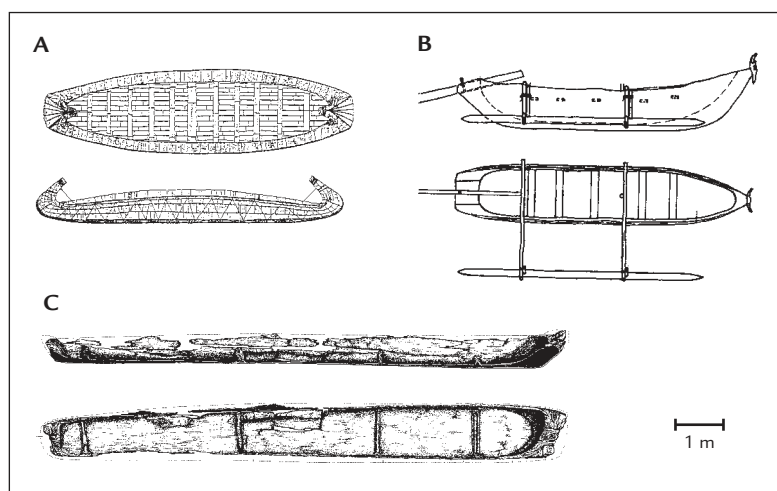
The hypotheses of all expeditions were formulated given geographical region (till recently small vessels of both types were used in coastal navigation), way of life of people in the Epipaleolithic/Mesolithic (Papyrella) and the Neolithic (Monoxyton), climatic conditions and tool possibilities (Fig. 2). H. Tzalas (1995, 442) states that the limits of stone tools available would have prevented the making of wooden vessels in the Mesolithic.

The important parameter for comparing is the size (length) of all vessels (Fig. 3). The comparison of length of the vessels Papyrella (5.48 m) and Monoxyton I (6.2 m) did not show much difference but Monoxyton II with 9.2m length was on average faster (4 km/h) than Papyrella (3 km/h). The width of the

Monoxytons was 1.2 m, while that of the Papyrella was 1.5 m (Tzalas 1995, 447). H. Tzalas (1995, 453) though states that in future it would be better to make the outside bundles of reed thinner so they do not decrease the vessel speed. He presumes that larger vessels were needed in the Neolithic due to a greater demand for transport (Tzalas 1995, 454). If we want to utilise the oldest clear depictions of vessel in the Aegean Sea from the Early Bronze Age (Broodbank 1989, 327; 2000, 98, Fig. 23) for design comparison there is a noticeable difference in size of a small boat from Naxos with a human figure and a quadruped and longboats. These longboats have angular bows reminiscent of wooden boats and

suggesting a trend which then prevailed.

During all expeditions the vessels were propelled by paddles, H. Tzalas (1995, 447) does not presume a sail for this period because of the technological limits of that time. At the beginning of Expedition Monoxyton I a simple sail for following/side wind was used (Fig. 4) but it was not useful for the dug-out canoe. It decreased the stability of the vessel and because of the wind's direction it could not be used to propel the boat. The crews of all expeditions were physically prepared, the crew members could keep regular paddling rhythm for long hours. At lower speed the vessel was



■ Fig. 3 Comparison of the vessels of Papyrella Expedition 1988 (A), Monoxyton Expedition 1995 (B) and the dug-out canoe from the lake Bracciano (C).



■ Fig. 4 Under sail near Tinos at the beginning of the expedition in 1995.

more difficult to steer. The Greek expedition found, thanks to measuring output of specialised sportsmen, that they used only just over 50 % of physical capacity (*Tzalas 1995*, 454). A question is how much it would be possible to increase the speed of the given vessel with higher output of the crew within the limits of its design. Monoxylyon II reached maximum speed on the voyage of 5 km/h.

The voyage of Monoxylyon I in the Aegean Sea started on the 8<sup>th</sup> of September 1995 and of Papyrella on the 8<sup>th</sup> of October 1988, the time was therefore similar. The presumption of the Papyrella Expedition was that strong northeast wind Meltemi blows from mid-July to mid-September. Despite that the weather conditions were unfavourable. The voyage took place even in wind of 5 to 6° Beaufort (in case of Monoxylyon II Expedition there was during the sailing along French coast a wind speed of 7–9° Beaufort). Although it is presumed (*Papageorgiou 2014*) that the decisive factor for the development of early maritime voyaging is the circulation at sea surface, all expeditions noted as the main factor was strong winds which created unfavourable waves. Concerning sea currents *H. Tzalas (1995, 454)* states that their influence would be possible to study if in the future an expedition would also travel back, that means from Melos back to the Greek mainland. In the case of the Monoxylyon Expedition 1995 there was a clear influence by the northwest wind which created large waves but neither in the Aegean Sea (Monoxylyon I) nor in the western Mediterranean (Monoxylyon II) was there a notable influence by sea currents or seemed in comparison to the strength of the wind negligible.

The problem of both experiments was the human factor. If I state at the end of this article that the results of the experiments corresponded with archaeological evidence and models of the possible earliest maritime voyaging, these are influenced by the current level of knowledge (currently known archaeological evidence, modern level of experiences and abilities, knowledge of natural conditions). We however do not know the difference

## Box 1: Reconstruction of the crafts

In contrast to the Monoxylyon 1995 Expedition the boat for 1998 Expedition didn't have a hypothetical design (similar to model of a boat from Tsangli) but it was a reconstruction of a real Neolithic log-boat which was discovered in the Lake Bracciano in 1994. The boat belongs to the early Neolithic, it was found close to the sea coast and therefore it could be a sea going craft. It was studied from many perspectives, it survived relatively well and the site as a whole gives us number of interesting insights (evidence of distant contacts, models of boats, situation of a possible port and so on). We have a radiocarbon date for the layer which corresponds with the time of the work on the boat. The date was extracted from the post P765 (dated 6565 ± 64 BP, calibrated 5450 BC), which was blocking the bow of the craft (*Fugazzola Delpino 1995, Fugazzola Delpino – Mineo 1995*).

Because our object was to build a craft able of faring and we wanted to test it on sea we tried to reconstruct the original look of the boat. We had to estimate some of the data because of the damage. The whole boat was dug from one trunk without any of the cracks or repairs which were on the original. We considered the free wooden parts as rope supports (maybe mast and sails?). We excluded a floater. The object was to build a stable craft not needing any supports that would slow it down.

The boat was powered with paddles but with retrospective we think that use of sail might be possible.

While building the reconstruction of the boat we used these parameters:

**The length** – was shortened by 1.25 m to 9.2 m because the used tree was rotten at its crown. Otherwise the size of the trunk corresponded with the presumed scale of the trunk from which the Bracciano boat was built. This didn't really influence the journey.

**The number of cross-braces** – with shortening the length the number decreased to 3 in comparison with the original 4.

**The height of the sides** – because of the damage to the original and because we were going to test it on the sea was increased to 90 cm. This proved very successful while going into waves.

**The width of the sides and the bottom** – smallest size on the reconstruction was 5 cm. The smaller sizes of the original (2–4 cm) were believed to be a result of changes in the wood. The scale corresponded. Our estimates were based on supposition that thinner sides would endanger the integrity of the craft. The drying on the land might be also dangerous then. The log-boat of the Monoxylyon II Expedition was built according to the find from Bracciano. It is possible to consider it as a replica more than a reconstruction. All the characteristics are very close to the original despite the shortening of the length because of the rottenness of the trunk. The biggest problem open to discussion is the thickness of the sides and the bottom. The original dehydrated by long term storage had very thin sides and bottom. We needed to keep them thicker otherwise the wood would crack in higher temperatures. On the other hand during the voyage it was clear that the mass was still slowing the speed of the boat. More thinning of the sides might mean that it wouldn't be possible to pull the boat from water because of possible damage. That seems to be the limits of the right parameters of the boat.



■ **Fig. 5** Monoxylon II vessel has enough space for two paddlers to sit side by side, the first two benches in the bow were occupied by one paddler only.

in the paddling performance and level of maritime knowledge between modern and prehistoric people. Some authors do not undervalue the potential for maritime voyaging already in the Palaeolithic peoples (Howitt-Marshall – Runnels 2016). It is possible that in the Epi-palaeolithic or in PPN experience of generations of maritime voyagers could have reached our current knowledge gained by modern analysis (model for Cyprus for example Bar-Yosef Mayer et al. 2015). It is possible that 'pioneering' settlements with 'packages of maritime knowledge' were already established in the Neolithic on the west coast of Turkey (Horejs et al. 2015). The temporary firm point is our knowledge is the performance of vessels in recent maritime voyaging experiments. They are the basis for judging cargo capacity and performance of vessels, which with further studies we can either reduce or increase.



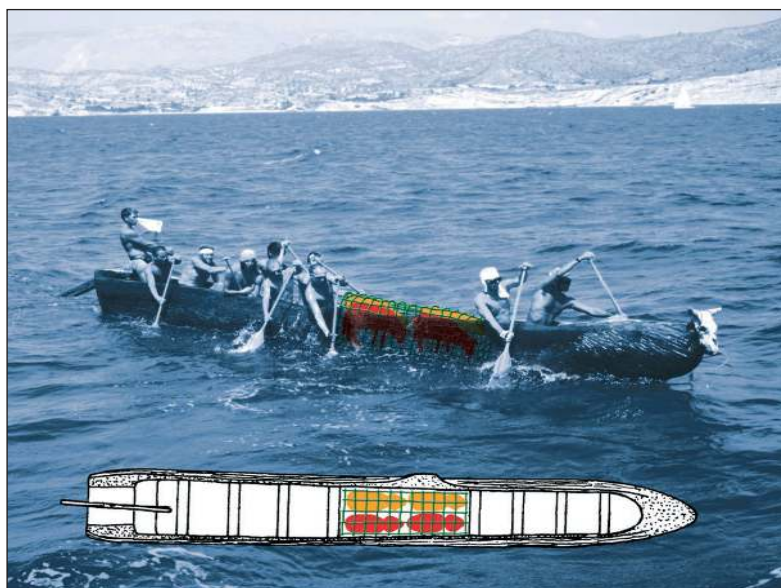
■ **Fig. 6** The Monoxylon II crew used nine to ten paddlers, though there was enough space for 13.

As cargo we can presume people, obsidian, ceramic vessels, agriculture produce and domesticated animals. The first concrete model of agriculture colonisation with stating parameters of a hypothetical cargo was presented on the example of Crete by Cyprian Broodbank and Thomas F. Strasser (1991). They presumed a one-time settlement of Crete with a functional community of about 40 people and a cargo of one to two tonnes with a fleet of 10 to 15 vessels. The presumed time limit was two days otherwise transported cattle would become uncontrollable. More recently the problem was discussed in detail by J.-D. Vigne et al. (2013), who used results of the expeditions mentioned here in his interpretation. To transport big ruminants to the island they do not presume the use of reed vessels as they are not firm enough (Vigne et al. 2013, 170). However, they do not see the dug-out boat as suitable either. They consider it usable for transportation of people and obsidian but not for animal cargo. The transfer of 70 km from Anatolia or 100 km from Levant would take, with regard to the speed of Monoxylon II voyage, about 30 hours according to the authors, but ruminants according to them would not tolerate transport longer than three or four hours, then they would suffer serious physiological problems (fermentation of food while digesting; Vigne et al. 2013). Even if the PPN voyagers, according to the authors, used the speed of sea currents the crossing would still take 10 to 12 hours. The animals would have to be transported standing because of the above given reasons. That would cause problem for bigger animals, like cattle. If it was solved by transporting young animals instead of adults, they would have to have been weaned. Animals of about seven to eight months would weigh 100 to 150 kg. The only solution J.-D. Vigne et al. (2013) see in use of larger and more complex boats, which were presumed in Cyprus case already by Steven Mithen (2003, 101). The ruminants are not the only reason (Vigne et al. 2013, 169–171) but also the transport of a domestic mouse, though as an unwanted passenger. They do not suppose that mice could find refuge in a simple dug-out boat. As a solution they presume two dug-out boats

connected by a deck and equipped with a sail for higher speed.

From the experience of our voyage of a total length of about 1100 km in a dug-out canoe in the Mediterranean, I would like to point out some alternative possibilities or problems. Primarily connecting two dug-out canoes into a catamaran like vessel creates a boat with radically decreased speed. That indicates to me a model of animal transport in a single boat, especially as the inner space of Monoxylon II was sufficient (Fig. 5) would still leave enough space for crew. In reality the space was enough for 13 paddlers while the experiment showed that ten were enough (Fig. 6). It should also be mentioned that the length of the canoe was cut for transport on EU roads from the original 12 m to 9.2 m, so the original cargo capacity was larger still. Animals would not need to be transported lying down with tied legs but could be transported for example in a cage (Fig. 7). That would allow them to either stand or lay down, according to need. Modern transport of animals by car is done in a similar way. Even if some of the animals would die during the transport, we always have to account for repeated voyages. J.-D. Vigne et al. (2013, 170) identified the domestic mouse as an invasive species on the island and therefore they count at least two voyages to Cyprus a year. If we imagine cargo of corn or animal feed these would probably give an ideal shelter to unwanted rodents.

Repeated voyages were modelled by Daniella E. Bar-Yosef Mayer et al. (2015) for the most favourable conditions (wind directions, stable weather). They suggested an optimal route with a use of sail from southern Turkey to the northern coast of Cyprus, where the finds of Anatolian obsidian are the most numerous. The return voyage seems to be most favourable easterly to Levant and against the clock along the coast back to south Turkey. Transfer from northern to southern Cyprus (where there is smaller amount of Anatolian obsidian) would have happened along the coast. The voyage from Turkey to Cyprus could have taken 14 hours and in summer could all have happened during daylight.



■ Fig. 7 Hypothetical placing of a cage to transport domesticated animals.

### Problems of the Sail Use Origins

There is a problem for the use of sail as suggested above (Vigne et al. 2013) at such an early period. C. Broodbank (2010, 254) places the earliest use of sail in the southeast Mediterranean, Mesopotamia and Persian Gulf. In the last named region there is evidence of reed boats (Fig. 8; Schwartz 2002) from the sixth millennium BC, including depictions of a mast (Carter 2010, 192, Fig. 15.2b). It seems that these boats were created by an outside layer of reed bundles (one imprint of a cord documents tying a bundle, another construction of a boat), not rafts made from large bundles as used by Thor Heyerdahl (Vosmer 2000). The oldest wooden hulls on Nile appeared probably in the mid fourth millennium BC, together with evidence of sail (Ward 2006, 119–120). That could mean that the origins of sail use were connected to reed boats as the propulsion of larger vessels would probably not have been realised any other way. The advantages were obvious. With a sail it was possible to transport up to 20 tonnes of cargo in one go (Broodbank 2010, 259). In comparison, a longboat with a presumed cargo of one tonne was still propelled by oars. C. Broodbank proposes that the oldest Mediterranean sailing boats appear in the Nile delta at the end of the fourth millennium BC. The surviving depictions show only slow a spread of sail use in the Mediterranean. It

reached Iberian peninsula probably only in the second millennium BC. The reason of the slow speed could be tradition, difficulties with technology transfer or relation to social complexity documented mostly in the east Mediterranean (Broodbank 2010, 255–258). It is difficult to imagine the use of sail in Cyprus in a period earlier than in the Persian Gulf.

### Conclusion: View from Sea

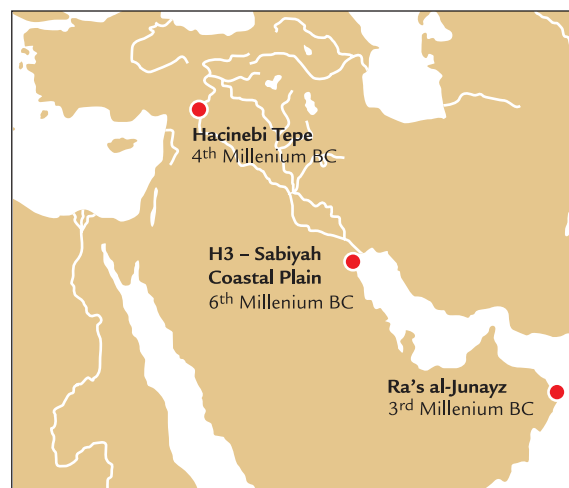
Coastal navigation is from the experience on the Monoxylon II Expedition easier than crossing open sea. Even there waiting for favourable wind seems important and not because of sail use (Fig. 9). The second fundamental factor was the ability to land, or pull the vessel on the bank. During the Monoxylon Expeditions anchoring the dug-out canoe proved difficult on sandy and rocky coasts. In the former and case the vessel filled with sand and water, in the latter waves threw it on the rocky bank (Fig. 10). So sea currents are not the only factor governing the use of boats in their period (for example Papageorgiou 2014).

Crossing to small distant islands was probably very difficult. After João Zilhão (2014) revision of obsidian in North Africa he states that in the Mesolithic and the Neolithic there is no evidence for voyages over 150 km, which means there is no evidence of a connection of the Aegean to North Africa via the

## Box 2: Building the crafts

The first dug out canoe was from a poplar and was built in 1992 with help of fire setting. The log got its rough shape within 10 days. Another 100 hours were spent on cutting to the final shape.

Since January to May 1988 we were building the log-boat according to the original from the Lake Bracciano in The Centre of Experimental Archaeology in Vsestarý. The boat was partly dug with polished stone tools (the front 3 m from the 8 m of inner space length). With one replica of a polished stone axe and an original Neolithic adze it was cut out space 72 cm deep, 80 wide and 300 cm long. The tools never worked together. There were usually 1–3 experimenters with variable experience. Most of the time they were using the axe, only while working the outer surface did the use of the adze. Together it was worked 100 hours, one fifth of it with the adze. The axe was sharpened once half way through the work. After 50 hours of work the axe handle cracked. With the axe they cut out chips up to 5 cm diameter and about 50 cm long or wider and shorter splinters. The adze was creating smaller splinters up to 2 cm while cutting across and big splinters to 10 cm while cutting the surface. In the upper part of the trunk a 20 cm thick layer of the surface was cut out with help of oak wedges. The full length of the boat is 9.2 m, width 1.0–1.2 m and height up to 1 m. The rest of the boat was worked with iron axes, adzes and wedges. The tree was cut down in December 1997 and all the time it had enough humidity necessary for working. The experimenters estimate the time demand for building the whole boat with stone tools to be 300 hours. That means at least a month of work for one person or at least 10 days for a three men group. In one moment more people could work and swapping allowed faster progress.



■ Fig. 8 Finds of reed boats in Near East (after Schwartz 2002, Fig. 4).

## Box 3: The Expeditions Routes

The route of the 1995 voyage was planned to the South leeward sides of the islands. Most of the occupation is still situated there. The sea surface there can be completely calm. Between the islands there is a different situation. The greatest distance is more than 50 km (Ikaria-Mykonos), the rest is only about 25 km. Most of it was easily crossible in the log-boat. No influence of sea currents showed, not even in the places where they are supposed by V. Nikolov. Strong wind creating waves caused problems and on the open sea therefore there some places were very difficult to cross. We had to be tugged by an accompanying craft for 40 km between Ikaria and Mykonos as because of time reasons we couldn't wait for the weather to improve. According to the experience of local inhabitants this area is difficult to cross most of the year. Such areas I named for myself 'zones of discontinuity'.

The Monoxylon II Expedition was through the Western Mediterranean (**Fig. 1**) where the Bracciano boat came from. Italian archaeologists suppose that it was used for sea faring. The voyage took place under different conditions from those in the Aegean Sea. We chose that to test the crossing to the Lipari Islands and coastal faring, the most probable early sea going in the area. We selected coastal areas with supposed relation to Neolithic coast that meant places where sea faring could have taken place in prehistory. Even here we had to remember that there was a different shape of coast in the Neolithic, especially in Northern and Central Italy, Southern France and Eastern Spain.

The route of the expedition 1998 was divided into 5 stages. The main object was to observe the faring characteristics of the boat and influence of natural conditions as they are supposed by various theories and models.

### Monoxylon I (1995)

**8/9** Ormos – Kirikos (Samos – Ikaria) 30 km 9,15 h 2 crews  
**9/9** Kirikos – Nikolaos (Ikaria) 25 km 7 h / 2 crews  
**13/9** Nikolaos – O. A. Annas (Ikaria-Mykonos) 14 h 2 crews (11 km + 40 km pulled\*)  
**14/9** O. A. Annas – Ormos Ornos (Mykonos) 11 km 4 h 1 crew  
**15/9** Ormos Ornos (Mykonos – Tinos) 24 km 9,30 h 2 crews  
**17/9** Tinos – Petrangathi (Tinos – Andros) 35 km 11 h 2 crews  
**18/9** Petrangathi – Gavrio (Andros) 20 km 7 h 2 crews  
**19/9** Gavrio – Karystos (Andros – Euboia) 7 h 2 crews (14 km + 15 km pulled\*)  
**20/9** Karystos – Marmari (Euboia) 25 km 7,45 h 2 crews  
**21/9** Marmari – cape (Euboia) 12 km 3 h 1 crew  
**22/9** cape – Marathon (Euboia – Attika) 17 km 3,30 h 2 crews  
**23/9** Marathon – Nea Makri (Attika) 7 km 1,30 h 1 crew (\* pulled by the accompanying craft)

### Monoxylon II (1998)

#### Sicily

**7/8** Milazzo – Vulcano: 31 km 12.30–20.45 1 crew  
**8/8** Vulcano – Milazzo: 31 km 9.00–18.00 1 crew  
**9/8** Milazzo – Bagnara: 51 km 5.15–21.30 3 crews (4,15 h = 17 km + 4,30 h = 19 km + 3,45 h = 15 km)  
**10/8** Bagnara – pulling the boat out

#### Central Italy

**11/8** Mondragone – Sinnessa: 6 km 19.00–20.20 1 crew  
**12/8** Sinnessa – Lido di Fondi: 50 km 6.45–20.05 3 crews (6 h = 21 km + 6 h = 27 km + 1 h = 2 km)  
**13/8** Lido di Fondi – Terraccina: 12 km 8.05–10.30 1 crew pulling the boat out  
**14/8** Rome – Museo L. Pigorini  
**15/8** the Lake Bracciano 22 km 9.00–18.00 2 crews (4 h = 8 km + 6 h = 14 km)

#### Northern Italy – France

**16/8** San Remo 4 km 14.00–15.00 1 crew

**17/8** San Remo – Nice 57 km 6.05–20.00 3 crews (5 h = 23 km + 6,30 h = 24 + 2,30 h = 10 km)  
**18/8** Nice – Miramar 38 km 7.15–16.00 2 crews (4 h = 21 km + 5 h = 17 km) mistral in the afternoon  
**19/8** Miramar – Gigaro 58 km 6.45–20.45 3 crews (4,15 h = 19 km + 5,45 h = 21 km + 4 h = 18 km)  
**20/8** Gigaro – La Tour Fondue 43 km 7.30–18.20 2 crews (4,30 h = 18 km + 6,20 h = 25 km) mistral in the afternoon  
**21/8** La Tour Fondue – Port Niel 5 km 7.00– 9.00 1 crew mistral – pulling the boat out  
**22/8** Saintes Maries –de-la-Mer, mistral  
**23/8** Saintes M.-Ecluse de St Gilles 38 km 8.00–23.00 3 crews (6 h = 15 km + 6 h = 15 km + 3 h = 8 km)

#### La Pettit Rhone

**24/8** Ecluse St Gilles – la Grande-Motte 29 km 7.15–16.00 3 crews (2,30 h = 14 km + 3,30 h = 11 km + 2,30 h = 4 km) mistral – pulling the boat out  
**25/8** le Cap'Agde – Portiragnés 10 km 7.00–13.00 1 crew

#### Spain

**26/8** Valencia – Playa de la Dehesa 10 km 17.00–20.00 1 crew  
**27/8** Playa de la Dehesa – Piles 54 km 7.00–21.00 3 crews (5,30 h = 26 km + 5,30 h = 18 km + 2,40 h = 10 km)  
**28/8** Piles – Cala Blanca 38 km 7.50–16.30 3 crews (2,30 h = 12 km + 3,30 h = 17 km + 2,30 h = 9 km)  
**29/8** Cala Blanca – Altea 43 km 7.45–19.20 3 crews (4,30 h = 18 km + 4,30 h = 20 km + 2,15 h = 5 km)  
**30/8** Altea – Campello 37 km 7.20–16.30 2 crews (5 h = 20 km + 4 h = 17 km)  
**31/8** Campello – Alicante 16 km 8.20–12.10 1 crew pulling the boat out  
**1/9** Sevilla – transfer

#### Portugal

**2/9** Sines  
**3/9** Sines – Setúbal 20 km 9.00–13.00 1 crew + tugging of the boat to Setúbal  
**4/9** Setúbal – Sesimbra 29 km 9.00–17.15 1 crew pulling the boat out

importation of obsidian from Pantelleria. During the Monoxylon Expedition 1995 we experienced problems on the route from Ikaria to Mykonos (50 km which I called a 'zone of disconnection'; *Tichý 2001*). At the same time as the expedition (September 1995) the same route was, by coincidence, described as a 'barrier to agriculture spreading' (*van Andel – Runnels 1995*).

An example of a 'careful progress' is also the crossing of the Adriatic Sea with an intermediate landing on the Palagruža island with evidence of Neolithic impresso pottery (*Forenbaher – Kaiser 2011*). Or did they cross directly to the 'heel' of Italy? The closest landing place from Palagruža in any direction is 45 km on other islands and 57 km on the Italian coast. *Stasio Forenbaher and Preston T. Miracle (2014)* have since adjusted the model of spread of agriculture in the Adriatic Sea. It seems that the oldest settlement on the Italian side (Tavoliere) and the Adriatic impresso pottery could have originated between Tavoliere and Dalmatia. That means in the area connected by islands of the Adriatic Sea (Tremi, Pianosa, Palagruža, Sušac, Vis).

Cyprus and Crete stand out among the big 'true islands' with early evidence of domesticated species. Their presence though is later towards the west, despite the evidence of early Preneolithic settlement on Sardinia and Corsica proved navigational abilities in the area (*Vigne 2013*). Towards west the reliability



■ Fig. 9 Monoxylon II is entering 'mistral' in the French territory.

of data on the presence of gatherers also decreases (*Ammerman 2014, 204*). The connection to the mainland is documented in Cyprus for PPN A, in PPN B there was already established a number of new mammals (*Ammerman 2014, 205–206; Vigne 2013*). I believe that as Cyprus is 70 km from the closest mainland, the voyage did not need to take more than 30 hours as stated by *J.-D. Vigne (2014, 136)*. The Monoxylon II vessels reached daily distances of up to 58 km in 14 hours. *D. E. Bar-Yosef Mayer et al. (2015)* consider similar time for voyage from Turkey to Cyprus under optimal conditions realistic. Another possibility is the use of the small island north-east of Cyprus, which is nowadays submerged below the sea surface, for stopovers. Although *J.-D. Vigne et al. (2013)* are not certain if it was still available in the Epipalaeolithic.

There is still the question if the same mechanism of repeated voyages to

Cyprus could have worked for the agriculture colonisation of Crete, where the only site with Early Neolithic evidence is Knossos X. Recently there are documented Mesolithic sites on the southern coast (*Strasser et al. 2010*), but *A. J. Ammerman* does not consider their dating certain (*2014, 204*). The discovery of the Mesolithic on Crete has weakened the 'one-time' hypothesis (*Broodbank – Strasser 1991*), there was even considered a possibility of a relationship between gatherers and farmers (*Nowicki 2014, 48–49*). Despite this Crete remains an example of 'a jump' over a long distance (*Leppard 2014* presumes use of ecologic niches). Although the route using the Kasos Island could have been only 50 km long (*Broodbank – Strasser 1991, 239*), it is navigation from a small to a big island over open sea. Even such distance could be surmountable in a simple vessel although the navigation over open sea could be the most demanding of the voyages discussed here.



■ Fig. 10 Night surf threw Monoxylon II on the rocky shore in Spain.

It seems that the results of the experimental voyages correspond with archaeological evidence and models of earliest maritime voyaging. The possibility of coastal navigation was used frequently with regards to its feasibility (along the southern coast of modern Turkey, from northern to southern coast of Cyprus, along coast of the north-west Mediterranean). Routes over open sea navigation from mainland to Islands (Cyprus) require a deep empirical maritime knowledge. Where there is evidence of human presence on smaller islands, chains of islands were probably used to reach them (Melos, Lipari Islands) or they were used

as a stepping stones (Paraguža) but the open sea would be more of a barrier. In case of navigation between smaller islands or on the way to a bigger island such a 'barrier' would be the distance around 50 km (Ikaria – Mykonos, Rhodos – Karpathos – Kasos – Crete). Despite all this there was no place in the Mediterranean Sea untouched by early maritime voyaging. During the colonisation both transport of people (for the routes to Cyprus, Crete and Aegean Islands: *Haak et al. 2010; Fernández et al. 2014; Paschou et al. 2014*) and animals (along the coast of southern Turkey; *Arbuckle et al. 2014*) occurred. The contrast between 'careful progress' using available land and historical consequences (migration of people, transport of live animals) can be explained by the deep knowledge of first navigators on the choice of suitable conditions in given

regions. Even then the reach of early maritime voyaging would be limited in certain regions.

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## Box 4: Sea going characteristics of the experimental crafts

The following text considers only the Monoxylon II vessel, as it was based on an excavated example. To follow the requirements of archaeological experiment it would be necessary to remove the influence of the human factor (modern person) which is not possible with some features of a replica dug-out canoe.

During the Monoxylon II Expedition the average day travel was 32 km in day and the crews worked on average 11 hours a day, once 15 hours and three times 14 hours. There were altogether 15 full days on sea. Others didn't mean a whole day journey usually because of pulling out the boat or putting it on water. Altogether about 800 km was covered in 200 hours giving an average speed of 4 km/h. Transfer over mainland between single stages or bad weather on sea took several days. The accompanying craft finished in Southern Italy and next changing of crews depended on landing by coast which was made difficult by modern built-up space. Wind of 2 Beaufort was probably the weakest we encountered. In France the wind reached in several places up to 7–9 Beaufort. The strength was verified by weather forecasts and reports from the port authorities. The boat went on in the end even in two metre high waves although this was not possible without bailing.

The boat of the Monoxylon II Expedition was stable. In contrast to 1995 we didn't need to use a side float that increased water resistance and decreased speed. During the whole time, even in the biggest waves we were never in danger of turning over. That was because the centre of gravity was below the sea surface. The maximum speed was 5 km/h. It wasn't in the power of the crew to increase it without being exhausted. We were testing speed mostly on Bracciano where the going was easy. The speed of the craft was influenced only by sea currents, tide and wind. I would mark the wind as the most influential among them. If

people were able to use it they achieved much. We don't know about beginnings of sails but if the square groove in the bottom of the Bracciano boat was a socket for mast and a bit of cloth found near by remain of a sail then it had to be very early. We felt the strength of head wind in Miramara in France where it was catching leaves of our paddles and decreased our speed to a minimum.

The mass of the craft helped to cut the waves. The influence of sea sickness seemed to be stronger on the modern yacht but that wasn't general. The mass was increased by a massive bow and stern that hold together a thin shell of bottom and sides. The same function was played in the Bracciano boat by the 4 cross braces. Because they are found in many prehistoric and historic European log-boats there was a lot of discussion about their function. According to our experience from building, through manipulation both on land and in water to faring I believe they were there to reinforce the boat. The mass also influenced the possibilities of steering. We can barely presume a more complicated helm than a big paddle, as we can see still on the pictures from the Aegean Early Bronze Age. For the paddle to work it was necessary to keep the boat moving. Problems started in 2 m waves when the helm was leaving the water.

The load capacity is an important parameter to consider for the possibilities of Neolithisation and transfer of materials. The crew of the log-boat could be made of at maximum 15 people. Although it was more than meter shorter than the original, the original length wouldn't increase this number by more than two people. There were usually 9–11 people paddling, one was a steersman. There was still plenty of space for load. During the expedition we were carrying only obsidian, dinkel wheat and

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water supplies but in the mentioned number of crew there was still plenty of space left. The transport of obsidian was optimal the load functioned as ballast. We loaded more than 100 kg of the stone which we carried from Sicily as far as Portiragnes. It would be possible to carry more. Even our amount would be enough for making a large number of knapped tools. Two linen bags of dinkel wheat were from the load point of view no burden. One of them was left in Portiragnes and about a half of the other one was sown in March 1999 and it germinated 100 %. An area about two to four metres means space with amount of wheat sufficient to provide after a second sowing harvest for the new cereal colony. The width of the boat would allow you to carry a much bigger load.

Some experience relate also to observing the boat on dry land. The necessity for protection from sun might be well documented also by the supposed boat shelter found at Bracciano. The swelling of wood should probably be balanced with the braces left in the bottom. During our handling of the boat on sea and on dry land it was possible to see the vibrations of wood. The cross braces were functioning as armatures. This feature clearly shows the experience of Neolithic boat builders. The log-boat from Bracciano could have had several generations of predecessors.

This experience is also a reason why to look in different way at the ethnological and ethnographic parallels. In the case of Bracciano the log-boat gained thanks to different material (oak) completely different qualities. The building of the craft in the original scale showed its hugeness. I think personally it would be pointless to build such a big boat just to go over a lake. That also supports the view of Dr Mario Mineo from L. Pigorini Museum that these boats were used for sea faring.

The possibility of landing and anchoring is an important characteristic of the coast. We don't know anything about ports and anchoring during the Neolithic if Bracciano itself wasn't such a port. The look of the coast certainly changed so we don't have a firm base for our presumptions. It is only possible to say that a certain type of coast is represented by the Greek islands rocky coast. There it is necessary to pick a place for landing. Another possibility is the Central Italian sandy coast where the soft sand makes landing difficult. In France the line of the coast was broken and it was necessary to look for a port. It was possible to suppose suitable places in big bays. The main problem was the infamous mistral that can enforce several days break in voyage. In extreme conditions when we were testing the boat when others would barely set on sea. In the area of Spanish Valencia the coast is again very sandy. In combination with breakers it creates an unfavourable landing situation by bank and even less suitable situation for anchoring or fastening the boat to the bank. We used to bail sand and water in the morning but it's not too elegant. But in Spain there are inland lakes connected to sea. They could have been suitable ports.

Faring along the Atlantic coast of Portugal was a separate task. There we tested part of the coast between today Sines and Sado estuary which connected two concentrations of Neolithic occupation. There is a strong tide which demands anchoring in ports. One of them could have been hidden on the rocky promontory in Sines where it would precede its famous medieval successor. We can suppose the next landing possibility only 90 km to the North in the estuary of the Sado River. Between them there is a long sandy beach hammered with breakers. The conditions couldn't be better in the past as the evidence as the Roman settlement swept by an Atlantic tidal wave shows. That would again mean higher speed or night faring to cover the distance.

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## Souhrn

### Nejstarší námořní plavba ve Středomoří: pohled z moře

Cílem této statí je pohled na nové překvapující nálezy ze Středomoří v obdobích mezolitu/epipaleolitu a PPN/neolitu ze zkušeností z plavebních pokusů expedice Monoxylon. Takový přístup je možné označit jako „pohled z moře“, který využívá výsledky praktické činnosti k náhledu na nová fakta či názory týkající se nejstarší námořní plavby.

Hypotéza o významu dlabaných člunů pro nejstarší námořní plavbu ve Středomoří (Tichý 1992; 1994) byla založena na výskytu lesů na pobřeží Středomoří (Butzer 1970), nálezů dlabaného člunu na bývalém mořském pobřeží v severní Evropě (Andersen 1986), tradici „dlouhých lodí“ zřejmě dřevěné konstrukce na počátku doby bronzové ve východním Středomoří (Broodbank 1989) a výskytu kamenných broušených seker v období neolitu. Nález neolitického dlabaného člunu v jezeře Bracciano (Fugazzola Delpino – Mineo 1995; Fugazzola Delpino 1995) s možným využitím pro transport obsidiánu z Liparských ostrovů učinil hypotézu reálnější. Možné využití dlabaných člunů pro nejstarší námořní plavbu je alternativou k hypotéze o použití rákosových plavidel k přepravě obsidiánu, kterou praktickým pokusem nastínil Harry Tzalas

(1989; 1995). V kontextu převratných nálezů z období kořistníků mladého dryasu (Ammerman 2010; 2011; 2013; 2014) a zemědělců PPN A i PPN B (Vigne et al. 2013; Vigne 2013) na Kypru, možných kontaktů mezolitických populací v Egejském moři (Sampson 2014; Efstratiou 2013) a „pionýrské osady“ s „balíčkem námořních znalostí“ na západním pobřeží Turecka (Horejs et al. 2015) se stává aktuální otázka, zda rákosový člun spojit pouze s kořistníky a dlabaný člun se zemědělci. Vyhovuje rákosový člun i potřebám přepravy nákladu zemědělců? Je nevyžádaný, zároveň s důležitými diskuzemi o povaze nákladu (Zilhão 2014, Vigne et al. 2013), stále respektovat technologické možnosti kořistníků a zemědělců stavět to či ono plavidlo. Seán McGrail (2010, 104, tab. 8.1) navrhuje, že loď z prken nemohla být postavena před příchodem neolitických technologií. Podobně i stavba dlabaného člunu z kmene vyžaduje existenci kamenných broušených seker, nebo alespoň velkých štipaných seker, protože k tvarování většího plavidla nestačí jen oheň. Protože aktuální nálezy současnost kořistníků a zemědělců předpokládají, objevil se i názor (Nowicki 2014, 48), že nebyl asi žádný zřejmý rozdíl mezi typy plavidel v mezolitu/epipaleolitu a neolitu. Porovnání jejich vlastností je tedy důležité. Již dříve (Tichý 2000; 2001) i zde uvedené názory neprosazují dlabaný člun na úkor ostatních plavidel jako plavidlo jediné nebo převládající. Považují jej ale za plavidlo, které směřovalo k tradici dřevěných lodí ve Středomoří. Tedy k té tradici, která byla základem pozdějšího vývoje mořeplavectví.

„Pohledem z moře“ se zdá, že možnost příbřežní plavby byla využívána frekventovaně s ohledem na její realizovatelnost (podél jižního pobřeží dnešního Turecka, ze severního na jižní pobřeží Kypru, na pobřeží středozápadního Středomoří). Mezi plavbami na otevřeném moři se snadnější zdála být plavba od pevniny k ostrovům (Kypr), i když i ta předpokládala hluboké znalosti o námořní plavbě. Tam, kde je archeologicky doložena přítomnost lidí na menších ostrovech, byly na cestě k nim využívány v co největší míře řetězce ostrovů jako jistota (cesta na Mélos, cesta na Liparské ostrovy), nebo přímo zastávka (Paragruža). Na otevřeném moři mohly vzniknout „bariéry“. V případě plavby buď mezi menšími ostrovy nebo na velký ostrov mohla být „bariérou“ i vzdálenost kolem 50 km (Ikaria – Mykonos, Rhodos – Karpathos – Kasos – Kréta). Přesto nezáleželo místo ve Středozemním moři, které by bylo časnou plavbou zcela nedotčeno. Z podstatné části tedy probíhala při kolonizaci přeprava lidí (pro trasu Kypr, Kréta a egejské ostrovy Haak et al. 2010; Fernandes et al. 2014; Paschou et al. 2014) i zvířat (při jižní pobřeží Turecka Arbuckle et al. 2014). Protiklad mezi „opatrným přístupem“, využívajícím na trase dostupné pevniny, a historickými důsledky (migrace obyvatel, přeprava živého nákladu zvířat) lze vysvětlit hlubokými znalostmi prvních mořeplavců o volbě vhodných podmínek v daných oblastech. I tak zůstal využívaný dosah časné plavby uzavřený v určitých regionech.

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