

To see or not to see: A study in maritime visibility

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Περίληψη

Η Ελλάδα είναι άρρηκτα συνδεδεμένη με τη θάλασσα που την περιβάλλει και οι θαλάσσιες μετακινήσεις έπαιζαν ανέκαθεν σημαντικό ρόλο στην ιστορία της. Το ίδιο ισχύει και στην περίπτωση της Εύβοιας, καθώς η γεωγραφική της θέση εν μέσω μυριάδων θαλάσσιων διαδρομών, συνέβαλε σημαντικά στην κοινωνική και οικονομική ανάπτυξη του νησιού. Ωστόσο τα θαλάσσια ταξίδια δεν ήταν ακριβώς ένα εγχείρημα χωρίς κινδύνους. Μία από τις βασικότερες και σημαντικότερες αποφάσεις που έπρεπε να πάρει ο θαλασσοπόρος ήταν η πορεία του πλοίου. Τόσο η πλεύση κοντά στις ακτές όσο και αφήφιση των ανοιχτών θαλασσών ενέχουν τους δικούς τους κινδύνους και ο καθορισμός λανθασμένης πορείας θα μπορούσε να θέσει σε κίνδυνο τη ζωή του πληρώματος. Υπάρχουν πολλοί λόγοι να πιστεύουμε ότι η ορατότητα πρέπει να ήταν σημαντικός παράγοντας στη διαδικασία λήψης αποφάσεων, καθώς σημεία αναφοράς όπως βουνά και ακρωτήρια χρησιμοποιούνταν ως σταθερά σημεία πλοήγησης. Το ερώτημα που γεννάται είναι η απόσταση από την οποία ήταν ορατά αυτά τα εμφανή σημεία. Παραδόξως μέχρι σήμερα οι αρχαιολογικές έρευνες δεν έχουν δώσει μεγάλη προσοχή στο θέμα του οπτικού πεδίου πάνω από τη θάλασσα και οποιεσδήποτε προτάσεις σχετικά με αυτό το θέμα συνήθως βασίζονται σε ξεπερασμένα, συχνά εσφαλμένα δεδομένα. Η συνεργασία που επιδιώχτηκε με εμπειρογνώμονα της ατμοσφαιρικής οπτικής τελικά οδήγησε σε μια καλύτερη κατανόηση της ορατότητας στη θάλασσα. Στο παρόν άρθρο παρουσιάζεται η λειτουργία του μοντέλου που χρησιμοποιήθηκε καθώς και τα αποτελέσματά του τα οποία θα εφαρμοστούν σε κάποιες από τις διαδρομές που περνούν από την Εύβοια προκειμένου να εξηγήσουμε με παραδείγματα τη σημασία της ορατότητας στη θαλάσσια πλοήγηση.

Introduction

The study of islands has changed greatly over the last few decades.¹ It was but 40 years ago that John Evans introduced the anthropological concept of island biogeographies to the field of archaeology.² His notion of islands as semi-isolated laboratories emphasized the dividing rather than the connecting character of the surrounding seas and was highly influential in many subsequent studies.³ Those days seem long past. Contemporary studies highlight the connectedness and openness of the Mediterranean insular world, and differ so greatly from past research that one can safely speak of a

1. This research was carried out as part of my Research Master's programme at Vrije Universiteit Amsterdam, under the supervision of Prof. J. P. Crielaard. I should like to thank him for his support and guidance. The comments of the anonymous reviewer have also been most helpful.

2. Evans 1973.

3. Boomert and Bright 2007, 6-7.

paradigm shift.⁴ The connecting qualities now credited to island societies mirror Plato's oft-cited conception of the Mediterranean Sea as a mere frog pond, one that was traversed with great ease by the people who inhabited its terrene borders.⁵

The prevailing interpretation of a closely interconnected Mediterranean in ancient times is not one that needs to be challenged. The island of Euboea is a prime example of an island that benefited greatly from its location *vis-à-vis* the sea, favourably situated as it is between the mainland and the Aegean islands.⁶ However, the facilitating qualities of the Aegean maritime environment are sometimes stressed to the point that the region is reconstructed as something of a seaman's utopia.⁷ While we should not underestimate the human ability to adapt, we should remember that risk was an inherent part of any serious sea journey. It is enlightening in that respect that the ancient Greeks perceived the sea as a perilous place with the potential to permanently take away both people and things.⁸

Besides the human factor, which includes such elements as the skill of a navigator or shipwright, the natural environment in all its facets obviously played a major role in seafaring. Winds and other weather conditions, sight, currents and tides, geographical conditions, and the presence of places for anchorage, mooring or shelter all played roles.⁹ Most of these elements have been extensively studied elsewhere and fall outside the scope of this article.¹⁰ Strikingly, however, there is one aspect that has not yet received much attention in archaeological circles, namely the study of maximum visibility at sea, even though there is much evidence to suggest that visibility played an important role in navigating the Aegean in antiquity.

Maritime visibility is the subject of this article. I aim to demonstrate that its usual treatment is incomplete and that the way maximum visibility is normally depicted is overly simplified and does not conform to real-world situations. I first give an overview of the subject, and then present an exploratory study in this specific field, using a method that differs from the one-dimensional way in which this subject is usually treated. A combination of ancient written sources, archaeology, contemporary seamanship and advanced computer models were employed to create a visibility model that takes the various human environmental factors into account.

The area of focus is broad and can roughly be defined as the Aegean in post-Mycenaean and pre-Classical times, a period when seagoing vessels were still relatively small and a maritime infrastructure (port facilities, lighthouses, etc.) had not been fully developed. Although the research is inherently fundamental, I exemplify its results by means of a well-known passage from Homer's *Odyssey* that mentions a journey from Lesbos to the sanctuary of Geraistos, located at the south-eastern end of Euboea. My findings are, however, relevant to the entire Mediterranean.

Navigation and visibility

The process of maritime navigation can be described as guiding a vessel from its point of origin to its destination. In an era without navigational tools, it was mainly the maritime environment itself that guided the navigator.¹¹ The smell of algae in the water, sightings of birds or the rise of a characteristic

4. Morris 2003, 31-32.

5. Pl. *Phd.* 109b.

6. Crielaard 2006.

7. e.g. Berg 2007.

8. Lindenlauf 2004, 421.

9. See Morton 2001 for an in-depth analysis.

10. Tartaron 2013 provides a concise synopsis with references.

11. The earliest evidence for the use of the sounding lead and line in Greece dates to the 5th century BC. See Oleson 2008, 124.

wind all helped navigators to gauge their position in a familiar world.¹² Most important of all was sight. Pilotage, the act of progressing according to visible, familiar waypoints, is likely the oldest and surest way of finding one's waterway.¹³ The Greek coastal landscape is exceptionally well suited to this.

The Aegean is littered with islands, the terrain of which is in sharp relief. Their number and proximity led Peregrine Horden and Nicholas Purcell to state that 'mutual visibility is at the heart of the navigational conception of the Mediterranean'.¹⁴ They are not alone in connecting coastal visibility with maritime navigation. Fernand Braudel, in his seminal work on the Mediterranean, declared that a visible coastline is the navigator's surest compass.¹⁵ That the significance of coastal visibility is not a mere modern invention becomes clear when one turns to ancient literature.

Sailing manuals appeared in Greece from the 6th century BC onwards.¹⁶ Although only a few remains of these have survived, much information is latently present in almost all literature dealing with sea travel, including Strabo's *Geography* and Homer's *Iliad* and *Odyssey*.¹⁷ Numerous times in these works, landmarks are mentioned together with an adjective, such as the Homeric notions of 'high-sloped Mimas' (*Od.* 3.171) and 'the great rocks of Gyrai' (*Od.* 4.500). Strabo describes how Leuke Akte ('white headland') was the first landmark one passed when sailing from Sounion to Euboea (Strab. 9.1.22).

The fact that geographical features visible from the sea were mentioned in conjunction with sea journeys, and were given names to distinguish them from each other, indicates that these points were important for maritime navigation. In addition, these landmarks were often connected with stories about events that had transpired here in the historical or mythical past, which indicates that many locations were laden with meaning. The great rocks of Gyrai were where Aias met his demise on his return journey from Troy (Hom. *Od.* 4.499-4.509). The point to be emphasized here is that it does not matter whether Aias was fictitious or real, or whether he perished at that precise location, but rather that, by connecting this landmark with such a catastrophic event, the great rocks of Gyrai became a dangerous place that was best avoided.

If indeed the observability of landmarks was of substantial importance for navigation, it is logical to ask from what distance these landmarks could be seen, as the visibility distance could at times have influenced the route that was eventually chosen. Contemporary archaeological literature seems rather conclusive in this respect. Jamie Morton mentions that 'many Greek promontories and islands could be seen from ships fifty, or even one hundred miles away'.¹⁸ Horden and Purcell state that 'there are only relatively restricted zones where, in the clearest weather, sailors will find themselves out of sight of land'.¹⁹ The Aegean region again seems an ideal place for sailing, a place where navigational issues do not exist, owing to a plenitude of clear sight and ever-visible landmarks.

This notion is also reflected in the maps that accompany the texts. Fig. 1 shows a visibility map as presented in Thomas Tartaron's recent study of Mycenaean maritime networks.²⁰ The area surrounding Euboea, or indeed the whole Aegean, is depicted as a region where land is always in sight. An identical map was used in Cyprian Broodbank's study of the prehistoric Cyclades.²¹ These are but two examples; going through both recent and considerably older literature, however, it becomes apparent that the same map is reproduced in virtually all archaeological publications that touch upon the subject of maritime visibility.

12. For an example of an ethnographic study on navigation, see Lewis 1972 on finding land in the Pacific.

13. McGrail 1991, 86.

14. Horden and Purcell 2000, 393.

15. Braudel 1972, 106.

16. Morton 2001, 180, n. 48.

17. Morton 2001, 180-181.

18. Morton 2001, 144.

19. Horden and Purcell 2000, 126.

20. Tartaron 2013, 109, fig. 4.9.

21. Broodbank 2000, 40, fig. 4.

Strangely enough, none of these authors mentions the way this map was created. One of the first to explain the process underlying the creation of the visibility zones was the German scholar Wilhelm Schüle.²² He states that the distance to a point on the horizon can be calculated using the following formula:

Distance to point on horizon in kilometres = $3.8 \cdot \sqrt{(\text{point height in metres})}$,

or:

$$d = 3.8 \cdot \sqrt{h}$$

To illustrate: Mt Ochi, the tallest mountain (1397 m) on southern Euboea, would theoretically be visible from a distance of $3.8 \cdot \sqrt{1397} \approx 142$ kilometres.²³ The process is, of course, reversible: anyone standing on Mt Ochi would be able to see equally far, with lines of sight extending as far as Chios and Naxos.

Schüle is not the original author of the visibility map. For that, we have to go back as far as 1901. German cartographer Henkel, who wanted to create a map demonstrating the extent of visibility in the Mediterranean, used a pair of compasses to draw circles around the prominent mountains on the mainland and the islands.²⁴ The diameter of the circles was governed by the formula provided above. In other words, the circle around Mt Ochi denoting its visibility would have a radius of 142 km. By applying the same calculation to all of the main peaks in the Mediterranean basin, he created a map showing a great many interlocking circles, with the encircled areas being those that had at least one landmark in sight.²⁵ Fig. 2 shows both the preparatory and the completed map, which is identical to the maps that are still used nowadays.

In the pre-digital era in which Henkel worked, the idea behind his research was sound and the resulting map is very clear. More than a century later, common GIS software packages, such as ArcGIS, still use an adapted version of this formula to create a viewshed and, admittedly, it works fine for short-distance viewshed analyses on land. However, compared to land-based studies where the view of the horizon is often obstructed by the undulating Greek landscape, viewing distances rapidly increase when dealing with maritime environments. This becomes problematic when other factors that gradually reduce visibility over distance are left out of the equation. One basic example will exemplify the problem of using a formula that takes into account only an object's height and its distance from the observer.

The example is drawn from ongoing fieldwork by VU University Amsterdam at Karystos-Plakari, a site located on a coastal hill of approximately 90 masl, overlooking the Bay of Karystos and the open sea further to the south.²⁶ Fig. 3 shows a viewshed from Plakari. Islands as far as Naxos (some 140 km away) are supposedly in view of anyone standing on its summit. Fig. 4a shows a photo taken from that same point, looking in a southerly direction. Several islands are in view, although faraway places such as Naxos are not. Even Fig. 4a is not the norm, though, as just as often the view from Plakari looks like Fig. 4b. Apparently, the computer-based model conflicts with the real-world situation. Not only is the maximum visibility distance grossly exaggerated in the former, but there is a variability in the viewing distance that is simply not accounted for.

This point is corroborated by a field study carried out in July and August of the years 2011-2014. The maximum viewing distance from Plakari was gauged systematically by looking at the visibility of islands situated towards it south. Observations were recorded multiple times a day, starting at sunrise and ending at sunset. The one point that stood out is that the maximum visibility varied greatly,

22. Schüle 1980, 17.

23. For a more elaborate treatment on visibility to and from southern Euboea, see Tankosić 2011, 69-72.

24. Henkel 1901, 284-285.

25. Henkel 1901, pl. 21.

26. See Crielaard and Songu, this volume.

even over the course of just one day. Morning and evening were comparatively clear, whereas a haze relatively often obstructed visibility in the afternoon. It was possible for the nearby island of Kea to be clearly visible during the morning hours but hidden in haze half a day later, only to reappear during the evening hours. Naxos was never in sight.

In relation to this variety in maximum visibility stands an assertion by Christos Agouridis, who recounts how contemporary fishermen know exactly how often and when cases of extreme visibility occurred during their lifetime, indicating their rarity.²⁷ In other words, the aforementioned formula allows one to create a map denoting a utopian situation in which visibility is unobstructed. However, the actual, average maximum viewing distance is more likely to fall somewhere between the conditions pictured in the two photos, which also became apparent during our visibility assessment. In addition, we should probably also allow for seasonal variability.

Two things can be inferred from these photos and our observations in the field: long-distance visibility is exaggerated in literature, regardless of the method used to measure it; and visibility is not a static given, but a flexible and very complicated variable that requires further investigation. The example of Kea appearing and disappearing over the course of a single day is illuminating in this respect.

Visibility reviewed

A start has been made at developing a new model of visibility in the Aegean region, in collaboration with Prof. J. P. Crielaard, professor at VU University Amsterdam, and Prof. A. M. J. van Eijk, an atmospheric optics expert working for the Netherlands Organization for Applied Scientific Research.²⁸ This article presents the preliminary, non-technical results.²⁹

Visibility itself is a loosely defined concept ('the distance one can see') and is most often described in a qualitative way. We opted for a quantitative approach. Visual range is defined here as the point at which the contrast between the target and its background drops beneath the 2% threshold at which the human eye can detect a difference in contrast.³⁰ Contrast is a factor that is measurable, making it well suited to computer modelling.

An increase in distance between observer and his/her viewing target results in a decrease in contrast. This is caused primarily by the presence of molecules and aerosols in the atmosphere, small particles that scatter and absorb light. By estimating the number of particles in the atmosphere, the decrease in contrast over a given distance can be calculated, leading to a maximum visibility for those parameters.

In the case of molecules, only those that are naturally present and would have filled the atmosphere in ancient times (i.e. oxygen, carbon dioxide and water molecules) are incorporated in the analysis. In contrast to molecules stand aerosols, which are defined as a suspension of solid or liquid particles in a gas. There are many aerosols, ranging from volcanic ash and carbon particles from fires, to sea salt and pollen. We opted for a conservative approach and again only included natural aerosols, leaving out the carbon particles from burning. These have a huge impact on visibility, but it is hard to estimate the amount of wood burning that would have taken place in the period dealt with here. The quantity of natural aerosols is comparatively much easier to assess, based on the situation today.

27. Agouridis 1997, 17.

28. See <https://www.tno.nl/en/about-tno/>.

29. This section is primarily based on personal communication with Prof. Van Eijk, to whom I am greatly indebted. The final outcomes are based on a computer model that was created and run by him. See Van Eijk et al. 2011 for an introduction to the EOSTAR model.

30. Ogburn 2006, 406.

The quantity of both molecules and aerosols in the atmosphere depends greatly on the weather, particularly wind speed and temperature. For example, when the wind picks up, the amount of sea salt in the lower atmosphere gradually increases, resulting in reduced visibility. Another example is the dust storms that carry sands from northern Africa across the Mediterranean Sea.

In order for the model to run, historical weather data from the European Centre for Medium-Range Weather Forecasts were acquired. The dataset includes factors such as wind speed and air temperature, and covers measurements that were taken four times per day over the course of three years. The implicit assumption is that contemporary weather can be compared to weather conditions in ancient times. This follows the general agreement that weather patterns have not changed much since then.³¹

Using the input and variables as specified above, our model comes up with a year-round average visibility of roughly 30(!) km, a figure that matches fairly well with the aforementioned observations from the Plakari hilltop. No doubt there are seasonal variations and even variations over the course of a day; yet, the general conclusion has to be that actual visibility is far removed from the unhindered views presented in most research studies.

Does it matter? In some cases, it just might. Book 3 of the *Odyssey* contains a well-known passage in which Nestor relates how part of the Greek army has arrived on the island of Lesbos in the aftermath of the Trojan War (*Od.* 3.168-3.175). Wanting to return home as soon as possible, they ponder which of two possible routes to take. One leads via the Cyclades, passing south of the island of Chios.³² The alternative is much shorter, crossing the open seas directly towards the south-east coast of Euboea. An unspecified, divine omen leads the heroes to opt for the latter and they arrive, after a day's journey, safely at the sanctuary of Geraistos.

What led them to choose the open sea route over the Cycladic route? The former is much shorter and seems the logical choice, but apparently there was room for doubt. This may lie in the fact that Euboea's eastern side was well known for its inhospitable coastline in ancient times, as is the case even now. A correct approach was crucial in order to avoid the feared Hollows of Euboea, and a navigational error would almost certainly have led to shipwreck.³³ It was for the navigator to judge whether the army's wish to return home as quickly as possible outweighed this danger. For that, he would have had to base his decision on the maritime conditions at that particular moment.

Winds were of no concern. It is explicitly mentioned that a favourable northerly wind accompanied the heroes during this part of their journey. Nor was there a need for stopovers at harbours. They wanted to get home as soon as possible and did not wish to make any detours. Lastly, factors such as currents or geographical conditions could not have been decisive in this specific decision-making process, since they were static and do not change on a day-to-day basis. If a current had prevented them from taking one of the routes, that route would not have been an option in the first place.³⁴

Under these circumstances, I propose that it was the prospect of good visibility that won them over, something that is best illustrated graphically. Fig. 5 shows a map of the Aegean. The aforementioned 'average visibility' is presented here as a white area that extends 30 km from all coastlines. Anyone in this belt would, on most days, have land in sight. The grey areas, on the other hand, represent zones within which land is generally not visible on the horizon. The broken line shows the route taken by the Greek army.

31. Agouridis 1997, 2.

32. The remainder of this route is unclear. See Malkin and Fichman 1987 for a discussion of the possibilities.

33. 'Hollows of Euboea' is the name given to the north-eastern coastline of southern Euboea, which consists only of cliffs. Many are the tales of naval disasters in this region. In 2005, an underwater survey of part of this area by a team of Canadian and Greek researchers discovered a cluster of anchors of varying dates close to Cape Kaphireas as well as shipwrecked cargo dating to the Roman period: Rupp 2006, 215.

34. There are, of course, many more factors that influence sea travel. An extensive overview falls outside the scope of this article.

As can be noted, the route to Geraistos took the fleet through an area that in some places is devoid of landmarks. Anyone sailing here ran the risk of having to rely on other, less precise means of navigation, resulting in a loss of direction. As explained earlier, this could be highly dangerous. The interplay between prevailing strong winds and currents meant that a wrong approach would lead ships to certain disaster at the foot of Euboea's unforgiving cliffs. Conversely, if visibility was excellent, Mt Ochi functioned as a long-distance beacon that helped the helmsman steer the correct course, thus greatly decreasing the risk for all involved.

Conclusion

In general terms, I have demonstrated that maritime visibility is a rather overlooked niche in the study of the ancient Aegean. Contemporary research stresses the interconnectedness of its inhabitants, blessed as they were with a landscape that facilitated maritime journeys in almost every way. Henkel's age-old visibility map of the Mediterranean is often used to illustrate the fact that navigation was an easy task, owing to the abundance of ever-visible landmarks.

Its creator, however, sounds less sure of the accuracy of his map when he writes: 'Freilich fehlt das Material darüber, wie weit die praktische Sichtweite mit der theoretischen übereinstimmt. Vielleicht wäre diese Karte geeignet, zu Beobachtungen darüber anzuregen.'³⁵ This study is meant as an initial impetus to do just that. Observations in the field and the first runs of the advanced EOSTAR model show that one should indeed be careful not to take Henkel's map as the norm.

If we want to improve our models of long-distance visibility, more needs to be done. Current model outputs one number for the whole year, neglecting seasonal and daily variations. Skies are often more clear in winter, resulting in an increased viewing distance, which has repercussions for the model's average output. Fluctuations can be great, even over the course of a single day. There are often much better views during calm mornings and evenings than in the afternoon. The position of the sun also plays a role: when it sets, the contrast of any landmass lying between an observer and the sun increases, greatly improving the visibility of that landmass. One can also think of the light of the moon and stars, as the mariners of old were no strangers to night sailing.³⁶ We hope to eventually generate a set of detailed visibility maps of the Aegean that can be used to substantiate any claims regarding long-distance visibility.

The case-study presented above demonstrates the importance of taking visibility into account. It remains to be studied how we can integrate our findings into larger models. Although they might not change our general views of interconnectivity in the Mediterranean, they will surely lead to a more in-depth understanding of ancient seafaring.

35. Henkel 1901, 285, n. 1.

36. Agouridis 1997, 17.

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Figures

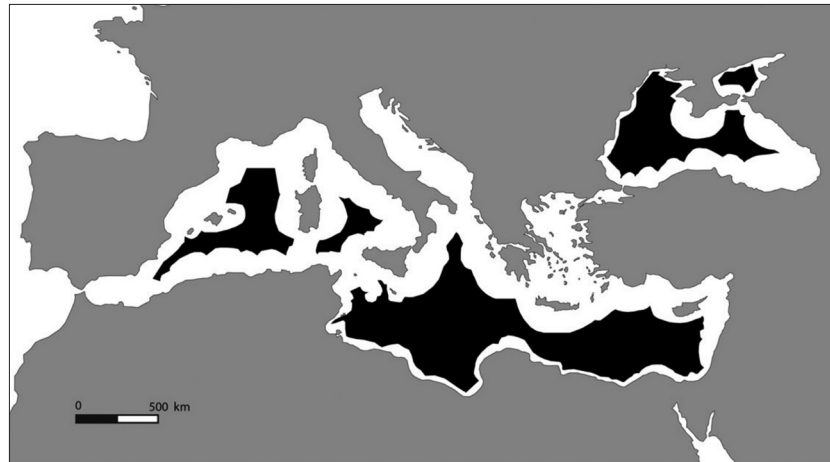


Figure 1:
Visibility in the Mediterranean
(After Tartaron 2013, 109, fig. 4.9).

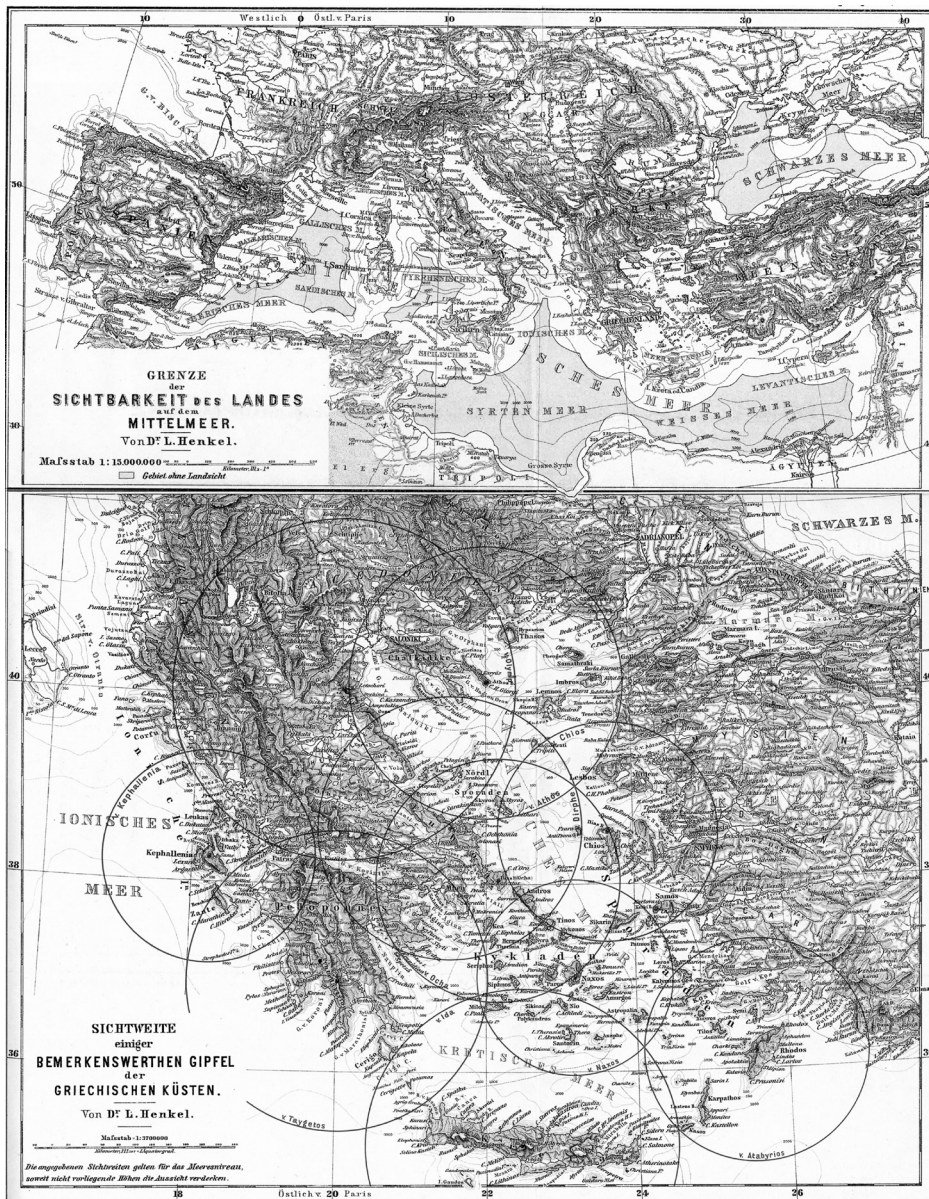


Figure 2: Visibility in the Mediterranean (After Henkel 1901, pl. 21).

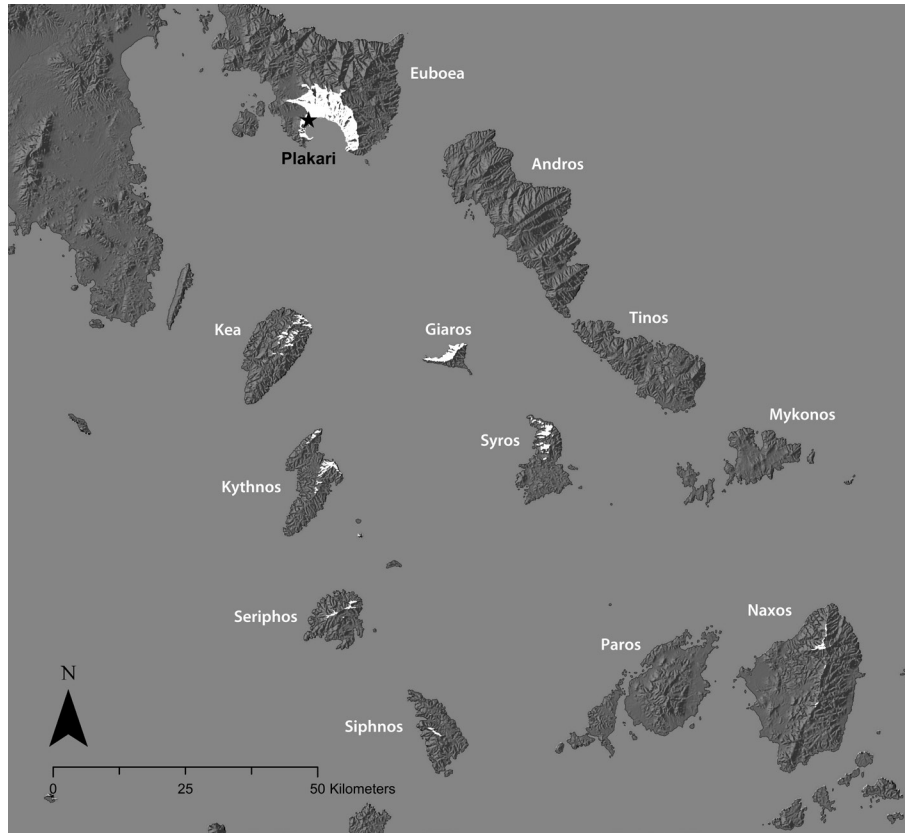


Figure 3: Viewshed from Plakari with visible areas in white.



Figure 4: Southward view from Plakari hilltop toward the islands of Kea, Kythnos and Seriphos.

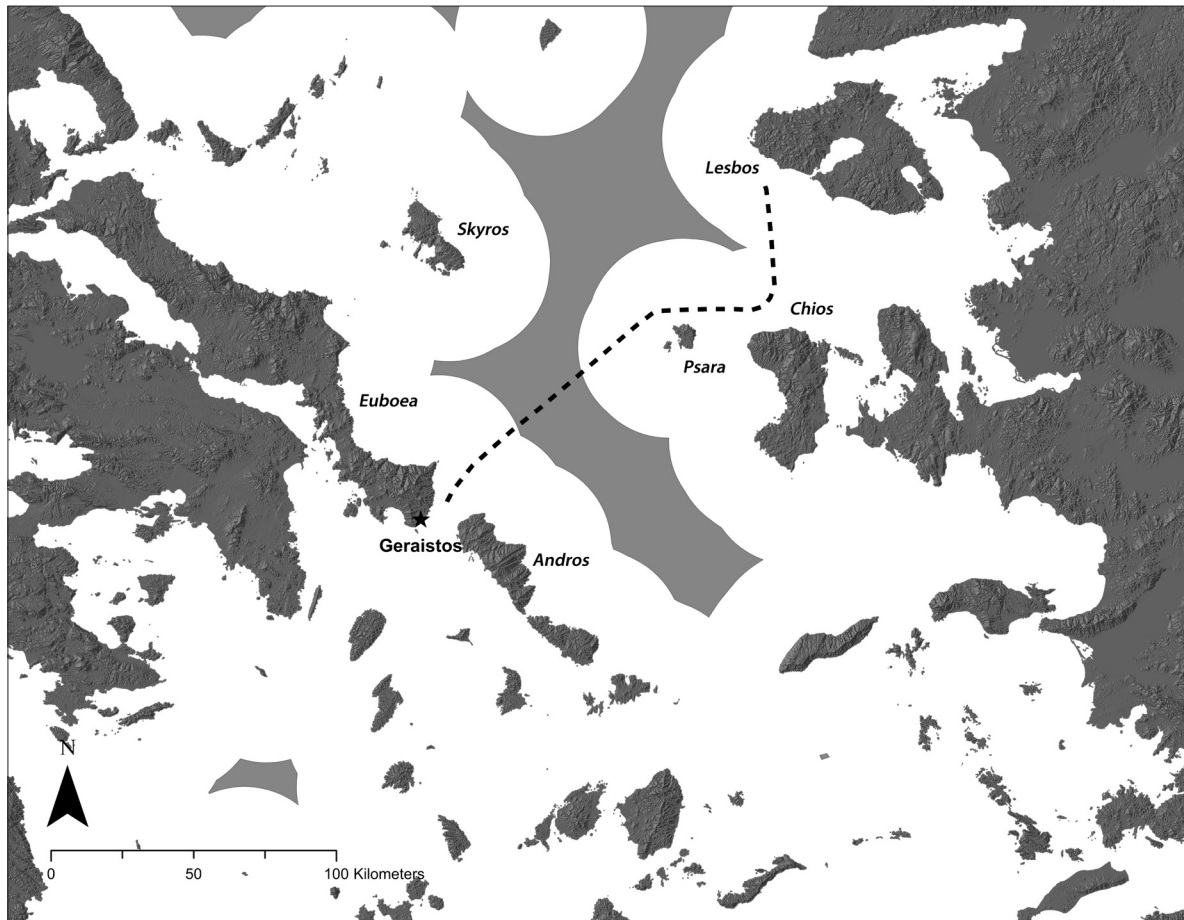


Figure 5: Average visibility map. The broken line represents the sea route from Lesbos to Southern Euboea as described by Homer (Od. 3.168-175).