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Middle Pleistocene sea-crossings in the eastern Mediterranean?

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ABSTRACT

Lower and Middle Palaeolithic artifacts on Greek islands separated from the mainland in the Middle and Upper Pleistocene may be proxy evidence for maritime activity in the eastern Mediterranean. Four hypotheses are connected with this topic. The first is the presence of archaic hominins on the islands in the Palaeolithic, and the second is that some of the islands were separated from the mainland when hominins reached them. A third hypothesis is that archaic hominin technological and cognitive capabilities were sufficient for the fabrication of watercraft. Finally, the required wayfinding skills for open sea-crossings were within the purview of early humans. Our review of the archaeological, experimental, ethno-historical, and theoretical evidence leads us to conclude that there is no a priori reason to reject the first two hypotheses in the absence of more targeted archaeological surveys on the islands, and thus the latter two hypotheses should be tested by future research.

1. Introduction

The possibility that humans reached the Mediterranean islands in the Palaeolithic has been the subject of discussion for decades (e.g., Cherry, 1981, 1990; Bednarik, 1999b; Broodbank, 2006; Simmons, 2014). Until recently, the consensus has been that seafaring—narrowly defined—did not emerge until the Terminal Pleistocene, ca. 12,000 BP (Broodbank, 2006, 2013: 148–156; Ammerman, 2010; Ammerman, 2013: 9–30), a consensus challenged, at least for the Greek islands, by the discovery of early Palaeolithic stone tools on Alonnisos in the Northern Sporades (Panagopoulou et al., 2001), Gavdos and Crete in the southern Aegean (Mortensen, 2008; Kopaka and Matzanas, 2009; Strasser et al., 2010, 2011; Runnels, 2014; Runnels et al., 2014a, 2014b), the western Ionian islands of Kephalonia and Zakynthos (Kavvadias, 1984; Tourloukis, 2010; Ferentinos et al., 2012), and Melos and Naxos in the Cyclades (Chelidonio, 2001; Carter et al., 2014).

If one assumes that some of these islands were separated from the mainland during much if not all of the Pleistocene, Palaeolithic hominins would have made open sea-crossings to reach them. These recent Palaeolithic discoveries have suggested to some scholars that maritime activity in the Mediterranean began in the Middle Pleistocene (Bednarik, 1999b, 2001, 2003, 2014; Simmons, 2014: 203–212). Nevertheless, the distances to be crossed are difficult to calculate, ranging from as little as 5 to as much 30 or 40 km (Ferentinos et al., 2012; Simmons, 2014: 63, table 3.2), and near-shore islands may have been extensions of mainland home ranges, visited perhaps as part of a subsistence strategy that included aquatic resources in coastal environments. For some scholars, this "triggered a slight 'stretching' of behaviour" (Broodbank, 2006: 205), but for others the suspicion is that deep-water 'oceanic' islands required the use of watercraft to reach them (Runnels, 2014).

The evidence for Palaeolithic sites on the Greek islands, and the degree of separation of these islands from the mainland, have been discussed elsewhere (e.g., Broodbank, 2014; Leppard, 2014; Runnels, 2014; Simmons, 2014), and here, for purposes of discussion, we accept as working hypotheses that there are Palaeolithic sites on the islands, and that some of the islands may have required watercraft to reach them. From this, other hypotheses emerge. Were archaic hominins in possession of cognitive and technological abilities sufficient for the construction of watercraft and the planning of open sea-crossings that, amongst other actions, would have required at least rudimentary wayfinding or navigational skills? Whilst some scholars hold that these abilities are manifested only by anatomically modern humans (AMH) ca. 45–35,000 BP (e.g., Davidson and Noble, 1992; Leppard, 2015), the hypothesis that these abilities were present amongst pre-*sapiens* hominins is manifestly speculative. To develop this hypothesis, we draw on experimental evidence for tool-making and cognition, ethno-historical data on the construction and use of watercraft, and

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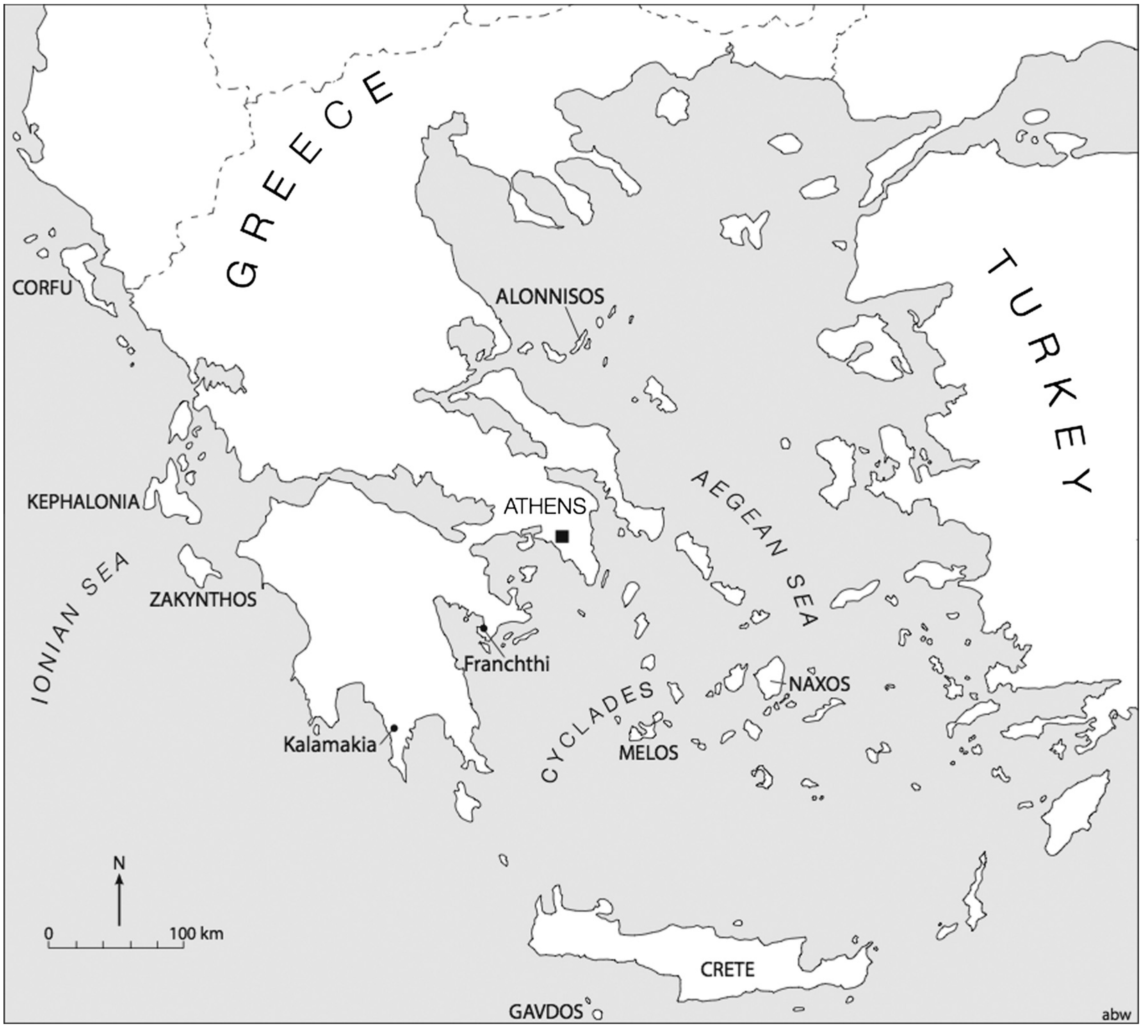


Fig. 1. Map of the Aegean showing places mentioned in the text (Map: Al B. Wesolowsky).

theoretical considerations of archaic hominin cognitive abilities. Such speculative hypothesis-building is fraught with uncertainties, and here we do not specify which hominin species were involved, nor do we attempt to address the timing of the putative sea-crossings beyond the limits of the 'Middle Pleistocene', ca. 790–130,000 BP. Even the terminology applied to maritime activity is vexed (Broodbank, 2006: 200; Simmons, 2014: 205), and we have selected the term 'sea-crossing' to refer to the construction of watercraft, wayfinding, and planned efforts to reach offshore islands. Our focus is on the Greek islands (Fig. 1), but our findings may be applicable to the Mediterranean as a whole.

2. Coastal resources and maritime adaptations

The first question must be whether there is evidence for the exploitation of aquatic (marine and freshwater) environments by archaic hominins. It appears that there is a long history of such behaviour (e.g., Bailey and Carrion, 2008). The earliest evidence comes from Olduvai Gorge in East Africa during the Early Pleistocene, ca. 1.9 mya to 800,000 BP, where hominins caught and ate freshwater fish, including airbreathing catfishes (Stewart, 1994: 235–242; Broadhurst et al., 1998; Erlandson, 2010: 129). Although the sample is small, and coastal foraging and fishing, even for large pelagic species such as bluefin tuna, do not necessarily require the use of boats (Bailey and Carrion, 2008; Anderson, 2010: 5, *contra* O'Connor, 2010: 50), we can assume that aquatic resource exploitation was part of the cognitive and technological capability of Middle Pleistocene hominins.

In the western Mediterranean, hominins foraged the coastlines for inter-tidal shellfish at Terra Amata (400,000 BP) and Grotte du Lazaret (250,000 BP) in southern France (Villa, 1983; de Lumley et al., 2004), and by the early glacial, ca. 128–60,000 BP, Neanderthals were collecting shellfish from sites in Italy (Stiner, 1994), Spain (Cortés-Sánchez et al., 2008; Zilhão et al., 2010), and Portugal (Bicho, 2004; Bicho and Haws, 2008; Haws et al., 2011). In the Upper Palaeolithic, it is probable that coastal resources played a larger role in AMH subsistence strategies along the maritime littoral of the Mediterranean (e.g., Kuhn and Stiner, 1998; Pettitt et al., 2003), but how important were these resources for archaic hominins? Most of the evidence relates to Neanderthals, and there is considerable ambiguity concerning its interpretation. Direct isotopic evidence for the Neanderthal diet suggests that they were 'top-level' carnivores deriving most of their dietary protein from terrestrial game (see Richards and Trinkaus, 2009; Erlandson, 2010: 130), but at Gorham's Cave in Gibraltar Neanderthals consumed bluefin tuna—a pelagic species of fish that inhabits both inshore and offshore environments—bream, and large marine fauna such as monk seals and dolphins (Garrod et al., 1928; Waechter, 1951; Waechter, 1964; Stringer et al., 2008). The archaeological evidence suggests that marine resources, including mussels, limpets, pelagic fish, and marine mammals played an important part in their diet, perhaps facilitating the late survival of Neanderthals in the southern Iberian peninsula (Stringer et al., 2008). In Greece, the use of coastal resources has been proposed for Kalamakia Cave (Mani) and for open-air sites in Epirus (Darlas and de Lumley, 1999: 298; van Andel and Runnels, 2005; Harvati et al., 2013). What remains unknown is whether, if coastal Neanderthals had a broader dietary spread than their inland relatives, it affected their adaptive and technological strategies in maritime environments.

3. Early Palaeolithic on the Mediterranean islands

The second line of evidence is archaeological. Early (Lower and Middle) Palaeolithic type artifacts have been reported from a number of Mediterranean islands, but the small sample sizes, the lack of excavated stratified sites and radiometric dates, and the lack of associated ecological materials or hominin fossils, are problematic (Broodbank, 2013: 82–108). Simmons (2014: 131) concludes that "despite abundant claims for early sites, a critical evaluation of available and published information points to generally inconclusive data for both the Lower and Middle Paleolithic"—a conclusion that refers primarily to the islands in the western Mediterranean. Nevertheless, he considers the newly-emerging evidence for Palaeolithic visitation of the islands in the eastern Mediterranean, particularly those in Greek waters, to be stronger (Simmons, 2014: 182–193, 201–202).

Of all the islands in the eastern Mediterranean known to have been separated from the mainland by open sea in the Pleistocene, Cyprus is perhaps the best prospect for the study of early maritime crossings. Some 70 km south of Turkey, the distance would have been significantly reduced during sea-level lowstands, and the island is inter-visible with the Asiatic mainland. It is reasonable to assume, therefore, that coastal foragers and hunter-gatherers in the areas around the northeast corner of Mediterranean basin would have been aware of the "insular giant" (Broodbank, 2013: 148) across the sea. Despite claims for possible Middle or Upper Palaeolithic stone tools (e.g., Stockton, 1968; Vita-Finzi, 1973; Adovasio et al., 1975; Adovasio et al., 1978; Baudou and Engelmark, 1983; Baudou et al., 1985), these artifacts are few in number and remain undated. Thus the earliest securely dated site remains the Late Epipalaeolithic rockshelter on the south coast at Akrotiri *Aetokremnos*, ca. 11,000 Cal BC (Simmons, 1999; Simmons, 2004; Simmons and Mandel, 2007; Simmons, 2014: 132–158). Although the presence of earlier horizons of human visitation or occupation in the Palaeolithic is hinted at by the stone tool finds (Knapp, 2013: 43–48; Simmons, 2014: 114–115, 159–174), it is clear that additional research will be necessary to settle the question. In this regard, it is significant that a biface of Palaeolithic type has recently come to light, which highlights the need for further specialised, targeted surveys to search for possible Palaeolithic sites (Strasser et al., 2016).

Turning to the Greek islands, Crete and Naxos have recently produced significant numbers of Palaeolithic stone tools (Runnels, 2014). Like Cyprus, they would have required watercraft to reach them in the Pleistocene. On Crete, early Palaeolithic assemblages have been reported from three locations: Loutro, Plakias, and Mochlos (Mortensen, 2008; Strasser et al., 2010; Strasser et al., 2011; Runnels et al., 2014b). At Plakias, more than 200 artifacts in vein quartz and quartzite were collected from nine find spots. They are dated to greater than 130,000 BP by their direct association with raised marine terraces dated by 14C and local uplift rates, and a highly developed paleosol dated by Optically Stimulated Luminescence (OSL) (Strasser et al., 2010, 2011). The geological contexts for these artifacts are secure, as they were extracted from within the marine terraces and the paleosol outcrop. Nor is the artifactual nature of the artifacts in question. A detailed study of morphotypological characteristics of the Plakias sample identified forms such as bifaces, picks, cleavers, and scrapers that are typical of early Palaeolithic traditions in the region (Runnels et al., 2014a). Although they express differences of opinion about the cultural affinities of the Plakias lithics, other scholars accept the Plakias artifacts as Palaeolithic tools (e.g., Galanidou, 2014; Sakellariou and Galanidou, 2015). To aid readers in evaluating the nature of the Plakias artifacts, three dimensional realistic photo scans of selected pieces are hosted on the Plakias Survey Web Site (http://plakiasstoneageproject.com/interactive/).

The other site, Stelida on Naxos, is associated with a large chert outcrop that served as a source of raw material and atelier for the production of early Palaeolithic artifacts (Carter et al., 2014). The surface distribution of artifacts has been surveyed, and, crucially, excavations carried out in 2015 produced artifacts of early Palaeolithic type in stratified deposits, now in the process of being studied by geomorphologists and through OSL assays (T. Carter, personal communication, 2015). This last example reminds us that this field is fast changing in light of ongoing surveys and excavations, and that all of our conclusions will undoubtedly have to be modified in the near future. That said, we conclude that there is prima facie evidence that Palaeolithic hominins reached some of the Greek islands.

4. Mediterranean palaeoenvironment

A third question: what were the environmental conditions in the Aegean in the Middle and Upper Pleistocene? The reconstruction of the palaeoenvironment requires more data than are presently available (Simmons, 2014: 40–75), but it is widely accepted that the Pleistocene climate was predominantly glacial with fluctuating sea levels. Indeed, sea-level lowstands reconfigured shorelines around the Aegean basin, creating new landmasses like the central Cycladic Island, and reducing the distances between offshore islands and the Greek mainland (Lambeck, 1996; Kapsimalis et al., 2009; Broodbank, 2013: 129) (Fig. 2). Even if we knew precisely when archaic hominins attempted sea passages to the islands, and the palaeoenvironmental characteristics of winds and currents were correctly estimated, there is the vexing problem of the reconstruction of palaeoshorelines to determine how close or far any particular island was to the mainland. We need data comparable to those used for the southern reaches of the Red Sea (Lambeck et al., 2011), but, unfortunately, the geophysical history of the Aegean is complicated by a staggering complexity of geomorphic and tectonic processes requiring more local data on earth models and glacio-hydro-isostasy (Runnels, 2014).

Acknowledging the limitations of the models, our selection of the Greek islands considered to be 'offshore' during the bulk of the Pleistocene is based on older reconstructions of palaeoshorelines (e.g., van Andel and Shackleton, 1982; Shackleton et al., 1984; Lambeck, 1996; Kapsimalis et al., 2009; Ferentinos et al., 2012). These reconstructions are at odds with those of Lykousis (2009), which are based upon seismic reflection profiles of prograding terrestrial sediments on the subsiding sea floor and suggest that at times in the last 400,000 years the northern and central Aegean was dry land with a broad belt of land stretching between Turkey to Greece laced with rivers and lakes (Tourloukis and Karkanas, 2012). The absence of earth model estimates and earth rheology in the Lykousis model, however, is reason to use the older reconstructions for the moment. Even in the absence of fine-grained palaeoshoreline reconstructions, it is evident that some Greek islands remained separated from the mainland for long periods of time (Runnels, 2014). This 'oceanic' isolation is inferred from the presence on these islands of endemic fauna, such as

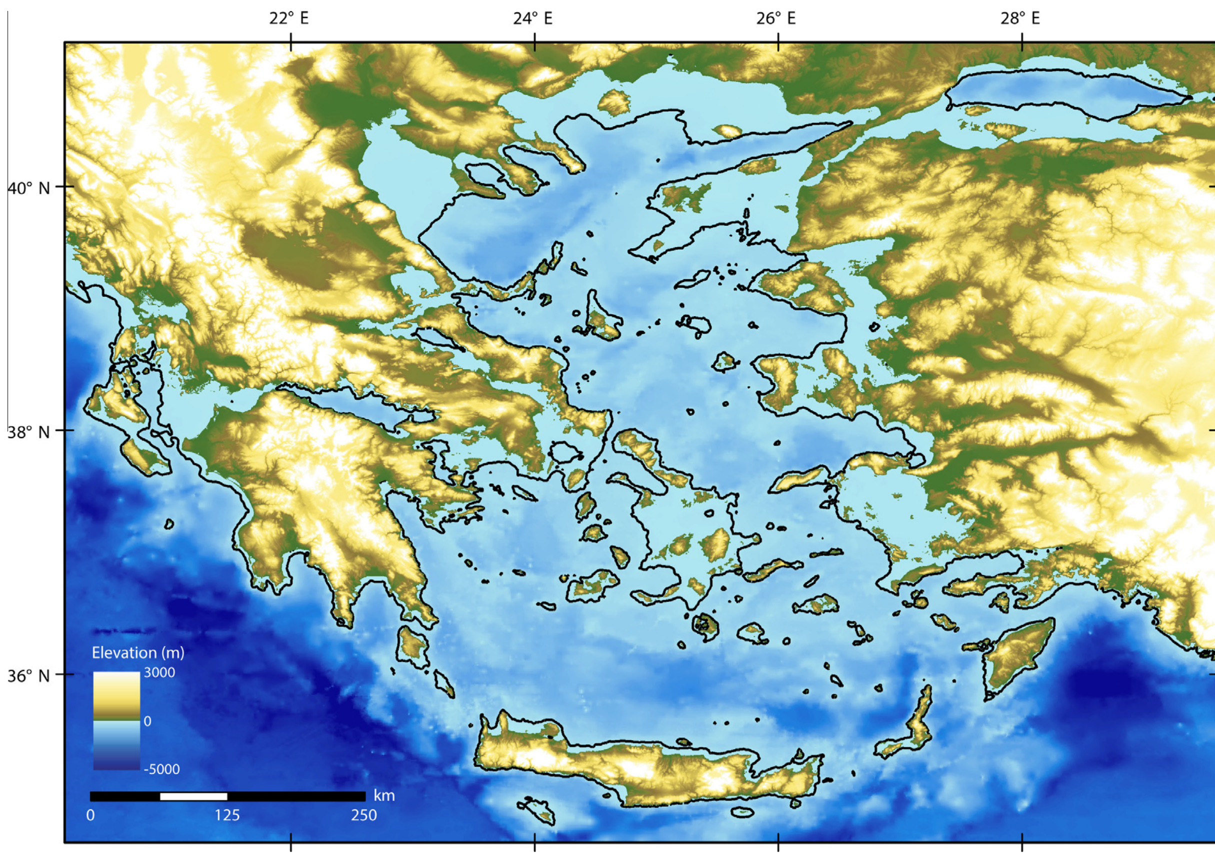


Fig. 2. The Aegean Sea in a glacial sea-level lowstand of −130 m (Map: Karl Wegmann and Sean Gallen).

hippopotami and elephantids, that were nanized as the result of 'insular dwarfism' and an absence of mainland predators (Simmons, 1999; Mavridis, 2003; van der Geer et al., 2010; Simmons, 2012; Lomolino et al., 2012, 2013; van der Geer et al., 2013, 2016; van der Geer, 2014).

5. Hominin cognitive and technological capabilities

A fourth, critical question, is what were the cognitive and technological capabilities of archaic hominins? Were they on the order of those commonly attributed to AMH or Neanderthals, or were they, as some research suggests, insufficient for the construction of watercraft and the planning of logistically-complex sea-crossing adventures (Cherry and Leppard, 2015; Leppard, 2015)? Did early hominins have the ability to assess the risks involved with the crossing of open water, which we assume required complex thought processes? Controlled risk taking in early human cognition involved—minimally—social intelligence, self awareness, communication, and planning (Renfrew, 2007). In our view, the sophistication of early cognition can be inferred from the successive adaptive radiations of archaic hominins from Africa to Eurasia following terrestrial dispersal routes.

Hominins left Africa ca. 1.8 mya, as witnessed by sites such as Dmanisi (Dzaparidze et al., 1989) and Ubedeiya (Bar-Yosef, 1980, 1987; Clark, 1989), and perhaps Riwat in Pakistan (Dennell et al., 1988a, 1988b). Beginning ca. 1.4–1.0 mya, hominins, perhaps *H. erectus*, were established in most of Eurasia (Shea, 2013: 47–80). These dispersals required a considerable degree of cognitive and technological ability of different grades of archaic hominins. *Homo floresiensis* on Flores—a nanized descendent of *H. erectus*, or perhaps a small-bodied hominin that arrived by a separate adaptive radiation of African hominins (Falk, 2011: 183–187)—was part of this or an earlier dispersal, and raises the possibility that hominins in Southeast Asia made sea-crossings as early as 840,000 BP (e.g., Bednarik, 2003, 2014; Simmons, 2014: 26–37; *contra* Smith, 2001; Dennell et al., 2013). Although, for some scholars, Flores remains an outlier and evidence for passive dispersals in sweepstakes events (e.g., Leppard, 2015), we concur with Bednarik (2003) that archaic hominins manifested in the Eurasian dispersals *collectively* a significant degree of effective communication and, importantly, some level of narrative thought—perhaps the most important element because it presupposes the ability to consider cause and effect (causality) and calculate risk.

Clues to the connections between hominin cognitive abilities and dispersals may be sought in the social brain hypothesis and the theory of mind that relate the greater size of hominin brains to greater complexity of their social groups (Gamble, 2013: 68–74). Gamble notes the larger size of an individual's active network amongst larger-brained grades such as *H. erectus*, which, unlike other primates, lived in social groups numbering at least 120 individuals. At this scale, language (as a form of vocal grooming), along with new forms of artifacts, would have been necessary to create and maintain social relationships. Language may have been essential for making symmetrical stone tools (e.g., Acheulean bifaces) that required elaborate flaking techniques. As social groups increased in size and individuals engaged in larger and more active networks, there was a corresponding value to knowing what other members of the group were thinking and feeling.

> The ability to recognize another mind and adjust social reasoning accordingly through a narrative chain of belief about other people's intensions … brought about a social world of hominins … of imagination layered with interpretations and

codes of conduct that were not dependent on being within sight of other humans.

[Gamble (2013: 174–177)]

Recent experimental studies demonstrate that teaching in the form of facilitated observation, symbolic communication, gestures, and, perhaps, verbal language, were vital components in the transmission of increasingly complex lithic technologies in the early Palaeolithic (Morgan et al., 2015). An Acheulean handaxe with bilateral symmetry and a lenticular cross-section is a Euclidean relation achieved in the 'concrete operational phase' of human cognition characterized by organizational features such as reversibility, conservation, and the pre-correction of errors (Wynn, 1991: 54–58). The appearance of the first stone artifacts in East Africa, ca. 3.3 mya—the Oldowan Industrial Tradition—underscores the shift in early human cognitive and motor processes that led to the spread of increasingly complex lithic technologies throughout Africa and Eurasia. The spatial sophistication and symmetry of Acheulean handaxes demonstrate a marked increase in technical skill over the earlier Oldowan as the knapper had to plan ahead to impose a preconceived form on a carefully selected blank. This level of technical intelligence can be seen in stone tools from archaeological horizons at the end of the Acheulean, ca. 300,000 BP (Wynn, 1979, 1989), although the production of symmetrical handaxes appear as early as 1.7 mya.

In what form later Acheulean flintknappers transmitted their increasingly sophisticated technology remains unclear, but the imposition of a specified shape and form by a complex process of reduction would have required 'proto-language' to effectively communicate the technique to others in the group (Morgan et al., 2015). Indeed, the increasing complexity of Acheulean, Levallois and Mousterian lithic technologies, the last two often associated with Neanderthals, required more intricate and precise methods of manufacture, and demonstrates that hominins developed some capacity for teaching (Morgan et al., 2015: 6). Thus verbal or gestural form of communication may have existed as early as 1.7 mya (Morgan et al., 2015: 6). We can add to this the line of inquiry being pursued by archaeogeneticists who have identified a genetic polymorphism DRD4-7R linked tentatively to curiosity and restlessness (Dreber et al., 2009; Matthews and Butler, 2011). It is described as a novelty-seeking trait that favours curiosity, innovation, and risk taking, and it may be necessary to look within our genome to find the cause of hominin dispersals in the peculiar form of animal consciousness that manifests itself in the desire to explore and to innovate.

To the above, add the evidence for the exploitation of aquatic resources by archaic hominins (Stewart, 1994; Stiner, 1994; Erlandson, 2001; Bailey and Milner, 2002; Bailey, 2004), including 'low-tech' foraging strategies such as shellfish collecting and shoreline scavenging (Erlandson, 2001, 2010), and 'high-tech' strategies such as off-shore fishing with harpoons, lines and nets, which have long been viewed as a relatively late development in the Palaeolithic (e.g., Dennell, 1983). Some scholars suggest that the development and maintenance of larger brains may have stemmed from the early exploitation of energy and nutrient-rich aquatic resources—essentially a 'shore-based' scenario of human evolution (Cunnane et al., 1993; Broadhurst et al., 1998, 2002; Crawford et al., 1999). Erlandson (2010) argues that our hominin ancestors would have been drawn to lakes, rivers, estuaries and marine habitats for the easy access to fresh water and the availability of a variety of dietary resources packed with long-chain fatty acids and 'brain-specific nutrients'.

If the consumption of long-chain polyunsaturated fatty acids found in coastal resources enabled some form of brain expansion in early hominins, including the improvement of retinal quality, there may have been a significant leap in cognitive development (Cunnane et al., 1993; Broadhurst et al., 1998, 2002; Crawford et al., 1999; Parkington, 2001; Uauy and Dangour, 2006). These fatty acids, including docosahexaenoic acid (DHA) and arachninoid acid (AA) present in Omega 3 and Omega 6, which are crucially important in the visual and neurological development of newborn infants (Jensen, 2006; Milligan and Bazinet, 2008), can be found in coastal resources (Bicho et al., 2011: 16; Bicho, 2015: 108), including marine shellfish. Indeed, limpets produce the highest levels of DHA and AA, and appear most frequently at early sites with coastal resources in the Mediterranean (see above).

The exploitation of coastal ecological niches would have required a complex degree of pro-social behaviour in early hominin groups, largely due to reduced mobility, a higher degree of sedentism, and larger populations, as well as the development of specialised technologies. Human adaptations to coastal environments, therefore, can be described as human resilience 'in action', and a definitive phase of innovation in human evolution (Bicho, 2015: 108). Over time, the continued development of aquatic and coastal foraging may have resulted in specialised knowledge systems and adaptive technologies that contributed to the (gene-based?) desire to go further and further offshore. As groups of *H. erectus* spread through Africa and Eurasia, and Neanderthals radiated throughout Europe, the need to cross open water barriers would have presented a distinct problem. In sum, the antiquity of aquatic resource exploitation and the link between marine diet and human brain evolution, and the emergent properties of narrative thought, imagination, and language may be the necessary elements for understanding the origins of Palaeolithic maritime activity.

Recently, Leppard (2015) reviewed much the same evidence as we adduce above, but reached a completely different conclusion, viz. that the logistical, technological, and organizational capacities for open sea-crossings can be associated with certain 'neurophysiological architecture' that can be correlated only with anatomically modern humans, emerging late in evolutionary terms. Noting that the "prevailing interpretation has been…of bodies of water as biogeographic barriers to dispersal in *Homo*" (Leppard, 2015: 4), he examines the necessary capabilities for 'purposive colonization' in the form of modelling spatially distant habitats, communication in the form of language, and cognitive processes, including balancing risk, abstraction, decision-making, and communication of complex concepts. Although duly cautious that "we cannot be certain at exactly what point in the evolutionary history of *Homo* modern cognition emerged" (Leppard, 2015: 4), he concludes that the evidence for complex technology in the form of compound tools, modern language, symbolic behaviour, and controlled fire are only manifested in the aggregate after ca. 300,000 BP amongst AMH (Leppard, 2015: figure 3), although he allows for the possibility that it could be extended to Neanderthals and potentially *Homo heidelbergensis* (Leppard, 2015: 14, figure 2, which shows, by the way, considerable overlap in the hominin grades amongst archaic *sapiens* and *H. erectus*, especially ca. 500–400,000 BP).

So, how far apart are we in reality? Some of the difference may be semantic, as we are not arguing for 'colonization' so much as 'exploration' or 'traversing' of islands by early humans, nor are we so far apart in terms of chronology. Leppard (2015: 8, 10 and figure 3) is willing to see some of this complex modern behaviour as early as 600,000 BP, which is not so different from the estimate of ca. 800,000 BP by some proponents of early sea-going (e.g., Runnels et al., 2014a). The difference may also be epistemological. Leppard (2015: figure 3) characterizes his summary of the behaviours correlated with different grades of archaic humans as a J-curve, where Flores, at more than one million years, is described as an 'outlier' (as is presumably Crete, with its question mark, on the same graph at ca. 800–300,000 BP). But we regard this same graph as a sigmoid function or S-curve that represents a process that progresses from small beginnings—a long lag phase at the beginning with very low archaeological visibility, which accelerates exponentially beginning ca. 600,000 BP, and achieves a stable, archaeologically-visible plateau, sometime after 50,000 BP. In short, we do not regard the separate dispersal events of archaic hominins and AMH as discrete steps ('punctuated equilibria') but as points along a logistical curve, with differences of degree rather than kind.

6. Early watercraft

We turn now to evidence for early watercraft. We use the term 'watercraft' to avoid the unwarranted connotations of terms such as 'boat' or 'ship'. Watercraft are constructed of buoyant materials capable of carrying five to ten adult humans over bodies of water five to seven kilometres in extent or more. We assume that watercraft are necessary to cross open bodies of water of that extent in the case of able-bodied adults, much less the young and the aged. Whilst most AMH demonstrate an innate ability to swim, especially in the first six months of life, a phenomenon known as the 'mammalian diving reflex' (Goksör et al., 2002), humans need to learn swimming techniques, or strokes, in order to create propulsion in the water. Without any form of effective propulsion, the individual would simply tread water and drift with the current. To what extent swimming behaviour was transmitted between archaic hominins remains unknown, despite claims by Morgan (1982, 1997) and others that our evolutionary ancestors underwent a period of semiaquatic adaptation—the so-called 'Aquatic Ape Hypothesis'. Nevertheless, swimming and diving behaviour in non-human primates, particularly Rhesus monkeys and, more recently, two captive apes (one common chimpanzee and one orangutan), demonstrates instinctual reactions and learned behaviour during juvenile play; observations that strongly contradict the view that non-human primates are adverse to complete submersion in water (Rawlins, 1982: 135–139; Bender and Bender, 2013). Even so, open-water swimming is a skill that requires a degree of experience and training, especially over long distances and across straits or channels where there are tides and strong surface currents. As such, it is unlikely that groups of archaic hominins or AMH employed this method to cross open water channels. The risk would have been too great.

How hard was it to construct such a watercraft? Referring to the Atlantic Ocean, Kehoe (1971: 275–276) notes that:

> two rafts, two dugout canoes, two dories propelled only by oars, several dories fitted with sails, conventional sailboats as small as five feet eleven inches in length, and unconventional boats including kayaks, folding boats, and an amphibian jeep have successfully floated across [it]

At least two of these adventurers made the crossing *without any stored food or water*, relying entirely on fish for food and fluids for journeys up to 65 days. Remarkably, they made it in reasonable health (Kehoe, 1971: 276–279). Kehoe argues that hide[skin]-covered boats with light wooden frames were easy to make and to keep in repair, and could sail over—as opposed to through—the waves with up to 20 persons (Kehoe, 1971: 277–279). Other possible Palaeolithic watercraft include logs, rafts, reed-bundle rafts, sailing rafts, and dugout canoes (Greenhill, 1976; Johnstone, 1988; McGrail, 2001; Simmons, 2014: 76–101).

In its simplest form, a sailing raft consists of lashed logs or bundles of reeds laid side by side so that the narrow ends form a rudimentary prow (Doran, 1971) (Fig. 3a). It is both relatively simple to construct, and yet has the capability to cross significant bodies of open water whilst carrying multiple adult human beings. When equipped with a centreboard to prevent drift, it is also capable of sailing close to the wind (Doran, 1971; Huth, 2013: 382–402). Sailing rafts have made experimental sea-crossings of considerable length, such as those achieved in the Pacific by Heyerdahl (1950: 35–60) (Fig. 3b) and Eric de Bisschop, who covered just over 8000 km in a single voyage lasting six months (Doran, 1971: 123–134). Reed or papyrus watercraft require relatively little complex technology to build (Fig. 3c). Papyrus bundles secured and sealed with bitumen at the Neolithic Kuwaiti site of As-Sabiyah ca. 7000 BP (Connan et al., 2005) provide evidence for the antiquity of reed-built rafts in the neighbouring Near East.

In the Mediterranean there is no physical evidence for prehistoric watercraft, but experimental research has provided much food for thought. For example, an experimental sailing raft of canes made the crossing from Kythera to Crete in 48 hours (Robert Hobman, personal communication, December 2014, http://greece.greekreporter.com/2014/07/16/from-kythera-to-crete-on-a-raft/). Despite criticism of the significance of this project, especially the use of anachronistic methods and technological strategies during the construction phase of the raft (Cherry and Leppard, 2015), it demonstrates one simple possibility: Mediterranean canes bound into bundles and lashed together with cords can be paddled across open water from the Greek mainland to Crete in two days carrying ten persons. In another experiment, a replica papyrus reed boat—or 'papyrella'—was paddled successfully from the mainland to Melos and other Cycladic islands in 1988 (Tzalas, 1995) (Fig. 3d).

Other types of watercraft include skin-covered boats, which were well-known in antiquity (Fig. 3e), e.g., the river craft in Mesopotamia (Casson, 1963: 257–259), and in the Po Valley in northern Italy (Lucan 4. 131–132). Wooden dugouts are represented by a well-preserved specimen from the lakeside Neolithic settlement at La Marmotta (ca. 7500 BP) in central Italy (Tichy, 2000). This ten metre-long dugout was hewn from the trunk of a single oak (Fig. 3f) and was capable of making sea-crossings of considerable length. An experimental replica with a crew of eleven achieved rates of travel of 32 km a day in the open Mediterranean (Broodbank, 2013: 213–214).

These experiments suggest that three technologies are required to build simple watercraft: sharp-edged cutting tools, fire, and cordage. Were these technologies available to archaic hominins (a question separate from whether they used them for this purpose)? The answer is yes. Stone tools capable of cutting reeds and wood, striping cane, and scraping skin are the earliest of all our known technologies, and Lower Palaeolithic cutting tools such as handaxes, cleavers, choppers, picks, and scrapers (Shea, 2013: 84–105) can be used to cut reeds or work timber, and transverse-edged cleavers could be used to hollow out a fire-charred log for a dugout canoe. Fire also has an early pedigree, and evidence for the controlled use of fire is documented at least one million years ago (Berna et al., 2012; Shea, 2013: 55–70). Finally, cordage from plant fibres, animal hair or skin required few tools other than sharp stone flakes for cutting and scraping. Indeed, skin working and cordage are probably as old as stone-toolmaking (Schick and Toth, 1994: 160–162), and knowledge of fibres has significant time depth in the Palaeolithic (Soffer et al., 2000; Klein, 2009: 678; Kvavadze et al., 2009). We note that research is pushing the origins of fire and the manufacture of fibre cordage back in time, and technologies that were once thought to be the exclusive products of AMH in the last 50,000 years appear to have much earlier origins (McBrearty and Brooks, 2000, *contra* Klein, 2009: 649–653). There is good reason to conclude that early hominins had the technical elements necessary for constructing watercraft in the Middle Pleistocene.

Some scholars criticize such experiments on epistemological grounds (e.g., Cherry and Leppard, 2015), arguing that experiments depend upon modern human capabilities making it difficult, if not

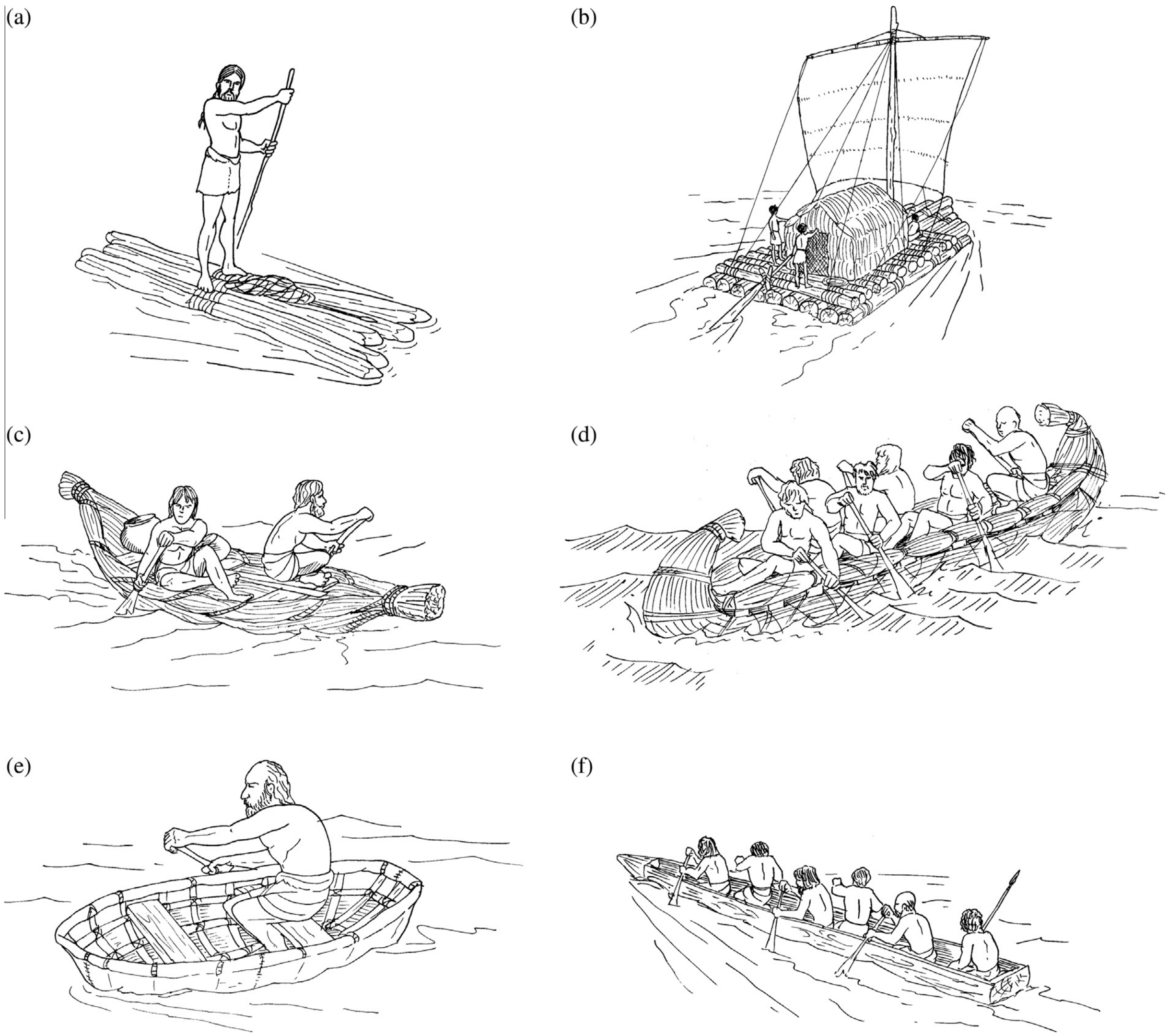


Fig. 3. (a–e) Varieties of prehistoric watercraft (Drawings: Yannis Nakas).

impossible, to use the results to evaluate the abilities of archaic hominins as they are inherently unfalsifiable truth-claims. We agree that experiments carried out by modern humans exhibit cognitive and technological capabilities that are not analogues for archaic hominins, but they do show that—technologically—simple watercraft with sea-going properties would require, maximally, sharp-edged stone tools to cut canes and shape wooden paddles, which are capabilities well within the known capabilities of the archaic hominins who shaped wooden spears at Schoningen or constructed huts at Terra Amata. They needed only the ability to bundle the canes and a knowledge of cordage to tie the bundles together. Although we agree that sea-going truth-claims cannot be tested with experimental data, which require irrefragable archaeological data from islands that can only be reached by sea-crossings, experimental trials with watercraft are useful for uncovering the necessary degree of technological and cognitive requirements for building watercraft.

7. Wayfinding

One question that has been rarely considered in the context of discussions of Palaeolithic maritime activity is connected with wayfinding. In its simplest definition, wayfinding means knowing where one is and determining one's direction of travel (Huth, 2013: 22–23). Were archaic hominins able to find their way across open water, and, importantly, their way back again?

There are two types of voyaging: 'in sight of land' (land is in full view throughout the voyage, astern, abeam or ahead) and 'out of sight of land' (open-sea passages, land remains out of sight until a landfall is made) (McGrail, 2001: 95). Despite conventional wisdom about hugging the coast, sailors consider out of sight of land voyaging safer because there are fewer navigational hazards like shoals or shallows. Locally variable sea breezes and wind velocities often make sailing in sight of land dangerous because one can be blown onto a lee shore (McGrail, 2001: 94–95). To cross from the Greek mainland to Crete, Naxos, or Melos during Pleistocene sea-level lowstands, the opposite shore would have remained in sight for most of the voyage, although open channel crossings ranging up to 10–25 km approach the limit of in sight of land voyaging. Fog, haze, darkness, and large waves will obstruct visibility making in sight of land voyaging something of a theoretical concept. Even the narrowest of straits can become deadly, as is demonstrated in our time by the appalling numbers of refugees in the eastern Mediterranean who have died at sea.

In either mode, position-fixing at sea and maintaining dead reckoning were essential. Huth relates how two kayakers died after getting lost in a fog bank off the coast of Cape Cod in Massachusetts within two miles of a long shoreline (Huth, 2013: 11–13). Thus hominins would not have attempted to reach offshore islands by drifting. Although 'accidental drifting' may take place by chance or necessity, such an episode would not have been repeated often enough to result in a detectible human presence on an island. Unless a founder population is replenished with newcomers from time to time, the chance arrival of small groups is insufficient to create a visible archaeological signal (Broodbank and Strasser, 1991; Simmons, 2014: 206). Moreover, drifting was useless if one wished to return home or make multiple reciprocal crossings, i.e., drifting only refers to the manner of propulsion, such as letting the wind and currents move a raft, and does not imply a lack of navigation and steering. During the 'drift voyage' of the Kon-Tiki the mariners were always in control of the sailing raft, using a steering oar to maintain a heading whilst a centreboard served as a 'keel' to help the raft sail before the wind (Heyerdahl, 1950: 113). Aegean waters are unpredictable, and in the Pleistocene, when straits were narrowed by glacial sea-level lowstands, there were correspondingly faster and more unpredictable currents. To reach an offshore island, even one in plain sight across a narrow channel, it would have been necessary to control the direction of travel—a point of importance if one planned to return to the point of departure. The growing evidence for Palaeolithic presence on Crete points to repeated visitation of the island, as opposed to a one-off 'sweepstakes' colonization event. A few individuals stranded on the island more than a hundred thousand years ago would be invisible archaeologically (Runnels, 2014); repeated crossings would have been necessary, as they were in the Early Neolithic (Broodbank and Strasser, 1991).

In our view, purposeful Palaeolithic sea-crossings in the Aegean were not prevented by prevailing winds and currents; apart from our present ignorance of the wind and current patterns in the Pleistocene Mediterranean, we should heed the words of an experienced sailor:

> Wind and current directions and strengths are by no means as persistent as pilot charts and climatic atlases suggest—they are presented only as averages…[f]aith in the persistence of direction of strength has engendered much debate, and often the winds and currents flow in the same direction as the favored theory. But this faith is not shared by oceanographers and meteorologists, and many a sailing man has had occasion to be skeptical. They know that the average conditions portrayed on pilot charts and in atlases often do not represent the actual conditions as they are experienced on an individual voyage. Recent investigations of ocean and coastal currents reveal that they are anything but ever-flowing and unidirectional
>
> [Edwards (1971: 302)]

Referring specifically to Crete, an authority from the age of sail notes that:

> the currents on the coast of the Island of Candia [Crete] are variable, and subject principally to the influence of the local winds…[and] no law can be given from experience … especially in the southern part and in the channels leading to east and west sides of Candia; for not only do the local winds, but also those from a distance when strong, sometimes retard and change the direction and strength of the currents
>
> [Wyman (1870: 160–161)]

Prevailing winds played an important role in establishing maritime networks in historical periods, including the formation of trade routes, but for early mariners sea currents were equally important. Small, lightly-built watercraft that were rowed or paddled would have been slower and more susceptible to the movement of surface currents and swells than to winds, giving them more independence of movement.

The Medieval Geniza document repository from Cairo can throw additional light on Mediterranean wayfinding in the age before the magnetic compass. The practices described in those documents reflect ancient lore and experience (Goitein, 1967). They include records of shipping activities from the tenth to the thirteenth centuries produced by merchants who sailed from Egypt (chiefly Alexandria) to all parts of the Mediterranean. The documents describe both in sight of land and out of sight of land voyaging, with the former chiefly on the south-to-north route from Alexandria along the Syro-Palestinian coast, and the latter when they traversed the western Mediterranean (Goitein, 1967: 318–320). Out of sight of land travel was a vital commercial need to reduce the time required for the voyage, and ships sailed straight from Alexandria across the Mediterranean to Italy, Sicily, Spain, or southern France (*contra* Gertwagen, 1996: 78). These voyages took as few as eight days of sailing on the open sea (Goitein, 1967: 318–319, 325–326), and direct long-distance open-sea routes were more numerous than routes that hugged the coast (Goitein, 1967: 319). Sailors did not find sailing out of sight of land challenging on account of currents or prevailing winds: if they could not make headway against the wind by sail they rowed, an d—incredibly—the sailors in these documents show little interest in providing a supply of food or water for themselves, perhaps because "the Mediterranean seafarer did not find unsurpassable the difficulties in providing for himself adequately" (Goitein, 1967: 316), often subsisting on dried carobs that would remain edible for months (Goitein, 1967: 121). They could also have eaten fish, and obtained drinking water from them, like Heyerdahl's crew on the Kon-Tiki: they extracted a supply of fresh drinking water from the fish by chewing on the flesh, twisting it in a cloth, or cutting holes in the sides of larger fish (Heyerdahl, 1950: 89–97).

Is there archaeological evidence for early wayfinding? That the first African hominins made their way back to home base after exploring a neighbouring valley in search of food or stone for tool-making is demonstrated by Oldowan stone tools made from raw materials transported up to five kilometres from their sources (Schick and Toth, 1994: 126–127). Wayfinding means knowing where one is and determining one's direction of travel (Huth, 2013: 22–23), and wayfinding at sea without the use of physical instruments is called 'environmental navigation' or 'dead reckoning'. This kind of navigation relies on the close observation of changes or patterns in the sea, air, and sky to establish position and course, and reckoning one's speed to track progress (McGrail, 2001: 97). Experimental studies, like those of Bednarik's First Mariners Project, demonstrate that sensory perceptions of maritime space, such as changing cloud formations, water currents, and wind patterns, and how they varied in the vicinity of headlands or in the wake of islands, are fundamental skills for open-sea voyaging (see Bednarik, 1997, 1998, 1999a, 1999b, 2001, 2003). Observation of the general direction and speed of a surface current or swell can reveal the direction of a prevailing wind (Davis, 2001: 9), and strong undertows are often generated in the proximity of an adjacent shoreline. Surface currents can be used to gauge and maintain a particular course or heading, and when the winds abate, residual waves and currents continue to flow on the same heading, leaving the mariners with a directional clue (Lewis, 1994: 148–150). Ethnographic research in the Pacific shows that Polynesian navigators could detect patterns in wave and swell formations when in the vicinity of island groups (Huth, 2013: 291–317), permitting mariners to correct their headings when they observed a slight change in the shape of the swell. Other Pacific navigators detected currents and refracted waves by dipping their feet over the side of the boat or by immersing themselves and sensing the movement of the water flowing around their bodies (Lewis, 1994).

Palaeolithic mariners would have 'read' wind signatures to obtain their bearings; signatures that included strength, moisture, temperature, accompanying haze, cloud-cover, and the general state of the sky (Davis, 2001: 15). The ability to track wind regimes required the memorization of much detailed information, which early mariners in Oceania achieved in verse form (McGrail, 2001: 345). In Greece by Homer's time the names of the winds became synonymous with directions and the nature of the apparently featureless maritime spaces was transmitted from generation to generation in verse or song. In today's eastern Mediterranean, the most persistent wind is the Melemi—a northerly wind that blows with regularity from March to November. In the Aegean, the Meltemi accounts for 90% of all winds recorded in July (British Hydrographic Department, 1961: 5.29–30). Once it reaches Crete it veers in an easterly direction, and by the time it reaches the central Levantine Basin it is westerly–northwesterly. The open season for seafaring in the Aegean, which runs from May to September, coincides with the arrival of the Meltemi (Broodbank, 2000: 92–96), enabling mariners from the northern Aegean to journey south. These winds can blow at gale force, especially during July and August, at the height of the open season, forcing mariners to take shelter for days at a time. As Ammerman (2011: 44) observes, early seafaring was a "waiting game"; waiting for the right conditions, good visibility, and favourable winds and currents.

Once at sea, colour changes in the water reveal shallow-lying reefs, rocky outcrops, and the presence of shoals and sand bars. Even in the age of depth-finding sonar, pilot books make reference to the colour of the sea as an important navigational aid (Beresford, 2013: 194–198). Waters' study of navigation in sixteenth and seventeenth century England refers to the 'domestick' type of navigation or 'coastal pilotage', which relied on no instruments except "experience, the compass and the lead" (Waters, 1958: 4). The most important item on this list was experience. On voyages in sight of land it is reasonable to assume that they would have adopted the 'domestick' type of environmental navigation, using natural landmarks along the shore, and for voyages out of sight of land mariners employed dead reckoning.

Voyaging to the large oceanic islands of Cyprus and Crete required sailing at night and a degree of astronomical knowledge. The rising and setting of the sun and moon and the discernible patterns and rotations of the stars were no doubt observed, along with the constellations revolving around a celestial null point in the night sky where the stars rotate around the celestial pole (Davis, 2001: 139–140), specifically, the closer the stars are to the pole the less they change position (Morton, 2001: 215). These circumpolar stars served as reliable indicators of relative north for early

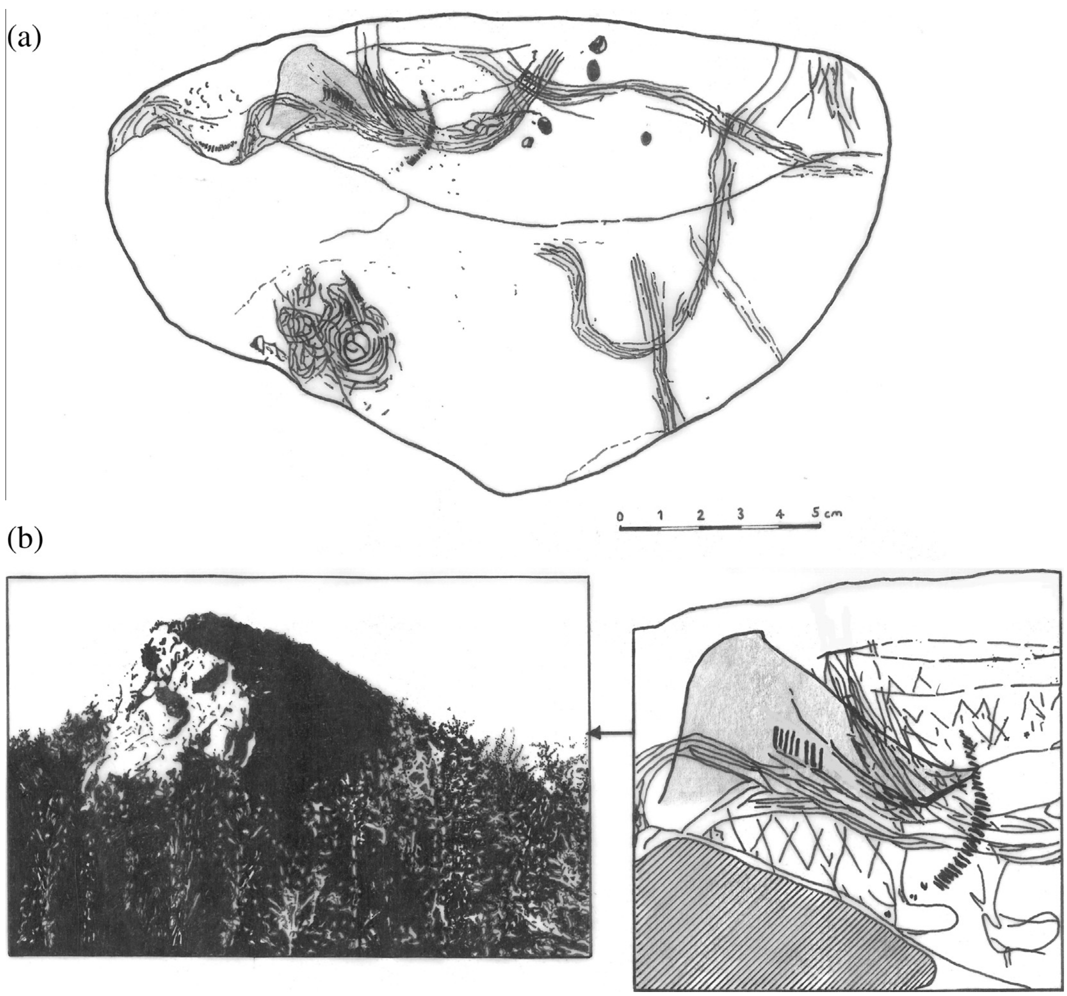
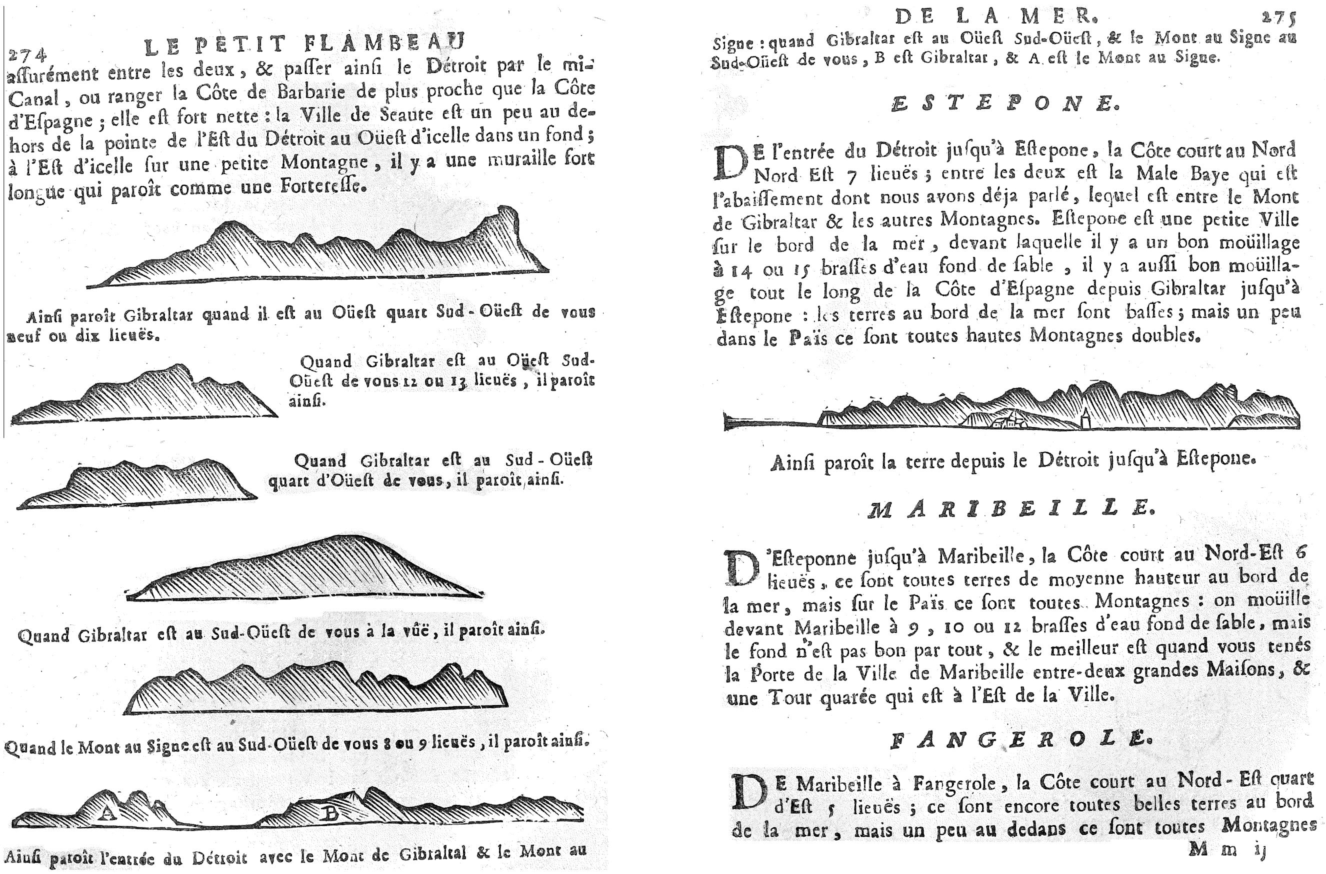


Fig. 4. (a) Drawing of an engraved stone from the Upper Palaeolithic levels at Abauntz Cave (Spain). (b) On the left, a photo of a hill with a distinctive shape as visible from Abauntz Cave, and on the right the same hill, as seen in outline, on the engraved stone. This is an example of a simple 'recognition view'. Such views in early modern Mediterranean pilots and portolans likely had their roots in much earlier 'maps' (Photo and Palaeolithic images redrawn by D. Howitt-Marshall after Utrilla et al., 2009).



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aſſurément entre les deux, & paſſer ainſi le Détroit par le mi-Canal, ou ranger la Côte de Barbarie de plus proche que la Côte d'Eſpagne; elle eſt fort nette: la Ville de Seaute eſt un peu au dehors de la pointe de l'Eſt du Détroit au Oüeſt d'icelle dans un fond; à l'Eſt d'icelle ſur une petite Montagne, il y a une muraille fort longue qui paroît comme une Forteteſſe.

Ainſi paroît Gibraltar quand il eſt au Oüeſt quart Sud-Oüeſt de vous neuf ou dix lieuës.

Quand Gibraltar eſt au Oüeſt Sud-Oüeſt de vous 12 ou 13 lieuës, il paroît ainſi.

Quand Gibraltar eſt au Sud-Oüeſt quart d'Oüeſt de vous, il paroît ainſi.

Quand Gibraltar eſt au Sud-Oüeſt de vous à la vûë, il paroît ainſi.

Quand le Mont au Signe eſt au Sud-Oüeſt de vous 8 ou 9 lieuës, il paroît ainſi.

A B

Ainſi paroît l'entrée du Détroit avec le Mont de Gibraltal & le Mont au

DE LA MER. 275

Signe: quand Gibraltar eſt au Oüeſt Sud-Oüeſt, & le Mont au Signe au Sud-Oüeſt de vous, B eſt Gibraltar, & A eſt le Mont au Signe.

ESTEPONE.

DE l'entrée du Détroit juſqu'à Eſtepone, la Côte court au Nord Nord Eſt 7 lieuës; entre les deux eſt la Male Baye qui eſt l'abaiſſement dont nous avons déja parlé, lequel eſt entre le Mont de Gibraltar & les autres Montagnes. Eſtepone eſt une petite Ville ſur le bord de la mer, devant laquelle il y a un bon moüillage à 14 ou 15 braſſes d'eau fond de ſable, il y a auſſi bon moüillage tout le long de la Côte d'Eſpagne depuis Gibraltar juſqu'à Eſtepone: les terres au bord de la mer ſont baſſes; mais un peu dans le Païs ce ſont toutes hautes Montagnes doubles.

Ainſi paroît la terre depuis le Détroit juſqu'à Eſtepone.

MARIBEILLE.

D'Eſteponne juſqu'à Maribeille, la Côte court au Nord-Eſt 6 lieuës, ce ſont toutes terres de moyenne hauteur au bord de la mer, mais ſur le Païs ce ſont toutes Montagnes: on moüille devant Maribeille à 9, 10 ou 12 braſſes d'eau fond de ſable, mais le fond n'eſt pas bon par tout, & le meilleur eſt quand vous tenés la Porte de la Ville de Maribeille entre-deux grandes Maiſons, & une Tour quarée qui eſt à l'Eſt de la Ville.

FANGEROLE.

DE Maribeille à Fangerole, la Côte court au Nord-Eſt quart d'Eſt 5 lieuës; ce ſont encore toutes belles terres au bord de la mer, mais un peu au dedans ce ſont toutes Montagnes

Mm ij

Fig. 5. A typical collection of 'recognition views' from a Mediterranean pilot or mariner's handbook that was in use for centuries. The individual views resemble the engraved outline view of a hill on the Abauntz Cave stone, e.g. on the lower left where a hill with a similar shape to the Abauntz Cave hill is visible on the approach to the Spanish coast at Gibraltar (marked 'B') (Mont au Signe). *Source:* Sieur R. Bougard, Le Petit Flambeau de la Mer ou le veritable guide des pilotes cotiers, Guillaume Gruchet, Havre, 1731.

navigators, a so-called 'star path' to help maintain a heading across open sea. Prior to the use of the magnetic compass, navigators set their headings by reference to these celestial bodies, by day fixing their position by the dawnstar, and holding the rising sun on their starboard bow for a northerly heading, and by night, fixing their position and heading by the evening star and the polestar (Beresford, 2013: 207). Early mariners in the Mediterranean would have studied the rising and setting of the moon, the motion of the constellations, and followed the star drift of the Milky Way, just as Homer tells us that Odysseus, on his way to Calypso's island, kept the Great Bear (Ursa Major) on his port side (*Odyssey* 5, 270–275). Pacific mariners also steered a course in relation to stars and constellations, leaving a rich tapestry of folklore relating to the sea and sky (McGrail, 2001: 97), including the development of a star compass, which enabled early mariners to track the stars that rose and set on the bearings of islands (McGrail, 2001: 340; Huth, 2013: 291–317).

Navigation out of sight of land was less important in the Aegean (Broodbank, 2013: 8–9). Many islands are inter-visible for the duration of a voyage and mariners approaching land line up prominent landmarks on the nearby shore to set a course, such as the cloud-capped Cretan sierra. A landscape outline visible from the sea is called a 'recognition view' and such views enabled mariners to maintain a heading when returning to the same stretch of coast (Purdy, 1834; Huth, 2013: 53–80). In the absence or failure of instruments, recognition views are helpful—if not vital—for finding one's way to the entrance of a harbour (Andrew Stewart, personal communication, 2012). McGrail (2001: 99, Table 4.1) notes that the distance between a boat at sea level and a visible point of land of 30 m elevation is 11.5 nautical miles (21.3 km). At 305 m in elevation, landscape features are visible from up to 36.3 nautical miles (67.2 km). Higher peaks would be visible at greater distances, and even when the land was not visible distinctive cloudscapes would reveal the existence of invisible landfalls (Lewis, 1994). Such wayfinding lore may have been preserved in visual form, and 'recognition views' may already have been in use as early as the Upper Palaeolithic. For example, an engraved stone from the Upper Palaeolithic levels in the Abauntz Cave in Spain ca. 13,660 years ago is thought by the excavators to depict the landscape with rivers and plains near the cave, and significantly, a profile of a hill visible from the entrance to the cave (Utrilla et al., 2009: 108, fig. 7) (Fig. 4a and b). The profile of the hill resembles the coastal-outline recognition views that were still in use well into the nineteenth century in handbooks for the use of sailors in the Mediterranean (e.g., Gaudy, 1771; Purdy, 1834) (Fig. 5). Such simple outline views of significant landscape features as seen from the sea may have a great antiquity.

Huth (2013: 11–29) assumes the existence of mental maps requiring linear conceptualisation where the traveller creates an image of a line of travel ('route knowledge') marked by a series of waypoints and orienting features (like the position of the sun, the moon, and the stars). In a similar vein, Strasser draws attention to conceptual or mental templates that aid travellers in visualizing the distances they must traverse to reach offshore islands. Maps of the Aegean made before the introduction of Mercator Projection showed islands as much larger in size, and lying much closer to the mainland than they are in reality. This was a means of visually representing the relative difficulty of travel: the mapmakers exaggerated the size of landscapes that were crossed slowly, and reduced the size of the sea expanses that were crossed rapidly (Strasser, 2003: 10).

For experienced sailors an appreciation of the local conditions would have become second nature. A *nakhoda*, or mariner, on a Red Sea *zarook*:

> never took bearings . . . he kept his eyes open, he knew his ship, and his life had been spent in the Red Sea [which] was to him as familiar as a well-lit street on a citizen's homeward journey
> [Villiers (1954), quoted in Ray (2003: 19)]

Experience and memory of place were ultimately the most important components in the early mariner's mental map of 'sea-marks', a virtual chart in the mind's eye.

8. Other environmental navigation techniques

The flight paths of migrating birds indicate the direction of lands beyond the horizon, as does the direction taken by land birds that fed at sea and return to their nests at the end of day (Davis, 2001: 90). The use of birds in navigation is attested in ancient sources (Boraston, 1911), including Greek and Near Eastern mythology (e.g., Callimachus, Hymns 2.65; Apollonius Rhodius, The Argonautica 2.328–334, 555–575, Homer, The Iliad 5.274, Homer, The Odyssey 5.63, 5.333, 12.417 and Hesiod, Works and Days 448, 486), and The Bible (Genesis 6–9). In the Polynesian oral tradition, references are found to the flyways of seasonal birds, and similar practices are found amongst the Norse mariners of the Atlantic (Huth, 2013: 406–414). Other signs of land might be smoke from forest fires, or land breezes carrying pollen and the scent of plants and wood, especially useful in conditions of low-visibility. Poor visibility severely restricted the ability to distinguish features on the horizon, and even in close proximity to landfall thick haze or fog can obscure landmarks. Phoenician seafarers in the Early Iron Age calculated a 'theoretical visibility' or geographical range in good weather based on the spot heights of mountain ranges around the Mediterranean basin (Aubert, 2001: 169, fig. 35). As such, there is only a very narrow corridor of open sea where land is theoretically invisible between Crete and North Africa. But theoretical visibility is only part of the story: haze, especially in the summer, requires careful consideration. Winds, dust and static pressure in the lowest stratum of the atmosphere (i.e. sea level) account for haze throughout the summer, and in the Aegean one day out of every two the visibility is reduced to less than 10 nautical miles (ca. 18.5 km) (Davis, 2001: 27–29). When visibility is poor, even the island-rich parts of the central and southern Aegean are devoid of visible landmarks. In short, navigation in the island-rich archipelago, often dubbed a 'maritime nursery' (e.g., Irwin, 1989: 168; Irwin, 1992: 5; Broodbank, 2000: 111), required a degree of proficiency in environmental navigational techniques.

9. Conclusions

Our purpose has not been to prove that archaic hominins were crossing the open sea in the Middle Pleistocene; the existing data are insufficient for that. Our purpose is rather to posit that the Palaeolithic attested on the Greek islands is enough to warrant the continued evaluation of working hypotheses to explain whence, when, and how archaic hominins reached those islands. We argue that this testing should be accomplished with specially targeted surveys on the oceanic islands in the Mediterranean. Targeted surveys, which employ site location models based on land-use, and are informed by palaeoenvironmental reconstructions that identify landforms with high probability of preserving archaeological sites of specific types and ages, have been used with success on mainland Greece and Crete to identify Palaeolithic and Mesolithic sites that had long escaped detection in the course of many diachronic regional surveys (Runnels et al., 2005; Strasser et al., 2010; Runnels, 2014). Stone tools are stubborn facts: but we need larger samples, more sites, more dates before their significance can be properly evaluated. There is nevertheless no a priori reason to reject the hypothesis that at times coastal foragers and hunter-gatherers crossed the Aegean to the islands, something evident from the point when Melian obsidian was first identified terminal Pleistocene levels at Franchthi Cave (Perlès, 1979). We suspect that the presence of Lower and Middle Palaeolithic artifacts may be the less archaeological-visible evidence that the beginnings of this behaviour must be sought in the Middle Pleistocene (Runnels, 2014). Another hypothesis is that the construction of watercraft capable of crossing the Aegean was within the technical capability of archaic hominins adept at using stone tools, fire, and cordage. And finally, we hypothesize that archaic hominins in the Middle Pleistocene, ca. 800–600 BP possessed the rudiments of environmental wayfinding and the cognitive impulses necessary for exploratory activity.

Early humans—perhaps those with the genetic combination of novelty-seeking traits—may have regarded open water with as much curiosity as they had for expanses of ice, grass, and sand, stimulating a spirit of exploration. Perhaps open horizons did not represent barriers but were potential roads for those who dared to travel them. Whence and when humans first found their way across the sea is presently unknown, and in the Aegean early maritime activity may have been largely in the form of the visitation or traversing of islands rather than the colonization and occupation events that emerged at the end of the Pleistocene. Although some scholars doubt the relevance of early Palaeolithic maritime activity for understanding human dispersals in the wider Mediterranean (Broodbank, 2014), we propose that if the main foundations for the exponential S-curve in maritime activity at the end of the Upper Palaeolithic had their beginnings in the Middle Pleistocene, the deep-time origins and development of maritime activity will be significant for the evaluation of hominin dispersals. The archaeological evidence for operational intelligence in early prehistoric contexts is not easy to find, but the existence of open sea-crossings may lead to a reassessment of the origins and development of such thinking in early hominins.

Apart from the new findings in archaeogenetics, it is evident that early hominins were able to undertake adaptive radiations that took them from Africa to Asia. These movements required them to surmount topographical barriers such as mountains, lakes, and rivers on continental scales—not to mention learning to survive in highly variable climatic regimes. In our view, this required the ability to conceive and build watercraft when necessary. The physical environment of the Mediterranean provided a favourable coastal configuration for the development of early maritime activity in that region, particularly in the Aegean (Broodbank, 2013: 75–76), where the unique regional conditions of intervisibility of land and narrow marine straits would have enticed Palaeolithic foragers and hunter-gatherers to explore the islands. It is time to consider the signs of Palaeolithic activity on the oceanic islands of the Mediterranean and the questions raised by their presence.

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Ancient sources

Apollonius Rhodius, The Argonautica 2.328–334, 555–575. (tr.) William H. Race. Cambridge, Mass., Harvard University Press (2008). Both of these passages refer to the use of a Rock Dove to test the feasibility of safe passage for Jason and the Argonauts through the Symplegades, or 'Clashing Rocks', that guarded the narrow straits of the Bosporus into the Black Sea.
Callimachus, Hymns 2.65. (tr.) A. W. Mair. London, Willian Heinemann (1955). This hymn to Apollo refers to the foundation myth of the Greek colony, Cyrene, in Libya, and Battus, it's first king. Battus established the city where Apollo had taken the "guise of a raven".
Genesis 8.6–12. The CTS New Catholic Bible. This passage from the first book of The Bible refers to Noah and the Flood. In it, Noah sends out a raven and then a dove to search for land after the deluge. As the waters gradually subside, the dove returns to the ark with an olive branch in its beak.
Homer, Iliad 10.274. (tr.) A. T. Murray and revised by William F. Wyatt. Cambridge, Mass., Harvard University Press (1999). In this passage, Odysseus and Diomedes have set out from the Greek camp at night to spy on the Trojans. They hear the cry of a heron hunting in the salt marshes near the sea; an omen from the goddess Athena.
Homer, Odyssey 5.270–275. (tr.) A. T. Murray. London, William Heinemann (1919–1953). This passage provides a description of navigation at night with specific mention of the Great Bear (Ursa Major), also referenced as the 'Wain'. In it, Odysseus sets a course from the island of Calypso keeping Ursa Major "on the left hand".
Homer, Odyssey 5.63, 12.417. (tr.) A. T. Murray. London, William Heinemann (1919–1953). Both passages refer to 'sea-crows', most probably cormorants – birds that hunt and swim in the open sea, and nest high up on the cliffs along the coastline.
Homer, Odyssey 5.333. (tr.) A. T. Murray. London, William Heinemann (1919–1953). This passage refers to a pelican, sea-gull or gannet (?) as a personification of Leucothea, the 'White Goddess', rising up out of the sea and settling on Odysseus' raft. The nearby Phaeacian coast has been identified by Homeric scholars as Corcyra, modern Corfu. It is interesting to note that this area is on the southern migratory path of pelicans from the Danube.
Hesiod, Works and Days, 448, 486. (tr.) Glenn W. Most. Cambridge, Mass., Harvard University Press (2006). Both of these passages refer to the behaviour of migratory birds in a broader discussion on farming practices throughout the year. The first passage notes the presence of migratory cranes above the clouds in late October or early November as an indicator of winter rain. The second describes the first calls of cuckoos in March as the sign to start ploughing the fields.
Lucan, Civil War, 4.131–132. (tr.) J. D. Duff. London, William Heinemann (1928–1957). This passage refers to the construction of small boats made of plaited willow frames and covered by ox-hide. It goes on to mention that similar watercraft are used by Venetii in the Po Valley and the Britons in the Atlantic Archipelago.