Small Worlds after All?

Landscape and Community Interaction in the Cycladic Bronze Age

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Small Worlds After All?

Landscape and Community Interaction in the Cycladic Bronze Age

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Archaeologists have considered the Cycladic islands (Greece) during the Early Bronze Age (ca. 3100-2200 BCE) to be a "false start" on the path to the emergence of civilization in the Aegean (Broodbank 2000; Tartaron 2008). While recent scholarship has reevaluated social development in the Minoan and Mycenaean archaic states, several contradictions characterize the current state of Early Cycladic (EC) scholarship. In this dissertation, I use small worlds analysis—a bottom-up approach that examines habitual interaction between the communities that comprise small world networks (Tartaron 2008; 2013)—to reconsider the nature of EC intercommunity interaction. By combining a small worlds approach with GIS settlement and landscape analyses, I address the following questions: what impact did subsistence strategies have on social organization, to what degree were EC communities reliant on one another, and what was the role of maritime travel in maintaining small world connections?

Analysis of archaeobotanical and zooarchaeological evidence shows that EC islanders employed a variety of subsistence strategies to minimize risk, diversifying production spatially and temporally rather than relying on the production of surplus (*contra* Renfrew 1972). Site catchment analysis reveals that available agricultural land could support a much larger population than is typically estimated for

this time period, emphasizing the viability of spatial diversification.

EC communities likely cooperated in agricultural production to ensure mutual survival (cf. Halstead 1981, 1986). While analysis of EC fortifications shows that warfare might have been a regular feature of island life, social nearness and community interdependence for subsistence meant that conflict was probably short-lived and minimally damaging. The fragmented Cycladic landscape meant that communities located in peripheral locations—such as one small world in southeastern Naxos—enjoyed long-lived and stable connections.

Finally, GIS analysis of small world maritime travel, combined with analysis of the agricultural production cycle, reveals that there was no "sailing season" for undertaking long-range maritime travel during the EC period. Rather, short-range journeys might have been undertaken opportunistically throughout the year. Long-range voyages were necessary for larger, more isolated communities that could not maintain habitual maritime connections with other communities, and voyages at the regional scale likely occurred only infrequently.

Biographical Sketch

Katie Jarriel received her BA in Anthropology, with minors in Classics and Fine Arts, from the Honors College at the University of South Carolina in 2010. While at Carolina, she excavated in Spain and studied abroad in Florence, Italy, where she discovered a love for the prehistoric Aegean. She began her doctorate at Cornell University in the Department of Classics in 2010, spending her summers excavating in Israel, Cyprus, and Greece. While at Cornell she also served as the Assistant Director of the Cornell Institute for Archaeology and Material Studies (2015-2017).

To my parents, Brett and Melissa, for their faith and unconditional support.

There lies the port; the vessel puffs her sail:
There gloom the dark, broad seas. My mariners,
Souls that have toil'd, and wrought, and thought with me—
That ever with a frolic welcome took
The thunder and the sunshine, and opposed
Free hearts, free foreheads—you and I are old;
Old age hath yet his honour and his toil;
Death closes all: but something ere the end,
Some work of noble note, may yet be done,
Not unbecoming men that strove with Gods.
The lights begin to twinkle from the rocks:
The long day wanes: the slow moon climbs: the deep
Moans round with many voices. Come, my friends,
'T is not too late to seek a newer world.
Push off, and sitting well in order smite
The sounding furrows; for my purpose holds
To sail beyond the sunset, and the baths
Of all the western stars, until I die.
- Excerpt from "Ulysses" by Alfred Lord Tennyson

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List of Abbreviations

AJA	*American Journal of Archaeology*
DEM	digital elevation model
EBA	Early Bronze Age
EB I	Early Bronze I
EB II	Early Bronze II
EB III	Early Bronze III
EC	Early Cycladic
EC I	Early Cycladic I
EC II	Early Cycladic II
EC III	Early Cycladic III
FN	Final Neolithic
GIS	geographic information systems
HRMA	horizontal relative moving angle
Island Archaeology	*An Island Archaeology of the Early Cyclades*
LCA	least cost analysis
Ma I	Markiani I
Ma II	Markiani II
Ma III	Markiani III
Ma IV	Markiani IV
PPA	proximal point analysis
SENS	Cambridge South East Naxos Survey
The Corrupting Sea	*The Corrupting Sea: A Study of Mediterranean History*
The Emergence	*The Emergence of Civilization: The Cyclades and the Aegean in the Third Millennium BC*
TPI	topographic prominence index
TRI	terrain ruggedness index

Chapter 1
Introduction

Ambivalent Islands

On a hazy day, when the water and sky are a constant field of blue and the Aegean sea throws back the sharp light of the sun, it is impossible to tell where the water ends and the islands begin (figure 1.1). Although the Cyclades are in fact a chain of drowned mountains that form part of a crescent-shaped archipelago in the southern Aegean Sea (figure 1.2), they seem to hover just above the water, as if sailing around with the breeze.

Ancient poets chronicled the phenomenon of the floating Cycladic islands. Pindar (fr. 33d8) is the earliest; he contrasts the rooting of the island of Delos after the mythical birth of Apollo with its previous movement, describing it as adamant-sandaled (ἀδαμαντοπέδιλοι), a term which implies both stability and motion. Sandals (πέδιλον) are objects of movement, but their adamantine prefix (ἀδαμαντο) keeps them rooted to the ground (Nishimura-Jensen 2000: 289-90). Callimachus, in his *Hymn to Delos*, describes the story of the island who gave up her freedom of movement to be the birthplace of a god. Before being rooted, Delos is thus described:

Figure 1.1. “Floating” Cycladic Islands

There is a slender island seen in the water,
Wandering on the sea; her feet are not in once place,
But she swims to and fro like flowering asphodel.
There the South Wind, there the East Wind, wherever the sea carries her.[1]
(Cal. *Hymn 4*. 191-4, trans. Nishimura-Jensen 2000.)

Delos is portrayed as "the ringleader of a clique of islands that roam the Mediterranean" (Nishimura-Jensen 2000: 290). It is never clear in Callimachus' poem whether the islands are geological formations or divine beings (Nishimura-Jensen 2000: 290), nor is it clear in the mythological tradition whether Delos and the other Cyclades were land or not-land. In Ovid's version, Apollo's mother Leto was forbidden to give birth on any place on earth:

> "...Leto, whom the great globe once refused the smallest spot to give her children birth. Not earth, nor sky, nor water would accept your goddess, outcast from the world, until Delos took pity on her wanderings and said, 'You roam the land and I the sea, homeless,' and gave her drifting refuge there. She bore two children."[2]
> (Ov. *Met*. VI.186-92, trans. Melville)

Here Delos is ontologically distinct from the earth, sky, and water—the primal elements that constitute the world itself.

The ambivalence of the Cycladic islands—vacillating between land and not-land, floating and fixed—persisted in the imaginations of travelers during the Romantic era. In the 19th century, European travelers would visit the islands in

---

1 ἔστι διειδομένη τις ἐν ὕδατι νῆσος ἀραιή,
πλαζομένη πελάγεσσι: πόδες δέ οἱ οὐχ ἑνὶ χώρωι,
ἀλλὰ παλιρροίηι ἐπινήχεται ἀνθέρικος ὥς,
ἔνθα νότος, ἔνθ᾽ εὖρος, ὅπη φορέῃσι θάλασσα.

2 Latonam…cui maxima quondam
exiguam sedem pariturae terra negavit.
Nec caelo nec humo nec aquis dea vestra recepta est:
exsul erat mundi, donec miserata vagantem
"hospita tu terris erras, ego" dixit "inundis"
instabilemque locum Delos dedit. Illa duorum
facta parens…

search of signs of the greatness of ancient Greece, whether it manifested in archaeological remains or the people themselves, since many travelers believed that the islanders were more "pristine" due to their isolation from the mainland (Berg 2012: 76). The contrast of the reality of the Cyclades with travelers' expectations of them resulted in an unsettled feeling of ambiguity toward the islands, which emerged in the travel writing of the time. As Berg (2012: 76-77) writes, the Cyclades were both familiar and foreign:

> Familiar because they, as part of Greece, contained the roots of Western civilization and because travelers were well versed in their ancient history and mythology, foreign because the Cyclades were part of an unknown region, heavily influenced by Ottoman culture and located at the margins of Europe.

The tension between the familiar and unfamiliar meant that travel to the Cyclades rode the line between safe and exotic. A trip to the Cyclades was just alien enough so that it was "a form of personal adventure, holding out the promise of a discovery of realization of the self through the exploration of the other" (Chard 1999: 35; see also Berg 2012).

Even descriptions of the physical landscape emphasize this island ambivalence. While observing the inhabitants of the Cycladic island Tinos, Riedesel (1774: 48; trans. Nishimura-Jensen) comments:

> No person is idle on this island. Despite being barren, the soil nevertheless produces more than twenty different types of wine, of which the Malvesian variety is the best…

The very soil of the Cyclades manages to be simultaneously productive and unproductive.

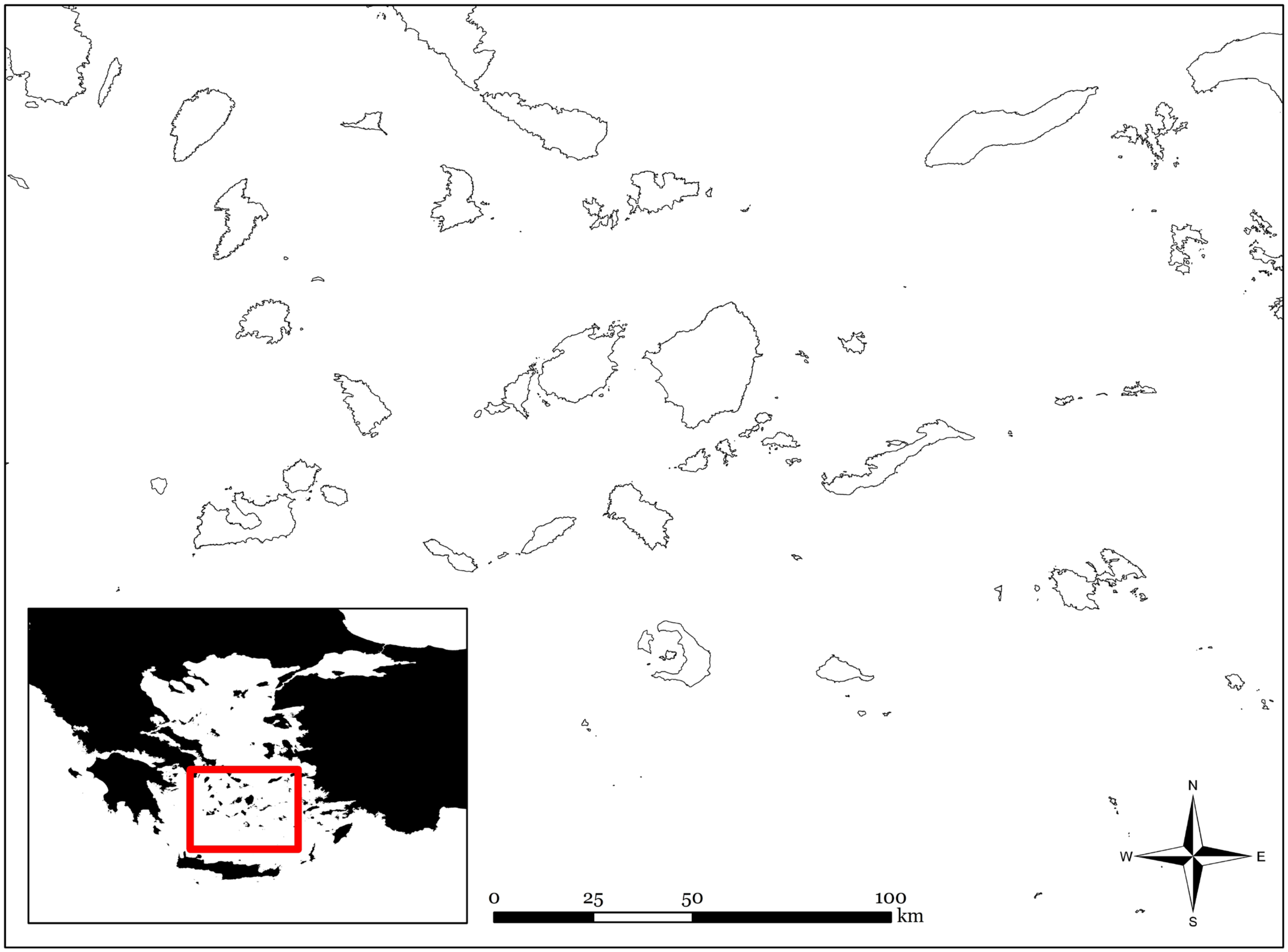

Figure 1.2. Map of the Cycladic Islands (Greece)

Objects produced in the Cyclades are not exempt from this ambivalence. When Cycladic figurines, small carved marble statuettes produced on the islands during the Early Bronze Age (EBA), first came to light in the 19th century, Classical art still dominated Western aesthetic ideals. As a result, the "primitive" figurines were dismissed as curiosities (Gill and Chippindale 1993: 602). However, with the changing aesthetics of modern art in the 20th century, artists like Picasso, Modigliani, and Brancusi emulated the simplistic and abstract forms of these "magical objects," as Picasso himself called them, in their own art (Reif 1990).[3] The increased esteem for Cycladic figurines led to extensive looting, forgery, and black market sale of the items during the second half of the 20th century, causing the destruction of archaeological contexts. Furthermore, the modern context in which these objects became valued introduced such art historical terms into the archaeological literature as "master," "hoard," "idol," "sculptor," and "art," which are not necessarily appropriate in their original Bronze Age context (Gill and Chippindale 1993: 656).

In the above instances of Cycladic ambivalence, it is through human bias—the contextual motivations of the poet, the traveler, or the artist—that tension emerges. Hellenistic writing about unstable geographies—such as Callimachus' *Hymn to Delos*—reflects the authors' perceived discontinuity between the literary traditions of the past and the Alexandrian present. The rootlessness of Delos becomes a metaphor for the poet's own sense of being uprooted within his genre (Nishimura-Jensen 2000: 288). Travelers during the Romantic era had an ambiguous relationship with the Cyclades because of the conflict between reality and

3 E.g. Amedeo Modigliani (1912) *Woman's Head*; Constantin Brancusi (1916) *The Kiss*; and Pablo Picasso (1907) *Woman with Joined Hands (study for* Les Demoiselles d'Avignon).

their own preconceived expectations about the classical past. Descriptions of the landscape and nature mirrored their own souls (Berg 2012: 76). The predominant aesthetics of the time and the esteem in which they are held by society determines whether Cycladic figurines are either primitive curiosities or “magical objects.”

Ambivalence regarding the islands persists in present-day archaeological approaches to the Early Cycladic (EC) period (see table 1.1). However, just as with the examples described above, the source of this ambivalence lies not in archaeological evidence itself, but in how archaeologists frame their research. Several contradictions—such as isolation/integration, marginality/abundance, egalitarians/emerging elites, and diffusion/autonomy—characterize the current state of scholarship. The interpretation of these contradictions affects how archaeologists understand the organization of Early Cycladic society, and they cannot be disentangled from one another.

Table 1.1. Early Cycladic Chronology[a]

Phase	Absolute Dates	Cultural Designation
Early Cycladic I (EC)	3100(+) to 2950 BCE	Grotta-Pelos — Lakkoudhes
Early Cycladic I-II (EC I-II)	c. 2950 to 2500 BCE	Kampos
Early Cycladic II (EC II)	c. 2650 to 2500 BCE	Keros-Syros
Early Cycladic III (EC III)	c. 2500 to 2250 BCE	Kastri

[a] Absolute dates follow Manning’s (2008; 2010) chronology. When referring to time period, I primarily use Renfrew’s (1972) cultural phases because archaeological publications reference material culture by relative chronology and cultural group.

Ambivalent Archaeologies

In *The Emergence of Civilization,* Renfrew (1972) conceptualized Early Cycladic social organization in the greater context of early state formation in the Aegean. In comparison with the later Minoan and Mycenaean palatial systems, the Cyclades in the Early Bronze Age seem like a society that for various reasons "failed" to achieve social complexity. As Tartaron (2008: 94; see also Broodbank 2000: 94) writes:

> In the Cyclades and on the mainland, however, this complexity is regarded as a "false start," unraveling with destructions and abandonments in the latter centuries of the Early Bronze Age before achieving what we would call state-level society.

Renfrew's characterization of Early Cycladic society as a "false start" implies that ancient cultures develop along a trajectory from simple to complex. This neo-evolutionist interpretation was characteristic of the New Archaeology, which influenced *The Emergence* and subsequent scholarship in the Aegean until relatively recently. Recognizing the limitations of neo-evolutionist thinking, Aegean prehistorians in recent decades have made an explicit effort to "deconstruct the dominant paradigms of state formation in the Aegean" (Tartaron 2008: 93). The bulk of this effort has focused on reconsidering Minoan and, to a lesser extent, Mycenaean palatial systems, and includes such volumes as Barrett and Halstead (2004), Catapoti (2005), Driessen, et al. (2002), Galaty and Parkinson (1999; 2007), and Schoep, et al. (2012).

Study of the Early Cycladic period has not received the same paradigm shifts as the later Minoan and Mycenaean palatial systems. Because there is no evidence of state-level society for the Early Bronze Age Cyclades, there has been less impetus for creating new paradigms about social organization. However, social organization in the Early Cycladic period is still considered within the greater context of Aegean early state formation; until the Cyclades can escape their status as a "false start"[4] relative to the archaic Aegean states, which would require archaeologists to fundamentally reconsider how they approach the subject, research questions about Early Cycladic social organization will not find satisfactory explanations. Here I consider three recurring "big questions" that underpin the study of Early Cycladic society and have far-ranging implications for understanding this time period:

Question 1: What role did agricultural surplus play in Early Cycladic social organization?

The degree to which the EBA Cyclades were socially stratified is a debate with deep roots in Mediterranean prehistory, one which originates with conceptualizations of emerging complex civilization in the wider Aegean. Evans's (1921-1936) reconstruction of Knossos and Minoan society—based largely on the sentiments of the contemporary British Empire—precipitated archaeological interest in the rise of prehistoric Mediterranean cultures. Childe (1957) concluded that in the Aegean, Crete formed the core from which all subsequent Aegean, Mediterranean, and European developments were traced; Cretan civilization, in turn, originated from the spread of Egyptian and Near Eastern civilizations (Manning 1995b). However, it was Renfrew (1972) who offered the first causal explanation for the emergence of civilization in the Aegean (see also Manning 1995b; Sherratt 1993; Watrous 1987). Renfrew concluded that the Aegean civilizations were local developments, downplaying the role of Near Eastern influence. His explanation centered on the rise of the palaces as distributive centers controlled by a social elite.

Renfrew (1972; 1982) hypothesized that surplus was fundamental to the

4 Cf. Manning (1994: 224-9) who argues that the so-called 'international spirit' view of the Early Cycladic period—including emphasis on long-boats and regional prestige good circulation—masks localized spatial and social inequalities. In Manning's view, Early Cycladic society should not be considered a false start so much as a "non-start" due to its very small scale, small population, and restriction of regional exchange and communication to the very few.

emergence of stratified society in the EBA Cyclades. In his model, the adoption of the Mediterranean "triad" of wheat, olive, and grapes at the end of the Neolithic period allowed for the exploitation of more marginal land, which in turn led to surplus and greater security for farmers. This facilitated specialization and the production of surplus for exchange, which led to the need for a redistribution system and, subsequently, social hierarchy. This hypothesis has formed the basis for virtually every subsequent study of EC agricultural production and social organization. Archaeologists—in particular those publishing archaeobotanical and zooarchaeological studies of the Early Cycladic period—have refuted or corroborated Renfrew's original claims (e.g. Asouti 2003; Blitzer 2014; Hansen 1988; Livarda and Kotzamani 2013; Margaritis 2013a; 2013b; Ntinou 2013; J.M. Renfrew 1977; 1982; 2006a; 2006b; 2013; Runnels and Hansen 1986; and Sarpaki 2012). Although subsequent models were primarily intended to explain the rise of the Minoan palaces in the Middle Minoan period in Crete (e.g. Manning 1994; 1995b; Watrous 1987), Renfrew's (1972) argument in *The Emergence* shaped the terms of engagement for archaeologists investigating any question involving subsistence, surplus, and society in the Early Cycladic period.

Gamble (1979), for instance, argued that a forceful elite coerced or cajoled the population to live in large, nucleated settlements rather than in small farming villages. Because of the distance between farmers and farmland, the population became dependent on the redistributive power of the elite. Gamble's argument is a circular one, however, since the basis of elite power takes shape only after settlement nucleation, which in turn is dependent on the pre-existing power of the elite. Furthermore, for the EB I and II periods typical Cycladic settlements are small and dispersed, and the material evidence for a controlling elite is minimal.

Van Andel and Runnels (1988) drew on Sherratt's (1981; 1983) secondary products revolution and emphasized the aspects of Renfrew's (1972) argument that highlighted the importance of trade in the development of social complexity. They argued that trans-Aegean trade routes, the use of animals for traction—which opened up extensive areas of land for agricultural production—and improved shipbuilding technology for the transportation of bulk goods enabled the accumulation of wealth by an emergent elite. However, issues of chronological fuzziness plague the cause-and-effect components of Van Andel and Runnels's argument (e.g. secondary products were widely exploited by the Neolithic in the Aegean, whereas the transport of bulk goods via ships is infeasible based on evidence for EBA sailing technology), and there is little archaeological evidence of social changes resulting from the causes they list. Furthermore, if trade was crucial in the development of complex social organization, the Cyclades—as controllers of central Aegean trade networks and access to crucial resources like obsidian and silver—should have emerged as a dominant force in the region.

Halstead (1981; see also Halstead 1989; Halstead and O'Shea 1982; O'Shea 1981) proposed a "social storage" model, according to which egalitarian communities relied on one another in times of agricultural crisis to survive. Halstead's approach was particularly apt for the Cyclades because of the dispersed nature of the settlements; seemingly small, co-dependent, egalitarian populations; and marginal agricultural landscapes. The social storage model also accounted for the lack of architectural evidence for storage warehouses in the EC period, since surplus might be stored "on the hoof" (Halstead 1987) or claimed by neighbors in times of need.

Manning (1994:229) recharacterized the concept of a social storage model to include the circulation of prestige goods. He suggested that prestige objects might serve as tokens of social storage, given upon receipt of subsistence goods. Manning further stated that small communities in marginal environments, as a general rule, establish as many affiliations as possible in order to seek relief in times of hardship. The small scale of communities such as those of the Early Cycladic period make possible this type of social storage (see also Wiessner 1977).

Question 2: To what degree were Early Cycladic settlements self-sustaining?

Despite emphasis on the importance of surplus in the emergence of social stratification in the Aegean, Cycladic archaeologists posit that the islands during the Bronze Age were highly marginal, having poor agricultural resources, scarcity of water, and little land for farming (Davis and Cherry 1979: 2). As a result, it is a possibility that their small populations were not self-sustaining. Prior to the availability of reliable survey data, Renfrew (1972: 249-253) estimated the entire population of the Cyclades in the EBA to be less than 35,000. Since then, survey data from Melos (Renfrew and Wagstaff 1982) has served as the primary basis for population reconstructions in the Cyclades (e.g. Cherry 1979: 37-43; Wagstaff and Cherry 1982: 137-8; Broodbank 2000: 87-90). Broodbank (2000: 87-90) estimated that few islands would have had the minimum 300-500 individuals to support an endogamous population (Adams and Kasakoff 1976; Jones 1976; MacCluer and Dyke 1976; Williamson and Sabath 1984; Wobst 1974). Because of the marginal Cycladic landscapes, Broodbank asserted that islanders would have been unable to create surplus crops to sustain themselves through poor seasons. This would form interdependence between island communities, whereby islanders would call on their neighbors during crisis (e.g. Halstead 1981).[5] Such interdependence would also create opportunities for power differences to emerge as leaders of particularly advantageous sites seized control over access, trade, communication, and other 'non-utilitarian' resources (Manning 1994: 226-7).

Question 3: What was the role of maritime travel in Early Cycladic society?

While the overall outlook on demography and island environments may be bleak, the Cyclades are often considered to be advantageously positioned within greater Aegean trade networks, and the prestige goods produced by the islanders have led to theories about long-range trade led by charismatic emergent elites. Depictions of longboats—vessels believed to have a crew of up to 25 individuals that ranged across the south Aegean region—on Early Cycladic artifacts have attracted archaeological attention as evidence that some individuals during this period had the resources and social clout to build longboats and muster substantial portions of the population to engage in long-range trade. These "big men"—the term derives from Polynesian ethnographic comparanda and describes highly influential and charismatic individuals within a community—would have increased their social standing and wealth through trade of exotic goods and the knowledge they gained from travel (Broodbank 1989; 2000; see also Berg 2010). Evidence of the long-range movement of Cycladic goods has been mustered as further evidence of the importance of Early Cycladic culture in the Aegean basin (Broodbank 1993).

5 See Manning and Hulin (2005: 272) for further discussion of how economic questions of the Aegean Bronze Age emerged from minimalist positions about the ancient economy. In particular, Renfrew (1975)—emerging from minimalist positions (e.g. Finley 1973; see also Snodgrass 1991) posited interregional trade as the driving force for social development in the Aegean: "it was interregional trade that provided the engine for social development, by stimulating producers to organize and intensify production, and by generating wealth and economic disparities leading to social stratification" (Manning and Hulin 2005: 272).

However, if settlement populations were as meager as some estimates suggest, it seems improbable that many places would have been able to produce a crew to sail even one longboat—at least, not on a regular basis. Either current populations estimates are incorrect, or long-range longboat trade was something that occurred only infrequently.

Along with the emphasis on prestigious material culture has been an emphasis on longboats, power, and Cycladic "big men," who were hypothesized to represent an emergent elite class based on achieved status and personal charisma (e.g. Broodbank 2000). The tendency in scholarship is to describe these "big men" as being representative of Cycladic society.[6] Longboat voyages, however, were likely seasonally constrained and may have only represented a small part of local Cycladic patterns of subsistence and social interaction.

Answers to the above questions have resulted in very different outlooks on the organization of early Cycladic society. On one hand, writers like Renfrew (1972) emphasize the "international spirit" of the EBA Cyclades, a time when "big men"—individuals leading their peers through charisma—sailed the Mediterranean trading in prestige goods and craftsmen produced masterpieces which would influence art for millennia. On the other hand, the Cyclades—a cluster of agriculturally marginal islands whose population was too small to be self-sustaining—might be considered a "false start" (Broodbank 2000: 94; Tartaron 2008: 94) in the development of civilization, a society which disintegrated following destructions and abandonments before achieving a state-level society (see also Wright 2004).

6 "Big men" may be characterized in the literature either as charismatic keepers of knowledge (e.g. Broodbank 2000) or as exploitative racketeers (e.g. Gilman 1981).

Reframing the "Big Questions" of the Early Cycladic Period

Aegeanists have noted the aforementioned contradictions in scholarship. In an attempt to unite the ambivalences that persist in Cycladic archaeology, Davis and Cherry (1979:2) write:

> The interplay between the conflicting poles of isolation and integration, the adaptations of island societies to their own habitat, and their responses to the outside world shaped the individual island cultures, gave to each its own special character, and make them worthy of study in their own right. (Davis and Cherry 1979: 2)

Despite an effort to frame these contradictions in a positive light, Cycladic archaeology is at an impasse. Even with an increasing number of archaeological projects in the region, which produce new and better data than in the past (e.g. by including faunal and botanical evidence and using more rigorous survey methodology), many of the "big questions" that have characterized Cycladic scholarship remain contested.

The analyses of the archaeological materials in Cycladic surveys are often oriented toward external connections, in particular identifying and describing trade networks in the wider Aegean and exploring the geographical extent of trade. Due to this, most archaeological attention has been paid to distinctive material goods—notably fine ware pottery and Cycladic figurines. Less attention has been paid to local patterns of exchange and resource distribution, which arguably would have had a greater impact on social organization and identity for EC islanders. Continual archaeological focus on discovering the highest order of Cycladic society, the maximum extent of trade, and the situation of Cycladic material culture within the wider exchange networks of the Aegean has lead to a dearth of study of local Cycladic communities, their subsistence patterns, and local models of social and economic interaction.

In this dissertation, I reorient archaeological focus to the scale of small worlds, which are “the small-scale, intensive networks of interaction among communities of the Aegean islands and coasts” (Tartaron 2008: 109; see also Tartaron 2013). Small worlds analysis—a bottom-up approach that examines habitual interactions between the communities that comprise small world networks—identifies and explains the rhythms of labor and production that shaped the patterns of daily life in past communities.

By adopting a small worlds approach, I reframe the “big questions.” For question #1, instead of focusing on surplus and stratification, I investigate the strategies that Early Cycladic islanders employed in subsistence production more broadly, and I examine the effects of subsistence production on social relationships. While Aegeanists have long recognized the neo-evolutionary underpinnings of Renfrew’s (1972) hypothesis, which assumes a particular trajectory of social development toward increasing stratification and complexity (that never manifests in the Cyclades), virtually every discussion of Early Cycladic subsistence either attempts to confirm or refute his premise. Despite increased attention to subsistence evidence—namely in the recovery of archaeobotanical and faunal remains—no consensus is emerging. By adopting a small worlds approach, I examine the types of subsistence activity in which communities in Early Cycladic small world networks engaged. Given the relationships between communities within a small world network, I investigate how support mechanisms operated during times of hardship and expand on Halstead’s (1981) social storage model. By looking at the social organization of subsistence activity at the small worlds scale, surplus becomes one of a suite of many subsistence strategies Early Cycladic islanders may have adopted.

For question #2, I reframe the paradox of marginality and self-sufficiency in terms of community interaction. While previous regional scholarship has tended to characterize the islands as environmentally marginal, with low populations, short-lived settlements, and interdependent communities, archaeological excavations have focused on prestige grave goods that signal emergent social stratification and the settlement stability it implies. Instead, in the present project I examine Early Cycladic community interaction more generally. By modeling habitual movement between communities, I allow the boundaries of Early Cycladic small world networks to emerge from past practices, thereby laying a groundwork for the study of intercommunity interdependence.

Finally, for question #3, I reorient the focus of seafaring from maximal travel and trade to habitual connectivity between communities that would have comprised maritime small world networks. Despite the recognition by many archaeologists that maritime travel would have been integral to the daily lives of islanders and hypotheses that interisland communities could have had closer and more intense connections than intraisland ones, little attention has been paid to local scale maritime intercommunity interaction. The preferential study of longboat travel has also led to the homogenization of the seascape. By focusing at the scale of small worlds, I differentiate sailing conditions within the Cyclades and during different times of year. The resulting analysis examines nuanced local seascapes and allows for the identification of small world maritime networks.

This dissertation lays a groundwork for investigating these questions. I combine a small worlds framework with GIS analysis of extant archaeological evidence about Early Cycladic subsistence and settlement patterns to create a basis from which further investigation along these lines can be launched. From this foundation, future research will be able to incorporate studies of material culture patterning and can also extend geographically and temporally to consider the Cyclades within the broader context of the Bronze Age in the Aegean.

Overview of the Present Work

Temporally, my dissertation spans the Early Bronze Age (ca. 3000-2200 BCE). Its geographical area of study focuses primarily on a part of the central Cyclades which encompasses southern Naxos, Amorgos, and the Erimonisia. This is one of the few areas in the Cyclades where the archaeological data are dense and well-published enough to paint a more specific picture of local variation (Broodbank 2000: 207-10).

Sources of Evidence

Due to the high costs of archaeological fieldwork, the increasing difficulty in obtaining archaeological permits in Greece and elsewhere, and the relative lack of comparative archaeology in the Early Cycladic period,[7] I am committed to archaeological analysis based on open-source and legacy data. All of the data in the present work derive either from open-source repositories—in particular basemaps and declassified satellite imagery—or previously published archaeological data. Where possible I have also used open-source software—notably Quantum GIS (QGIS)—in data analysis. I obtained photographs and on-the-ground experience of Cycladic

7 Despite the optimistic outlook of Cherry (1983:406) regarding the potential for "synthesis and comparison at a geographical scale considerably larger than that of the individual survey" due to the influx of survey data in the Aegean, the side-by-side comparison of survey projects has been slow to develop. While on the Greek mainland several projects have used comparative data to investigate research questions (e.g. Alcock 1993; Bintliff 1997; Cavanagh 1995, 1999; Cherry and Davis 2001; Halstead 1994; Mee 1999; and Mee and Forbes 1997), this has generally not been the case for the Cyclades. The myriad factors that have caused this delay are detailed by Alcock and Cherry (2004: 4-5).

landscapes and archaeological sites as a team member of the Cambridge Keros Survey in 2013 and the Cambridge Southeast Naxos Survey (SENS) in 2015, which shaped the way I approach questions about Early Cycladic movement and intercommunity interaction.

Outline of the Present Work

In the present chapter I have proposed adopting a small worlds approach to reframe and address some major recurring questions in Cycladic archaeology:

1. What role did subsistence strategies play in Early Cycladic social organization?
2. How did habitual movement between communities shape Early Cycladic small world networks, and what effect did this have on community interdependence?
3. How did habitual seafaring and the local seascape shape maritime small world networks?

A small worlds approach will allow me to reorient Cycladic archaeology away from previous paradoxical or unanswerable questions and begin to lay the groundwork for future study of Early Cycladic subsistence, community interaction, and social organization.

In chapter 2, I discuss the lineage of small worlds analysis in archaeology and anthropology. The aim of chapter 2 is to identify the type and scale of social interaction that comprise small world networks and to outline how they may be recognized and analyzed in the material record. Based on the previous critiques of small worlds applications, I outline a small worlds approach for the Early Bronze Age Cyclades that I adopt in my dissertation: first, communities are the social units that interact to form small worlds; second, the habitual interaction of community members geographically and temporally bounds small worlds; and finally, the methods of formal network analysis can help to delineate variables for modeling small worlds network interactions.

Chapters 3 and 4 set out parameters for investigating Early Cycladic community interaction. Chapter 3 focuses on subsistence activities and how communities might cooperate to ensure mutual survival, while chapter 4 conversely focuses on warfare and its operation in Early Cycladic society.

Chapter 3 examines the seasonal cycles of labor related to subsistence in the EC Cyclades that would have structured the patterns of community interaction which form small worlds networks. In light of recent publications of excavations at Dhaskalio (Keros), Markiani (Amorgos), and Phylakopi (Melos), I summarize the archaeological data for different types of subsistence production, supplementing the material evidence with comparanda from ethnographic studies and ancient literary sources. I then map the different types of subsistence activity and the intensify of their labor requirements throughout the year to model the labor patterns of Early Cycladic communities. Then I examine the subsistence strategies employed by Early Cycladic islanders to reduce the risk of agricultural failure and how these strategies contributed to community cohesion and organization.

One of the common critiques of a community approach to archaeological analysis is the lack of consideration of competition and warfare among population groups. In chapter 4, I define war as a socio-political phenomenon in non-state societies. I discuss the various sources of evidence that archaeologists may draw upon for the investigation of warfare for the Early Cycladic context. I then present a chronological overview of the evidence of fortifications at sites throughout the Cyclades, emphasizing those with sufficient archaeological investigation and publication to be useful for an inter-site comparison. Using data from these sites, I perform a cluster analysis to see which variables related to fortification appear to be significant and to differentiate patterns of fortification, both spatially and over time, for the EBA Cyclades. Finally, I discuss the dimensions and consequence of warfare in the early Cyclades, drawing from the archaeological evidence and ethnographic comparanda.

Chapters 5 and 6 turn to case studies to identify Early Cycladic small world networks. Chapter 5 focuses on land-based movement, while chapter 6 examines maritime networks.

In chapter 5, I create geographic information systems (GIS) models of how human movement through the landscape creates place, focusing on the intercommunity interaction of one potential small world on the southern coast of Naxos. In particular, the mapping of "action spaces" offers a methodology for archaeologists to study the formation of place as a result of human movement and social interaction in otherwise undifferentiated landscapes. By quantifying variables such as terrain analysis, travel times between sites, least-cost paths, and viewsheds, this methodology reveals dynamic places of habitual social interaction that would remain "hidden" in site- or region-based archaeological research. The resulting GIS models show that even during periods of decline on the rest of the island, the communities of southern Naxos—though geographically and agriculturally marginal—demonstrate evidence for long-lived and stable ties, indicating that this marginality may have increased, rather than detracted from, the strength of its intercommunity relationships.

While the previous chapter focuses on land-based travel and community interaction, chapter 6 models maritime connections in the central Cyclades. I reconsider past maritime network models in the Aegean (e.g. Broodbank 2000;

Knappett, et al. 2008; 2011), arguing that using travel time rather than absolute distance as a primary variable fundamentally affects archaeologists' understanding of intercommunity relationships. Using GIS I create isochrones of travel time using a cost-raster derived from wind and wave patterns, which I use to map the seasonal maritime movement of members of Early Cycladic communities.

After briefly summarizing the results of the present project, in chapter 7 I turn more broadly to the role of small world interaction in shaping Early Cycladic life, and I challenge the categorization of the Cyclades as a discrete conceptual unit. I finally offer some avenues for future research that take into account the findings of the present work, which contextualize the Early Cycladic period within the greater context of the Aegean Bronze Age.

Chapter 2
Small Worlds

Introduction – Defining Small Worlds

The concept of "small worlds" as a means of analyzing local interaction networks has been used extensively in anthropology, sociology, and archaeology (see Collar, et al. 2015: 23), though the term is construed inconsistently in scholarship (Tartaron 2013: 190). Tartaron (2008:109) defines small worlds as "the small-scale, intensive networks of interaction among communities;" "these interactions sustained essential ties among small communities living with limited subsistence and human resources." While Tartaron's project focuses on the Mycenaean coastscapes[8] of the Late Bronze Age, this definition works well as a starting point for defining the small worlds of the Early Bronze Age (EBA) Cyclades.

In this chapter I examine the place of small worlds analysis in broader archaeological and anthropological thought, with emphasis on applications of small worlds analysis in the prehistoric Aegean. I assess the aims, merits, and drawbacks of these previous approaches. Then, I detail the small worlds approach I adopt in this dissertation, including the role of the community in small worlds interaction and the delineation of small worlds based on the temporality of human movement. I conclude with a discussion of how small worlds analysis can benefit from other types of formal network analysis used in archaeology. The overall aim of this chapter is to identify the type and scale of social interaction that comprise a small worlds network and to outline an archaeological methodology for the identification

8 As opposed to landscape, a coastscape "centers on the shoreline and assumes a maritime orientation" (Tartaron 2013: 190).

and analysis of small worlds networks in the Early Cycladic (EC) period.

The Theoretical Lineage of Small Worlds

As Tartaron (2013: 190) notes, the term "small world" is widely used to describe a type of social network in anthropology and archaeology, but there is little unity among scholars in its conception or application. In academic literature generally, "small worlds" most commonly refers to a type of formal network analysis developed by Watts and Strogatz (1998; see also Watts 1997; 1999). In a small world network, most nodes are not neighbors, but the probability of their neighbors being neighbors is high, meaning that most nodes can be reached from every other node by a few number of steps (Watts and Strogatz 1998). In his PhD dissertation, Watts (1997: 2-3) explains this phenomenon as a formalization of the Six Degrees of Separation game, which posits that any two people on Earth are separated by six or fewer acquaintance links:

> The [small worlds] problem, as it stands in the sociological literature, addresses the possibility that such sporadic and seemingly isolated occurrences actually are symptomatic of the structural properties of modern society.

In a small world network, some nodes have significantly more linkages than others, and these nodes are called "hubs."

In 1998—the same year that Watts and Strogatz published their article on small world networks—Chase-Dunn and Mann (1998) and Sherratt and Sherratt (1998) published archaeological studies that influenced how subsequent archaeologists would deploy the concept of small worlds, though neither of these studies used the term "small worlds" explicitly. Both of these studies grew out of a critique of Wallerstein's (1974) world-systems theory.

Chase-Dunn and Mann's (1998) study applied a world-systems approach to smaller regional intersocietal systems of the Wintu people (located in what is now northern California) and their neighbors. They define world-systems as:

> …intersocietal networks in which the interactions (trade, warfare, intermarriage, etc.) are important for the reproduction of the internal structure of the composite units and importantly affect changes which occur in these local structures. (Chase-Dunn and Mann 1998: 8)

Their dissatisfaction with Wallerstein arises from his requirement that a world-system involve hierarchical or stratified interaction. The authors note that there are ethnographic and archaeological examples of societies—such as the Wintu and their neighbors—in which there exist intersocietal interaction networks that are primarily egalitarian. They argue that some stateless intersocietal systems did not have core/periphery hierarchies, and others had only episodic instances of them (Chase-Dunn and Hall 1991: 127).

Chase-Dunn and Mann go on to identify four different types of interaction networks: bulk-exchange networks, political/military interaction networks, prestige-goods networks, and information-exchange networks. They argue that the existence of these networks must be determined from a *local-centric* starting point, and then moving up and out in scale, rather than starting from a top-down framework (1998; see also Ames 2000: 394-5).

As Ames (2000) notes, Chase-Dunn and Mann's expanded definition of world-systems seems so broad as to no longer qualify as world-systems theory. Even though they attempt to move away from the hierarchical relationships required by Wallerstein's (1974) concept of world-systems, continuing to incorporate concepts of core and periphery imply relations based on domination rather than egalitarianism. This critique suggests that the type of interaction network Chase-Mann and Hall were searching for—a bottom-up method of theorizing intersocietal interaction among egalitarian communities—was in fact distinct from world-systems, though it did not yet have a name.

Sherratt and Sherratt (1998) similarly never use the term "small worlds" in their analysis of trade interactions in the eastern Mediterranean during the Bronze Age. While there were trade interactions between the long-established cities of the Near East and the more recently established, smaller polities of the Aegean, these relationships do not seem to fit the standard world systems core-periphery model. In particular, Sherratt and Sherratt (1998) note that intervening populations, especially coastal or nomadic communities, could link producers and consumers, bridging both geographical and cultural gaps. These intermediary communities function like "hubs" in a Watts-Strogatz small worlds network, controlling at a local level the transmission of goods, wealth, and knowledge between the older urban civilizations of the Near East and the newer, smaller Aegean societies (Sherratt and Sherratt 1998: 338).

Two years later, the year 2000 saw the publication of two major small worlds analyses in the Mediterranean: Broodbank's (2000) *Island Archaeology* and Horden and Purcell's (2000) *The Corrupting Sea.* In the former, Broodbank presented a reconsideration of the proximal point analysis he had published for the Cyclades in 1993, though he does not refer to the networks he identifies as small worlds until the 2000 book.

The goal of Broodbank's proximal point analysis (PPA) was to model local interaction networks with the aim of understanding the different theaters for the emergence of local identities in the Cyclades, particularly during the EB I-II transition (Broodbank 2000: 176-7). To create the PPA model, Broodbank took extant archaeological evidence of settlement patterns in the Cyclades during the Bronze Age and simulated the extension of those patterns across areas in the Cyclades where no archaeological work had been done. This resulted in a map of the Cyclades with different points on the islands; each point was associated with its three nearest neighbors based on Cartesian distance. The points with the most resulting connections were interpreted as the most central and as having the greatest importance in local networks.

Broodbank sees "small worlds" manifesting in his PPA model as clusters of close-knit settlements. For him, small worlds are the product of the relationship between demography and settlement patterns as they change over time (2000: 179-80). However, the overall focus of the model remains pan-Cycladic. This model does not analyze individual small worlds networks, but rather how small worlds networks emerge in a larger pattern of connections.

PPA reveals certain nodes that exhibit greater connectivity than others. Broodbank interprets these "hubs" as having the highest amount of communication and exchange between their neighbors and therefore as having the strongest and most enduring connections (2000). However, as Horden and Purcell's (2000) work shows, the strongest and most enduring connections between communities frequently occur in the most marginal places.

For example, human opportunism has often succeeded in making fragmented and marginal mountain landscapes into cohesive systems of production. Interdependence is most pronounced in extreme places (Horden and Purcell 2000: 18). Because of their liminality, communities in extreme locations—such as the marginal agricultural environments of the Cyclades—may become dependent on one another for survival and are in some ways bound together in their isolation. When assessing small worlds, it is therefore important not to assume that the volume of connections corresponds to the intensity or longevity of inter-community interaction. Rather, it is necessary important to find a way to model connectivity that does not rely on centrality.

Of all recent applications that might be deemed as "small worlds" approaches, Tartaron's 2013 book *Maritime Archaeology of the Mycenaean World* fits most explicitly into that category. Tartaron's goal is to reorient the study of maritime interaction networks—in this case of Mycenaean "coastscapes" in the Late Bronze Age—away from the international-scale and toward the scale of the "small world" (Tartaron 2013: 10-11). His local scalar focus is largely influenced by Horden and Purcell (2000) and his network approach draws heavily on Broodbank (2000).

Tartaron is explicitly concerned with defining small world interactions as well as the archaeological variables which contribute to a small worlds approach. Tartaron (2013: 117-8) emphasizes the importance of considering scale when developing methodology:

> Scale affects historical trajectories in distinctive ways. The analytical focus advocated in this book on local-scale interactions owes a debt to Horden and Purcell's emphasis on the durability of short-distance interactions among "microregions," with considerably more unstable linkages to the shifting fortunes of supraregional entities. This emphasis results in a very different history from the traditional "Great Men and Battles" version, but one that reflects more faithfully the true rhythm and full scope of Mediterranean life. One of these alternative histories can be written about short-distance maritime connections, which offer a fundamentally different view from the great interregional trading routes on which most scholarship has focused.

He notes that short-distance relationships arise from several factors that are not usually seen in the larger-scale, regional networks on which previous scholarship has focused:

> (1) they are easier to maintain from a practical point of view, since distances and environmental obstacles are less inhibitive; (2) they are often founded on long-established and deeply embedded social ties; and (3) the communities they bind may be less susceptible to changing political fortunes if they lie outside the mainstream of momentous historical events. (Tartaron 2013: 117-8)

According to Tartaron, the cohesion of small worlds arises due to habitual face-to-face-interaction, which is based on travel time and distance, local geographies, and various economic and social ties (2013: 190). Community proximity is determined by real travel time and distance, where linear distance is important only insofar as it relates to travel time. This becomes an especially important variable for maritime small worlds, where an outbound journey may take only one day, but the return journey could take four or five times as long due to adverse currents or weather conditions. Local geographic markers—such as stretches of coastline, bays and anchorages, or intervisibility—may also facilitate small world cohesion (*ibid*). Finally, the communities that comprise a small world often share cultural traditions, such as exogamy and kinship ties, language, mutual protection arrangements, and dense economic relationships (*ibid*). They may be united by economic ties, especially in areas where communities are dependent upon each other for subsistence due to marginality or the uneven distribution of resources (*ibid*).

If these are the conditions that facilitate the existence of small worlds the question remains: why do they cohere? While spatial and ecological variables might shape small worlds, they are essentially culturally defined unities (Broodbank 2000:

175). Small worlds emerge from the conscious decisions of communities to forge connections with one another, and there are many reasons communities would decide to develop strong ties. Economic support, intermarriage and kin group dispersal, and shared ritual activities are just a few (see Renfrew 1993: 10-11 for an extensive list).

While Tartaron's work is the most explicit in describing small worlds analysis and in developing an archaeological method for how to undertake such analysis, his discussion of small worlds lacks contextualization of how this approach developed from broader archaeological theory, namely world-systems theory and earlier work on agricultural risk management (e.g. Halstead and O'Shea 1981). While Tartaron emphasizes local and specific small worlds, he does not examine how his small worlds approach is largely indebted to world-systems theory—which is exactly the sort of large-scale, international approach that Tartaron wants to avoid. Furthermore, there is also a need to discuss specific scales vis-à-vis more recent archaeological applications of network analysis; while it is a strength of network analysis that scale can be modified up or down to fit a specific problem, Tartaron does not discuss how small worlds analysis is specifically suited to taking into account local variables. To fully develop a small worlds approach, there should be more discussion about how it differentiates from other network models and does not simply represent a narrowing of scale.

Approaching Early Cycladic Small Worlds

Based on the previous critiques of small worlds applications in the Aegean, in this section I outline a small worlds approach for the Early Bronze Age Cyclades. First, I discuss the role of the community as a fundamental component of small world networks. Second, I quantify and qualify the concept of habitual interaction as critical for the creation and bounding of small worlds. Finally, I examine how small worlds analysis intersects with formal network analyses to delineate variables for modeling small worlds network interactions.

The Role of Communities in Small Worlds Networks

The archaeology of past communities, which experienced a surge of interest in the early 2000s,[9] offers a framework for understanding how the various social components within a small world interacted in the past. However, community is not easily defined. For the Early Cycladic period, we might imagine a community comprised of several families living in close proximity to one another; perhaps they work together to accomplish large tasks like harvesting and herding flocks (see chapter 3). This community's members have individual routines, in which they socialize with one another and negotiate actions on a regular basis. They may conceive of themselves as sharing a social identity.

However, perhaps one woman from this hypothetical community married into it—her birth family is located on a nearby island, close enough so that she may visit them regularly. While she identifies with her current home, she perceives herself as a member of her family's community, as well.[10] Perhaps another man from this community has secured enough wealth and influence that he constructed a longboat, and on a semi-annual basis he rounds up a crew of young men from the village to undertake a journey. Over the years, he has learned how to navigate

9 See Amit 2002; Canuto and Yaeger 2000; Harris 2014; Knapp 2003; Kolb and Snead 1997; Mac Sweeney 2011; Marshall 2002; Moore 2007; Whittle 2003.

10 Broodbank (2000: 87): "The majority of [Early Cycladic] communities will have been dependent on exogamy for reproduction, and therefore will have had kinship bonds with other communities through marriage alliances, with more extensive lineage networks developing between groups of small segmentary communities." (See also Sherratt 2000.)

the Cycladic seas; he knows the best stopping points for shelter and the markers in the landscape that allow him to know where he is going.[11] He has met other men like him on other islands—some of them far away—but they are alike in their power, wealth, and knowledge of the sea, and therefore he feels connected to these other seafarers though he lives nowhere near them.

Any individual may simultaneously belong to multiple communities, and individual members of the same community may differ in their motivations, goals, and even perceptions of what their shared community entails (Anderson 1983; Isbell 2000; Mac Sweeney 2011). Despite an increase in the usage of "community" in archaeological literature, there remains no archaeological agreement on how to conceptualize community (Mac Sweeney 2011: 4).[12] In the 19th and for most of the 20th centuries, "community" was defined as a natural social entity; as Mac Sweeney (2011: 13) notes:

> The word 'community' was straightforwardly used to refer to the population living within a particular locale, and it carried almost no connotations at all of identity or conscious association.

This definition of community—one in which an external observer could unproblematically categorize a community based on coresidence—created problems in archaeology. Archaeologists have often assumed the existence of communities, frequently equating the archaeological site with the physical remains of a past community (Mac Sweeney 2011: 5). Due to available archaeological resolution in prehistory, smaller social units such as individuals and households may not be able

11 See Broodbank 1993.

12 Canuto and Yaeger's (2000) edited volume represents an initial attempt at creating a unified archaeological conceptualization of community, yet the approaches of the papers tend to fall into the "natural community" approach or the "imagined community" approach (Isbell 2000). Some of the authors (e.g. Yaeger 2000) believe that these two approaches can be unified, while others (e.g. Isbell 2000) believe they are fundamentally incompatible.

recoverable in any detail—the Early Cycladic period is one such example.[13] Archaeologists should be careful, however, not to assume that communities are a natural form of human social organization or that residential proximity necessitates a social collective. Recent critiques of this "natural" community approach have revealed the degree to which archaeologists have defined communities by research methodology as much as by past social reality (Isbell 2000: 245).

Cohen (1982; 1985) and Anderson (1983) were influential in reconceptualizing the community as a socially constructed unit that exists as an idea in the minds of its constituent members. Both scholars downplayed the circumstantial mechanisms of community, such as environmental factors, coresidence, and face-to-face interaction, in favor of the cultural mechanisms that lead to community formation (Mac Sweeney 2011: 15). These "imaginary communities" need not be tied to any physical location, nor do they require any interaction among their members (Anderson 1983).[14] However, "imagined communities" come with their own set of problems for archaeologists; if communities do not rely on interaction or shared physical location, communities can potentially be anywhere and relate to anything (Mac Sweeney 2011: 17). Taken to this conclusion, "community" ceases to function as an analytical category.

The concept of "geographic communities"—a specific type of community rooted in a particular locality—offers archaeologists a means of investigating past

13 Broodbank (2000: 51): "On the negative side [of our knowledge of Early Cycladic archaeology] must be admitted an ignorance of the contextual associations of much of the tomb material…in this respect, the virtually complete absence of any physical anthropology, a generally poor grasp of subsistence practices and gender roles, and in effect no archaeology of the household (although excellent preservation at the newly excavated site of Skarkos promises an imminent start."

14 See also anthropological diaspora studies (e.g. Lavie and Swedenburg's 1996 edited volume) for discussion of "third time-spaces," which are spaces in the interstices between displacement and rootedness (Lavid and Swedenburg 1996: 16).

communities that is rooted in material evidence. Geographic communities differ from other types of communities in that their sense of group identity focuses on shared place and the shared experience of coresidence (Mac Sweeney 2011: 19; see also Bell and Newby 1971: 21-32).[15]

Geographic proximity does not automatically produce social cohesion; however, the embodied experience of coresidence can result in a shared sense of social identity (Cohen 1985; Dawson 2002; Mac Sweeney 2011: 20; Peters 1992).[16] Proximity affords, but does not necessitate, a high level of personal interaction among individuals. This seems likely in EC settlements, where population levels were low and settlements generally dispersed. The specific historic circumstances of the Early Cycladic period may have made the *strategy* of communal living particularly beneficial to individuals in this context (see chapter 3). Through spatial and geographic study of EC material remains, I can consider the emplaced nature of the community (see Mac Sweeney 2011: 20).

There are three primary factors I examine when characterizing EC communities: the temporality of face-to-face interaction, the importance of the material world as a mediator of community interaction, and the relationship of the community area to the surrounding cultural landscape. Unless otherwise specified, "community" refers to the geographic community, which forms the focus of the present discussion.

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15 Mac Sweeney (2011: 19) notes: "There may be a number of subsidiary factors that also contribute to the geographical community's identity, such as descent or ethnicity, religious faith, profession, language, and nationality. However, all these factors are built on the essential foundation of the community's basic sense of commonality, which is shared place and the shared experience of residential proximity."

16 Practice theory (Bourdieu 1977) underpins this conception and describes the mechanisms by which a sense of collective identity can arise from coresidence (Mac Sweeney 2011: 20).

In geographic communities, members interact within their communities, but they also interact with members of other communities—the distinction is one of frequency. Members within a community interact on a daily basis, while members between communities—i.e. members of a shared small world—interact less frequently, but often enough to form relationships based on trust (Tartaron 2013). Yaeger (2000) identifies *habitus* (*sensu* Bourdieu 1977), such as the communal use of resources and shared forms of domestic architecture, as an important component of creating community solidarity. The cumulative effect of the different routines of individuals, which bring them into contact with one another in various scales, temporalities, and settings, can result in the reproduction of structures that enhance community identity (Whittle 2003: 22).

Second, it is important to consider the relationship of communities with the material world. Harris (2014) argues that previous approaches to community have been predominantly anthropocentric. On the one hand, communities, in particular sedentary agricultural groups, create physical "maps"—the manifestation of social and economic relationships through the modification of the physical landscape (Kolb and Snead 2007: 611). On the other hand, the material world mediates both intra- and intercommunity interactions. Pauketat, attempting to deanthropocentrize community, writes that communities should be recognized as a "quality of places, experiences, practices, and even human bodies" (2008: 249) and that the properties of communities emerge out of the relational field of these components (2008: 241). By considering the active role of places and things in the construction of communities, we can consider communities not as imposing themselves on particular places nor constrained by them, but as emerging through places of interaction (Harris 2014: 89).

In the present analysis, I emphasize the importance of the landscape as a mediator of community interaction. The physical components of the community might consist of a settlement (or a part thereof), areas where subsistence production is carried out (Kolb and Snead 1997: 612), as well as socially maintained boundaries and regularly traversed paths, though the exact nature of these features may vary on a case-by-case basis. For example, in Halstead and Jones's (1989) ethnographic study of traditional Cycladic farming communities, the places of intracommunity interaction included not only houses, but lowland and terraced fields, temporary housing near the fields for periods of most intense labor, threshing floors, winnowing areas, and the paths traversed by farmers and livestock. The shared spaces of daily routine and labor mediate social relationships and afford the formation of shared identity (see Whittle 2003).

Finally, I consider the relationship of the "community area" (Neustupny 1998) to the space of the broader social world. Neustupny (1998:19) defines community areas as places "where people lived, worked, cultivated, herded and foraged, sensitive to place in their choice of favorable soil, aspect and slope, but guided also by factors other than the practical" (Whittle 2002: 129). The community area is the spatial extent of the communal world. According to Neustupny (1998), it is surrounded by the "strange world," a zone rarely visited where society is comprised of circuits of otherness, including warfare and exchange. The world of community is separated from the strange world by a "zone of otherness," where people and other beings who are not members of the community, but who may share artifacts and symbols with the community, exist (Harris 2014: 82). I suggest that Neustupny's "zone of otherness" corresponds with the small world.

The implication of Neustupny's tripartite division of the landscape is that knowledge and identity are fundamental in the formation of the social boundaries which divide each zone. For example, he says that the circuits of otherness in the strange world are as likely to be constituted of known adversaries from nearby communities as strangers from a different system entirely (Whittle 2002: 129; see also chapter 4 in the present work). Furthermore, an individual's perception of the boundaries between these landscape zones may vary according to their knowledge and personal connections. This implies that the boundaries between these zones are fuzzy, and "otherness" is a description of degrees. Neustupny's emphasis on otherness highlights the need to consider antagonism as well as cooperation in community interaction (see chapter 4).

Just as it is not possible to draw firm boundaries around Neustupny's landscape categories, it is likewise not possible to draw firm scalar distinctions between households, communities, and small worlds. As Moore (2007: 95) notes:

> Shared perceptions of the landscape, embodied through material culture, may have allowed communities to perceive themselves as part of a shared, broader identity beyond the local community—even if that perception varied from household to household and did not translate itself to any bounded social group on the ground.

Both the conceptualization of shared identity and the physical movement and face-to-face interaction that afforded shared identity might vary by individual, household, or community. Differential wealth, power, knowledge, gender, and age may have been factors that resulted in multiple perceptions of belonging and shared identity among a community's members.

Unfortunately, the tools of archaeological analysis—in particular, the use of GIS—can result in the reification of boundaries and the loss of resolution when studying ancient communities. GIS models create edges and averages which obfuscate the porosity and multivalence that would have characterized communities in the past. To correct this, archaeologists must pay close attention to material patterning as relates to GIS models, as well as carefully considering the role of places that might have been culturally important in local communities' perceptions of the landscape and formation of shared identity.[17]

Quantifying and Qualifying "Habitual Interaction"

In the remainder of this chapter, I situate Cycladic communities within local small worlds networks. Both communities and small world networks are distinguished from larger spheres of interaction by a degree of familiarity; the members of their populations have decided to enter into mutually beneficial relationships established on trust. At the scale of the region or beyond, the relationships are more distant, involving larger social processes that structure engagements with strangers, and even potential enemies (see Chapman 1980; Graeber 2011; Humphrey 1985).

Small worlds are composed of communities of individuals whose relationships are formed through habitual face-to-face interaction. This both places broad limits on the scale of small worlds and characterizes the nature of social and economic interaction between the individuals of these communities. These interaction networks may arise through geography, kinship, economic, or other factors (Broodbank 2000: 175-210).

Travel Time

The habitual nature of interaction between communities within a small world lim-

17 See Moore (2007) for a study which integrates GIS and the study of communities of Iron Age Britain.

its the maximum travel time between them. Tartaron (2013: 186) provides a model for the different scales of interaction which vary in terms of geographic scale, temporality, and who may participate (see table 2.1).

When compared with other scales of interaction, the habitual sphere of the maritime small world means that social interaction occurs less frequently than everyday interactions, but frequently enough to where the participants establish mutual relationships based on trust. Because travel time is relatively non-strenuous—with a maximum of a two-day round trip—both nonspecialists and specialists may engage in this habitual interaction. In Tartaron's case, the specialists would be sailors who had the skills to man larger seacraft. The restrictions imposed on larger scales of interaction in the Cyclades would be primarily maritime; while the small size of the islands would not restrict overland travel, not all communities would have had interisland destinations reachable via a two-day round trip.

When based on real travel time, the boundaries that habitual interaction places on scale are fuzzy, as travel conditions—especially maritime ones—vary dramatically within the Aegean due to the confluence of multiscalar atmospheric processes (see chapter 6 for further discussion). Maritime movement in small worlds was most likely restricted to sailing during the day, since night-sailing would require specialized knowledge (Tartaron 2013: 192). In chapters 5 and 6, I use GIS to model habitual travel patterns for land-based and maritime small worlds, respectively.

Table 2.1. A Framework for Maritime Cultural Landscapes[a]			
Interaction Sphere	**Geographical Scale**	**Temporality**	**Operators**
Coastscape	Territorial coastal zone; passes to interior; inshore waters and the visual seascape	Everyday life	All: specialists and nonspecialists
Maritime small world	Many coastscapes, connected by no more than two-day round trip; depends on topography	Habitual	All: specialists and nonspecialists
Regional/ intracultural maritime sphere	Aegean basin; depends on technology and development of intracultural relations	Relatively infrequent	Specialists
Interregional/ intercultural maritime sphere	Outside Aegean basin and Mycenaean maritime culture area; depends on technology and development of intercultural relations	Infrequent	Specialists

[a]Adapted from Tartaron 2013: 186.

Embodied Experience

Small worlds interactions may be enhanced or diminished by qualitative and phenomenological structures (*sensu* Marquardt 1992: 105), such as community intervisibility and landmarks, as well as the geographical structuring of terrain and coast. While the physical features of geography and the conditions of wind and wave patterns may structure individuals' movements, the landscape (or seascape or coastscape) emerges as a result of the accumulation of practice. Patterns emerge through repeat engagement with the landscape, and therefore the landscape is never an objectively definable, static entity, but a constantly emerging phenomenon (cf. Bourdieu 1977; 1990; Giddens 1984). The physical features of the landscape may eventually become "bearers of memory" (Alcock 2002: 15). Social memories of communal landscape practice can lead to shared identities (see also Schama 1995).

The nature of the material record in the EBA Cyclades is such that it would be impossible for archaeologists to reconstruct the subjective experience of individuals. However, it is possible to assess the physical structures—e.g. climate, geology, topography, and natural resources—and the socio-historical structures—e.g. technology, economic and social relationships—that determine the potentialities of human relationships. These structures are essential in mediating the dynamics of human behavior (Pauketat 2008).

Interpersonal relationships

Finally, the nature of face-to-face interaction and its impact on social relationships shape and define small worlds networks. In local networks, where habitual relationships are established on mutual trust, "one is much more likely to discover everyone in debt to everyone else in a dozen different ways" (Graeber 2011: 22). Economic transactions need not directly exchange one good or service for another at the same time, but when one person needs an item, they may obtain it from another person with whom they have a mutual relationship with the understanding that in the future, this aid will be reciprocated (see Halstead 1981). This is particularly salient in small agricultural communities where subsistence is not assured. For example, in traditional farming communities on Amorgos and Karpathos in the 1960's, farmers who experienced a shortage might borrow grain from other farmers or exchange their labor for a part of the harvest. This risk management strategy benefits everyone: in the short-term, it enables the economic survival of many households, and in the long-term, farmers who are repeatedly successful gain wealth and influence (Halstead and Jones 1989: 55; see chapter 3).

Small Worlds and Formal Network Analysis

A comparison with formal network analyses allows several refinements to the small worlds approach discussed above: 1) a clearer definition of the types of actors and relationships that are the subject of a small worlds approach, 2) modeling based on *praxis*, and 3) challenging preconceptions about center-periphery relationships.

In a Watts-Strogatz model (Watts and Strogatz 1998), small-worlds networks have weak ties and strong ties. Strong ties are based on the closest and most frequent relationships between individuals or communities (or whichever base unit the model is using), and these relationships develop based on trust. Weak ties are not reliant on trust or closeness; they are good for the simple diffusion of ideas or objects which does not require frequent contact or trust (Collar 2013: 12-13).

Similarly, in a small worlds approach à *la* Tartaron (2008; 2013), there are ties created by varying types and frequencies of interaction. At the most local level, interactions between individuals occur on a daily basis. At the small world level, they occur habitually between individuals or groups in different communities. Both of these interactions are founded on relationships of trust. In this way, local and small worlds interactions both represent forms of strong ties.

Communities and small worlds are also connected to the outside world, represented through direct exchange (exchanging one item for another simultaneously) or other infrequent interactions. These interactions need not occur between people who know each other well or trust each other, but may occur between strangers and even potential enemies (Graeber 2011). These longer-range interactions represent weak ties.[18]

In the EBA Cyclades, "big men" would represent "weak ties," since they had access to long-range travel and engaged in modes of exchange with people on a regional scale. Individuals participating in exogamous marriages might also represent weak ties, which might transform into strong ties throughout the course of their lives as they continued to interact with their birth families.

Those individuals and interactions involved in the formation of strong ties have been under-studied in Cycladic archaeology. The material remains that were a part of these ties are difficult to locate archaeologically. Moreover, mathematically determining weak and strong ties in a formal network model is complicated. A small worlds approach such as the one outlined here could supplement formal analysis. The concept of habitual interaction based on real travel distance and local land- and seascapes allows for the demarcation of the geographical extent of strong and weak ties, though close analysis in conjunction with the archaeological material is necessary to ensure this reflects real social realities.

> Formal network analyses are also well-suited to a practice-based approach: The emphasis of network theory is on interactions as the drivers of change, and this is a fundamental switch in emphasis: instead of focusing on singular or purely functional reasons for change, understanding the power of interactions means that change can be viewed as decentralized, causally distributed, and a cumulative result of multiple individual behaviors. (Collar 2013: 6)

18 This is a broad generalization. It should be noted that the strength and weakness of a tie is contextually dependent, and individuals may have both strong and weak ties depending on the different roles they play in society (Collar 2013).

Similarly, practice theory emphasizes practice (the parallel of "interactions" in the above paragraph) in both constituting and being constitutive of social systems. The emphasis on *habitus* allows the researcher to describe the overall social system without bias or over-emphasis on top-down social structures. In the same way, a small worlds approach should allow the emerging pattern of habitual interactions to form an overall picture of inter-community interaction.

By allowing the definition of social structures to emerge through the study of *praxis*, formal network analyses are also well-suited to challenging assumptions about center-periphery relationships. As I noted earlier, world-systems theory has influenced small worlds analysis in the Aegean but carries with it the baggage of assumptions about the nature of the relationship between core and periphery. Conversely, Malkin (2003; 2011) uses small-world interactions to challenge these assumption in his study of the creation of Archaic Greek cultural identity. A Watts-Strogatz model allows Malkin to reveal the co-creation of notions of 'self' and 'other'—and thus the differentiation of Greeks from Others—through network interaction.

In general, formal network analyses are particularly well-suited to egalitarian or non-centralized societies. The fact that network models do not assume centrality but allow for the analysis of its presence and nature through assessment of inter-actions means that it is a methodology well-suited to societies where there is no clear evidence of a centralized political structure, such as the EBA Cyclades.[19] This approach would allow archaeologists to reformulate the debate about the degree of

19 Even Dhaskalio, which recent excavation suggests was a major settlement with regional ritual importance, shows little evidence of an administrative function, even when compared to other, smaller EC settlements such as Markiani on Amorgos or the cemetery at Aplomata on Naxos (Renfrew 2013: 713-714).

centralization in the EBA Cyclades in such a way that avoids top-down or externally imposed constraints on past social systems.

Although adopting aspects of formal network analysis into a small worlds approach allows archaeologists to approach questions about Early Bronze Age Cycladic society from a new perspective, one key problem still remains: the reconciliation of the relational space of the network, the experience of space through movement in the past, and the Cartesian representation of space in visualization and analysis.

Previous approaches have sought to reconcile relational space with the Cartesian mapping of space (e.g. Knappett 2011: 9); however, there have been few scholarly attempts to also include the constraints of human travel through a physical landscape in the literature of the Bronze Age Aegean. On bridging the divide between physical and relational space, Knappett, et al. (2008:1009) wrote:

> What is required is an approach that incorporates the fundamental notion that humans create space through social practices, while also acknowledging that physical parameters are not entirely redundant in this process.

In other words, archaeologists should take into account the fact that people create space in moving through and interacting with and transforming the landscape, but the physical properties of the landscape in turn shape how humans move through and interact with it.

When it comes to analysis, archaeologists have had the tendency to overlay relational networks on top of Cartesian representations of geographical space. Archaeology is largely concerned with geographical distributions, whether of people or artifacts, and so the tendency in archaeological analysis is to present relational networks as they correspond with geography (see Brughmans 2014: 23-24). However, this elides the physical processes of human movement that are central to the analysis of small worlds networks, being defined according to the extent and direction of habitual movements of individuals between communities. Even in projects which claim to model human movement, such as Broodbank's proximal point analysis, in the visualization and analysis of the networks, physical, experiential space is tacitly subsumed into Cartesian representations of space. As Leidwanger (2013: 3302) notes:

> The resulting models conceive of real or hypothetical directional routes over which communication and exchange flowed, but distance and time often are arbitrarily imposed on this network topology, or in some cases are left out entirely.

Leidwanger (2013: 3302-3303) goes on to argue that this type of modeling leaves little room for the complexities of real travel in a dynamic environment. The flattening and reification of experiential space in many archaeological network models is not wholly surprising, as the publication of archaeological data generally involves standardized representations of maps and geographies in calibrated two dimensions. Moreover, archaeologists have inherited a limited toolkit for exploring spatial networks because geographical space has been largely ignored by the disciplines of sociology and physics, where network analysis originated (Brughmans 2014: 24).

Closely considering how experiential space fits into this picture, however, will challenge archaeologists to think creatively, both in terms of how they present data and in terms of how the final presentation of data shapes the ways in which we think about archaeological problems. In this project, I seek to interject physical space into the equation through three-dimensional GIS modeling of ancient landscapes, and using GIS data in conjunction with network analyses to create a more robust picture of the lived realities of ancient peoples (see chapters 5 and 6).

Conclusion – Redefining Small Worlds

Based on Tartaron's (2008: 109) initial definition and the subsequent discussion of this chapter, a small worlds analytical framework for assessing local network relationships in the Early Cyclades should:

- Take the community as its primary unit of analysis.
- Be based on habitual interaction between communities, which represents mutual relationships based on trust.
- Incorporate variables such as real travel time over both land and sea and intervisibility when determining proximity and intercommunity ties.
- Include social as well as economic motivations for developing and sustaining ties.
- Reflect that marginal network ties are sometimes stronger and more long-lived than central ties.

In developing a methodology for small worlds network analysis, the network should model the phenomenon of intercommunity interaction and relationships on a local scale in the EBA Cyclades, whereby marginal communities may depend on one another in times of agricultural crisis (see chapter 3). A model with the following features should:

- Take as its nodes the community area, which includes settlements, agricultural catchments, boundaries, and paths.
- Reconcile geographical spatial relations with relations based on cost-surface analyses of travel time and distance.
- Represent change over time, especially as external variables that affect agricultural production and travel (e.g. the sail, the wheel and cart, equids) are introduced, other important variables.
- Model intervisibility using either GIS or network models which calculate intervisibility probability.

Because small worlds analysis relies heavily on environmental and demographic data for the reconstruction of ancient communities, agricultural production, and the ancient landscape—in addition to material remains and features from archaeological survey and excavation—GIS modeling in conjunction with a small worlds approach allows for analysis of ancient small worlds networks that is robust, textured, and multivariate in order to capture the rich complexity of Early Cycladic social networks.

Chapter 3
Subsistence, Seasonality, Society

Introduction

To understand Early Cycladic (EC) small world interaction, it is first necessary to understand the patterning of subsistence activities that would have structured everyday life within a community. This chapter's first section on subsistence offers an overview of recent archaeobotanical and zooarchaeological evidence from excavations in the Cyclades. In *Island Archaeology* (2000), Broodbank synthesizes the archaeological work that had been conducted up its publication. Therefore in this chapter, I focus on archaeological projects in the Cyclades published since 2000, in particular highlighting the excavations at Dhaskalio (Keros), Markiani (Amorgos), Akrotiri (Thera), and Phylakopi (Melos).

Using the data summarized from recent publications, the second section on seasonality describes the temporal rhythms that would have shaped subsistence activities, and therefore the lives of EC island inhabitants. I consider both the time of year that each activity would have taken place as well as the relative labor requirements for those activities.

The third section reframes Renfrew's (1972) seminal question of the role of agricultural surplus with regard to the development of social hierarchy in the prehistoric Aegean. Renfrew hypothesized that the adoption of the Mediterranean "triad" (wheat, olive, and the vine) plus an increased number of cultivated legumes by the Early Bronze Age (EBA) in the Aegean meant that more marginal land could be exploited. This resulted in increased production and greater security for independent farmers. Eventually, farmers specialized in certain crops, producing surplus for exchange, which created a redistribution system that led to social hierarchy.

In Renfrew's model, surplus becomes a particular point of achievement along a culture's inevitable trajectory toward increasing social complexity (see Moreheart and De Lucia 2015). However, even though the Cyclades adopt the same Mediterranean "triad" package as Crete and Mycenae, at no point do the islanders reach the same degree of social complexity during the Bronze Age. Despite ever-increasing archaeological evidence about Early Bronze Age subsistence, the viability of Renfrew's model remains in question. The Cyclades simply do not follow the rules of what a social trajectory "should" look like.

Therefore, in this chapter I reframe and reorient the question of surplus within the greater spectrum of strategies of risk management adopted by Early Cycladic islanders. This allows me to consider the greater problem of risk at the community scale and to better understand how Early Cycladic communities interacted with one another to ensure their mutual survival without presupposing an "endpoint" of complex social order. I expand on Halstead's (1981) social storage model, which although it has been critiqued by van Andel and Runnels (1988) as an unsatisfactory explanation for the emergence of the Minoan palaces, for reasons discussed below forms a sound basis for understanding the role of subsistence in EC social organization.

The primary evidence for this chapter comes from recent site reports from various excavations around the Cyclades, as well as recent archaeological syntheses of archaeobotanical and zooarchaeological evidence from the EBA Aegean, more broadly. Where archaeological evidence is lacking, I draw upon ethnographic comparanda from "traditional" Aegean island farming communities during the

20th century, prior to the widespread industrialization of the Greek agricultural landscape. Occasionally, ancient writers are useful for describing the growing cycles of crops or the labor requirements for ancient agriculture, although these are used cautiously. Unless there is evidence to the contrary, I assume that the growing seasons of various plant species are the same today as they were in the past.

Subsistence

Subsistence is a fraught term in archaeology, and unpacking the history of the term "subsistence" in archaeological thought is beyond the scope of the current project (see Pluciennik 2001 for such a treatment). Here I define subsistence as the level of production required for survival. Subsistence may include agriculture, animal husbandry, foraging, hunting, and other activities that result in production of food for consumption. Its counterpart "surplus" is defined as potentially useful production beyond the level required for survival.

In this section I present a summary of recent archaeological evidence for the different types of subsistence production—including growing crops, foraging for plants and mollusks, animal husbandry, and hunting—that were used by Early Cycladic islanders. I focus on those published since the year 2000, the date of Broodbank's *Island Archaeology*, which summarized previous work in the region and does not bear repeating here.

Agriculture

The archaeological data suggests that EC islanders grew two main types of crops: cereals and legumes. In addition to these, there is evidence for the cultivation of olive trees and grapes, though the degree of cultivation is unclear.[20] Islanders gathered and may have cultivated other types of fruits and nuts, and they foraged for various other plant species native to the islands to supplement their diets.

Cereals

There are three predominant types of cereals found in the archaeobotanical record of the Early Bronze Age Cyclades: emmer wheat (*Triticum dicoccum*), einkorn wheat (*Triticum monococcum*), and barley (*Hordeum vulgare*). This triad of cereals is also prevalent on the mainland and on Crete.

Emmer wheat is more suited to poor soils and warm, dry climates than einkorn, which would make it better suited to the Cycladic environment than einkorn. Emmer is also more productive than einkorn; an einkorn yield is typically less than half that of emmer (van der Veen and Palmer 1997). However, einkorn is hardier both against rain damage and in the winter (Margaritis 2013b: 398).

The proportion of emmer and einkorn at any given site or region seems to be one of cultural preference (Valamoti 2004: 111-15; 2009: 50-1); in southern Greece, emmer is by far the most common during the Early Bronze Age, while einkorn is more common at several sites in northern Greece (Hansen 1988: 43). Both einkorn and emmer are also present on Crete throughout the Early Bronze Age, but the former is always present in low numbers and its status as a separate crop remains unclear (Livarda and Kotzamani 2013: 10).

20 Fuller (2009) draws an important distinction between domestication and cultivation. While cultivation is "the direct involvement of humans in the management of the life cycles of plants" (Margaritis 2013b: 400), domestication is the changed genetic status of plants as the result of evolution due to long-term cultivation (Fuller 2009). Cultivation may occur in different degrees of intensity, ranging from the management of wilds plants to the clearing and sowing of fields. In the present chapter, I do not draw distinctions along the spectrum of cultivation with the exception of those crops sown by EC islanders because their increased labor requirements have a greater impact on seasonal subsistence activities, which are discussed below.

Evidence for preference for one type of wheat over the other is less clear for the Cyclades. Both emmer and einkorn are present at Dhaskalio (Keros); the former is present as both grain and chaff, which suggests it was intended for human consumption (Margaritis 2013b: 398). (If intended for fodder, it is unlikely that inhabitants would have gone through the laborious process of dehusking the grains.) Due to issues in preservation it is not always possible to distinguish the species of cereal seeds in the archaeological record, which can obscure the proportions of each type recovered from a site. For example, while all three varieties of cereals were found at Dhaskalio, some 107 of the 344 fragmented and whole specimens recovered did not have an attributed species (Margaritis 2013b: 396; see table 3.1).

Barley is the type of cereal most common in the Cyclades in the present day (Margaritis 2013b; J.M. Renfrew 2006a). Livarda and Kotzamani (2013) found that on Crete during the EBA, barley was of equal importance to wheat. They also determined that, *contra* to Hansen's (1988:44) hypothesis, six-row barley did not replace the two-row variety on Crete by the beginning of the EBA, despite its potential to produce three times the yield.

Under good conditions, wheat crops produce more than barley. However, barley is an extremely hardy cereal that is well-suited to the Cycladic environment. It is one of the main crops at the sites of Zas (Flint-Hamilton 1994), Akrotiri (Sarparki 1987), Kephala (J.M. Renfrew 1977), Phylakopi (J.M. Renfrew 1982) and Ftelia (Megaloudi and Marinval 2012). Despite the overall dearth of carbonized plant remains from Markiani, J.M. Renfrew (2006: 245) reports a single specimen of barley, the only cereal recovered from the site. She also hypothesizes that the carbonized straw was barley as well. Barley comprises approximately 25% of the cereal specimens from Dhaskalio (Margaritis 2013: 396: see table 3.1).

In the traditional diet of Aegean islanders, bread was made from wheat, barley, or a combination of the two. Households baked their own bread, which they might eat fresh or in the form of twice-baked rusk. Rusk preserves for a long time and can be softened for eating by soaking in milk (Tourlouki, et al. 2011). Bread was a staple of everyday life.

Unfortunately, the archaeological evidence from the EBA Cyclades does not allow reconstruction for the ways cereals might have been consumed. However, from evidence of the processing of crops at Dhaskalio (Margaritis 2013b) and on Crete (Livarda and Kotzamani 2013), it is clear that at least emmer and barley were intentionally cultivated crops that inhabitants prepared for human consumption.

Legumes

The production of legume crops complements the cultivation of cereals. Not only would legumes have provided a source of protein, amino acids, and albumen for the diets of EC islanders—nutrients lacking in cereal crops—the cultivation of legumes—in particular, their rotation with cereal crops—would have been important for preserving the soil (Margaritis 2013b: 399; Tourlouki, et al. 2011). Moreover, the consumption of some legumes in combination with cereals seems to lessen the adverse effects on humans of the former (Margaritis 2013b: 399).

The predominant legume species in the prehistoric Aegean were lentils (*Lens culinaris*), peas (*Pisum salivum*), and bitter vetch (*Vicia ervilia*). Smaller quantities of chickpeas (*Cicer arietinum*) and horsebeans (*Vicia faba*) are also present (Hansen 1988). Lentils, peas, and vetch are native to the Aegean, with chickpeas and horsebeans arriving by the Late Neolithic (Hansen 1988: 44). In recent studies on Crete

Table 3.1. Plant Remains from Recent Excavations of Early Cycladic Sites

Category	Species	Dhaskalio				Akrotiri[c]		Markiani[d]	
		Seeds[a]		Charcoal[b]		Charcoal		Seeds	
		n	%	n	%	n	%	n	%
Cereals	Einkorn (*Triticum monococcum*)	3	0.54						
	Emmer Wheat (*Triticum dicoccum*)	150	27.12						
	Barley (*Hordeum vulgare*)	84	15.19					1[e]	2.38
	Barley sp.	3	0.54						
	Cereal sp.	104	18.81						
TOTAL CEREALS		344	62.21	0	0	0	0	1	2.38
Legumes	Lentil (*Lens culinaris*)	4	0.72						
	Pea (*Pisum sativum*)	5	0.90						
	Bitter vetch (*Vicia ervilia*)	2	0.36					1	2.38
	Grass pea (*Lathyrus sativus*)	3	0.54						
	Spanish vetchling (*Lathyrus clymenium*)	2	0.36					39	92.86
TOTAL LEGUMES		16	2.89	**0**	0	0	0	40	95.24
Fruits and nuts	Olive (*Olea europaea*)	28	5.06	313	99.68	57		1	2.38
	Grape (*Vitis vinifera*)	14	2.53						
	Fig (*Ficus* sp.)	12	2.17	1	0.32				
	Almond (*Amygdalus* sp.)	92	16.64						
	Pomegranate (*Punica granatum*)					1			
	Pear/hawthorn (*Maloideae* sp.)					1			
TOTAL FRUITS AND NUTS		146	26.40	**314**	**100**	**59**	98.33	1	2.38
Greens and herbs	Field Gromwell (*Lithospermum arvensis*)	2	0.36						
	Darnel (*Lolium temulentum*)	12	2.17						
	Bedstraw (*Galium* sp.)	5	0.90						
	Small legumes (*Lathyrus/Vicia* sp.)	4	0.72						
	Gramineae	3	0.54						
	Mint (*Lamiaceae*)					1			
TOTAL GREENS AND HERBS		26	4.70	**0**	0	1	1.67	0	0
TOTAL UNIDENTIFIED		21	3.80	**0**	0	0	0	0	0
TOTAL		**553**	**100**	**314**	**100**	**60**	**100**	**42**	**100**

[a] Margaritis 2013.
[b] Ntinou 2013.
[c] Asouti 2003.
[d] Margaritis 2006b.
[e] This specimen was an impression of a barley seed.

and the Cycladic islands, Spanish vetchling (*Lathyrus clymenum*)—a plant toxic to humans but frequently used as animal fodder—has been identified (Livarda and Kotzamani 2013; Margaritis 2013b; J.M. Renfrew 2006a).[21]

During the Early Bronze Age on Crete, legumes were found as commonly as cereals, with a high diversity of species and several types grown as separate crops (Livarda and Kotzamani 2013). Lentils were the most common type of legume, which corresponds with the rest of prehistoric Greece (Valamoti 2009: 71). Livarda and Kotzamani (2013) found evidence of lentils in elite and non-elite contexts, concluding that they were incorporated at all levels of the social spectrum.

Due to overall low preservation in the Cyclades, it is more difficult to draw conclusions about the relative importance of legume cultivation. Excavations at Dhaskalio produced 16 total specimens of lentil, pea, bitter vetch, grass pea, and Spanish vetchling (Margaritis 2013b). There is no evidence of the by-products of legume processing at Dhaskalio, either because they were used as animal fodder or because the pods do not survive charring well (Margaritis 2013b: 399). At Markiani, archaeologists recovered a single specimen of bitter vetch and 39 specimens of Spanish vetchling (the latter were all from the same context) (J.M. Renfrew 2006a).

Olives and Grapes

Olive and grape cultivation is a key component of Mediterranean polyculture. While Renfrew (1972) emphasized the role of Mediterranean polyculture in pro-

21 While the raw form of Spanish vetchling is toxic to humans, ancient literary evidence (Plin. *HN*. 27.95) and ethnographic observation suggest that the plant was eaten by the poor in cases of famine. Soaking the seeds in water, baking, roasting, or boiling them seems to lessen the unpleasant effects of the plant (Margaritis 2013b: 399).

viding surplus for the advent of Aegean palatial systems, olives and grapes can be intercropped with cereals and legumes, leading to diversification in agricultural production which reduces risk for individual farmers (Gilman 1981: 6). Several studies have been published specifically investigating olive production in the Bronze Age due to its perceived importance in the onset of social complexity in the region (e.g. Blitzer 2014; Margaritis 2013a; and Runnels and Hansen 1986). It is for this reason—namely, emphasis placed by archaeologists on Bronze Age olive and vine cultivation—and not based on the extant archaeological evidence that in the present chapter I consider olives and grapes separately from other fruits and nuts. The actual evidence, especially for the Cyclades, is anything but conclusive. Until recently, few olive remains had been reported for the Aegean; instead, archaeologists largely inferred olive production from secondary evidence such as storage vessels, such as one unsubstantiated report of an EC jug from Naxos that contained olive oil (Hansen 1988: 45; Renfrew 1972: 285) or from Linear B tablets (Hansen 1988). In the past few decades, botanical analysis has provided more substantial evidence for the olive's role in EBA production.

Archaeologically, it is very difficult to differentiate the wild progenitor of the domesticated olive (*Olea europaea* var. *oleaster*) from the domesticated variant (*Olea europaea*) due to similarity of both morphology and geographical distribution (Hansen 1988: 45; Livarda and Kotzamani 2013: 16). However, as Margaritis (2013b) rightly argues, the emphasis on establishing the temporal moment of olive domestication, which many studies emphasize, is less important to archaeological understanding of ancient olive exploitation than is evidence of its ongoing cultivation:

> The direct involvement of humans in the management of the life cycles of plants defines the term 'cultivation' (Fuller 2009). The human agency of managing these species, over hundreds or thousands of years, led to the evolutionary changes of domestication. Cultivation is an ongoing activity; domestication is a changed genetic status, which has evolved on account of cultivation (Fuller 2009). Cultivation is a long-term strategy undertaken to manipulate yield levels and productivity; domestication, as a change in genetic status, was an unintended consequence. (Margaritis 2013b: 400)

A variety of sites around the Aegean attest to the cultivation of olive trees during the EBA. Olive trees are a common feature of maquis shrubland. It is likely that ancient cultivation of olive trees included pruning branches to use for fuel or construction and protecting the plants from grazing by herd animals, which would allow the olive bushes to grow into trees. Even minimal cultivation might increase the size of olive stones (Hansen 1988: 46; Margaritis 2013a).

In the Cyclades, olive exploitation is evident from recent finds at Dhaskalio and Akrotiri (Thera). At Dhaskalio a total of 28 whole or fragmented olive stones were found (Margaritis 2013b), and 313 pieces of olive charcoal were additionally recovered, the latter representing by far the greatest proportion among represented species of the charcoal material (Ntinou 2013). Likewise, the charcoal remains from Akrotiri are nearly all charcoal, with 57 out of 60 specimens belonging to *Olea europaea* (Asouti 2003). Moreover, at Akrotiri olive charcoals appear in large proportions from the samples dating to the EBA, the earliest samples examined, leading Asouti (2003: 481) to conclude that cultivation was ongoing at Akrotiri since at least that time. Finally, a single olive fragment is reported from Markiani (J.M. Renfrew 2006a).

Based on the latest archaeobotanical evidence, it is likely that Cycladic islanders began cultivating olives at least by the EBA. The question, then, is did they exploit olive production to such a degree that it fundamentally changed the nature of agricultural production in the Cyclades? On Crete, the earliest indications of more intensive olive exploitation come from Chamalevri during the Prepalatial period, where Sarpaki (1999) interpreted numerous charred olive stone fragments as the result of olive oil production, which would have been used as fuel (see also Livarda and Kotzamani 2013). The most substantial evidence for extensive olive exploitation comes from the Late Bronze Age. Shelmerdine's (1985) analysis of perfume industry at Pylos and Melena's (1983) analysis of Linear B tablets indicates that not only were Mycenaeans exploiting olives on a wide scale, they also preferred wild olives in perfume production (Hansen 1988). Organic olive residues come from Armenoi (Evans and Garner 2008), Pseira (Beck et al. 2008), Thebes (Evans and Garner 2008) and Mycenae (Martlew 1999) (Margaritis 2013a: 748).

Margaritis (2013a: 750-1) argues that even this increased visibility of olive exploitation in the LBA is not on par with what one might expect given its hypothesized importance in the Bronze Age economy. She states that the end products and by-products of this exploitation might not be archaeologically visible:

> Before consumption, olives might be stored as pickled fruits, traces of which would be unlikely to survive except as a result of fire. The visibility of the olive increases when large quantities are crushed for olive oil production or when the residues of eating are systematically collected, optimizing the use of its by-products. Visibility is affected if these by-products are discarded beyond the edge of the investigated area (Margaritis 2013a: 750-1)

Margaritis emphasizes that the patterning of olive exploitation in the archaeological record does not necessarily reflect the importance of the olive in Bronze Age agriculture, but rather it reflects how the by-products of olive production were used and discarded, as well as the design of archaeological investigation.

For example, while the quantities of olive stones at Dhaskalio are meager, just as is the rest of the archaeobotanical assemblage, the proportion of stones in the archaeological record does not necessarily reflect patterns of olive consumption by the inhabitants of the site. Olive stones and grape pips are less likely than cereals, for example, to come into contact with fire (Margaritis 2013b: 401). Margaritis (2013b) cautions against over-emphasis on the use of olives as fuel or building material, arguing that ancient people would have utilized all parts of the plant, with the edible parts taking precedence. Conversely, Hansen (1988: 45) cautions against interpreting the current evidence of exploitation to indicate the extensive use of olives—whether for food, fuel, or building materials—on the scale hypothesized by Renfrew (1972).

The evidence for Early Cycladic exploitation of the vine is scarcer than the evidence for olives. Vine exploitation and wine-making in the Aegean dates to at least the Neolithic period, as is the case from the site of Dikili Tash in northern Greece where the destruction levels of burned houses revealed a large quantity of grape pips (n = 2460) and skins(n > 300) that indicated the extraction of juice. These were found in conjunction with two-handled cups that the excavators connected to wine consumption (Valamoti, et al. 2007: 54). On Crete, Prepalatial Myrtos Fournou Korifi (J.M. Renfrew 1972) and Protopalatial Monastiraki (Fiorentino and Solinas 2006; Sarpaki and Kanta 2011) offer the earliest archaeobotanical evidence for grape by-products. Overall, however the evidence for grape cultivation on Crete remains sparse and open to debate (Livarda and Kotzamani 2013). The overall pattern in the Aegean seems to be that grape exploitation in the south arose earlier than in the north (Hansen 1988: 48)

As with olives, the distinction between wild (*Vitis sylvestris*) and domesticated (*Vitis vinifera*) varietals of grape may or may not be preserved in the archaeological records; the primary means of distinguishing the two is morphological (Hansen 1988: 47). Both grapes and olives have relatively low archaeological visibility compared with other archaeobotanical remains. Livarda and Kotzamani (2013: 24) posit that this may be the result of archaeological sampling and taphonomic processes. Sarpaki (2012) suggests that grapes would have been trodden near the vineyards, so that only a small part of the dregs would be transported back to the settlements for preservation. Because evidence of processing would occur outside of the areas typically investigated by archaeologists, wine production may have been an earlier and more widespread phenomenon than the material record indicates.

In the case of vine cultivation, archaeologists have often looked toward evidence of consumption—especially drinking vessels such as Cretan conical cups—to indicate exploitation of grapes and the production of wine. Livarda and Kotzamani (2013: 25) caution against the assumption that these vessels were used exclusively for wine and suggest distinguishing between production and consumption.

The Cycladic evidence for grape cultivation is more meager than that of olive cultivation. At Dhaskalio, Margaritis (2006b) reports 14 grape fragments; no grape charcoal was found (Ntinou 2013). At Dhaskalio (J.M. Renfrew 2013; see also Margaritis 2013b) and Markiani (J.M. Renfrew 2006b), as well as at Kavos (Keros), Chalandriani (Syros), and on Paros, Amorgos, and Siphnos more generally (see J.M. Renfrew 2013: 649 for the complete list) some ceramic sherds have evidence of vine leaf impressions. Vine leaves were used as mats for standing hand-coiled pots during their manufacture, which allowed them to be more easily turned. Once the pots were dried and fired, the impression of the leaf would remain imprinted on the bottom of the vessel (J.M. Renfrew 2013: 648-649).

Given the recent up-tick in archaeobotanical publications from the Bronze Age Cyclades and Aegean more broadly, is it possible to say anything further about the argument that Renfrew (1972) originally put forth? The current evidence seems to confirm the conclusion Broodbank drew in *Island Archaeology*:

> The Cyclades produce equivocal evidence for diversification, but nothing to suggest a divergence from practices that are equally likely (or unlikely) elsewhere in the Aegean. (Broodbank 2000: 83)

Recently, with concerted effort on the part of archaeobotanists to recover and analyze plant remains from BA sites in the Aegean, it is now possible to say that olives and grapes were being cultivated from the EBA onwards. However, there is still no way to prove the degree of intensity at which they were produced and consumed, or whether it would have led to the fundamental changes in exchange and social hierarchy that Renfrew suggests. Since no confirmation for this argument is forthcoming, in the discussion below I consider the way in which olives formed part of a suite of strategies adopted by Early Cycladic islanders to minimize risk.

Other Fruits and Nuts

In addition to olives and grapes, almonds (*Amygdalus* sp.) and figs (*Ficus* sp.) seem to have had a regular presence in the Aegean diet since the Neolithic period (Livarda and Kotzamani 2013). Other fruits present in the EBA archaeological record include pomegranates (*Punica granatum*) and pear/hawthorn (*Maloidaea* family). The evidence of figs and almonds in the EC Cyclades is very patchy.

At Dhaskalio, 12 fragments of fig and 92 of almond were recovered (Margaritis 2013b), the latter number being over three times the quantity of olive fragments found. A single piece of fig charcoal was also reported (Ntinou 2013).

Margaritis (2013b) reports that it was not possible to determine whether the almonds from Dhaskalio were wild or cultivated. While neither almonds nor figs were recovered in EBA Akrotiri, archaeologists recovered one piece each of pomegranate and pear/hawthorn charcoal (Asouti 2003).

Wild Greens

Even among present-day islanders who follow a traditional diet, the foraging of wild greens forms an important dietary supplement, especially during the cooler, wetter months (October through April) (Tourlouki, et al. 2011: 256). Archaeologically, the remains of wild greens are only recovered with the use of small-aperture sieves, meaning there is no record of wild taxa from spot finds (Livarda and Kotzamani 2013: 18).

Several wild greens species were found at Dhaskalio: field gromwell (*Lithospermum arvensis*), darnel (*Lolium temulentum*), bedstraw (*Galium* sp.), small legumes (*Lathyrus/Vicia* sp.), and members of the *Gramineae* family (Margaritis 2013b). At Markiani, a single piece of charcoal belonging to the mint (*Lamiaceae*) family was recovered (J.M. Renfrew 2006).

Throughout the Aegean, the presence of flax (*Linum usitatissimum/Linum* sp.) warrants further investigation (Livarda and Kotzamani 2013: 129). Flax is useful for a variety of purposes: as a source of oil and fiber, used in diet, lighting, cloth weaving, ropes, textiles, and nets. The wild progenitor of flax (*Linum usitatissum* sp. *bienne*) is found in the archaeological record throughout the Mediterranean (Zohary and Hopf 2000: 129).

Animal Husbandry

Early Cycladic islanders tended three main types of animals: caprinae—including both sheep (*Ovis aries*) and goats (*Capra hircus*)—pigs (*Sus domesticus*), and cattle (*Bos taurus).* Throughout the EBA, the faunal remains recovered from terrestrial animals in excavated contexts overwhelmingly belong to sheep/goats, with a small number of finds belonging to cattle and pigs (Broodbank 2000: 81). However, the recent publications of the excavation data from Dhaskalio (Trantalidou 2013), Phylakopi (Winder 2007), and Markiani (Trantalidou 2006) have provided additional information about animal husbandry practices, including evidence for the production of some secondary products. In all three sites, the faunal remains from terrestrial animals in excavated contexts continue to be sheep/goats. The ratio of sheep/goat remains to the two other primary types of terrestrial animal remains—cattle and pigs—varies by site, and there is no dominant chronological trend that may be distinguished (see table 3.2).

At Markiani, analysis of the age of slaughter of the sheep/goats sheds light onto the use of primary and secondary animal products. Trantalidou (2006: 225) concluded that half of the stock was slaughtered by age two or three, and butchering took place in or near the settlement. The slaughtering of animals at an age of less than two years has been associated with an emphasis primary products, especially meat-production (Payne 1973: 281-5). At Markiani, the chronological trend moves increasingly toward an emphasis on secondary products, such as wool production (see Trantalidou 2006: table 9.7). Wool and the textiles produced from it are both transportable and durable, making them good candidates for exchange.

This conclusion was further supported by increase in size of sheep/goats between MA II-IV periods (ca. 3000-2200 BCE), which indicates the appearance of a new larger, woolly variety of sheep, which is comparable to patterns seen on the Greek mainland at this time. It is further supported by the extraordinary assemblage of material evidence for spinning and weaving activities (see below). Based on the faunal data, animal husbandry was a main economic activity at Markiani (Trantalidou 2006: 228). The lack of age of slaughter analysis from other sites makes it impossible to determine whether this was a general trend in the area of study or the specialization of a particular site, and this would be a fruitful avenue to pursue for future research.

Table 3.2. Domestic Faunal Remains from Recent Excavations of Cycladic Sites

Site	Period	Sheep/Goats		Cattle		Pigs		Total
		N	%	*N*	%	*N*	%	*N*
Markiani[a]	MA I	10	90.91	1	9.09	NA	NA	11
	MA II	202	90.58	2	0.90	19	8.52	223
	MA III-IV	635	84.55	2	0.27	114	15.18	751
	TOTAL	**847**		**5**		**133**		985
Phylakopi[b]	0	179	86.47	10	4.83	18	8.70	207
	1	140	85.37	5	3.05	19	11.59	164
	1.5	*36*	*94.74*	*1*	*2.63*	*1*	*2.63*	*38*
	2	561	70.57	118	14.84	116	14.59	795
	3	285	64.77	99	22.50	56	12.73	440
	3.5	*83*	*76.15*	*14*	*12.84*	*12*	*11.01*	*109*
	4	326	72.28	44	9.76	81	17.96	451
	5	254	78.88	38	11.80	30	9.32	322
	TOTAL	**1864**		**329**		**333**		2526
Dhaskalio[c]	A	135	98.54	1	0.73	1	0.73	137
	B	458	99.57	0	0	2	0.43	460
	C	1332	98.52	10	0.74	10	0.74	1352
	TOTAL	**1925**		**11**		**13**		1949

[a]Trantalidou 2006.
[b]Winder 2007.
[c]Trantalidou 2013.

The final publication of the 1974-77 excavations at Phylakopi (Renfrew, et al. 2007) featured an updated analysis of the faunal remains by Winder which reconsidered the earlier conclusions of Gamble (1982; 1985). Cattle, pig, and sheep/goat bones are all represented at the site. Winder notes that the scale of refuse disposal—the primary context in which archaeologists recovered faunal remains—and the scale of the recovered assemblage was generally greater in fills deposited slowly over time than in units which were rapidly deposited and sealed, although that cattle remains behaved inversely to this overall trend (Winder 2007: 479-80). While Gamble (1982; 1985) had previously attributed shifts in cattle representation between different time periods to changing demands for animal traction, Winder concludes that the differential preservation of cattle remains is the more likely explanation for this patterning (2009: 478). He hypothesizes that the cattle bones in larger fills would have been subjected to more severe postdepositional processes that those in rapidly sealed deposits (Winder 2007: 480).

Furthermore, Winder argues that it is impossible to generalize about shifts in animal husbandry practices or economies over time because "the evidence that different species may have different deposition, survival, and recovery probabilities in different types of context" (Winder 2007: 480). He suggests that unless estimative methods can be found which take into account the variation in deposition, survival, and recovery probabilities—such as Probable Number of Individuals (PNI), the data for which are unavailable for the Phylakopi assemblage—it is unlikely that it will be possible for meaningful trends in the changes in animal husbandry will be discernible in the future.

The vast majority of bones recovered during the excavations at Dhaskalio (98-9% of the total animal remains) were sheep/goats (Trantalidou 2013). Trantalidou (2013) suggests that all species recovered at Dhaskalio were for consumption. She concludes that the proportions of remains from different species did not vary significantly over time, nor is there evidence for the presence of whole animals for sheep, pig, or cattle, which indicates that the remains were brought to the settlement for consumption (Trantalidou 2013: 433). There was no clear relationship between the presence of animal bones and the types of buildings or contexts in which they were found.

She hypothesizes that animal remains—aside from fish and shellfish, which could have been locally produced (see below)—would have been imported from nearby islands, as was the case for most other commodities on Dhaskalio:

> At Dhaskalio most sheep/goats were slaughtered at the age of 1-3 years. Pigs were quite young, too. We have no indication of newly born animals. The rarity of the youngest elements in the sample could point to the absence of winter occupation, at least at the very beginning of the calendar year. However, no further indications of seasonality occur. The age of animals at death, the fact that goats outnumbered sheep, and the emerging conclusion that nearly all commodities were imported could explain the small assemblage of spindle whorls and the paucity of evidence for weaving. (Trantalidou 2013: 440)

The faunal patterns, when considered in conjunction the paleobotanical remains, indicate that inhabitants of Dhaskalio did not live there year-round, but instead may have inhabited the site for a few months at a time, importing foodstuffs for consumption from nearby islands (Trantalidou 2013: 436; see also Margaritis 2013b).

The preliminary data from EC Skarkos (Ios) (Trantalidou under study; see Trantalidou 2006) thus far seem to corroborate the trends of other EC sites. In that assemblage (N=835), sheep/goats accounted for 90.30% of the total specimens, with pig representing 8.20% and cow representing 1.63%.[22]

Secondary Animal Products

Secondary products are those which can be repeatedly extracted from an animal throughout its lifetime (Sherratt 1981; see also Greenfield 2010). For the Early Bronze Age Cyclades, these would have primarily consisted of wool and milk. The third main type of secondary product is the use of animal traction. Due to the steep and rocky nature of the Cyclades, it is unlikely that plows or wheeled vehicles were used during the EBA (Broodbank 2000: 82), but it is possible that animals were used to drag loads or carry them on their backs.

The archaeological evidence for the use of secondary animal products can be difficult to interpret. The presence of spinning technology may indicate the herding of sheep for wool; however it might also indicate the creation of cloth from flax, which was an earlier technology (Russell 2004: 328). The lipids that form the direct evidence for milking are rarely recoverable, and plows and other vehicles typically do not survive in the archaeological record. In terms of the zooarchaeological evidence, an increased age at slaughter correlates with the exploitation of animals for secondary products (Greenfield 2010).

From the zooarchaeological evidence at Markiani, there is a trend throughout the occupation phases (Ma I-Ma IV) of increased age of animals at time of slaughter, which Trantalidou (2006: 225) interprets as signifying a shift from a meat production-oriented economy to a wool-oriented one. This is corroborated by the high number of spinning tools recovered during the excavation and survey

22 Fish (*pisces*) accounted for 1.63% and birds (*aves*) accounted for 0.35% of the assemblage, in addition to the domesticated species.

at the site: 171 spindle-whorls, 31 perforated clay discs, and 1 possible loomweight (Gavalas 2006: 200-201). Moreover, the vast majority of these objects were found in the same part of the site, indicating special working areas for spinning and weaving (Gavalas 2006: 208). While the report does not list the phases associated with all of the spinning objects, of those spindle whorls that were illustrated, 10 belong to Ma II (ca. 3000-2800 BCE), 15 to Ma III (ca. 2800-2500 BCE), and 31 belong to Ma IV (ca. 2500-2200 BCE)[23]. If this trend also applies to the entire body of spinning objects recovered, it would correlate with the increased age at slaughter of the sheep/goats at the site, further strengthening the argument of increased wool production and specialization at Markiani.

At Phylakopi, Winder's reevaluation of the faunal remains found that the relative abundance of cattle bones, previously interpreted by Gamble (1982) to indicate an increased demand in animal traction, was in fact due to the greater resistance of cattle bones to taphonomic processes than other animal species (2007: 478). Winder did not report the ages of the bones, only the percentage of the bones that were able to be aged, so it is not possible for me to comment on changes on the average age of slaughter of the animals over time.

The Early Cycladic contexts at Phylakopi (phases A and B) produced a few artifacts potentially related to spinning and textile production, though overall numbers were decidedly lower than in later phases (Cherry and Davis 2007). The terracotta spindle whorls from Phylakopi A and B parallel those recovered in other EC contexts (Cherry and Davis 2007: 401). Phase A yielded 2 spindle whorl, with only a single whorl securely dated to Phase B. Two more whorls were dated to

23 One of the spindle whorls is not securely dated but thought to belong to Ma IV (Gavalas 2006: 209).

phase B/C. None of the EC contexts produced loomweights or spools, the other two types of spinning implement preserved at Phylakopi. It is only in the later phases of the site (Phylakopi C-E) that the production of cloth assumes a greater importance in the daily life of the settlement (Cherry and Davis 2007: 403).

The evidence at Dhaskalio shows both sheep/goats and pigs being slaughtered at a young age (Trantalidou 2013: 440). Furthermore, there is no evidence that domestic animals were kept on Dhaskalio or Keros during the EBA (Trantalidou 2013: 433). Trantalidou (2013: 440) concludes:

> The age of animals at death, the fact that goats outnumbered sheep, and the emerging conclusion that nearly all commodities were imported could explain the small assemblage of spindle whorls and the paucity of evidence for weaving.

Indeed only 4 spindle whorls were recovered from the 2007-2008 excavation seasons (Gavalas 2013). The only other evidence for possible textile production at Dhaskalio were a few copper needles (Georgakopoulou 2013).

The high number of spinning implements at Markiani concentrated in a single location within the site, compared to the dearth of textile production tools at Phylakopi[24] and Dhaskalio, might indicate a degree of craft specialization at Markiani. However, more investigation is required to determine a true pattern of craft specialization among EC settlements.

Wild Faunal Resources

Wild faunal resources—birds, fish, mollusks, and small mammals—would have also supplemented the Early Cycladic diet. It is likely that EC islanders hunted

24 However, further investigation is needed to verify that the lack of evidence for secondary product production applies to the entirety of the site, rather than to the area that has been excavated to date.

birds to supplement their diet, although this practice has largely been ignored by archaeologists. A recent reconstruction of the Xeste 3 fresco from Akrotiri reveals more about this practice. Papageorgiou (2014) interprets the fresco as depicting a woman wearing a mesh net of birds on her back.[25] There are Cretan and Mycenaean parallels for carrying nets in this matter, as well as many Egyptian comparanda (Papageorgiou 2014: 121). It was a common practice to trap adult migratory birds with thrown nets (Papageorgiou 2014).

The collection and fishing of marine mollusks for human consumption was a common strategy of early Aegean islanders. Most of the gathering of these marine resources took place along the immediate coastline local to a settlement (Karali 2013: 447; Mylona 2014). Desse (1984) hypothesizes that fishing tools were kept close to the shore, which might explain their rare occurrence in settlement contexts. Archaeologically, the evidence of fish and mollusk consumption takes the form of fish bones, fishing tools, and representations in art (Mylona 2014).

Among the types of terrestrial animals which may have been utilized as culinary resources in the Early Cyclades are: red deer (*Cervus elaphus*), dogs (*Canis familiaris*), rabbit (*Lepus europaeus*), rat (*Rattus*), and weasel (*Mustelidae*). In many cases, it is unclear from context whether any or all of these species were consumed.

At Markiani, only four bird bones were recovered for the total occupation of the site, all of which were of uncertain date. All of the bird species were migratory (Trantalidou 2006: 230). Additionally, 14 fish bones were recovered. For wild terrestrial resources, the excavators found 3 specimens of dog, 22 of rabbit, and a single weasel fragment (Trantalidou 2006: 229). It is unclear from their contexts whether these remains represent animals that were consumed. Because the wild

25 The mesh pattern of her net was previously interpreted as a detail of her clothing.

faunal remains occur in much lower numbers than the domesticated species, Trantalidou (2006) concludes that EC residents at Markiani relied primarily on animal husbandry, occasionally supplementing their diets with wild resources. However, the large number of mollusk remains at Markiani (n=7370 for all periods) indicates that mollusks played a significant role in the diet of the inhabitants (Karali-Giannakopoulou 2006).

Bird bones were the only type of non-marine wild species recovered at Dhaskalio in EBA contexts, with a total of 5 fragments from across all phases (Trantalidou 2013: 432). While the EC bird remains do not indicate whether or not the birds were consumed, archaeological and ethnographic comparanda from other Aegean islands shows that shags and gulls were a dietary resource (Trantalidou 2013: 433).

All mollusk remains at Dhaskalio came from edible species (Karali 2013). The species recovered represent shoreline, shallow, and deep water species, indicating that residents at Dhaskalio adopted a number of strategies to recover marine resources. Approximately 7700 shells were recovered during the excavation (Karali 2013: 444). Only 10 fish bones were found for all phases at the site (Trantalidou 2013: 423), and several of them were found in the same contexts as the mollusk remains and other faunal remains (Karani 2013: 447), indicating the role of both wild and domestic as well as marine and terrestrial resources in the EC diet. Trantalidou (2013: 436) hypothesizes that only the fish and mollusks of the faunal remains at Dhaskalio would have been locally produced.

The overall low recovery of wild bird and terrestrial animal resources compared with the recovery of domesticated species may indicate that hunting was not worth the investment of labor, or it might indicate a cultural preference for the consumption of domestic animals (Trantalidou 2013: 440). In either scenario, the archaeological evidence suggests that EC islanders emphasized animal husbandry over hunting.

Seasonality

With a better understanding of the resources that Early Cycladic islanders exploited for subsistence, it is possible to sketch the annual temporal rhythms that would have structured the lives of residents of EBA communities. Understanding the seasonal requirements of agricultural production and the seasonal availability of wild resources forms the basis of this pattern. Ethnographic comparanda, in particular from traditional Greek farming communities offer insight to the seasonal patterns of labor and time-stress that would have also affected EBA agriculturalists.

The Agricultural Calendar

The primary cereals grown by EC islanders were barley, emmer, and einkorn, which share a similar growing season. These crops are sown from October through December; in April and May they are harvested; and they are winnowed, threshed, and stored in June and July (Halstead and Jones 1989). Hesiod (*Op.* 11. 485) reports the sowing of spring crops, but this seems to be an emergency in case the usual winter harvest failed (Isager and Skydsgaard 1995: 24).

Legumes can be planted in autumn and spring; with beans being sown slightly earlier than lentils, chickpeas, and peas. Legumes have a long period of blossoming, and therefore it is usually necessary to harvest them multiple times (Isager and Skydsgaard 1995: 42). Legumes tend to ripen approximately 100 days after planting.

The archaeological evidence detailed above suggests that it was likely that EC islanders cultivated olives for food, fuel, and building supplies. While the maintenance of olive trees probably occurred year round, as it was the product of protecting plants from grazing by herds and therefore was likely done by shepherds, the harvest of olives typically occurs in the winter months, from November through February, though that may be extended from autumn through early spring (Isager and Skydsgaard 1995: 40).

There is limited evidence for the growing of grapes as crops in the Early Cycladic period, and so the seasonal requirements of vine cultivation would have been more focused on the harvest of grapes, the production of wine, and the maintenance of vines than on sowing. Grapes are harvested in the autumn, in September and October,[26] although EC islanders may have cultivated grapes to varying degrees throughout the year (see Isager and Skydsgaard 1995: 29).

In terms of wild and semi-cultivated resources, Cycladic islanders exploited native fruits and nuts—which include almonds, figs, and pomegranates[27]—as well as wild greens. Almonds begin blooming in the spring, with green almonds fully formed by mid-summer. In August, the almond nuts reach maturity and dry out; this is when harvest occurs. Modern Greek fig trees produce two crops, one in late summer from the last season's grown and a main crop in autumn. If maintenance is performed on fig trees, it is best done in autumn, immediately following the harvest of the main crop. Pomegranate fruits ripen in the autumn winter months

26 Hesiod (*Op.*11.609ff.) suggests that the harvest takes place at the heliacal rising of Arcturus, around mid-September (see Isager and Skydsgaard 1995: 26).

27 It is unclear whether the single pear/hawthorn specimen from Akrotiri indicated consumption or some other use. Furthermore, because the species was indeterminate, it is difficult to assess the harvest season of any fruits if they were used for consumption. Therefore it is not included in the present analysis.

in the northern hemisphere, from September through February. Wild greens grow best in the cooler winter months, from October through April (Tourlouki, et al. 2011: 256).

While not strictly a subsistence activity, ethnographic evidence suggests that the gathering of lumber was a seasonal activity, which occurred in autumn from September through November (Halstead and Jones 1989). Seasonal gathering of lumber from known tree stands might have been an activity where members from different communities interacted with one another as they exploited the same resources during the same time of year.

Cycles of Animal Husbandry and Hunting

Knowledge about the life cycles of animals in the ancient Aegean is limited; the best evidence comes from Aristotle's *Historia Animalium* (Isager and Skydsgaard 1995: 84). According to Aristotle, sheep and goats bear young once a year under normal conditions, but they may lamb twice under favorable conditions. Sheep and goats may breed at any time of year, but most frequently they breed in the spring and give birth approximately five months later in the late summer/fall (Arist. *Hist.an.* VI.19). Both sheep and goats were milked, and cheese-making was a typical part of the process, occurring near the milking location so that the transport of milk could be minimized (Isager and Skydsgaard 1995: 91).

Pigs and cattle were likely kept near residential buildings, and there is limited evidence regarding the seasonality of their tending and reproduction. If EC islanders kept pigs and cattle, they would likely require year-round tending in the vicinity of the home.

The seasonal exploitation of wild marine and terrestrial resources needs further investigation. It is possible that EC islanders took advantage of migratory fishing locations—tuna, in particular, are migratory and appear in the late spring and early summer. The evidence of bird hunting from Akrotiri and Markiani indicates that seasonal bird hunting would have a task performed by island residents; the hunting of migratory birds would depend on the season in which flocks arrived in the islands. The four species recovered—falcon, buzzard, owl, and crow—winter in the Aegean (Trantalidou 2006: 230). Other wild resources, in particular small mammals and mollusks, could be exploited opportunistically year-round.

Figures 3.1 and 3.2 show the seasonal patterning of agricultural activity, animal husbandry, and the availability of wild resources that would have shaped the temporality of life for Early Cycladic communities. Growing crops takes place throughout most of the year, especially if extra crops were required in the spring to compensate for a poor winter harvest. The tending of animals would have likely required year-round supervision, whether the animals were kept in herds away from settlements or kept near residences. The lambing season in early fall might have represented a peak in husbandry activity. Foraging, hunting, and cultivating wild resources tends to take place in the cooler, wetter winter months, leaving a gap in the arid summer. While these figures show the temporal distribution of activities, it is still necessary to consider the intensity and labor requirements for each of these activities during the course of the year.

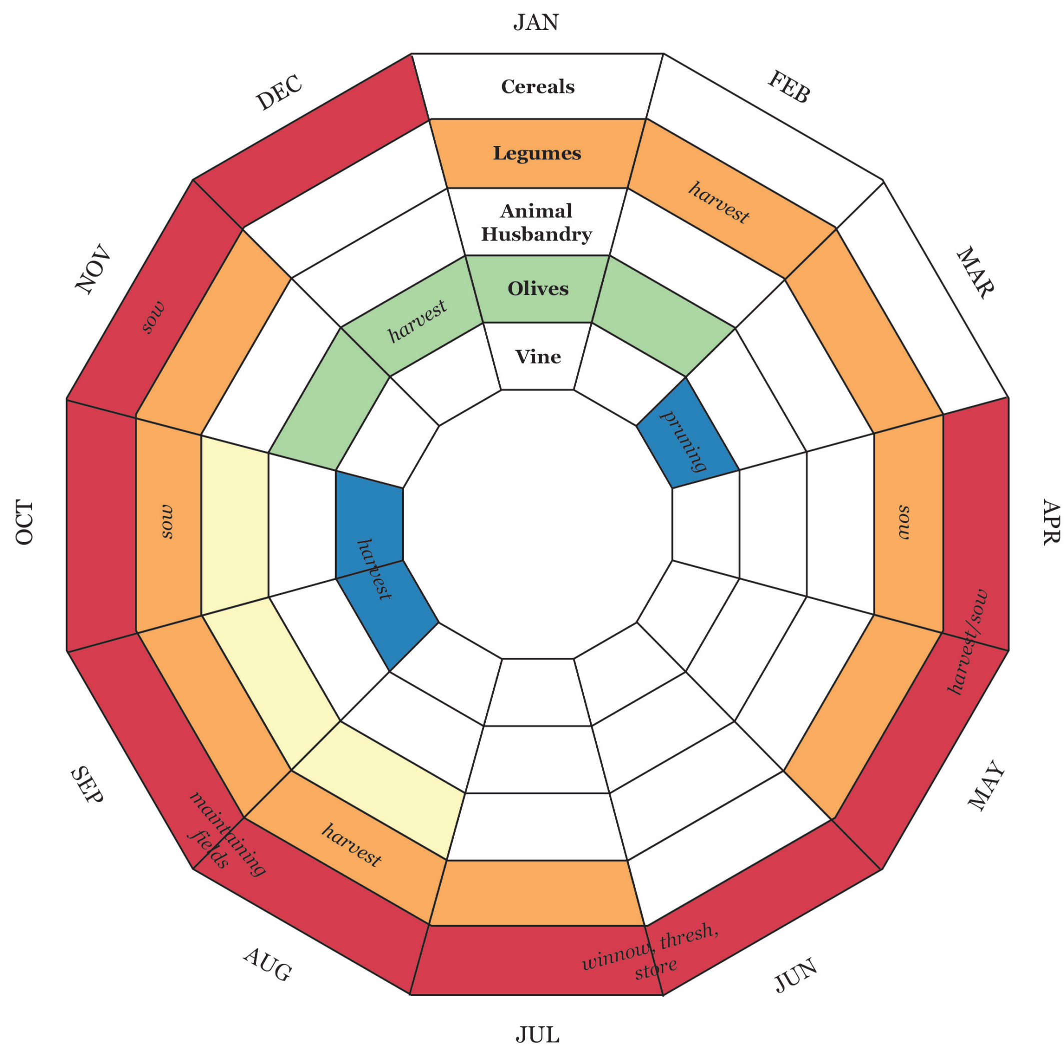

Figure 3.1. Seasonal Subsistence Activity of the Early Cycladic Period
This figure shows the times of year when various subsistence activities--the growing of cereal and legume crops, animal husbandry, and the cultivation and harvesting of olives and grape vines--would have taken place.

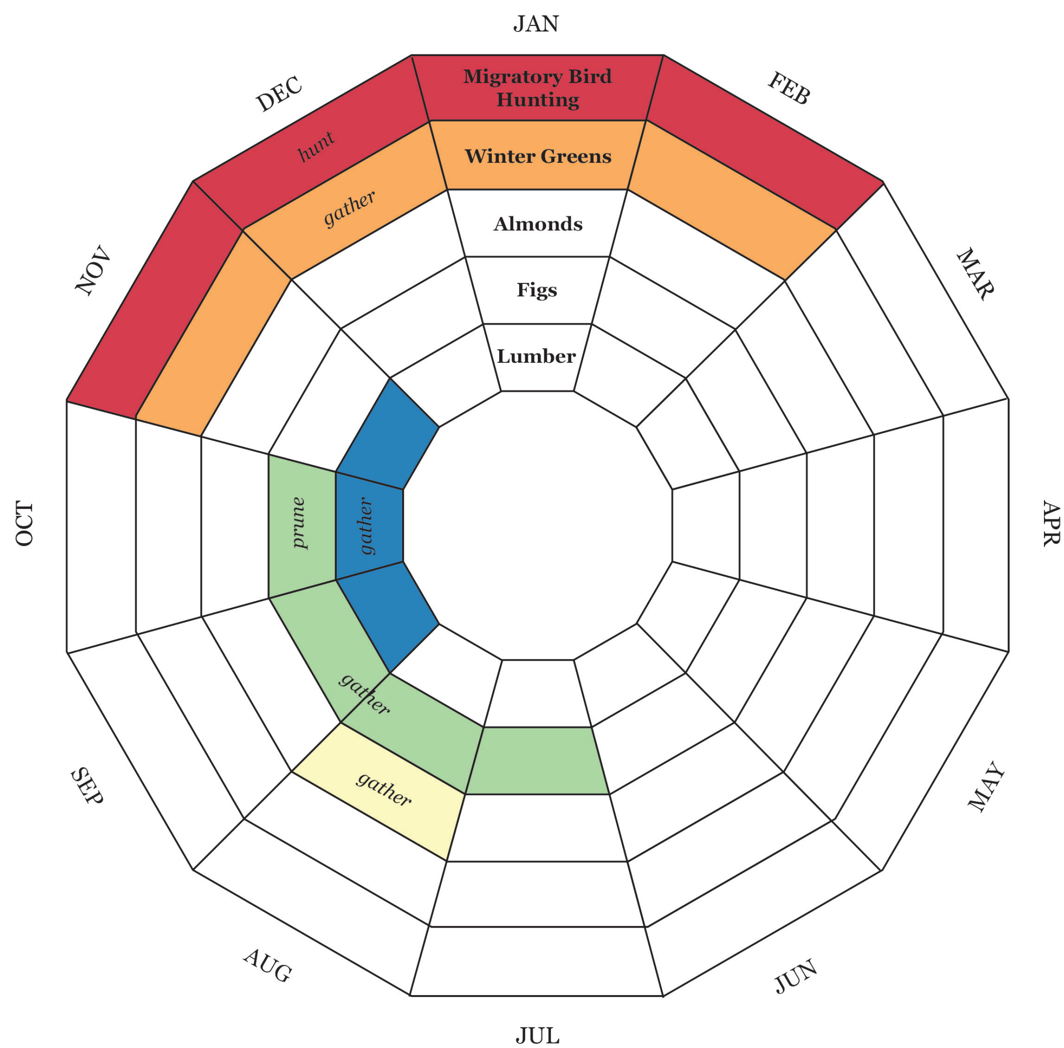

Figure 3.2. Seasonal Subsistence Activity of the Early Cycladic Period II
This figure shows the times of year when various subsistence activities--migratory bird hunting, the harvesting of almonds, figs, and winter greens, as well as the collection of lumber--would have taken place.

Seasonal Labor Requirements and Time-Stress

Halstead and Jones's ethnographic study of agricultural practices on Amorgos and Karpathos offers several insights into the strategies of farmers primarily producing crops for subsistence regarding seasonal labor and time-stress (1989: 53-54):

1. The highly seasonal nature of agricultural activity and the uncertainty of weather conditions required for some tasks result in extreme time stress during certain phases of the year.
2. Extensive agriculture is not possible without work animals, and work animals are not worth the cost to maintain without extensive agriculture.
3. Daily norms are difficult to describe when farmers face a wide range of day-to-day variability.

This section focuses on the issues of seasonal labor requirements and time-stress faced by subsistence agriculturalists.

In terms of seasonality and time-stress, Halstead and Jones describe patterns related to agricultural production in which certain points in the season are marked by very high time-stress, influenced by a variety of factors. First, variations in person-hours and the availability and variability of laborers affect time-stress. In one example, teen-aged daughters of the family might be unavailable to work in the fields since they needed to stay near the home to tend goats (Halstead and Jones 1989: 50). Also, in most cases, studied by the authors the bulk of the agricultural labor was performed by elderly women—due to the emigration of young people from the islands to the mainland—whose work rates might vary in comparison with hired day-laborers (Halstead and Jones 1989: 42). Time-stress is also affected by the type of crop and nature of the harvest. Barley, for example, takes half the time to harvest compared to wheat because it is approximately half as tall. Crops harvested in the middle of the stalk versus low on the stalk (the latter providing fodder for livestock) also affected the time of harvest and the labor requirements of transport from the field. These few examples demonstrate the variability that impacts labor requirements for agricultural production.

Furthermore, the scale of production must be considered. An early estimate of subsistence requirements in the Cyclades (Sanders 1916: 253) estimated 7.5 *stremmata*/person[28], while an elderly farmer from Amorgos suggested the minimum was closer to 12 (Halstead and Jones 1989: 47). Harvesting one *stremma*, assuming a harvest time of 1-3 person-days/*stremma*, would take between 7.5 and 36 person-days to harvest enough food to sustain a single individual. Since the time available for harvest is restricted to a very narrow window of around 30 days around the month of June, families with members too old, too young, or otherwise unsuitable to participate in the harvest would experience extreme time stress during this period (Halstead and Jones 1989: 47). The threshing and processing of cereals requires a similar intensiveness of labor.

Assuming good weather conditions, the reduced labor requirements for sowing combined with the longer winter sowing season (November-February) means that the sowing season would have required a much lower degree of time-stress than harvesting/processing (see table 3.3)

Figure 3.3 approximates the relative labor investment required for each of the subsistence activities described about for each month of the year, on a scale from "minimal" to "very high" labor requirements. Based on the ethnographic estimates of labor required for the production of cereal crops provided by Halstead and Jones (1989), the harvest season of cereals is the most intense period of sea-

28 A *stremma* (στρέμμα, pl. *stremmata*) is a Greek unit of field measure equal to 1,000 square meters, or 0.1 hectare. Its ancient Greek equivalent was the square *plethron* (πλέθρον), which varied in size but is usually thought to equal approximately 900 square meters. (See Hdt.7.199 for an example of the use of *plethron* as a measure of superficial extent rather than length, which is its most common meaning.)

sonal labor, while the time of the year for sowing and preparing the fields requires slightly less labor. If islanders chose to sow a second crop of cereals, the second sowing would overlap with the harvest of the first crop. Legume cultivation is less labor intensive than cereal cultivation because it does not require threshing and the harvest is more prolonged. A second planting of legume crops coincides with the field preparation and sowing cycles for cereals, as well as the lambing season, so the decision to plant a second crop of legumes in a given year would greatly strain the population's labor capabilities.

Table 3.3. Labor Requirements for Subsistence Production[a]

	Labor required/str.	Total time required/ person	Activity season
harvesting	1-3 labor-days	7.5-36 labor-days	30 days (June)
sickle	1-3 labor-days		
uprooting pulses	1 labor-day		
scythe	0.3 labor-days		
transport	7-10 donkey loads	dependent on distance of field from processing location	
threshing/processing	dependent on weather	comparable to harvesting	
plowing/sowing	0.5-1 labor-days	4-12 labor-days	4 months (November-February)

[a]After Halstead and Jones 1989: 47.

Animal husbandry is an activity that requires constant maintenance throughout the year. Year-round activities for sheep/goats would include herding/providing fodder and milking. The spring and summer show an increase in labor investment due to the need to provide pregnant ewes with better fodder and/or pasture to ensure their nutrition. This investment increases yet again in the late summer and autumn, which is the lambing season. For animals kept close to the settlement, namely cows and pigs, investment would be low but constant throughout the year.

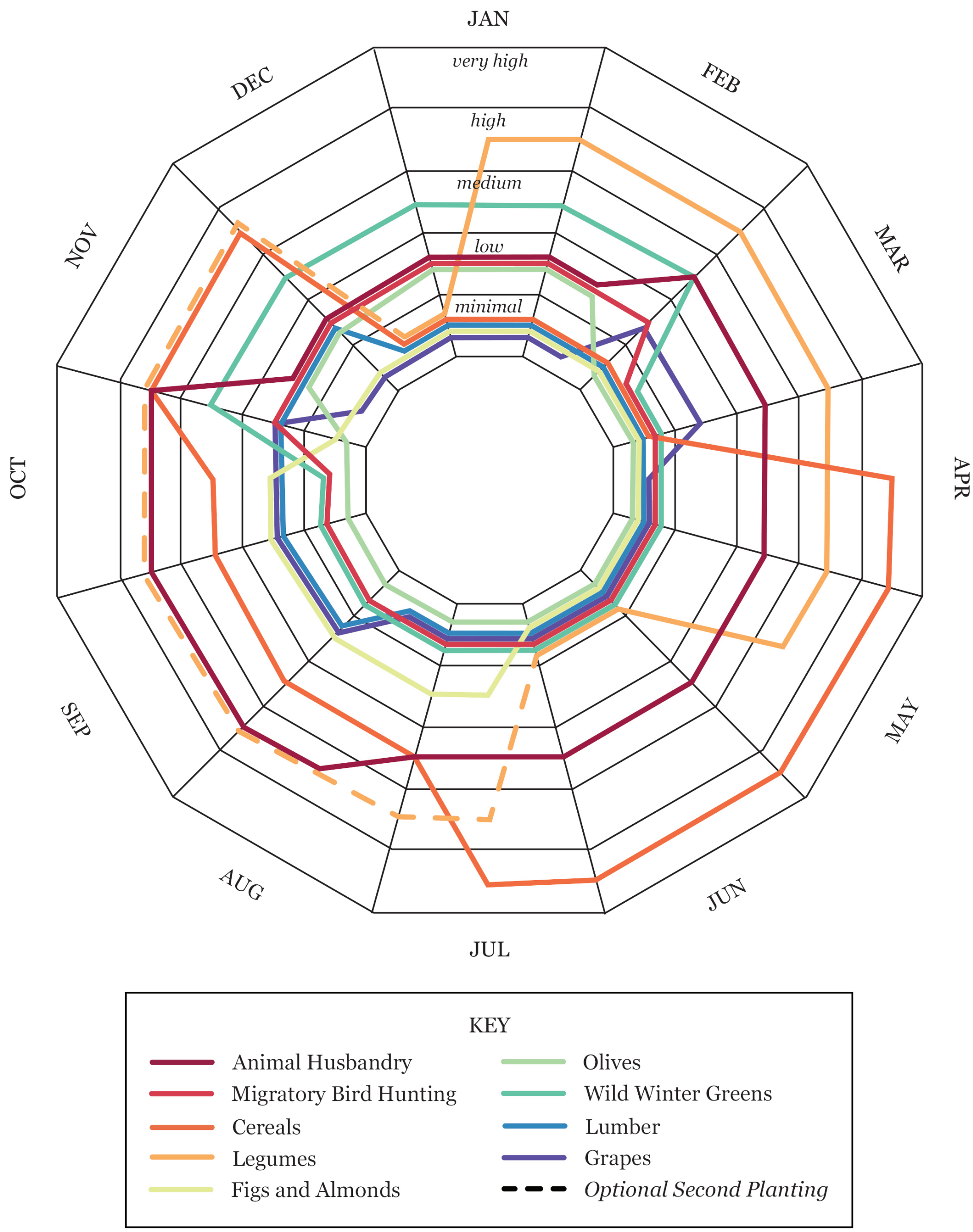

Figure 3.3. Seasonal Labor Requirements for Subsistence in the Early Cycladic Period
This figure shows the demands of labor for the various subsistence activities in which EC islanders would have engaged during all months of the year.

I consider foraging and hunting activities to have a "low" investment when they are in season due to the flexibility and lower time-stress of when these activities occur. Harvested crops will spoil if not threshed and stored in a timely manner, and lambing sheep demand immediate attention, but islanders would have greater choice regarding when to gather olives or spend a day hunting migratory birds. The exception is the foraging of winter greens because despite generally poor preservation they exhibit a wide range of species in the archaeological record and are additionally emphasized in ethnographic studies as providing an important dietary supplement. Therefore I classify foraging for winter greens as a "medium" intensity activity.

On average, life for an EC islander would have been very labor intensive. With the exception of December and part of January, every month has at least one subsistence activity requiring "high" or "very high" labor investment. Growing crops and animal husbandry are consistently the most intensive activities, even more so if there is a poor first harvest and a second harvest is required to prevent starvation.

Society

In this section I reorient and reframe the issue of surplus as it pertains to EC social organization. Rather than considering surplus as a stepping stone on the path to social hierarchy, here I evaluate the archaeological evidence for surplus alongside evidence for several other strategies that could be adopted by Early Cycladic islanders to mitigate risk[29] in subsistence production, especially given the microdiversity of Cycladic islandscapes and high interannual variation in precipitation. During

29 Here "risk" is defined as encompassing both "chance of loss" and "uncertainty of outcome" (see Marston 2011: 191).

the EC period the lack of evidence for storage buildings plus the temporal variation and flexibility of crop production suggests that the sharing of subsistence production among community members would have been a sounder strategy than the individual production of surplus for storage.

Marston (2011) has identified several markers of agricultural risk management that may be visible in the archaeological record. These fall into two broad categories: diversification and intensification. Marston stresses that multiple lines of evidence are needed to identify risk-management practices from archaeological remains (2011: 190). Where archaeological evidence for the EC period is lacking, I draw upon ethnographic comparanda from traditional Aegean island farming practices as a way of offering examples of how past subsistence practices may have operated.

Diversification Strategies

Diversification strategies are those which vary by type, location, and time of year the production of foods grown, raised, or gathered for subsistence (Marston 2011: 191). Because of this variation in production, the failure of one type of resource has a limited effect on overall subsistence returns. There are three main categories of diversification strategies: crop diversification, spatial diversification, and temporal diversification.

Evidence for Crop Diversification

Archaeological evidence for crop diversification includes diversified holdings (whether stock or crops), planting multiple crop types together in the same field (e.g. the planting of maslins[30]), crop rotation, supplementation of the diet with wild foods, and various agropastoral strategies (Marston 2011). The archaeobotanical and zooarchaeological evidence for the Early Cycladic period indicates that diversification of holdings was a strategy adopted by early islanders, but it does not seem more diverse than subsistence practices elsewhere in the Aegean, which used the same suite of crops and domesticated animals. There is also not evidence that subsistence practices were substantially more diverse during the EBA than in the Neolithic (Livarda and Kotzamani 2013: 22).

The co-occurrence of barley and wheat varietals indicates that islanders may have planted cereals together in the same field to mitigate unpredictable rainfall in a given year. In Halstead and Jones's (1989) ethnographic study, farmers explicitly identified the use of maslins of barley and wheat as a mechanism for minimizing risk in crop yield. According to Marston (2011: 192) in a good year, the mixed crop may be sieved to yield a wheat-rich fraction and a barley-rich fraction, the former of which would be eaten by people and the latter of which could be fed to animals. In a bad year, however, the overall yield would decrease, but drought-resistant barley would form the main component of the human diet, while animals could be fed only hay.

It is clear from the archaeobotanical evidence that EC islanders supplemented their diets with wild and cultivated natural resources. Fruits and nuts gathered in summer and fall might be preserved year-round, and wild greens could be gathered in the winter months. The evidence of foods toxic to humans, such as Spanish vetchling, indicates that foraging was not just a strategy for human subsistence but

30 Maslins are mixtures of seeds of related species deliberately prepared before planting to yield a mixed crop (Marston 2011: 191).

also supplemented the diets of animals as well.

Agropastoral strategies for risk management are more difficult that other diversification strategies to identify based on the archaeological evidence for the Early Cycladic period, in part because there are many types of agropastoral strategies that result in mitigated risk. It is important to consider the trade off in labor between agricultural and herd-management strategies—an increase in agricultural risk management may result in labor that cannot be afforded to the management of herds, and vice versa. This is especially the case in arid and semi-arid regions such as the Cyclades where interannual rainfall is highly variable (Marston 2011: 192).

The zooarchaeological evidence for the Early Cyclades does not indicate a clear pattern of animal husbandry strategies. If EC islanders were specialized pastoralists, one might expected emphasis on the raising of sheep/goats, as well as evidence of seasonal transhumance and increased mobility (Halstead 1996). While sheep/goats dominate the faunal assemblage, research has not yet been undertaken to assess the range of movement of EC herds. Comparanda from the Neolithic evidence at Skoteini and Zas caves indicate the presence of sheep/goats year-round, indicating restricted mobility that constrained the scale of herding and the quality of nutrition available due to restricted forage (Halstead 1996: 31). The presence of cattle and pigs at various EC sites also indicates animal husbandry practices that focus on the settlement, rather on more mobile pastoralism. In particular, the not insignificant number of pigs combined with the evidence for specialized animal slaughter at Markiani indicates localized animal husbandry strategies. This would mean more of the population was available to participate in diversified crop strategies to mitigate risk. More archaeological work is needed, however, to confirm this emerging pattern.

Evidence for Spatial Diversification

Spatial diversification entails spreading out agricultural production over geographic space to take advantage of different micro- or macro-environments to reduce overall variance in crop yield (Marston 2011: 192-3). Especially in an area like the Cyclades, where there is a high degree of microdiversity, crops grown in one area may succeed while crops in another nearby area may fail even during the same year (Broodbank 2000: 84). The use of "broken terrain" cushions against both rainfall patterns and infestation, and this was a strategy adopted by modern Cycladic farmers (Halstead and Jones 1989: 52). Therefore, it seems likely that this was a strategy adopted by EC islanders (see chapter 5).

Mobility—specifically for the purposes of hunting and foraging—is also a strategy of spatial diversification. Communities that supplement agriculture with hunting and foraging—which based on the above evidence would include EC communities—may be mobile on a daily or seasonal basis (Marston 2011: 193; see also O'Shea 1989). The exploitation of coastal resources is prevalent at many Early Cycladic sites and demonstrates spatial diversity in foraging, while the presence of migratory bird bones at EC sites may indicate seasonal hunting.

Communities engaging in shared production similarly diversify the spatial location of production. When communities engage in shared production, they embed risk management within the social conventions of the greater community (Marston 2011: 193). Food sharing is a common feature of small-scale societies. Marston (2011: 193) argues that it is an effective strategy of risk management:

> [Food sharing] pools the results of spatially (and possibly temporally) variable foraging or food production efforts, thus mitigating local differences in productivity through an additional level of diversification.

Shared production reduces risk of subsistence failure at the household level, and additionally, the practice of exchange of subsistence resources can mitigate risk at the community level (see Halstead 1989).

Ethnographically, shared production is elaborated in patterns of inheritance and dowry that involve reallocation of land and livestock (Marston 2011: 193). For example, in Tourlouki, et al.'s (2011) study of northern Karpathian villages, both patrilineal and matrilineal land inheritance ensured that land would be distributed among all children. In the cases of both the Karpathian villagers and those on Amorgos (Halstead and Jones 1989), selling off land in times of subsistence failure was only ever a last resort. Both of these social norms have the effect of resisting the consolidation of land holdings into the hands of the few, and therefore may indicate the importance of shared production at the community level. It seems feasible that such an approach would have been adopted by EC islanders as well (discussed in more detail below).

Evidence for Temporal Diversification

Temporal diversification involves the stretching out of food availability throughout the year, thereby reducing seasonal variation in consumption patterns. This may present itself as the scheduling of crops. In the EC period, the main cereals and legumes could also be planted for a second growing season if the main harvest was poor. Cereals crops would have been predominantly planted in winter, but there might be a second spring planting, whereas legumes were preferentially planted in springtime with the possibility of a second fall planting. This flexibility in the scheduling of crop cycles would have mitigated the effects of a bad harvest at any given year.

Storage is also a form of temporal diversification because the storage of harvested crops can provide year-round nutrition (Marston 2011: 193). There is no conclusive evidence for storage facilities during the EC period (see Hansen 1988). Ethnographic comparanda suggest that in traditional Aegean farming models, farmers would store their harvested crops inside the house (Halstead and Jones 1989), so the lack of archaeological evidence for specialized storage facilities does not necessarily preclude its practice.[31] According to Marston (2011: 193), however:

> Storage can be considered functionally interchangeable with sharing as a risk-reduction strategy: two years of harvests stored is equivalent to sharing between two participants. This comparison is limited, however, by the relative degree of spatial and temporal variability in a region. In spatially variable environments, where climatic conditions are relatively stable from year to year, sharing would be more effective at reducing subsistence risk, while in temporally variable environments, in which year-to-year climatic variation is more severe than annual variation within a region, storage is a more effective risk-management strategy.

The Cyclades exhibit high degree of both spatial variation and interannual variation, meaning that both storage and sharing strategies might have benefited EC islanders. However, because the archaeobotanical evidence suggests a preference for crops with high degrees of temporal flexibility, the combination of sharing plus temporal diversification might have outweighed the benefits of storage, especially when combined with the likelihood of shared production discussed above.

31 While the architectural remains at Panermos (Naxos) have been suggested to be a storage facility (among other interpretations), spatial syntax analysis of the site (see Appendix A) and comparison with roughly contemporaneous settlements throughout the Cyclades leads me to conclude that its function was domestic (see chapter 4).

Intensification Strategies

Intensification strategies are those which boost mean production of food resources beyond mere subsistence, so that the chance production will fall below the subsistence threshold in any given year is reduced (Marston 2011: 191). The two forms of intensification strategies visible in the archaeological record are overproduction—the deliberate planting of more crops that a household might be able to use to minimize the risk of subsistence failure—and irrigation. There is little to no evidence of either of these practices for the EC period. Overproduction entails an increased investment in labor and possibly spatial expansion (though not necessarily spatial diversification). It is more likely to produce a surplus than other methods of risk management, and therefore might be more commonly adopted in places where storage is also a risk management strategy, such as Minoan Crete, where there is evidence for structures devoted to long-term grain storage (see Privitera 2014) and palatial centers are located in areas where spatial expansion of agricultural production was possible (see Manning 1994: 233). Halstead's (1981) social storage model offers an explanation for the archaeological invisibility of storage facilities in the EC period; extra crops might be shared with neighbors in need or fed to animals which could be slaughtered for meat (Halstead 1987). At present, there is no evidence for irrigation and/or water management practices in the archaeology of EC landscapes—residents of the prehistoric Aegean seem to prefer to locate settlements near reliable water sources (Tartaron 2008)—therefore this does not seem to have been a risk management strategy adopted by islanders.

Risk, Subsistence, and Society among Early Cycladic Small Worlds

Based on the archaeological evidence, EC islanders adopted several diversification strategies to mitigate the risk of subsistence failure in a given agricultural cycle. Contrary to Renfrew's (1972) supposition, however, there is no substantial evidence that storage was one of them. Rather, the combination of shared production and temporal diversification of crops were a more beneficial strategy for mitigating risk than the production of surplus and the use of storage that has served as the standard model for this time period.

If this is the case, how might the mechanisms of shared production played out in Early Cycladic small world interaction? Halstead's social storage model (1981), when viewed through a small world lens, offers an explanation for how shared production operated and the social incentive for communities to participate. In small community networks, everyone is always in "debt" to one another. When close personal ties exist, people are willing to give goods in exchange for future goods. Local, habitual interaction facilitates an economic system based on trust and the moral obligation to one's neighbors (Graeber 2011). Such "neighborly lending" interactions are observed widely in anthropological studies, especially in societies that do not rely on currency. These interactions are facilitated by the on-going habitual interaction between the peoples in these communities, who desire to foster positive relationships of trust. For the early Cyclades, this type of habitual interaction would not have been limited to a single community but likely occurred on the scale of small worlds networks, whereby frequent social relationships between communities developed through habitual interaction. As Manning (1994: 229; see also Wiessner 1977) notes, it behooved small communities in marginal environments to develop as many social affiliations as possibly, thereby increasing their security net in instances of a bad harvest year.

Since small worlds are based on habitual, face-to-face interaction, it is reasonable that goods might be given between communities, with the understanding of future reciprocation. This translates to how communities supported one another in times of agricultural crisis, understanding that in the future they would be supported in difficult times. Small-world economic interactions coexisted with participation in regional exchange networks that operated by more centralized redistribution (especially later in the Bronze Age when Minoan Crete dominated the region) and also at the same time that emergent elites were engaging in gift-economies to solidify their own power (cf. Renfrew and Cherry 1986).

Sustained inequality in production—which is more likely in semi-arid places with high microdiversity like the Cyclades (Halstead 1989)—also afforded opportunities for individuals to seize power. Halstead and Jones's (1989) ethnographic study shows how community-wide shared production resulted in power imbalance. In times of crisis, farmers on Karpathos and Amorgos would initially seek aid from their relatives for loans of food. An alternative strategy would be to work for richer neighbors, offering labor in exchange for grain. If cash was available, farmers bought grain from other farmers. In more desperate situations, they resorted to the sale of fields or children, and in the most extreme scenarios, families might abandon their farms entirely and emigrate. In larger areas, farmers could have very different success rates in the same year, while in spatially smaller communities, if one failed, all were likely to fail. During repeat periods of good harvests, after farmers had stored 1-2 years of crops, they could begin selling off the excess. (The buying and selling of cash crops is, of course, one of the products of the modern economic system.) These risk-related transactions in times of both want and surplus had long-term consequences for life in small farming communities.

Consistently successful farmers could convert excess crops to cash and eventually into land, while needy farmers must dispose of labor, cash, and finally land to make good on shortfalls of grain. In the short-term, these risk-related transactions ensured the survival of a maximum number of households. In the long-term, this led to inequalities of wealth in which successful farmers acquired rights to the labor of others. By acting as suppliers of grain in difficult years, they became established as intermediaries for the disposal of surplus in years of plenty.

Gilman (1981) has noted the lack of archaeological evidence supporting control of subsistence production as the basis of elite power in the Early Bronze Age; rather, the co-option of information—potentially deriving from elites' authority as negotiators—is key to understanding Early Cycladic social differentiation. Manning (1994: 224-229) hypothesizes that the Early Cycladic communities where social differentiation was feasible would have been limited to a few key 'trader' sites. Control over interpersonal relationships, information, prestige goods, and knowledge of the outside world (discussed in chapter 6) served as the source of power and social status. This explanation accounts for the emergence of influential individuals—such as the "big men" of the Early Cycladic period—without necessitating an inexorable trend toward statehood.

Discussion of power and inequality in the EC period leads to the topic of conflict. While the aforementioned evidence suggests that cooperation among EC communities was essential in their survival during bad harvest years, it does not follow that all intercommunity relationships were amicable. In archaeological research, violent and contentious intercommunity interactions are often overlooked in favor of cooperative ventures; in particular, the archaeologies of food and warfare have developed relatively independently over the past few decades (Wilson and VanDerwarker 2016:1). In the next chapter, I examine the archaeological evidence for warfare in the Early Cycladic period and discuss its implications for social organization and community interaction.

Chapter 4

Fortification as Evidence for Warfare in the Early Cycladic Period

Introduction

The previous chapter emphasized the importance of shared production and cooperation by Early Cycladic (EC) communities to ensure mutual survival. While such cooperative ventures no doubt shaped island life, violence and conflict are no less integral to understanding community interaction. What would archaeological evidence of warfare look like for the Early Bronze Age (EBA) Cyclades (ca. 3000-2200 BCE)? Archaeologists might expect to find evidence of skeletal trauma or unburied bodies, but no reliable skeletal data exists for the Cyclades. While there is evidence for the production of daggers beginning as early as the Final Neolithic (FN) period, and daggers are associated with burials of high prestige (Nakou 1995; Broodbank 2000: 253), an increased presence of weapons does not necessarily indicate an increase in actual fighting (Ferguson 2006: 490).

In the material record of war, there is more 'indirect' evidence (e.g. fortifications or defensive settlement patterns) than 'direct' evidence (e.g. burned sites or unburied bodies). The mobilization for war is more archaeologically visible than evidence of violence and destruction (Solometo 2006: 25). Furthermore, as Allen and Arkush (2006:7) note, the analysis of changes in fortifications or other defensible settlement patterns is a reliable indicator of changes in the type, frequency, and scale of war.

Otterbein's (1970) ethnographic study of warfare and the conditions under which inhabitants will fortify their settlement in pre-state, small-scale cultures found that only when the frequency of attack was higher than once a year would people invest in fortification. Practically speaking, the creation of defensible infrastructure was not worth the expenditure unless there were frequent attacks. Ethnographic comparanda demonstrate that "fortification" requires substantial investment of time, labor, and resources and relies on collective engagement by the community as a whole.

Previous discussions of fortification in the EBA Cyclades tend to treat fortification as a presence/absence phenomenon. Any existence of defensive architecture represents fortification (e.g. Broodbank 2000: fig. 105). It is my contention, however, that the relative time, labor, and resource investment in the fortification may distinguish those settlements which expected regular attacks from those whose defensive engagements were more sporadic. By teasing out the patterns of chronology, settlement location, nucleation/dispersal, and degrees of fortification, I present a nuanced understanding of warfare and its relation to social structures during the EBA in the Cyclades. Shifts over time in settlement patterns from unfortified to fortified, from indefensible to defensible, and/or from dispersed to nucleated might indicate a response to violent attack, while the reverse might also demonstrate a change in the nature of war.

In the Cyclades, the degree of fortification and defensibility falls on a spectrum of investment. Four broad categories based on extant data may be defined: a) fortified, high topographic prominence; b) fortified, low topographic prominence; c) unfortified, high topographic prominence and (d) unfortified, low topographic prominence.[32] "Fortification" denotes the presence of architecture which has

32 These four categories are adapted from Otterbein (1970).

defense as its dominant function. An example of a fortified, major investment in defensive infrastructure is the perimeter wall and bastion system at Kastri. The bastions which restrict the entry of the otherwise unfortified settlement at Mt Kynthos represent a fortified, moderate investment. Finally, the location of Mikre Vigla on a steep hill of restricted access presents a case of an unfortified, but defensible, low investment. In this final example, it is not possible to determine without further evidence whether the primary factor in site selection was defensibility or some other variable, such as high visibility from the surrounding area (Barber and Hadjianastasiou 1989: 146). The evidence for fortification throughout the Early Cycladic period is discussed in further detail below.

Fortification exists during all time periods of the EBA in the Cyclades, but at no point are all settlements fortified. Broodbank (2000: 314) has noted a "horizon" of increased investment in fortification during/at the end of EB II,[33] and the fact that this is followed not long after by widespread destruction and abandonment of settlements has raised questions about invasion or a dramatic increase in warfare. However, increased investment in fortification construction during EB II seems to occur in regions beyond the Cyclades—at sites like Troy, Poliochni, Liman Tepe, and Lerna—and is therefore it is not a purely local phenomenon (Broodbank 2000: 318; see also Kouka 2013; Wiener 2013: 583).

Increased understanding of the phasing and intensity of warfare in the EBA Cyclades stands to advance scholarly discussion of several broader issues in Aegean prehistory. First, although archaeologists recognize correlation of warfare with the development of social complexity (see LeBlanc 2006), the question remains

33 Broodbank (2000: 314) lists the sites of Kastri, Mt Kynthos, Kastraki, Spedos, Panermos, Dhaskalio, Markiani, and Danakos as sites which were fortified during late EB II.

whether it is a cause or consequence. Through a closer examination of warfare, archaeologists can gain a more nuanced understanding of some of the mechanisms of power and prestige that defined Cycladic socio-political relationships. Second, some scholars have argued that the relationship between increased fortification and the arrival of Anatolian material culture on the islands marks invasion of the islands by peoples from the east (Barber 1984; Doumas 1988; MacGillivray 1984; Stos-Gale, et al. 1984; *contra* Broodbank 2000: 313-315). Analysis of the probable motivations, scale, and modes of war will illuminate varying scales of Cycladic social, economic, and political interaction within and without the islands themselves. Finally, the role of warfare and violent destruction in the widespread abandonment of settlements at the end of the EBA (dubbed by Rutter (1983) as the Early Cycladic 'gap') has long been debated by Aegean prehistorians. As Broodbank (2000: 321-22) notes:

> The single feature[about the EC 'gap'] that has most impressed archaeologists is the very large number of settlements that ceased to exist at this juncture, with some terminated by acts of violence, as at Panermos (Doumas 1992a), but others simply abandoned, as seems to be the case at Markiani (French and Whitelaw 1999: 168). In most cases, this cessation was permanent. Moreover, it affected not just farmsteads and hamlets, but also the big, central settlements…[N]orthern Syros, the Erimonisia, southern Naxos, and Amorgos lost their former prominence, and entered an extended phase of relative obscurity that in some areas has lasted almost without interruption until the present day.

In the present study, I first define war as a socio-political phenomenon, limiting the focus of discussion to non-state societies.[34] Then, I discuss the various sources of

34 In an effort to move away from the neoevolutionary model which implicitly assumes that societies progress in increasing complexity over time through the different social categorizations, I refer to "non-state" and "state" societies as my principal social classifications. "Non-state" denotes a society in which there is no strong socio-political hierarchy and no centralized locus of political power.

evidence that archaeologists may draw upon for the investigation of warfare for the Early Cycladic context. Next, I present a chronological overview of the evidence of fortifications at sites throughout the Cyclades, emphasizing those with sufficient archaeological investigation and publication to be useful for an inter-site comparison. Using data from these sites, I perform a cluster analysis to see which variables, related to fortification, appear to be significant and to differentiate patterns of fortification, both spatially and over time, for the EBA Cyclades. Finally, I discuss the dimensions and consequence of warfare in the early Cyclades, drawing from the archaeological evidence and ethnographic comparanda.

Defining "War"

Before the present examination of war in the EBA Cyclades can begin, the definition of "war", in particular in non-state societies, must be understood. Implicit or explicit neoevolutionary perspectives in Cycladic scholarship have prevented violence in the EBA Cyclades from being termed "war", a term that has been reserved for state societies. In the early Cyclades, acts of violence and destruction against other groups are most commonly referred to in the literature as "raiding." I follow Ferguson (1984:5), who defines war as "organized, purposeful group action, directed against another group involving the actual or potential application of lethal force." Raiding, therefore, is classified as a type of warfare (however, of various modes of warfare, raiding is distinct because of the limited usefulness of fortifications in defending against it). "Lethal force" may mean many things; it may be the use of weapons to kill or injure, or it may be the intentional destruction or theft or resources, such as the burning of stored foods, fields, and homes (Keeley 1996; Kelly 2000). Groups that are reliant on stored food are particularly susceptible to resource destruction (Solometo 2006: 26). In the Cyclades, where subsistence is tenuous in the best of times, settlements might have been especially vulnerable to the destruction of their crops. In fact, this vulnerability may have led to the avoidance of crop destruction within the Cyclades. In circumstances of warfare when cultural groups are closely linked, the objective is often not to cause destruction, starvation, or property damage, but to take captives and/or settle disputes—often through pre-established rules of warfare or one-on-one combat (Allen and Arkush 2006).

Precontact warfare among the Iroquois offers a comparative example; Carpenter (2001: 34-5; 2004) argues that the primary goals of Iroquois warfare were the taking of captives and the avoidance of casualties. To achieve these goals, opposing sides might parley before battle to agree to the terms of fighting, and they might agree to decide the outcome of battle through single combat. Precontact intratribal warfare tactics contrast sharply with those used against them by invading European forces, who burned and destroyed Iroquois towns and crops. The Iroquois would subsequently adopt the same tactics when assaulting European settlements (Keener 1999).

Sources of Evidence

Allen and Arkush (2006: 7) list a variety of evidentiary sources for the investigation of war in the past: fortifications, reexamination of archaeological excavations and collections with new interpretative techniques, ethnographic comparanda, and analogy from cross-cultural ethnography and military science. I draw on all of these bodies of evidence in the present study, focusing primarily on the reassessment of Early Cycladic fortification systems that have been previously published in survey and excavation reports. A study of these fortification systems contributes to the discussion of warfare in the EBA Cyclades in several ways. First, as mentioned above, archaeologists have tended to discuss fortifications as a presence/absence phenomenon; however, the labor, time, and resource investment into a fortification system such as the one at Kastri would have been dramatically different than for the one at Panermos (figure 4.1). In the Cyclades in particular, the cost of defensive architecture must be carefully considered, since the traditional construction techniques of domestic architecture produce walls which are not uncommonly 0.7 m 1.0 m thick, the latter of which measurement has been used to categorize a "fortification" when in the guise of an enclosure wall. I argue that, in order for architecture to indicate a defensive function, wall thickness as an isolated measurement is not enough. It should be considered in the greater context of the site, factoring in the average thickness of domestic construction and defensive elaborations such as bastions and gates, as well as considering the natural defensibility of the site's location.

Second, the evidence for the mobilization for war is more commonly present in the archaeological record than evidence for violence and destruction (Haas 1990; Wilcox and Haas 1994; Solometo 2006: 25). Because there is more 'indirect' evidence (e.g. fortifications, defensive settlement patterns) than 'direct' evidence (burned sites, unburied bodies) in the material record, an assessment focusing on the former stands to more accurately reflect the practices of war in this early Aegean context.

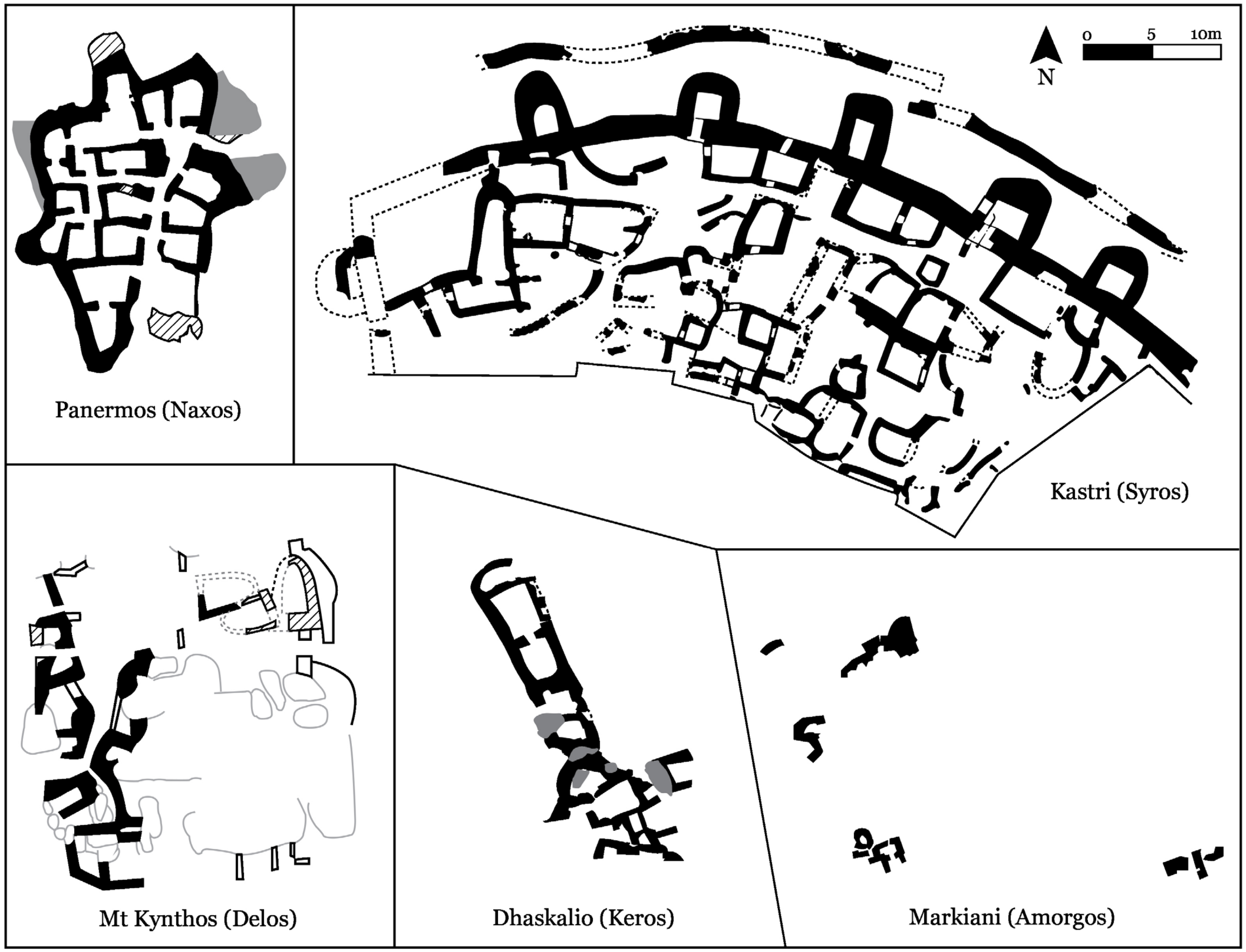

Figure 4.1. Size Comparizon of Early Cycladic Fortified Settlements

Artifactual Evidence of Cycladic Warfare

Previous archaeological consideration of war in the early Cyclades has focused on the assessment of the iconography of Cycladic longboats and metal weapons from burial contexts which may relate to war practices. However, neither of these sources of evidence is directly linked to the actual practice of warfare.

The iconography of Cycladic longboats has been interpreted as depicting "special-purpose prestige craft used for warfare, raiding, and high-status activities such as ceremonial processions and long-range voyaging" (Broodbank 2000: 100). This interpretation is based primarily on ethnographic parallels from the Maori and Pacific Northwest. However, there are no preserved remains of Cycladic longboats, so their size and capacity can only be guesswork. Furthermore, all securely provenanced depictions of longboats come from a single site, the cemetery at Chalandriani, which has been interpreted as evidence for Chalandriani's privileged place in Cycladic warrior society (see chapter 6). For this hypothesis to be validated, archaeologists need to establish more explicit connections to the practices of war in the Early Cycladic period.

Likewise, metal objects have been a source of archaeological interest, particularly given their widespread circulation as prestige objects throughout Europe during the Early Bronze Age (Nakou 1995: 9; Renfrew 1972: 325). Metal weapons—in particular, metal daggers—existed in the Cyclades since the Final Neolithic (FN). Sherratt (2002) proposed that the first Aegean spears—used in canoe skirmishes or activities of group violence—were daggers tied on poles. However, it is in the EB II period that they acquire a symbolic dimension, being attested as grave goods and featuring stylistic and material elaboration (Broodbank 2000:

253). They are usually interpreted as symbols of male prestige, but since the sex of the burial is usually determined by the presence of daggers (since there is no skeletal evidence preserved in the Cyclades), this argument is tautologous. In addition to daggers' (and other metal objects') symbolic relationship with personal identity, Nakou (1995: 18) argues that the distribution of metal extraction locations and production in the Aegean suggests that the knowledge of metalworking itself was restricted to a limited group of individuals. She posits a correspondence between the control of metallurgical knowledge/access to extraction sites and communities that monopolized long-distance voyaging (see also Broodbank 1989; 1993). However, as in the case of the longboats there is very little evidence linking metal weapons and/or metallurgical production to direct practices of warfare. No use-wear analysis of daggers or other metal weapons—which might shed light on the function of these objects—has been undertaken in an Aegean context (Nakou 1995:12).

While a full examination of the evidence of weaponry—including both metal and stone artifacts—from settlement contexts in all EC periods is beyond the scope of the present project, it is possible to sketch some initial impressions. In his survey of metal and stone artifacts from the entire Aegean during the EB II period, Cosmopoulos (1991:139-174) reports a total of 180 metal objects that could be classified as weapons, 115 of which were excavated from a settlement context (see table 4.1). Of these, two are from Cycladic settlements: a long dagger from the destruction level at Panermos (Doumas 1964:412; Angelopoulou 2008) and a knife from Chalandriani IIIb (Branigan 1974: cat. 647). Five metal weapons are attested in Cycladic burial contexts from this time period, three long daggers from Ano Koufonisi (2) and Dokathismata (1) as well as two spearheads from Ano Koufonisi

(1) and Dokathismata (1).

For stone objects that could be used as weapons, Cosmopoulos (1991:175-226) reports 243 total artifacts, 179 of which were found in settlement contexts (see table 4.2). Of these, eight are from Cycladic settlement contexts and nine are from Cycladic burial contexts. The seven blades recovered from Cycladic settlement contexts are from Chalandriani (1), Dokathismata (1), Korfi t'Aroniou (1), Kato Akrotiri (1), Kastraki (1), Kastri (1), and Delos (1). A stone sling bullet was also recovered from the destruction level of the settlement at Panermos (Doumas 1964: 412). The nine blades recovered from Cycladic burial contexts are from Spedos (3), Avdeli (3), Ano Koufonisi (1), Chalandriani (1), and Keros (1).

It is difficult to say whether the extremely low numbers of metal and stone weapons reported for the Cyclades represents lower usage in the past than other areas of the Aegean, or whether this representation is due to other post-depositional factors, such as recovery practices, erosion, and/or looting. Furthermore, Cosmopoulos's (1991) survey represents only one period of Aegean prehistory, so it is impossible to describe changes in the quantities and depositional contexts of weaponry over time. From this evidence, the presence of artifacts that could be used as weapons in the Cyclades is extremely low when compared with the Greek and Anatolian mainlands—at least in terms of absolute numbers[35]—and therefore other archaeological evidence is necessary to adequately understand warfare in the Cyclades during the Early Bronze Age.

35 It is beyond the scope of this project, but it would be worthwhile to compare the ratios of metal objects of warfare to other variables like settlement size and population estimates to see how the Cyclades compare with findings from mainland Greece and Anatolia, especially since there is more archaeological evidence for settlements on the mainland.

Table 4.1. Early Bronze Age II Metal Objects in the Aegean[a]

Class	**Total**	**All Aegean Contexts**		**Cycladic Contexts**	
		Burial	*Settlement*	*Burial*	*Settlement*
Arrowhead	10	1	9	0	0
Blade	4	0	4	0	0
Double Axe	2	0	2	0	0
Flat Axe	7	1	6	0	0
Knife	39	6	33	0	1
Long Dagger	79	27	52	3	1
Short Sword	1	1	0	0	0
Spearhead	20	11	9	2	0
Triangular Dagger	18	18	0	0	0
TOTAL	**180**	**65**	**115**	**5**	**2**

[a]Summarized from Cosmopoulos 1991:139-174.

Table 4.2. Early Bronze Age II Stone Objects in the Aegean[a]

Class	**Total**	**All Aegean Contexts**		**Cycladic Contexts**	
		Burial	*Settlement*	*Burial*	*Settlement*
Arrowhead	23	2	21	0	0
Blade	192	60	132	9	7
Knife	9	1	8	0	0
Sling bullet	19	1	18	0	1
TOTAL	**243**	**64**	**179**	**9**	**8**

[a] Summarized from Cosmopoulos 1991:175-226.

Cycladic Fortifications Overview

This section presents a summary of the architectural evidence about features which have been interpreted as evidence of possible fortification. As I discuss below, "fortification" is a problematic term with no simple definition, so in the analysis section of this chapter, I assess the likelihood that the architectural elaborations listed below actually served a defensive purpose.

EC I Grotta-Pelos

During the Early Cycladic I period, most settlements were small and located in close proximity to the sea. While they typically lack fortification, in some cases such as Markiani (Amorgos) and Zoumparia (Despotiko), there exists evidence for an enclosure or perimeter wall (Economidou 1993: 38). Architectural elaboration in this period may have continued from defensive site selection in the Final Neolithic and influenced fortification systems in the later EB II period (Economidou 1993: 39).

Two sites—Markiani (Amorgos) and Zoumparia (Despotiko)—show traces of an enclosure wall, but the latter has not been excavated. Grotta (Naxos) has houses but no evidence of fortification (Kontoleon 1949). The sites of Samari (Melos), Cheiromylos (Despotiko), Panagia (Folegandros), and Gerani (Keros) show evidence of architecture, but none have been intensively mapped or excavated (Economidou 1993).

EC I-II Kampos

During the EC I-II transition (the Kampos group), the fortification wall at Markiani remains the exception, rather than the rule. Three excavated sites—Grotta (Naxos), Pyrgos (Paros), and Panermos (Naxos)—present domestic structures with walls ranging from 25 cm to 50 cm thick, but they do not have evidence for investment in fortification (Economidou 1993).

EC II Keros-Syros

The EC II period (the Keros-Syros cultural designation) shows several new architectural forms that are not evident in earlier periods. First, a new type of wall occurs, which consists of two parallel stone walls with a gap filled in with small stones, pebbles, and dirt. In most cases, the two double walls are approximately 25 cm thick with a 50 cm gap between them, yielding a total thickness of approximately 1 m (Economidou 1993: 69). An example of this construction technique is found at Grotta (Naxos), where House Γ has a double wall of 1 m thick filled with earth and sherds.

While all settlements except Ayia Irini continue to be small (less than 6,938 m^2), settlement density is high. Grotta, Skarkos, and Markiani were all intensively occupied and buildings were constructed close together (Economidou 1993:71). Skarkos (Ios), the best preserved site of the period with walls preserved up to a height of 3 m (Marthari 2013: 55), features domestic walls of 70-85 cm thick on the ground floor and 45 cm thick on the upper story. However, due to extensive modern field terracing systems, it is at present impossible to determine whether an enclosure wall surrounded the site.

Most settlements continue to be unfortified and are not located in places where it seems defense was a major priority. However, the thick wall at Markiani is further elaborated with the addition of a bastion (Economidou 1993: 78). While there are arguments that the earlier wall was a retaining wall or a windbreak, the addition of a bastion contributes to a defensive characterization of this feature (French 1990; Marangou 1990; Marangou, et al. 2006). In addition to the bastion, a central building complex was added, with walls 35 cm 75 cm thick.

During this period, Mt Kynthos (Delos) and Paroikia (Paros) both have walls of uncertain purpose. On Mt Kynthos, a wall on the NW part of the hill on which the settlement is located—which is also the most accessible side of the hill—perhaps represents the anxieties of the inhabitants about invasion. Plassart (1928:

16) argued that this was a fortification wall dating to the EC II period. However, Mt Kynthos is located on a defensible and prominent hill, so fortification via architectural elaboration does not seem necessary for defense. Furthermore, the thickness of the wall is similar to that of the walls of domestic structures, which points to its use as a retaining wall rather than a fortification wall (Economidou 1993: 77-8).

Recent excavations at Dhaskalio (Renfrew, et al. 2013: 346) revealed domestic walls ranging between 46 and 70 cm thick in Trench VI. While earlier studies describe Dhaskalio as a fortified settlement, the recent excavations (Renfrew, et al. 2013) interpret the large walls that ring the islet as an extensive system of terraced platforms. The majority of excavated exterior walls at the site date to the Keros-Syros period, and they range from 18 cm to 100 cm thick, although the degree of preservation varies (Boyd 2013).

Paroikia exhibits a massive, curved wall on the NW side of a house. Its width ranges from 70-100 cm, and its construction differentiates it from the domestic architecture, where the walls are approximately 50 cm thick. However, this wall seems to only enclose one house and not the entire settlement (Economidou 1993: 78). Stephanos (1904) reports traces of a settlement with a fortification wall at Phyrroges (Naxos), but no further archaeological investigation of this site exists.

<u>EC III Kastri</u>

During the EC III period (the Kastri phase), most settlements are located on high hills (>30 m asl) and near the sea. In sites where the settlement size can be estimated, settlements continue to be typically small in size (Economidou 1993). Settlements tend to either be investments in sites from previous periods or short-range relocations to more defensible points near existing sites (such as the building of Kastri some 600 m from the earlier site of Chalandriani on Syros) (Broodbank 2000: 313-15).[36]

Several settlements exhibit potential fortification. The excavated settlements are Markiani, Dhaskalio, Panermos, and Kastri. These sites have thick walls, bastions, and towers, with gates and narrow passageways to restrict access to the site. Kastri and possibly Dhaskalio have large free-standing walls with bastions. At Panermos, rooms are continuously packed behind a thick-walled perimeter. However, the tiny size of the site calls into question both its fortified nature and its use as a domestic settlement (see appendix A). At Mt Kynthos, there is no preserved enclosure wall. However, access to the site is restricted by a narrow passageway (3 m long by 1 1.5 m wide) flanked by a pair of bastions (rooms η and ζ). Walls of similar thickness are found in the living spaces at the site, so the bastions may have functioned more as watchtowers than to repel attack (Economidou 1993: 95). At Markiani, no major changes occur at the site in this period, but a second wall is added to the earlier enclosure wall. It is considerably thinner than the earlier enclosure wall (Marangou, et al. 2006).

Unlike the exterior walls which primarily date to the Keros-Syros phase, the majority of domestic walls excavated at Dhaskalio date to the Kastri phase (Renfrew, et al. 2013). Their widths range from approximately 25 cm to over 70 cm thick. Three exterior walls were dated to this phase, all approximately 45 cm thick.

The unexcavated settlements that may have fortification walls are Kastraki,

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36 It is relevant to note the continuity with settlements from the previous period because some archaeologists have interpreted the co-occurrence of these defensible settlements and new forms of Anatolian pottery as evidence for violence and invasion from the east. Broodbank (2000: 313-315) argues against the elision of Anatolian pottery with the propensity to fortify.

Spedos, Avyssos, and Nero. Given the current evidence, these unexcavated settlements seem to lack the same degree of architectural elaboration as the previous settlements—they do not have bastions, gates, or inside rooms—but further archaeological investigation is needed before firm conclusions may be drawn (Economidou 1993: 137-8). One major EB III site, Ayia Irini, does not have evidence of fortification.

Table 4.3. Occupation Phases and Architectural Remains of Excavated Early Cycladic Settlements[a]

Settlement	**EC I** Grotta-Pelos	**EC I-II** Kampos	**EC II** Keros-Syros	**EC III** Kastri
Markiani	Rectilinear and curvilinear wall remains, enclosure wall	Continued occupation, no new buildings	Central building complex; enclosure wall elaborated with bastions	Additions to the enclosure wall
Mt Kynthos			Single wall	Main occupation period, bastions, apsidal structures
Grotta		Houses A, B, and rectilinear walls of Γ	Houses A, B; curvilinear walls of Γ	
Panermos		Single house		Fortifications, main complex
Ayia Irini	No architecture		Houses E, ED, D	
Phylakopi	Single wall		No architecture	First city walls
Dhaskalio			Terrace walls surrounding the site, some walls on the summit	Summit structure, some terrace walls added
Paroikia			House remains, semicircular wall	Curvilinear walls, rectangular houses
Pyrgos		House A-B	House C-D	House walls, apsidal houses, houses

[a]Adapted from Economidou (1993: 97-101) with updates from recent publications.

Categorizing Cycladic Fortifications

Identifying "Fortification"

When it comes to understanding Early Cycladic warfare, part of the challenge is the lack of any standard definition of what constitutes a fortification wall. While the function of a fortification wall is to protect a location from aggressors, its formal characteristics may vary by culture, location, and chronological period. Within Cycladic scholarship of the Early Bronze Age, there is little agreement as to what defines a fortification. The tendency in the archaeological literature is to ascribe the term to any exterior wall of a site, even when its actual function is not known (and in EC archaeology, it rarely is). In this section, I seek to identify EC fortification through two major avenues: the spatial analysis of settlement locations by creating a topographic prominence index (TPI) and the quantification of the physical characteristics of walls for different phases of occupation.

The idea is to identify the defensibility of sites relative to the natural defensibility of their location, as measured through topographic prominence, and the architectural elaboration of defensive walls or restricted access to the site. We might expect a fortified site to be in a defensible location, with good visual control over the surrounding area and restrictive terrain, and to have exterior walls or bastions that are more robust than the walls of domestic architecture. An unfortified site might be located in an easily accessible area with no exterior walls. However, the majority of EC sites fall somewhere in-between these two extremes. Through the quantification and spatial analysis, I aim to tease out meaningful patterns from the web of EC settlement data.

A further difficulty is the wide variation of thoroughness of publication data for Early Cycladic architecture, which makes inter-site comparison difficult. There are very few EC sites where the above criteria may be applied given the current state of archaeological publication. Many publications do not record the thicknesses of walls. Where possible, I extracted measurements from site plans, but only when the quality of drawings was of a high enough resolution that I felt reasonably confident in an accurate estimate. In the sites investigated in the early part of the 20th century, even the exact location of the site was often not recorded. I have reconstructed these locations to the best of my ability through a combination of gazetteer notes, original map drawings, and the modern toponyms of place in the islands. Given the difficulty of the evidence, all of the data presented here should be considered estimates which would be improved by more detailed publication and a reexamination of the sites identified in early gazetteer-style surveys.

Spatial Analysis of Cycladic Fortifications

As discussed above, I classified the data according to two major variables in order to determine the degree of fortification for the sites during different occupation phases (table 4.3): topographic prominence and architectural features, namely wall thickness and the presence of bastions.

Topographic Prominence

Topographic prominence describes the elevation of a site relative to average elevation of the surrounding topography. In addition to being a topographic measurement, the prominence of a location also has social significance. As Llobera (2001: 1007) notes:

> The prominence felt at a location has often provided a way to address issues about hierarchy, rank, and significance within a landscape. In a sense, it is connected to the symbolism associated with the vertical scale and the fact that prominent locations are related to visual and physical control (Higuchi 1989) which may contribute eventually towards their symbolic significance.

Places with high topographic prominence may serve as landmarks which anchor the space around them. They may both visually dominate and visually control the landscape, and high prominence may restrict access to the site itself. In this sense, high topographic prominence is a measure of the defensibility of a site; sites with high topographic prominence may be sooner alerted to threat of attack and more difficult for attackers to reach.

I used three criteria to classify each site's topographic prominence: elevation, ruggedness, and visibility. To measure the relative elevation between sites, the digital elevation model (DEM) of the study area was categorized according to a quantile distribution on a scale of 1 to 5 (from lowest to highest) (see table 4.4 and figure 4.2). The elevation for each site was extracted from the DEM using GIS and then categorized according to the rules of table 4.5. No sites considered in this study were located in category 5. Since the relative comparison of elevation between sites is more important than absolute elevation for the purposes of this project, I did not assign qualitative descriptors for category 5; categories 1, 2, 3, and 4 are described as "low," "medium," "high," and "very high," respectively. For the consideration of defense, elevation is an important factor of topographic prominence.

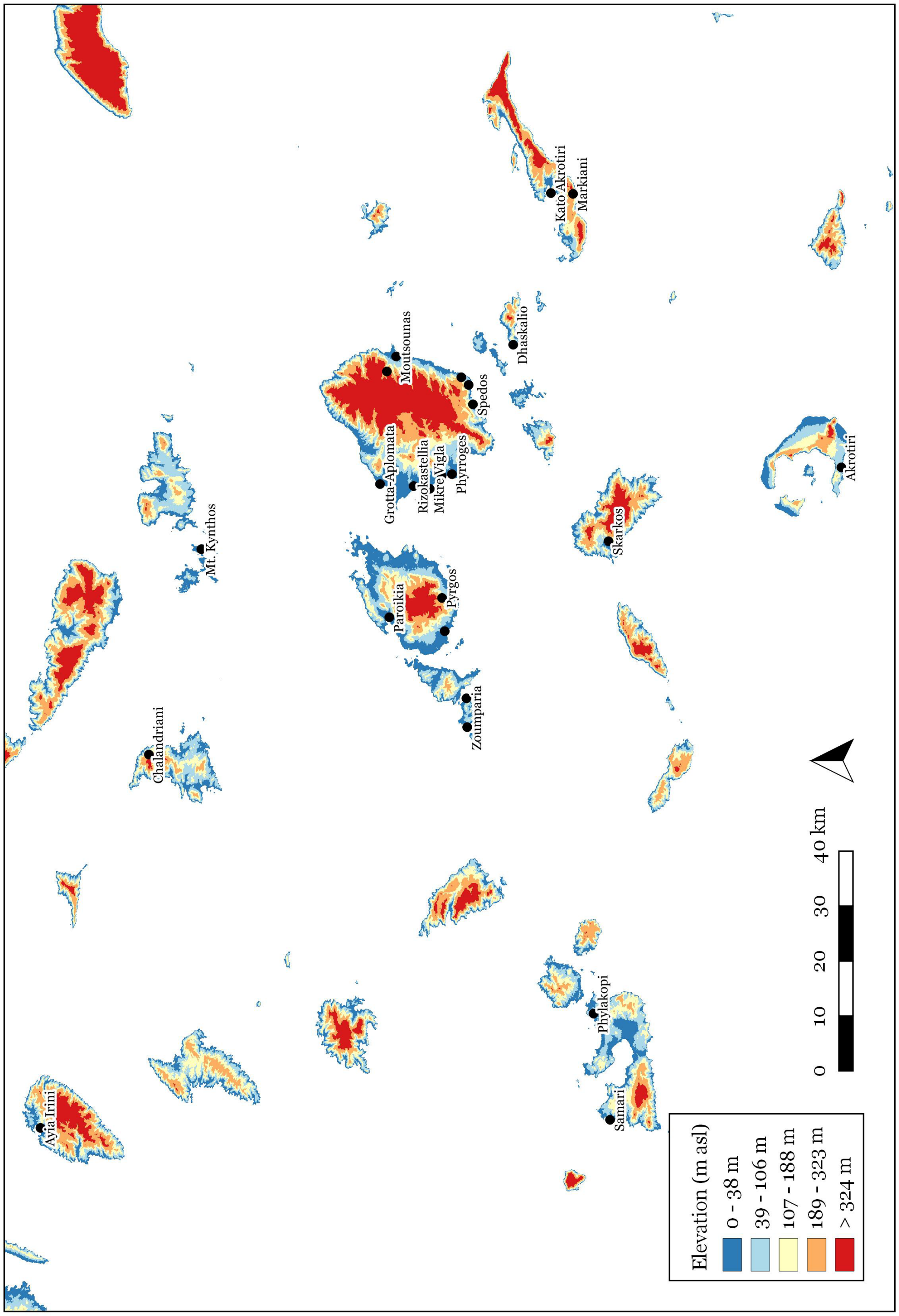


Figure 4.2. Elevation of Early Cycladic Sites

Table 4.4. Quantile Classification of Elevations in the Study Area

Elevation Category	Elevation (m asl)	Description
1	0-38	Low
2	39-106	Medium
3	107-188	High
4	189-323	Very High
5	324+	—

Ruggedness measures the average change in elevation between a location and the surrounding pixels of the DEM raster. I created a terrain ruggedness index (TRI) of the Cyclades using the Ruggedness Index Terrain Analysis tool in QGIS, and categorized the results according to quantile distribution on a scale of 1 to 5 (with 1 being the least rugged) (figure 4.3). The ruggedness of a site's location affects its accessibility, and therefore its natural defensibility. More rugged sites would be more difficult to access and attack, while less rugged sites would be easier targets.

To measure the visibility from each site, I used the Viewshed (3D Analyst) function in ArcMap. I assess the relative visibility between each sites by tabulating the total number of raster cells visible within a 5 km by 5 km square (a total of 135,300 raster cells) centered on the site. Creating a fixed limit around sites ensure their comparability by eliminating distortion at the edges of the DEM that would occur if the full viewshed extent was considered. The resulting data were classified by quartiles (table 4.5) and each site was assigned to a visibility quartile on a scale of 1 to 4, with one being low visibility and four being very high visibility (table 4.6).

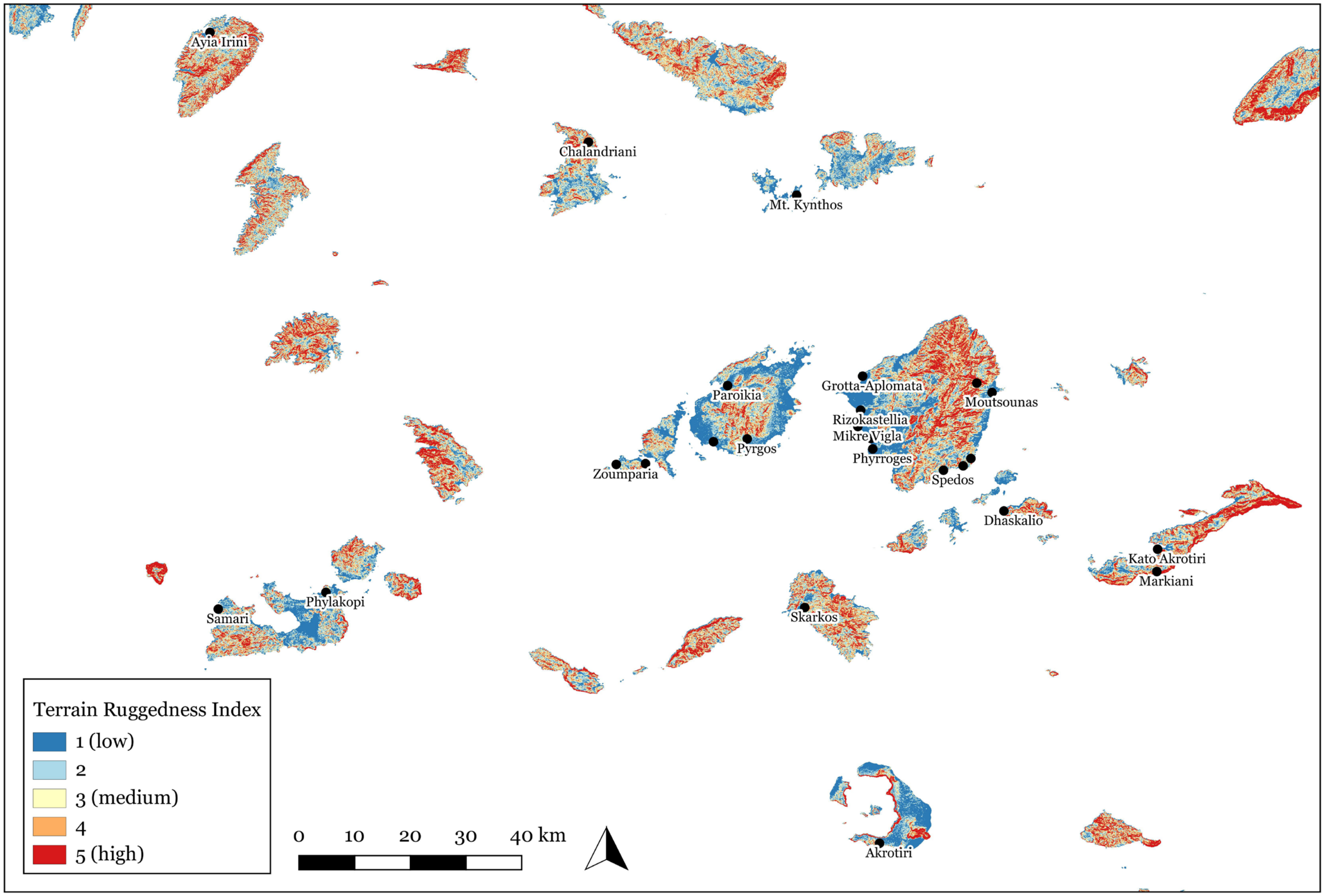


Figure 4.3. Terrain Ruggedness Index (TRI) of Early Cycladic Sites

Table 4.5. Quartile Classification of Viewshed Analysis		
Visibility Quartile	**Visible raster cells (n)**	**Description**
1	707-14719	Low
2	14720-24689	Medium
3	24690-45103	High
4	45104-75526	Very High

Table 4.6. Visibility of Study Area Sites

Site Name	Visibility		
	Visible Raster Cells	*% Visible*	*Quartile*
Akrotiri	27142	20%	3
Avdeli	2989	2%	1
Avyssos	22428	17%	2
Ayia Irini	33172	25%	3
Chalandriani-Kastri	33216	25%	3
Cheiromylos	21284	16%	2
Dhaskalio-Kavos	57634	43%	4
Dokathismata	42552	31%	3
Grotta	45104	33%	4
Kastraki	51655	38%	4
Kato Akrotiri	24060	18%	2
Korphi t'Aroniou	24690	18%	3
Markiani	46609	34%	4
Moutsounas	47806	35%	4
Mt Kynthos	20837	15%	2
Panermos	14720	11%	2
Paroikia	9632	7%	1
Phylakopi	1908	1%	1
Phyrroges	6297	5%	1
Pyrgos	707	1%	1
Samari	51554	38%	4
Rizokastellia	17820	13%	2
Skarkos	7417	5%	1
Spedos	25281	19%	3
Zoumparia	75516	56%	4

The topographic prominence index (TPI) score was calculated by adding together the elevation, TRI, and visibility scores (see table 4.7 and figures 4.4 and 4.5). Since TRI was categorized on a scale of 1 to 5, it is weighted slightly higher than elevation and visibility, but overall each category is roughly even. In the absence of archaeological evidence to indicate a cultural preference for one of these variables in site selection over others, I felt it appropriate to make TRI the most important variable by a slight margin, since it would have the greatest impact on a site's natural defensibility. Future permutations of this study might consider the effect of different categorical weights on the overall TPI score.

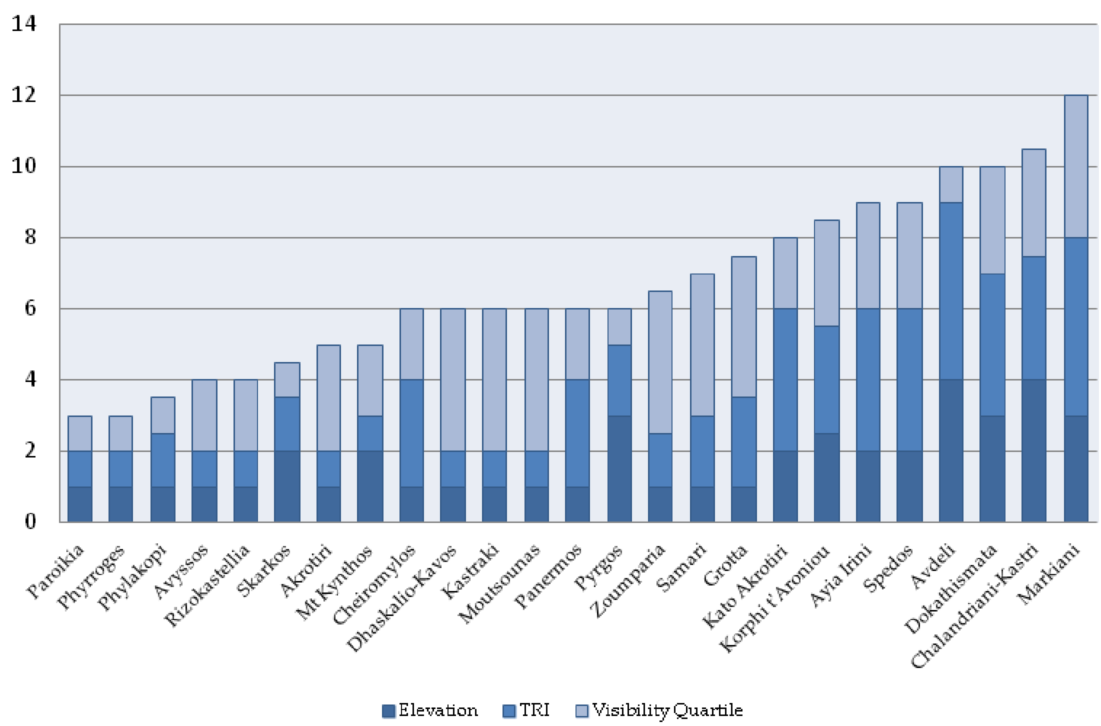


Figure 4.4. Topographic Prominence Index Scores of Early Cycladic Sites
Topographic prominence for each site was calculated by adding together a site's elevation, terrain ruggedness index (TRI), and visibility quartile values.

Table 4.7. Topographic Prominence Index (TPI) Scores of Study Area Sites

Site Name	Elev. Cat.	TRI	Vis. Quart.	TPI
Akrotiri	1	1	3	**5**
Avdeli	4	5	1	**10**
Avyssos	1	1	2	**4**
Ayia Irini	2	4	3	**9**
Chalandriani-Kastri	4	3.5[a]	3	**10.5**
Cheiromylos	1	3	2	**6**
Dhaskalio-Kavos	1	1	4	**6**
Dokathismata	3	4	3	**10**
Grotta	1	2.5	4	**7.5**
Kastraki	1	1	4	**6**
Kato Akrotiri	2	4	2	**8**
Korphi t'Aroniou	2.5	3	3	**8.5**
Markiani	3	5	4	**12**
Moutsounas	1	1	4	**6**
Mt Kynthos	2	1	2	**5**
Panermos	1	3	2	**6**
Paroikia	1	1	1	**3**
Phylakopi	1	1.5	1	**3.5**
Phyrroges	1	1	1	**3**
Pyrgos	3	2	1	**6**
Samari	1	2	4	**7**
Rizokastellia	1	1	2	**4**
Skarkos	2	1.5	1	**4.5**
Spedos	2	4	3	**9**
Zoumparia	1	1.5	4	**6.5**

[a]While the immediate vicinity of Chalandriani-Kastri is relatively gentle terrain, it is circumscribed by a stretch of very rugged terrain that one would have to pass through to access the site.

Architectural features - wall thickness, gates, and bastions

In many cases, it is difficult to interpret whether thick, external walls to a site were intended as fortification walls or for some other purpose. There is a spectrum of architectural elaboration ranging from very clear defensive purpose—such as the regular bastions and double ring of exterior walls at Kastri—to the dubious de-

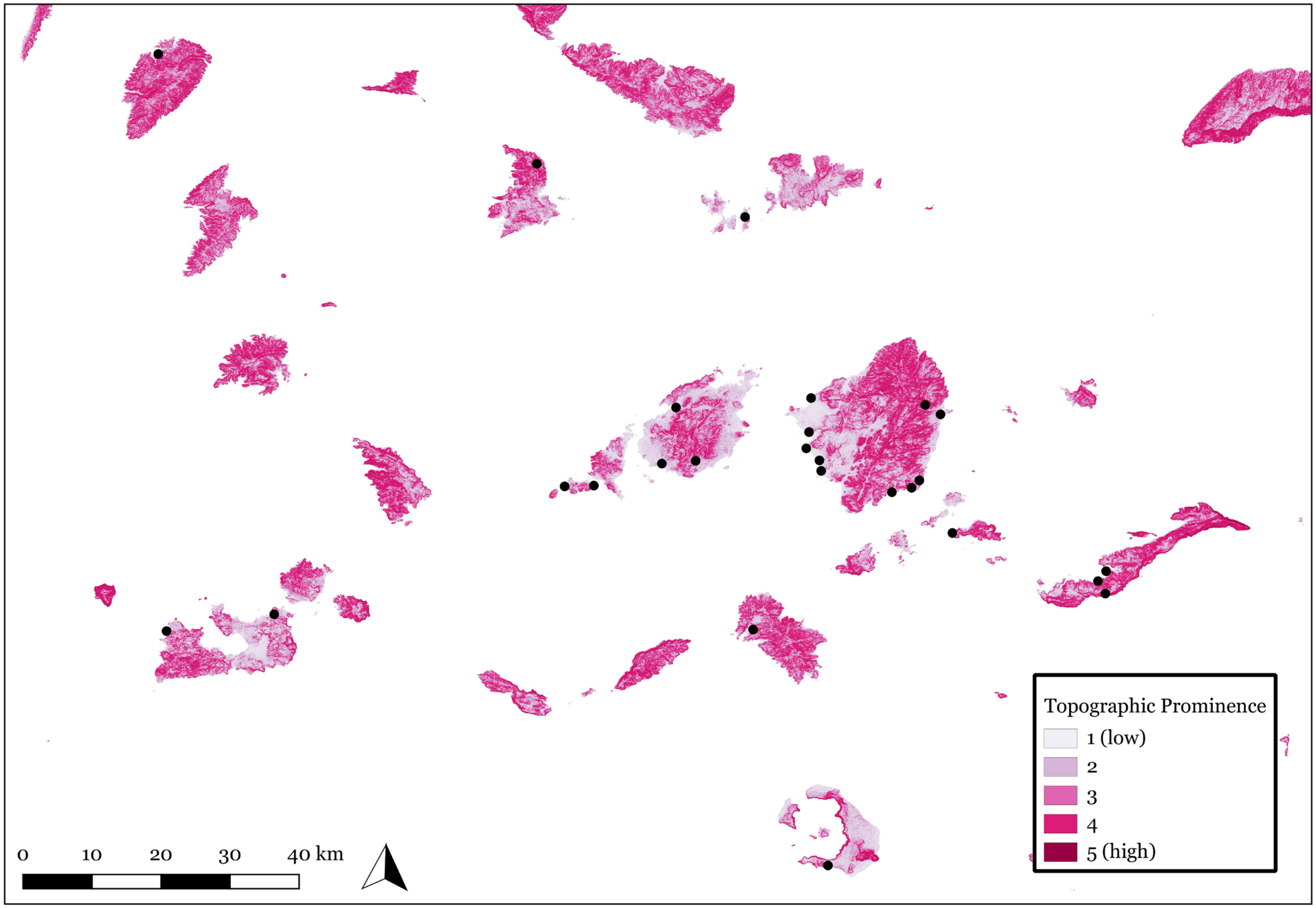


Figure 4.5. Topographic Prominence Index (TPI) Map of Early Cycladic Sites

fensibility—such as the enclosure wall surrounding a single house at Paroikia. At Markiani, the wall along the northern portion of the site has been interpreted as an enclosure wall, a terrace, a fortification, and as a windbreak, and it does not follow that any one of these functions necessarily excludes the others. In light of this ambiguity, I use the term *enceinte* to indicate any wall or architectural elaboration along the perimeter of a site which could potentially serve a defensive function (see Keeley, et al. 2007). By this definition, the gates restricting access to Mt Kynthos are considered *enceintes,* as are enclosure walls and bastions. The question of whether these *enceintes* functioned as defensive structures is discussed below, in comparison with domestic wall thicknesses and topographic prominence.

The thickness of domestic walls serves as a baseline for testing whether or not *enceintes* served a defensive purpose. This study assumes that fortification walls would have been substantially thicker than the walls of the settlement buildings they enclose, which I refer to here as domestic walls.[37] The average thicknesses of *enceintes* and domestic walls for each period for the EBA Cyclades are summarized in table 4.8.

In the six sites where *enceinte* and domestic wall thicknesses may be compared to one another—Dhaskalio, Kastri, Kastraki, Markiani, Mt Kynthos, and Panermos—in all but one case the ratio was nearly equal to or greater than 2:1 (see figure 4.6). The single exception was Dhaskalio, where, as mentioned previously, the exterior walls have been interpreted as architectural terraces rather than as enclosure walls. In the two cases where *enceinte* thickness could be estimated but not domestic wall thickness—Markiani (EC I) and Spedos (EC III)—the *enceinte* thickness in both cases was greater than 1 m.

37 For comparison, the fortification wall at Troy I (ca. 3000/2900-2600/2550 BCE) is on average approximately 2.5 m thick, while based on drawings of the site plan, the row houses from Troy I have walls ranging from approximately 0.75 to 1.75 m thick (Blegen, et al. 1950; Ivanova 2013), resulting in an *enceinte*/domestic wall ratio of approximately 1.4 to 3.3.

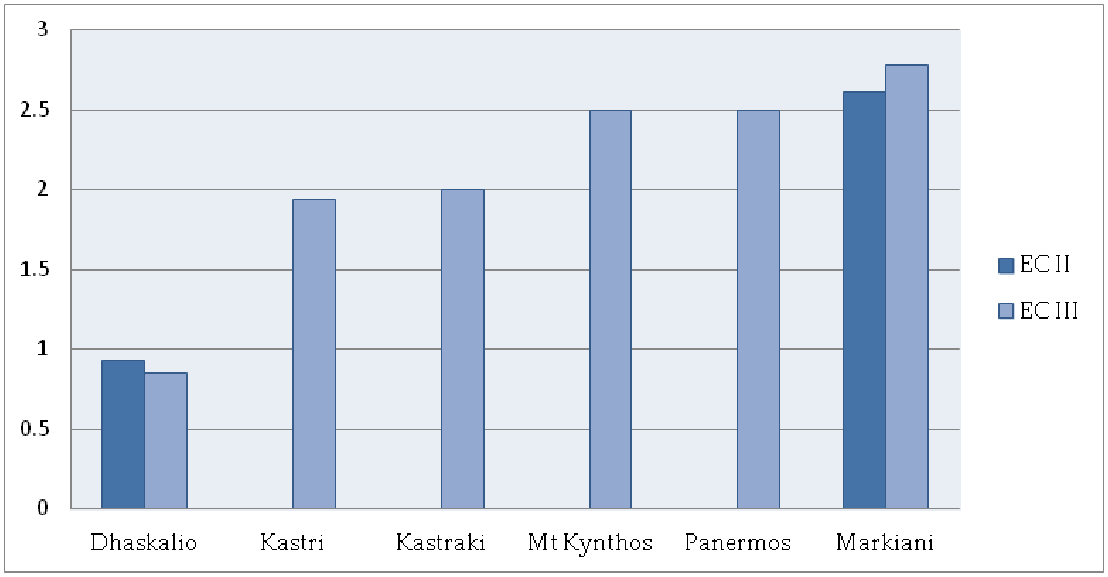


Figure 4.6. Ratio of *Enceinte* to Domestic Wall Thickness

In their study on cross-cultural features of fortifications (i.e. architectural features with a primarily defensive function), Keeley, et al. (2007) identify three archaeologically visible features that are universally used in military defenses: V-sectioned ditches, defended gates, and bastions. There is no evidence at present for the first of these in EC settlements, however arguments may be made for the presence of the last two. Defended gates may be defined as points of access into a settlement which provide defenders with protection, height, and a "screen of maneuver" (Keeley, et al. 2007: 62). Gates are constructed at the points of greatest access to a settlement, where there are the fewest natural hindrances, and therefore, they are the points of greatest weakness of a defensive perimeter.

Table 4.8. Average *Enceinte* and Domestic Wall Thicknesses by Chronological Phase[a]

Site name	*Enceinte* (cm)	Dom. Wall (cm)	Ratio
EC I (Grotta-Pelos phase)			
Markiani[b]	115	—	n/a
Zoumparia[c]	n/a	n/a	n/a
EC I II (Kampos phase)			
Grotta[d]	—	50	n/a
Markiani[e]	n/a	n/a	n/a
Panermos[f]	—	25	n/a
Pyrgos[g]	—	42.5	n/a
EC II (Keros-Syros Phase)			
Ayia Irini[h]	—	85	n/a
Dhaskalio-Kavos[i]	53	57	0.93
Grotta	—	n/a	n/a
Markiani	150	57.5	2.61
Paroikia[j]	—	50	n.a
Phyrroges[k]	n/a	n/a	n/a
Pyrgos	n/a	n/a	n/a
Skarkos[l]	n/a	77.5[m]	n/a
EC III (Kastri phase)			
Avyssos[n]	—	70	n/a
Ayia Irini	—	85	n/a
Chalandriani-Kastri[o]	155	80	1.94
Dhaskalio-Kavos	45	53	0.85
Dokathismata[p]	n/a	n/a	n/a
Kastraki[q]	100	50	2
Korphi t'Aroniou[r]	—	45	n/a
Markiani	160	57.5	2.78
Moutsounas[s]	—	n/a	n/a
Mt Kynthos[t]	125	50	2.5
Panermos	150	60	2.5
Paroikia	n/a	n/a	n/a
Phylakopi[u]	—	70	n/a
Pyrgos	—	37.5	n/a
Spedos[v]	180	n/a	n/a

[a]The designation "n/a" indicates insufficient information; either not enough archaeological investigation has been done to offer a secure estimate, or the publication records for the site do not include wall thickness. The designation "—" indicates that the feature is not present or was destroyed by post-depositional processes.
[b]French and Whitelaw 1999; Marangou, et al. 2006.
[c]Doumas 1977: 25; Zapheiropoulou 1960: 2463.
[d]Kontoleon 1949.
[e] Though occupation was continual, this was not considered a separate phase by the excavators.
[f]Angelopoulou 2008.
[g]Tsountas 1898: 167.
[h]Barber 1987; Caskey 1971; Wilson 2013.
[i]Renfrew, et al. 2013.
[j]Rubensohn 1917.
[k]Doumas 1977: 25; Stephanos 1904.
[l]Marthari 1990; 2008.
[m]This number represents ground-floor wall measurements only. Skarkos is the only site in the Cyclades where domestic architecture is preserved above the ground floor level, so for comparability, I include only the ground floor measurement. The average wall thickness of second story walls at Skarkos is a considerably thinner 45 cm.
[n]Renfrew 1967; Tsountas 1898.
[o]Bossert 1967; Tsountas 1899.
[p]Tsountas 1898: 166, pl. 9: 21, 24, 29.
[q]Doumas 1977: 25.
[r]Doumas 1965.
[s]Zapheiropoulou 1965.
[t] MacGillvray 1980; Plassart 1928.
[u]Mackenzie 1898; Renfrew, et al. 2007.
[v]Doumas 1977: 25.

The extant example of a possible defended gate structure in the EC period is Mt Kynthos, where passageway θ represents the likely main entrance to the site (see figure 4.7). It is the only break in the perimeter, which is otherwise ringed by natural bedrock boulders. Two small rooms, κ and η, which have thick walls, flank the narrow passageway to control it (MacGillivray 1980).

Bastions are architectural features external to a barrier wall which are large enough to hold several defenders and their ranged weapons. The only document-ed function of bastions, especially when regularly-spaced, is to direct fire against attackers (Keeley, et al. 2007: 55).

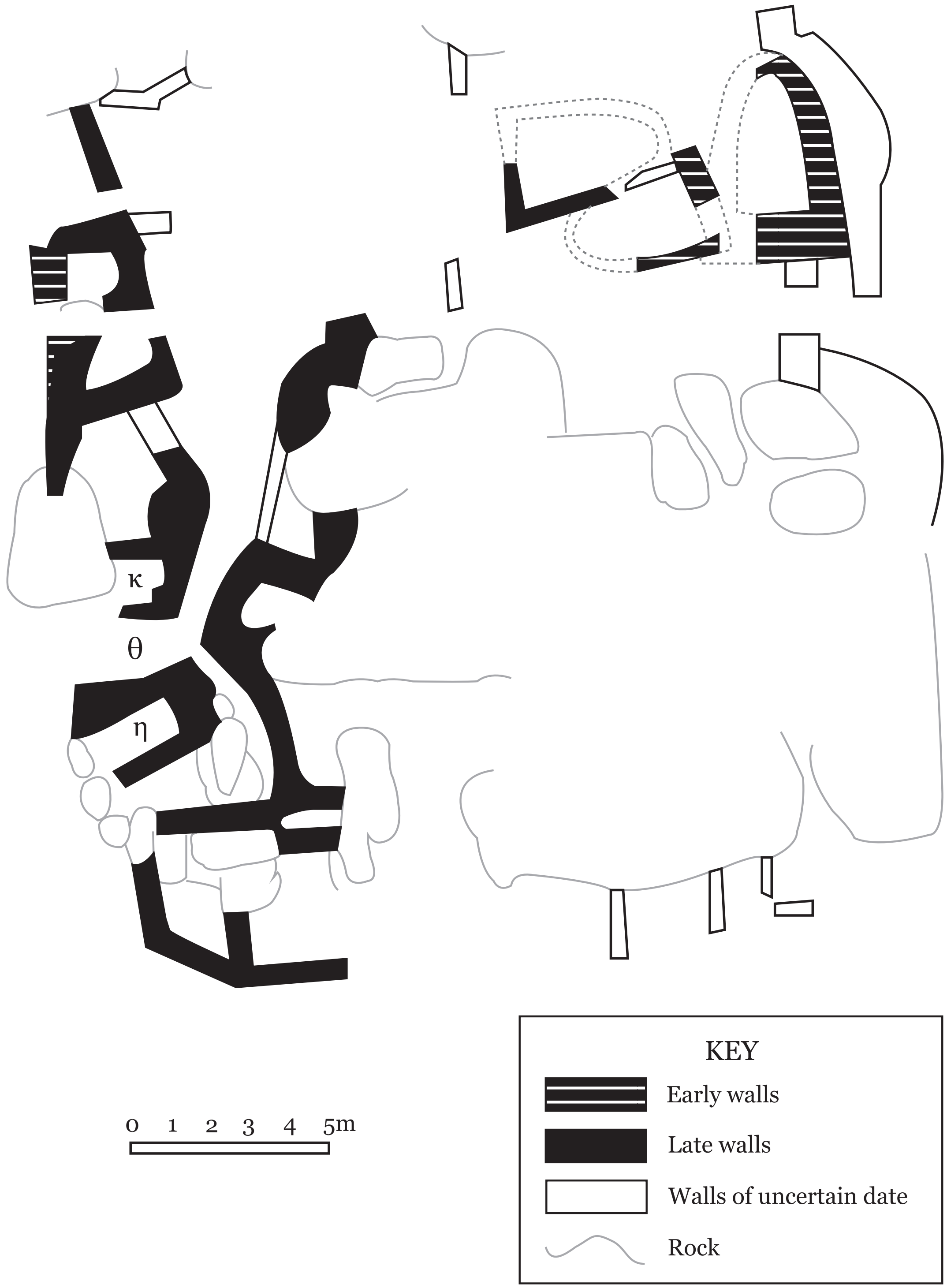


Figure 4.7. Site Layout of Early Cycladic Mt Kynthos (Delos)
After MacGillivray (1980: figure 1).

The clearest example of a series of regularly-spaced bastions along a perimeter wall is at Kastri (figure 4.8). Bastions α through ε are regularly spaced along the thick perimeter wall, and their interior space is approximately 4 m^2. Markiani and Panermos also contain features which have been interpreted as bastions, though their classification as such is decidedly less clear. At Markiani, so-called bastions were added to the enclosure wall at the north side of the site during the EC II (Keros-Syros) period. However, because the wall is only preserved for a short length, it is not clear whether these structures continued at regular intervals along the perimeter. At Panermos, the so-called bastions are not located along a perimeter wall but within the main architectural complex at the site. Towers α through ε (figure 4.9) have been interpreted as bastions primarily due to the extreme thickness of their walls (cf. Angelopoulou 2008). I conducted a spatial syntax analysis (Hillier and Hanson 1984) of the site (discussed in detail in chapter 5), which did showed that these "towers" were not distinguished from the rest of the architectural remains by access or function, and they are located at varying minimum depths. This indicates that wall thickness alone is not sufficient to categorize an *enceinte* as defensive.

Interpreting the Data

None of these variables in isolation is enough to conclude that an EC settlement served a defensive function. When considered together, however, topographic prominence, wall thickness, and the presence of defensive architectural features can indicate that defense was at least partially a function of a settlement. Furthermore, the changes in architectural elaboration through the addition of *enceintes* over time may show changes in the practices of warfare and/or the choices of inhabitants to respond to it.

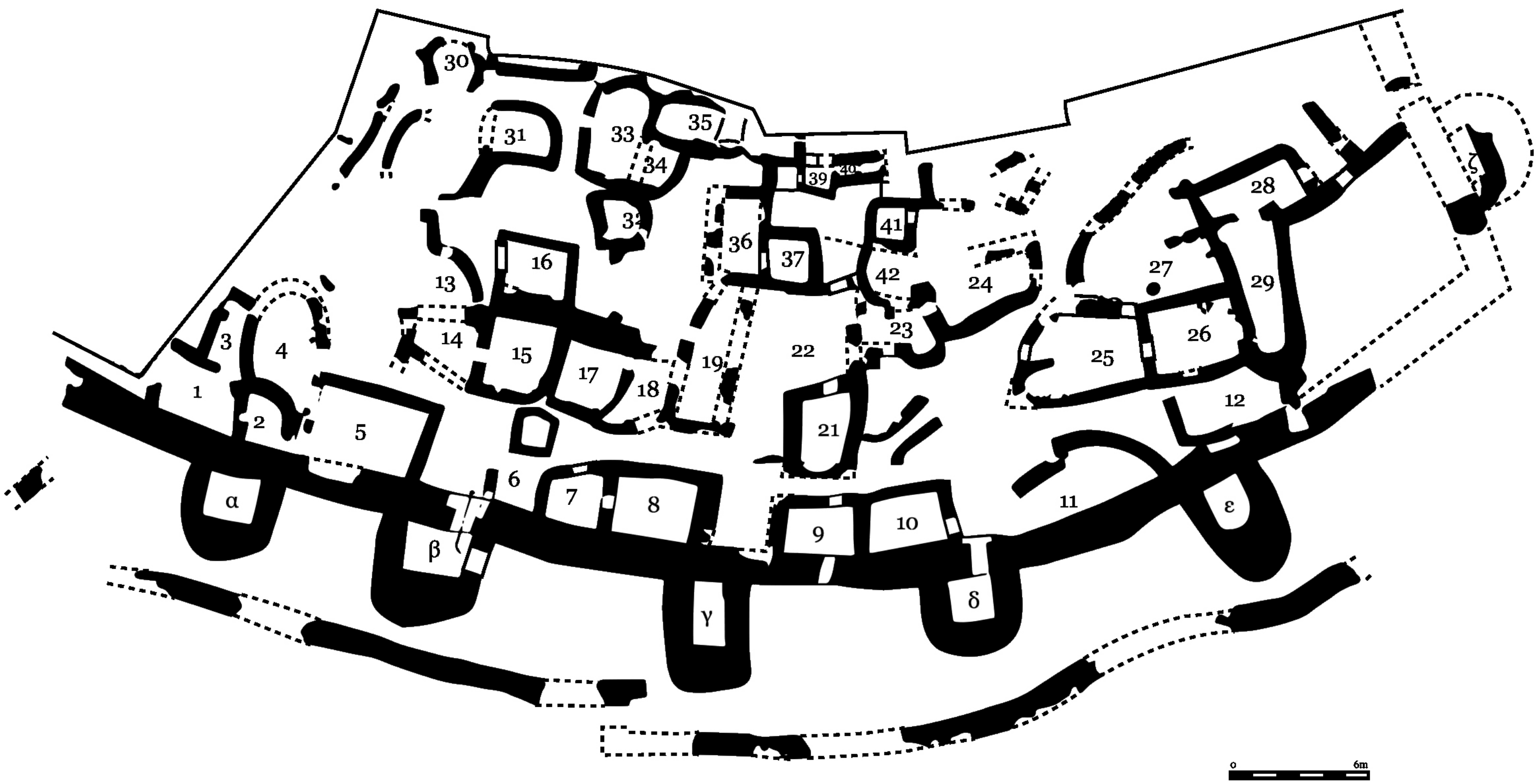


Figure 4.8. Site Layout of Early Cycladic Kastri (Syros)
After Bossert (1967: 56).

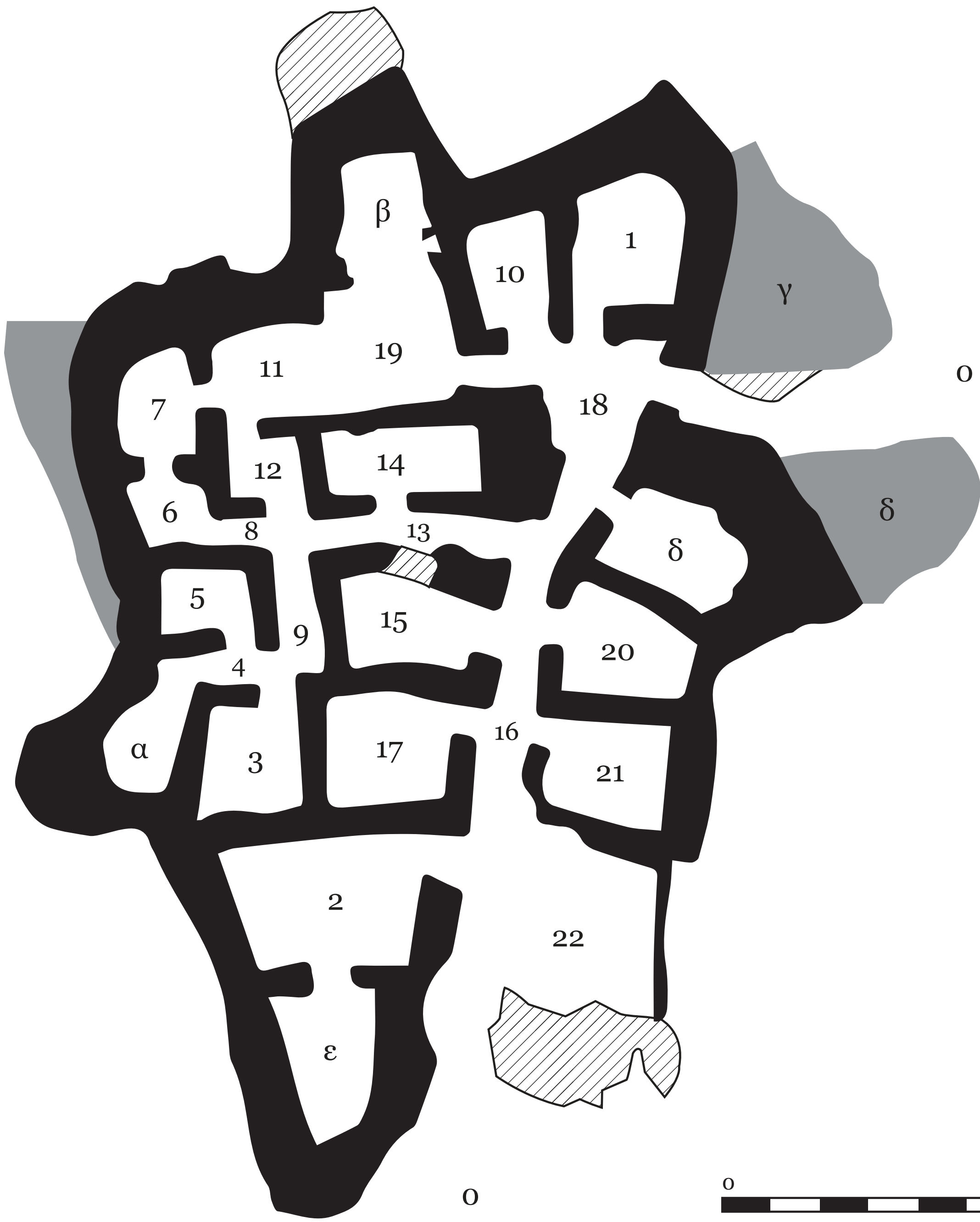


Figure 4.9. Site Layout of Early Cycladic Panermos (Naxos)
After Angelopoulou (2008: fig. 16.1).

Based on a combination of these variables, I assign to each site a degree of fortification, loosely adapted from Otterbein 1970): 0) no fortification, low topographic prominence; 1) no fortification, high topographic prominence; 2) fortification, low topographic prominence; and 3) fortification, high topographic prominence (see table 4.9). If a site's TPI score is in the top 40% (7 or higher), it is considered to have high topographic prominence.

0. No fortification, low topographic prominence

This category is the easiest to assign. It is very unlikely that the settlements in this category served a defensive purpose. For the EC I-II transition (Kampos group), this includes the single house at Panermos and Pyrgos. During EC II (Keros-Syros phase), Dhaskalio, Paroikia, Phylakopi, Phyrroges, and Skarkos fall into this category, although in the latter three cases more archaeological data is required to confirm the lack of fortification. Dhaskalio and Skarkos are major sites during this period, so it does not follow that the EC centers necessarily needed to serve a defensive function as a safe haven to which the peoples of the surrounding area flocked in times of duress.

During the EC III period, the settlements at Avyssos, Dhaskalio, Moutsounas, Phylakopi, Paroikia, and Pyrgos have both low TPI and no fortification. I also argue that Panermos and Kastraki fall into this category. Although the thick walls at Panermos have been described as bastions, as discussed above, this alone is not enough to persuade me that they served a defensive function (see appendix A). Because the enclosure wall at Kastraki encircles only a single house, despite its impressive thickness, I have also concluded that it is unlikely that this is fortification.

1. No fortification, high topographic prominence

Sites with no fortification but high topographic prominence are naturally defensible, but without additional evidence it is impossible to say whether the natural defensibility of a locale was a primary factor in settlers' choosing to establish themselves there. Beginning in the EC I-II transition through the end of EC II, Grotta has no fortification and has a low TPI score. During the EC II period, Ayia Irini also fits into this category, and it continues to be unfortified through the EC III. Dokathismata and Korphi t'Aroniou exhibit no fortification and high TPI during the Kastri phase.

Ayia Irini, Dhaskalio, and Grotta are all major settlements in the Early Cycladic during their respective occupation phases, yet none of them is fortified. However, all have high visibility in common. This indicates that visual prominence may have been a major factor in the development of settlements into local centers during this time. A fourth major unfortified settlement, Skarkos, is therefore something of an anomaly, since its inland location does not afford particularly good visibility or defensibility. Though beyond the scale of the present project, future research might consider the prominence of these settlements from the surrounding landscape. There is also the possibility of defensive features located beyond the settlements themselves, such as watchtowers, which may be overlooked in excavation, which would require targeted archaeological investigation to discover.

2. Fortification, low topographic prominence

The only settlement that falls securely into this category is Mt Kynthos, however its low TPI may be due to the fact that Delos as a whole is low in both elevation and ruggedness. Mt Kynthos is located on a high part of the island, but this elevation is low in comparison with the other Cycladic islands. Considered on a local scale, it is likely that Mt Kynthos would be classified as having high TPI and therefore, relatively high natural defensibility.

Further archaeological excavation at Zoumparia is needed before being able to securely assign it a degree of fortification score. If the *enceinte* there—surface remains of a perimeter wall were reported—is in fact a fortification, it would fall into this category.

3. Fortification, high topographic prominence

The settlements in this category have their natural defensibility enhanced with fortifications in the forms of walls, bastions, and/or gates that restrict access to a site. Throughout the EBA, Markiani is a fortified site, and the settlers chose to elaborate on the earlier fortifications as time passed, adding bastions and extending the enclosure wall. It is furthermore the only site from those selected for this study to be occupied for the entire duration of the EBA, although excavation evidence did not indicate architectural changes during the EC I-II transition (Marangou, et al. 2006).

No other sites in this category emerge until the EC III period, when Kastri and Spedos are constructed. All three of these sites have visual command over the coastline below, and all are on elevated, rugged terrain. The double perimeter wall and regular bastions at Kastri make it the most elaborate fortification on the islands during the Early Bronze Age. More archaeological research at Spedos is needed, however, its high TPI and the 1.8 m thick fortification wall surveyed by the Cambridge Southeast Naxos Survey (SENS) demonstrate its defensive purpose, as is discussed in more detail in chapter 5.

Without exception, sites in this category were fortified from the earliest phases of their occupation. While at Markiani, subsequent occupants of the site embellished the earlier defensive architecture, in no case does the stratigraphic sequence suggest that a previously unfortified site was fortified during a later period of occupation, at least within the Early Bronze Age.

One question that arises from the data is how do these patterns change during the rest of the Bronze Age? Unfortunately, such consideration is beyond the scope of the current project, but it would be worthwhile to investigate whether sites of high topographic prominence but no fortification during the EBA are those selected for fortification in the later periods. This might illuminate the degree to which topographic prominence factors into decisions about where to build defensive sites.

Table 4.9. Fortification Classification of Early Cycladic Settlements by Chronological Phase

Site name	TPI	Enceinte (cm)	Dom. Wall (cm)	Ratio	Other features	Deg. of Fort.
EC I (Grotta-Pelos phase)						
Markiani	12	115	—	n/a	Encl. wall	3
Zoumparia	6.5	n/a	n/a	n/a	Encl. wall	2?
EC I II (Kampos phase)						
Grotta	7.5	—	50	n/a		1
Markiani	12	n/a	n/a	n/a		3
Panermos	6	—	25	n/a		0
Pyrgos	6	—	42.5	n/a		0
EC II (Keros-Syros Phase)						
Ayia Irini	9	—	85	n/a		1
Dhaskalio-Kavos	6	53	57	0.93	Terraces	0
Grotta	7.5	—	n/a	n/a		1
Markiani	12	150	57.5	2.61	Bastion	3
Paroikia	3	—	50	n.a		0
Phylakopi	3.5	n/a	n/a	n/a		0
Phyrroges	3	n/a	n/a	n/a		0
Skarkos	4.5	n/a	77.5[a]	n/a		0
EC III (Kastri phase)						
Avyssos	4	—	70	n/a		0
Ayia Irini	9	—	85	n/a		1
Chalandriani-Kastri	10.5	155	80	1.94	Bastions, double encl. wall	3
Dhaskalio-Kavos	6	45	53	0.85	Terraces	0
Dokathismata	10	n/a	n/a	n/a		1
Kastraki	6	100	50	2	House encl. wall	0
Korphi t'Aroniou	8.5	—	45	n/a		1
Markiani	12	160	57.5	2.78	Encl. wall extended, bastions	3
Moutsounas	6	—	n/a	n/a		0
Mt Kynthos	5	125	50	2.5	Gates?	2
Panermos	6	150	60	2.5	Bastions/towers?	0
Phylakopi	3.5	n/a	n/a	n/a		0
Paroikia	3	—	70	n/a		0
Pyrgos	6	—	37.5	n/a		0
Spedos	9	180	n/a	n/a	Encl. wall	3

[a]Only the wall thicknesses of first story walls were used to calculate average wall thickness.

Discussion: The Dimensions of War in the EBA Cyclades

Solometo (2006) lists the following dimensions of war: social distance, social scale, tactics, goals, frequency, predictability, and duration. In addition to these, I discuss leadership and geographical extent of war, with particular regards to the island geography of the Cyclades.

Social Distance

In the EBA Cyclades, the social distance between warring groups would likely have been quite close. Cycladic islanders shared much overlap in terms of cultural markers with similar material culture, settlement patterning, iconography, etc. Social distance is measured by number and nature of kinship ties, perceptions of group identity, trade relationships, and other beneficial relationships (Solometo 2007: 27). The archaeological evidence for the EB II period in particular is so cohesive as to have been dubbed a time of "international spirit" for the islanders, in which commonalities between groups on different islands throughout the Cyclades would have recognized shared cultural identity (Broodbank 2000). While the strong social relationships between EBA Cycladic communities might have led to frequent friction, their social nearness would have encouraged swift reconciliation, less risk of death for warring individuals, and less property damage than in warfare between more socially distance groups (Koch 1974; Meggitt 1977; Solometo 2006: 28; see chapters 3 and 6).

Social Scale

The size of groups participating in warfare would have likely been quite small. Given what little evidence we have about sailing technology, the mode *du jour* of travel—the Cycladic longboat—could have carried approximately 25 individuals, not including any goods or persons captured as a result of war. Even taking into consideration that multiple boats could have been used, the high resource cost of wood, the high labor cost of agricultural subsistence, and the overall low population levels of the Early Cycladic period would have meant that a very limited number of the population would have been available to participate in war.

Tactics

Since the EBA Cyclades were a small-scale, decentralized society, it is likely that warfare would have taken the form of raiding. As Allen and Arkush (2006: 5) write:

> Raiding warfare may be practices for plunder, prestige, revenge, and vacated territory (and of course, for defense against enemies with similar goals)… Raiding warfare tends to be conducted so as to harass, decimate, and terrorize the enemy group. Surprise attacks on villages, ambushes of work parties, and hit-and-run raids are common, while organized battles may be relatively bloodless, with projectile fire but little hand-to-hand combat.

Raiding parties traveling by sea would likely have been relatively small. Given the low population density and overall numbers in the EBA Cyclades, mustering the required number of warriors would have been difficult. Bintliff (2012: 108-109) estimates that to support a longboat crew of 25, the corresponding community size would have to be approximately 125 individuals, including children. The small crew size of sailing technology indicates that raiding parties would likely not have exceeded one or two longboats' worth of fighters. Very few sites would have been able to muster more than one boat's worth of raiders. For example, of the large Cycladic cemeteries, only Chalandriani's population—which ranged from 38-250 individuals (the variation depends on how long of a time period is represented by the cemetery)—*might* have produced a large enough local population to crew a longboat (Broodbank 1989; 2000: 178). The risk of raiding via longboat would have to be carefully calculated, since the loss of even one boat could have been disastrous to a community.

Periodic larger gatherings—such as those at Dhaskalio, which the excavators of the site estimate consisted of 300-500 individuals (Renfrew, et al. 2013)—might have furnished populations large enough for war, but whether the purpose for such gatherings included warfare remains to be determined. If this was indeed the case, the targets of warfare may have comprised "others" outside the gathering community, such as to the east,[38] although this requires broader contextualization of the Cyclades within their southern Aegean setting.

<u>Motivations and Goals</u>

Because the EBA Cyclades lacked a centralized political power structure, it is unlikely that settlements would have had the infrastructure or population to sustain lengthy campaigns of conquest. Combat may have recurred with predictable frequency (see below), but these were likely short-lived. The two most possible motivations for Early Cycladic warfare were a) material gain and b) prestige and/or revenge. In the first case, if the goal of warfare would be to decimate or otherwise incapacitate the enemy, the destruction of subsistence goods would have had

38 Rutter (1983) noted the importance of the Anatolianizing elements in Kastri assemblages to the topic of the Early Cycladic "gap." The Anatolianizing phenomenon of Kastri material culture is debated by Aegean prehistorians (see Broodbank 2000: 309-19 for a critique of the literature), with some arguing that it represents migration of peoples from Anatolia and others seeing it as evidence of trade. Pullen (2013) stresses that Kastri material culture was not a coherent cultural package, and more archaeological study is required to elucidate the relationship of the Cyclades with Anatolia during this cultural phase.

a devastating effect on enemy populations. War parties might have also sought the capture of women, since Cycladic island populations were by most estimates low and dispersed.[39]

In the second of these two instances—prestige and revenge—"war parties motivated by revenge or prestige are likely to pursue tactics resulting in a limited number of enemy fatalities to repay past offenses or to meet the requirements of a display of bravery" (Solometo 2006: 29). The taking of women would be one motivation for revenge attacks, especially given the low population numbers of the Cyclades.[40] If revenge or prestige was the goal of war, during which enemies would exchange single deaths, enemy encounters likely took place away from settlements (ibid). War parties also might have been motivated by material goals—such as the acquisition of prestige objects.

Because the participating groups were likely to have small social distance, "warriors from related communities are more likely to avoid the deaths of non-combatants and to minimize property destruction than socially distant enemies" (Solometo 2006: 29). Furthermore, groups with close social distance are unlikely to disrupt the local economy through the destruction or theft of subsistence goods, and the small size of Early Cycladic transport vessels would mean that stealing bulk goods during a raid would be cumbersome and unlikely.

This indicates that generally, Cycladic islanders were more likely to go to war for prestige or revenge. Likewise, shared ceremonial precepts might have meant that the destruction of religious centers or structures of social importance would

39 The adoption of war captives to supplement population levels is attested in precontact Iroquoian warfare, forming a primary reason for going to war (Carpenter 2001: 35-4; 2004).

40 As Maschner and Reedy-Maschner (1998: 22) write, "status and prestige, access to mates, and revenge are just as critical to the success of many societies as are foodstuffs."

have been prohibited (Solometo 2006: 29). Because the EBA Cyclades were not politically centralized nor does there seem to have been an institutionalized social hierarchy, it is unlikely that conquest would have been a motivation for war. However, in a context of emerging social hierarchy, war might have been a way to prove one's leadership capabilities, gain social standing, acquire small prestige items, or construct masculine identity. As Broodbank (2000: 253, 256) writes:

> In the Cyclades, the reasons for fighting, besides glorification through combat, are likely to have been the accumulation of prestigious objects, the seizing of animals or crops as a wealth-accruing strategy (or desperate measure in lean years), and the capture of people—maybe often women, given the latter's importance for reproduction in a world of exogamous settlements…In fact, there is likely to have been an often invisibly fine line dividing trading from raiding between island communities. In this sense, Renfrew's dating of the origins of 'piracy' to the EB II period slightly misses the mark (Renfrew 1972: 399), for piracy can hardly exist without recognized sea-laws, and there must be a strong suspicion that the only sea-laws that existed in the early Cyclades were those that were made and unmade by the practices of powerful island people.

Due to their close social distance it is unlikely that EC communities would engage in permanent war or attacks that resulted in high casualties or property destruction. Rather, warfare would be motivated by prestige or revenge, which may also be labeled "wars of redress." In his study of island warfare in Papua New Guinea, Sillitoe (1978) identified several characteristics of wars of redress. In all cases, intercommunity marriage to the enemy was permitted, and there were a large amount of individual ties between rival groups. Causes for war included theft, interpersonal disputes, sexual offenses, payment failures, sorcery, and property disputes, though this last was by far the least common. These types of conflict were overwhelmingly settled with peace and/or reparation, allowing for the maintenance of close social ties (Sillitoe 1978: table 5, p. 262). Therefore it is possible that EC islanders engaged in warfare with one another and simultaneously maintained close interpersonal ties between community groups. In the absence of a centralize justice system, war was often a means of righting perceived wrongs as well as an opportunity for young men to gain social prestige.

Leadership

In non-state, small-scale societies, decisions that affect the group—including decisions to go to war—are usually made through discussion, consensus, and shared risks and rewards (Sillitoe 1978; see Allen and Arkush 2006: 5). There exists no political infrastructure to compel individuals to fight on behalf of a larger cause, so the decision to go to war must have a consensus based on "personal and community-wide sentiment" (Solometo 2006: 25).

Moreover, in the Early Cycladic period, much scholarly emphasis has been placed on the so-called "big men," the emergent elites who marshaled longboat crews through their personal charisma and sailed throughout the region, acquiring prestige items and social capital (Broodbank 2000; cf. Hekman 2003). A big man may be defined as a leader "who achieves some degree of control over the actions of other men because he excels in certain activities where success earns him high status" (Sillitoe 1978: 253). The origins of Cycladic big men in archaeological scholarship are drawn from ethnographic comparanda, in particular from Melanesia (e.g. Godelier and Strathern 1991). For its importance as a factor in both non-state warfare and in the particular case study of the early Cyclades, I add "leadership" as a dimension of war to Solometo's (2006) list.

The archaeological evidence of leadership in the early Cyclades is restricted to data from burials. Hekman (2003) studied the burials from Chalandriani and concluded that, in some instances, due to the quantity and composition of grave goods, individuals who were likely heads of families or community leaders could be identified (Hekman 2003: 197). Hekman posits that the community of approximately 75-100 individuals residing at Chalandriani during the EC II period would have required a leader, if not permanently, then at least in times of crisis (2003: 196). There was indeed one such tomb, number 268, which held 29 artifacts, which was twelve greater than the next wealthiest burial. As Bintliff (2012: 112) notes, however, funerary wealth at Chalandriani was evidenced more by quantity of goods, rather than quality, and it is impossible to say whether these artifacts represent individual possessions or graveside offerings to the deceased. However, Bintliff (2012) and Kilian-Dirlmaier (2005) agree that it seems likely that the rare appearance of very rich graves in small EC communities was likely facilitated by the successful organization of high-risk, high-reward maritime ventures, which may have included both trade and warfare.

Sillitoe's (1978) study of big men and warfare in Papua New Guinea offers a comparandum of how communities in non-state societies make joint decisions to go to war under the influence of a few, powerful individuals. Because big men do not enjoy permanent increased status, but instead face rivalry from within their own group, they must judge opportune moments to either advocate for war or oppose it as best furthers their own aims. This leads to several types of social patterns.

First, the successful big man is one who can manipulate situations to his own advantage, but their role in decisions about whether to go to war is largely unseen (Sillitoe 1978: 254). Rather, they subtly influence discussions about war to control the overall climate of opinion in favor with their plans. For example, a big man who feels he would benefit from going to war with another group might support the right to vengeance on behalf of another.

Second, the volatility of a big man's power leads to maintaining intercommunity social ties. Because alliances shift and residences change, big men maintain external social relationships to extend their influence, call upon allies in times of war, and take refuge should their power be challenged (Sillitoe 1978: 254). This might mean maintaining relationships with groups with whom a big man's own community goes to war, highlighting the complex and multivariate intercommunity relationships present in non-state societies.

Finally, ethnographic comparanda reveal demographic patterns related to decisions to go to war. Although community decisions more generally may be made by all genders, the group that makes decisions on warfare is typically comprised of adult males. Furthermore, old men are less favorably inclined to warfare and more likely to seek diplomatic compromise, while young men are more eager to go to war for the chance to gain social standing (Vandkilde 2006: 114-115).

Early Cycladic warfare was likely conducted under the influence of individuals who stood to gain or lose a great deal from the decision to go to war, and they could have a profound influence on group decisions to go to war. Based on ethnographic comparanda, the choice to start a war was likely a male one, and it benefited young men more than old ones. War might have material benefits for successful fighters, such as prestige goods, although success in war likely did not lead to a permanent increase in status. Therefore, those who would benefit most from warfare would have not been "big men" whose power was already established, but rather those who aspired to power. Despite intercommunity warfare, individuals maintained personal ties with members of other communities, demonstrating the value of alliance and cooperation.

Frequency and Predictability

Fortification indicates that groups subject to continual warfare (i.e. in which warfare occurs one or more times per year) are likely to fortify their settlements, while *all* groups who experience conflict less than once per year do not invest in fortifications (Otterbein 1970; Solometo 2006: 30). While not a guarantee of continual warfare, the archaeological evidence for defensive constructions—which require a high investment cost in labor and resources—indicates a high frequency of armed conflict in the past (Solometo 2006: 31). Because the social distance in the EBA Cyclades was close, it is likely that warfare among Cycladic communities was highly predictable. Groups with close ties will contain "informants" who can pass along information of impending armed conflict (Solometo 2006). Year-round high labor demands for subsistence—as discussed in chapter 3—make it unclear whether there would have been an opportune period of the year for conducting warfare.

Duration

The duration of individual attacks among non-state societies is usually brief (Solometo 2006: 32). Tribal war parties typically lack the supply capability to finance lengthy sieges (Turney-High 1949; Solometo 2006). Moreover, in the Cyclades, the method of transport to war—likely Cycladic longboats—would mean a very limited capacity for supplies to carry on a sustained attack, especially if room was to be left over to supply a return voyage and carry back any spoils of war. The close social distance of Cycladic communities would also provide a strong incentive to reconcile (see Solometo 2006: 32-33). As Kelly (2000:119) writes, "Conflict among related groups is thus likely to result in the cyclical alternation of war and peace."

The large-scale gatherings at Dhaskalio (see Renfrew, et al. 2013) might have been fundamental in renewing intercommunity relations and maintaining or restoring peace. Periodic ritual gatherings would reinforce a shared sense of cultural identity. In the context of warfare, the sanctuary at Dhaskalio might gain additional prominence within the Cycladic region as a site for managing rivalries.

Geographical Extent

In addition to Solometo's (2006) dimensions of war, I posit that the geographical extent of war—how the physical topography of the islands and available sailing technologies impacted intercommunity interaction and travel—would have had a profound effect on shaping the nature of warfare in the EC period. I suggest that Cycladic island landscapes would have altered warfare in three ways: 1) restricting the scale of war, 2) affecting the nature of war, and 3) inhibiting the formation of large-scale political bodies.

First, the consideration of the scale of warfare is especially important for maritime groups, since travel by boat would have been the most likely vehicle for conducting war against other groups. I discuss the extent of maritime travel in greater detail in chapter 6, but for outbound trips lasting more than a day, raiding parties would have needed safe havens to stop over on their voyages, which would require intimate knowledge of the land or guaranteed allies to host them.

Second, the island topography would have impacted the nature of warfare in two ways. The first is related to maritime travel; islanders conducting war would not have been able to carry back goods beyond what would fit in their longboats. This means that it would be difficult to steal bulk goods, animals, or other products related to subsistence. The kidnapping of people might be more feasible, but it is most likely that if goods were stolen, they were small prestige objects. Ecological conditions also affect the nature of fighting. Sillitoe (1978) found that types of warfare tended to correspond with different types of terrain. For example, battles and frequent raids occurred on the most stable ground, such as mixed forest and grassland, while infrequent raids occurred in swamps and rainforest. This is partly because high cover and difficult terrain make the communication required for battle tactics impossible. Sillitoe (1978) also found that wars of redress, such as those that would have been likely in the Cyclades, would have occurred more frequently in high population areas, and therefore tend to correlate with terrains that support high populations, such as grasslands. Translated to the rocky and fragmentary landscapes of the Cyclades, based on Sillitoe's (1978) findings we would expect fighting to occur near population centers, which might explain choices to settle on areas of prominent or rugged terrain.

Finally, the topography of the Cyclades and the presence of natural buffer zones, such as mountainous areas, poor agricultural areas, and the sea, may have inhibited the intercommunity alliances that in other parts of the world increased social complexity by dramatically raising carrying capacity. Comparison with Polynesian societies offers a parallel. As Leblanc (2006: 459) notes, it was unusual for whole island or multi-island political groups to form given the fragmented nature of the landscape:

Much of this may have been due to topography, with water barriers and high island ridges providing defensive features and limiting communication, thereby hindering the formation of larger polities. In particular, if there were natural buffer zones that were unproductive, then there was no carrying-capacity benefit to increased polity size. Based on these three types of impact that the natural topography would have had, I submit the landscape itself—as I investigate in the following chapter—as a major actor that influenced the nature and outcomes of EC warfare.

Chapter 5
Small World Networks
The Case of Southern Naxos

Introduction

In the previous two chapters I set out parameters for investigating Early Cycladic (EC) community interaction. In chapter 3, I examined recent evidence for EC subsistence production and posited that communities during the Early Bronze Age (EBA) in the Cyclades would have likely cooperated to ensure mutual survival during times of hardship. Chapter 4 focused on antagonistic forms of interaction by examining the evidence of fortification and warfare for this time period.

In the present chapter, I draw on the previous chapters to examine a particular Early Cycladic small world—comprised of the habitual interaction of communities within its bounds—on the southern coast of Naxos. I create geographic information systems (GIS) models of how human movement through the landscape creates place. In particular, the mapping of "action spaces" offers a methodology for archaeologists to study the formation of place as a result of human movement and social interaction in otherwise undifferentiated landscapes. This methodology reveals dynamic places of habitual social interaction that would remain "hidden" in site- or region-based archaeological research. The resulting GIS models show that even during periods of decline on the rest of the island, the communities of southern Naxos—though geographically and agriculturally marginal—demonstrate evidence for long-lived and stable ties, indicating that the marginality of this small world may have increased, rather than detracted from, the strength of its intercommunity relationships.

Case Study: Southern Naxos

In the present chapter, I focus on the landscape of the coast of southern Naxos as a case-study for modeling human mobility (see figure 5.1 for all Early Bronze Age sites of Naxos). I chose four areas of interest—Spedos, Panermos, Korphi t'Aroniou, and the Kalandos Valley (see appendix A)—based on several variables that unite them in terms of archaeological settlement patterns and topography.

First, the settlement distribution of Naxos during the Early Bronze Age indicates that these four areas of interest remained closely associated throughout the period. Figure 5.2 shows the distribution of Early Bronze Age settlements on Naxos through the different cultural phases of the era. The settlements are circled with 5 km radius buffers to give a general indication of which sites might have been in close contact with each other—this serves as a general illustration for habitual movement which is refined by the GIS models below. Emerging out of the Final Neolithic, the Grotta-Pelos phase (ca. 3100-2950 BCE) shows a relatively even settlement distribution across the island. The presence of the long-lived settlement at Zas Cave links the western settlements of the island with those of the south. During the Keros-Syros phase (ca. 2650-2500 BCE),[41] new settlements emerge to cluster with existing settlements, creating three distinct regions in the west, south, and northeast. This clustering is amplified during the Kastri phase (ca. 2500-2250 BCE), when the decrease in overall settlement numbers results in further isolation.

Second, the topography of Naxos isolates these four sites from the rest of the island. Topographically, the Mt Zas massif—which runs the length of the

41 The Kampos phase is omitted in figure 5.2 because the majority of early site surveys do not acknowledge it as a phase distinct from the preceding Grotta-Pelos phase and the subsequent Keros-Syros phase. Due to recent efforts for absolute dating in the Early Cycladic period (see Manning 2008), this results in a substantial 300-year gap between the Grotta-Pelos and Keros-Syros phases.

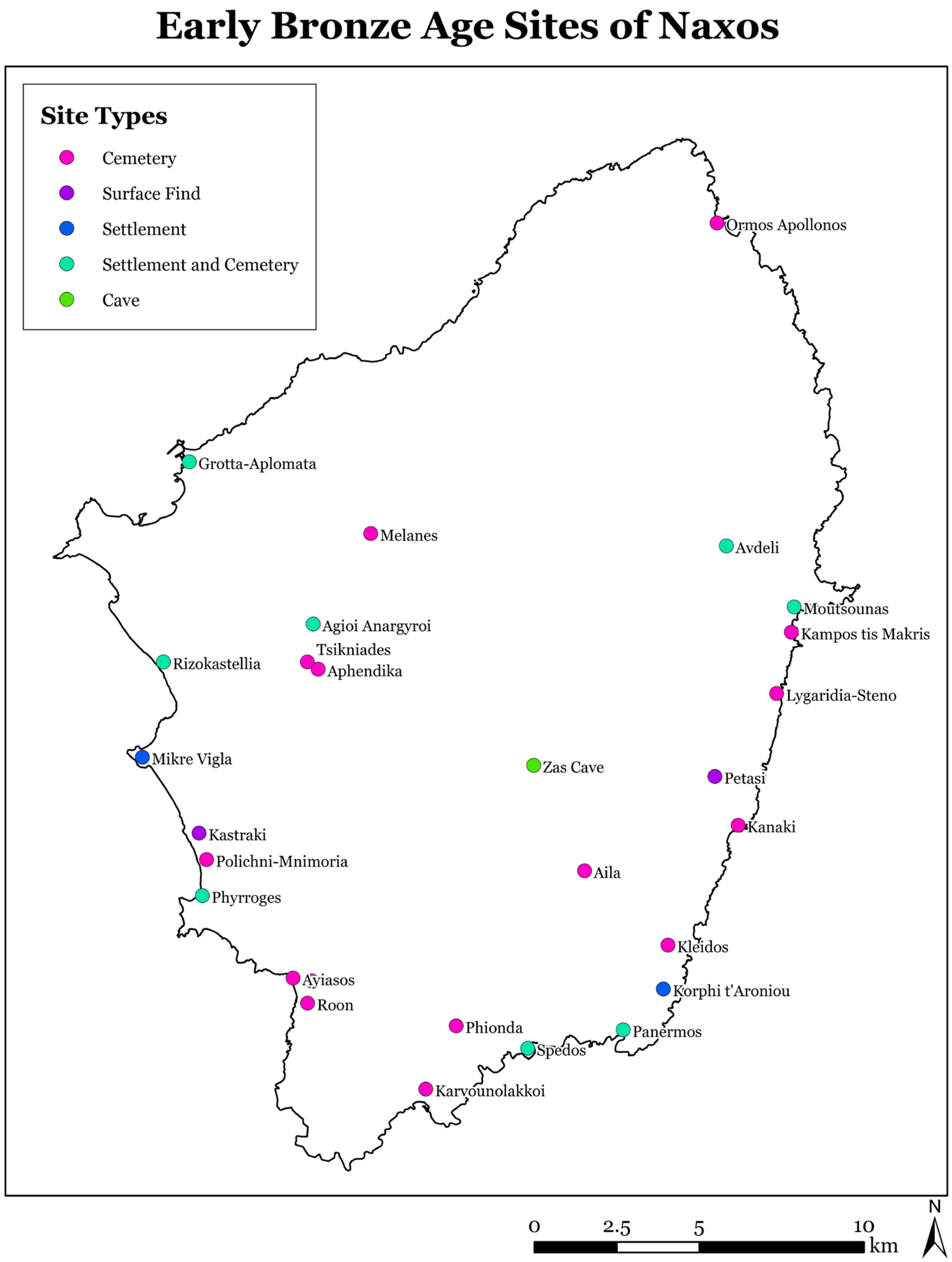


Figure 5.1. Early Bronze Age Sites of Naxos
This figure shows the Early Bronze Age sites of Naxos categorized by site type.

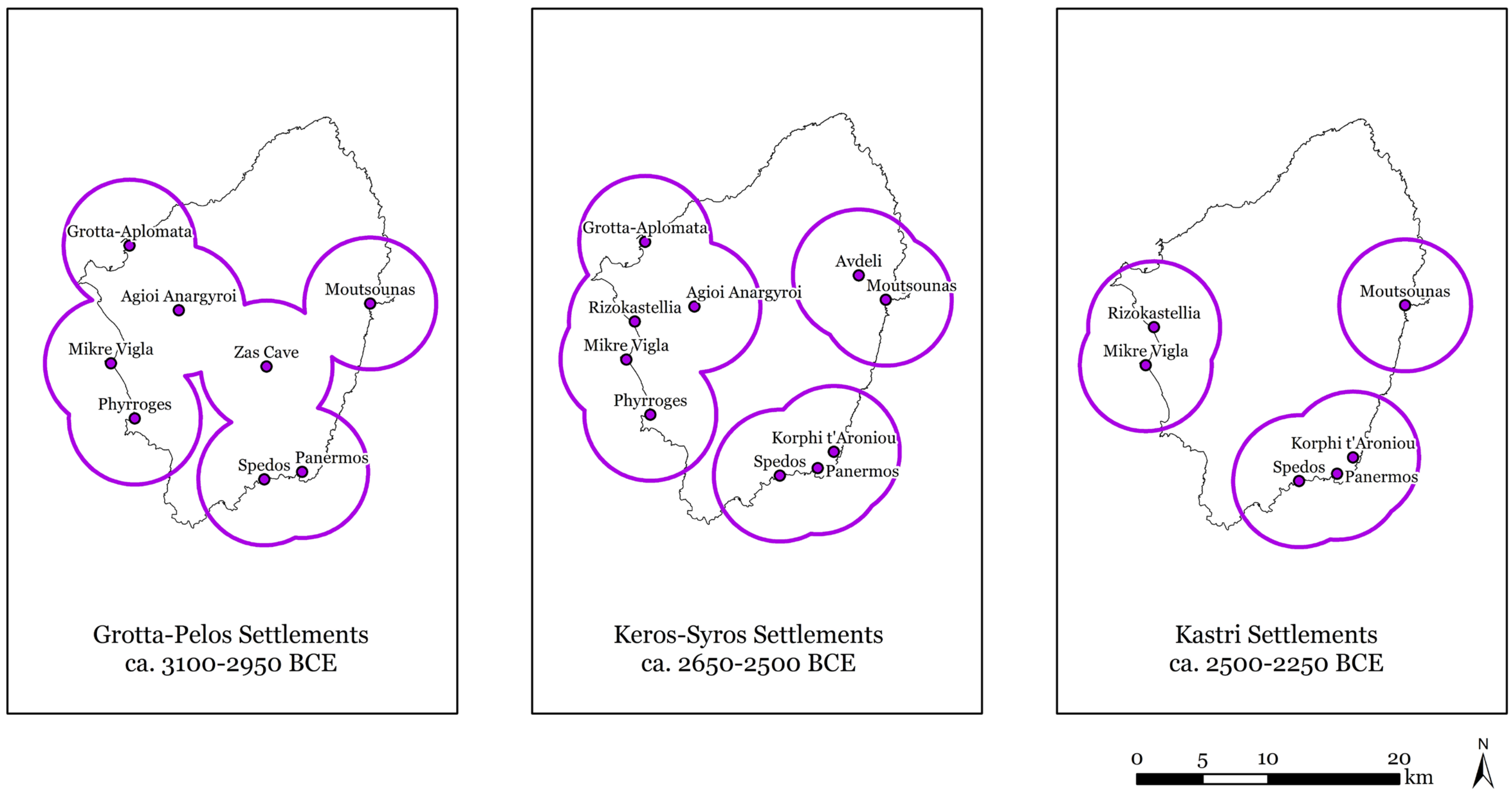


Figure 5.2. Early Bronze Age Settlements on Naxos by Chronological Period
This figure shows changing settlement patterns on Naxos during the Early Bronze Age. Each settlement is drawn with a 5 km buffer to illustrate potential overlapping spheres of contact and influence.

island roughly from south to north—separates the southeastern part of Naxos from the northern and western parts of the island. The massif creates a physical impedance to accessing sites in the west—such as Ayiasos, Lakkoudes, and Roön—and to the north—such as Aïla—via land routes, though on a map these sites appear nearby (figure 5.3).

Likewise, the environmental conditions of southern Naxos are differentiated from the west coast. Unlike the relatively lush north and west parts of the island, southern Naxos has an arid, marginal climate. In this, it more closely resembles the Erimonisia, Amorgos, and the eastern coast of Ios. Water is scarce. Arable land is located in valleys between steep ridges, creating a fragmented agricultural landscape (Broodbank 2000: 208).

Geologically, the predominant bedrock-types differentiate the eastern and western parts of Naxos. In the northwestern part of the island, the lithology is primarily comprised of granodiorite and alluvium. In the east, however, marble and schist alternate as the parent bedrock material. This directly affects the quality of soil and agricultural potential of the region. The geological, tectonic, and geomorphological status of the island result in a wide variety of formations of different soil types, ranging from very high to very low (practically impermeable), and soil depths that vary from a few centimeters in upslope regions to very deep in valleys and plains (Soulis and Dercas 2007: 183). In terms of geology, southern Naxos has more in common with the Erimonisia to the south than with the northwestern portion of the island.

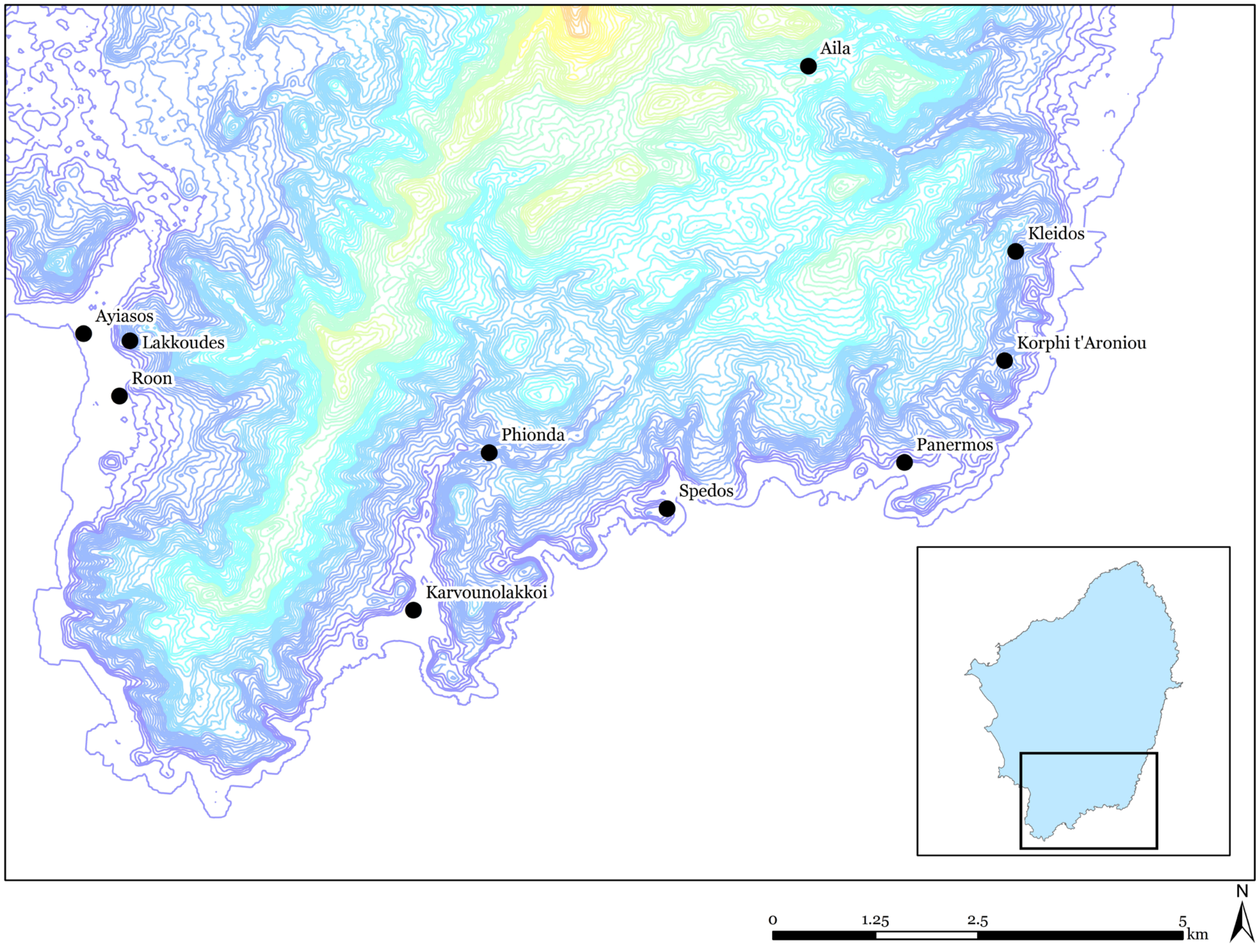


Figure 5.3. Southern Naxos Sites and Topography
This figure shows that despite geographic nearness, the Mt Zas massif separates the sites along the southeastern coast of Naxos from those in the southwest.

Human-Landscape Mobilities

"Mobility" is useful both as a framing device and analytical approach. As a framing device, it allows the consideration of both the mobility of the physical landscape as well as the mobility of humans as they operate within and are affected by the landscape. Even within the time-frame of the Early Bronze Age, climatological evidence suggests environmental changes that may have profoundly impacted the lives of the Cycladic islanders (discussed below).

Most often we think of landscape mobility in terms of the movement of humans, animals, and objects within and over the landscape. However, it is important to consider the mobilities of the landscape itself—i.e. physical changes of the landscape due to geological, climatological, and anthropogenic factors—as having a major impact on human activity. The changes in the physical landscape itself are not typically considered a type of mobility in archaeological scholarship, but how the landscape moves over time is profoundly influenced by and influences the humans operating within that landscape (see Leary 2014: 11-12).

As an analytical device, "mobility" offers an opportunity to examine human-scale experience in the past. As discussed in chapter 2, the definitions of the extent of the daily sphere and habitual sphere of human interaction are defined in terms of how far humans travel in one or two days' time, respectively. It follows, then, that the discussion of human-landscape interactions should occur in terms of mobility rather than in terms of fixed locales.

Because they can be seen on the ground, excavated, and recorded, sites are often the starting point for archaeological investigation (Leary 2014:4). Beginning from the perspective of mobility, however, allows for the identification of places that are not as archaeologically visible or associated with a site under investigation.

The landscape is occupied by moving bodies—both human and animal—and things, and the places where routes of movement cross and overlap form nodes of activity and interaction that would have been meaningful to past inhabitants of the landscape (Lee and Ingold 2006; 78; Ingold 2009; 2011; Leary 2014:4).

To consider how the inhabitants of these four areas of interest might have interacted with one another in the greater landscape, I undertook a series of GIS analyses which are primarily based on mobility, including the creation of site catchments, potential action spaces, and least-cost paths. There is always a danger when using tools that measure human operation in purely functional and optimized terms of relegating human movement to an involuntary reaction rather than as a fundamentally social phenomenon, which Ingold (2004, 2011) has criticized as a "head over heels" approach. This is especially true for the case study of southern Naxos; until the Cambridge South East Naxos Survey (SENS) is published, there is no way of comparing the distribution of material remains with the models produced by GIS analysis to examine when and where the patterns correspond or do not. To ameliorate this limitation somewhat, in the present project I use previous archaeological interpretations of individual settlements to examine moments of human choice within the greater cultural landscape. Furthermore, the calculations I use for movement speed and distance are based on real-world comparanda, which anchors the GIS models in actual human experiences.

There is tension, however, between movement-based definitions of place and the archaeological tools for assessing place. In the Cyclades, the first archaeological surveys were attempts to identify various sites within the landscape, and the resulting gazetteers of these locales are sometimes the only record of the knowledge of a site. Often, as was the case with the early excavation of the Spedos cemetery, the exact location of a site was not even recorded, essentially severing the "site" from its situation within the greater landscape and redefining it as a collection of artifacts from a particular excavation event. Sites and places in earlier archaeological work would have been synonymous, as sites were the only places of which scholars had an archaeological record.

While advancements in archaeological research mean that sites are now considered within their greater landscape context, the relationship between tools such as GIS and landscape analysis can create problems. Because of the way GIS handles data, for certain types of analyses—such as least-cost paths or isochrones, both of which are used in the present project—it requires starting points and end points, which reifies a fixed notion of place in the greater landscape. GIS creates very discrete boundaries, which not only distorts results at the edges of those boundaries but also makes difficult the analysis of variation in human activity. Archaeologists should be mindful of the theoretical implications of GIS tools—which can reify an econometric understanding of human movement—and ameliorate the aforementioned issues by considering aggregate overlaid paths or carefully selecting boundaries for analysis, for example.

Despite these limitations, there have been several successful attempts at integrating research oriented on human experience with GIS in recent years (e.g. Gibson 2007; Kosiba and Bauer 2012; Rennell 2012). These projects incorporate dynamic GIS applications, such as digital elevation models (DEMs), intervisibility, and cost-surface and path modeling, and all maintain an approach which centers on embodied experience within their respective landscapes. By incorporating these same sorts of models, the GIS analyses presented here allow for the recognition of places as overlapping nodes of human movement that might not be as archaeologically visible as settlements with architectural remains or cemeteries.

This type of approach has the possibility of being a useful predictive tool for further archaeological investigation as well as being able to potentially explain the distributions of archaeological material collected during intensive pedestrian survey. However, it is important that these models remain grounded, so to speak, in the archaeological data so that correspondences and tensions with the material record may be used to indicate moments of human choice. The emergence of dynamic digital tools has allowed the creation of models such as viewsheds and cost-surface models that are innately grounded in a physical presence within a landscape. However, while visibility and cost-surface analyses, for example, provide information about *what* is observed, the meaning of that observation must be situated in a greater social context. In other words, archaeologists must consider *whose* landscapes they are reconstructing.

Mobilities of Landscape

Though rarely does the environment directly determine the trajectory of cultural change, geography and the physical landscape exert a considerable influence on the development of anthropogenic landscapes over time by offering a range of possibilities within which human actors may operate (Wilkinson 2003: 11). Therefore the close consideration of the environment and how it changes over time is necessary for a full understanding of the development of cultural landscapes.

When analyzing past landscapes, it is often difficult to separate influences that stem from climatic change from those that are the result of anthropogenic factors. Rather than operating in isolation, these two forces more likely operate in tandem. As Wilkinson (2003: 15) writes:

> When natural and human factors interact, the result may be either a cascade of responses or a complex sequence of feedback processes. Consequently, the form or layout of the resultant landscape may be difficult to anticipate. It is these multi-variable feedback processes—combining both environmental and human factors—that result in the landscape signatures visible to archaeologists.

The reconstruction of past landscape mobilities is a challenging task, and much work remains for archaeologists and geologists in the Cyclades. This section presents a summary of the extant evidence for the climate and geological conditions of the Early Bronze Age. In particular, I consider the ramifications of the so-called 4.2 ka cal BP event—a period of widespread aridity for the northern hemisphere occurring ca. 2200 BCE—for the apparent cultural changes that accompany the end of the Early Bronze Age in the Cyclades. In subsequent sections of this chapter, I combine the environmental data with cultural material and human activity to create a multi-dimensional picture of the sequence of landscape changes of southeastern Naxos throughout the Early Bronze Age.

The Climate of Present-day Naxos

Present-day Naxos has a semi-arid climate with an annual rainfall mean of 373 mm. Most of the rainfall occurs during the winter months, which corresponds with the agricultural growth season. The rest of the year (April-October) averages only about 20 mm of precipitation per month (Soulis and Dercas 2007: 183).

The amount of rainfall varies widely from year to year (figure 5.4). In a study of the changing rainfall regime in Greece, Pnevmatikos and Katsoulis (2006: 336) determined that over a period of 86 years ranging from 1900-1999, Naxos experienced 23 dry years and 23 wet years. In general, the Cycladic islands are one

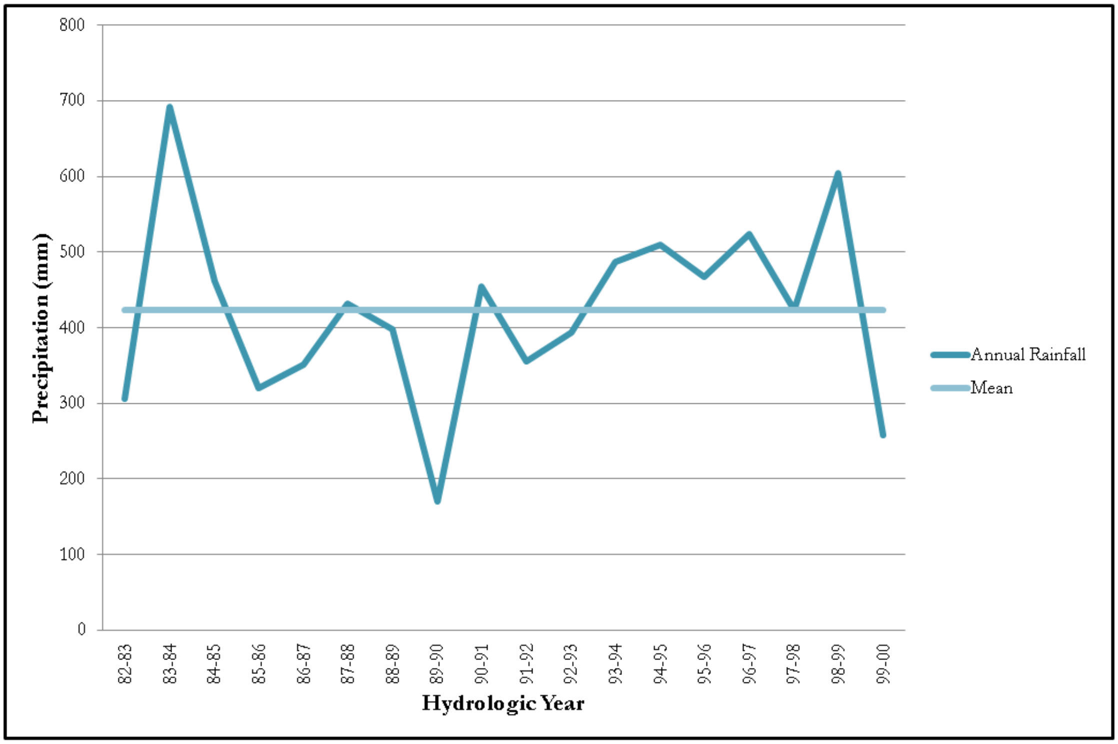


Figure 5.4. Naxos Annual Rainfall Patterns (1982-2000)
Adapted from Soulis and Dercas (2007).

of the worst parts of the southern Aegean for rainfall (Broodbank 2000: 78), suffering frequent water shortages due to high interannual rainfall variability (Wiener 2013: 582; see also Van Andel, et al. 1986: 113; Broodbank 2000: 77-8; Wilson 2008:98). When combined with Naxos's steep relief and variable geological, geomorphologic, and soil conditions, the availability of water for agricultural production fluctuates widely both temporally and spatially (Soulis and Dercas 2007: 191). Unlike some other Cycladic islands which suffer from a dearth of natural water sources, the springs and seasonal water flows on Naxos compensate to some extent for modest rainfall (Broodbank 2000: 78). However, in the long-term none of the Cyclades have sufficient water to sustain modern population levels (Wiener 2013: 582-3).

Compared with other Cycladic islands presented in Pnevmatikos and Katsoulis (2006), Naxos had the lowest percentage of dry years and second-lowest percentage of wet years, which might indicate a lower degree of inter-annual variability—and therefore greater weather predictability—than other islands (table 5.1). As a point of comparison, Melos, which experienced dry years one-third of the time, can expect droughts sufficient to threaten agricultural production at least once per decade (Broodbank 2000: 78). Based on the same ratio, Naxos would expect a crop-threatening drought at least once every thirteen years.[42]

Extrapolating understandings of ancient environments from modern data is a problematic endeavor, however. Since rainfall amounts are largely influenced by topography and wind patterns, one might expect some general characteristics—such as high interannual variability and a semi-arid climate—to hold true for the past as they do for the present. This needs to be considered carefully, however, in the context of environmental and climatological evidence from the Bronze Age to avoid drawing false parallels.

Table 5.1. Wet and Dry Years for Select Cycladic Islands[a]

Meteorological Station	**Total Years**	**Dry Years**		**Wet Years**		**Mean Annual Rainfall (mm)**
		n	%	n	%	
Naxos	86	23	26.74	23	26.74	387
Melos	48	16	33.33	11	22.92	423
Syros	47	16	34.04	18	38.30	369
Kythera	59	17	28.81	16	27.12	543

[a]Adapted from Pnevmatikos and Katsoulis 2006.

42 This is, of course, dependent on the crop in question. Of the two predominant cereal crops of the EC period, barley (*Hordeum vulgare*) is the more drought-resistant; modern domesticates require 390-430 mm of annual rainfall for optimum results (see chapter 3).

Early Bronze Age Naxos - Climate, Chronology, and Collapse

Present-day concerns about climate change have led to an increase in studies about how the Greek environment has changed over time. As recently as the past thirty years, Greece has experienced long periods of drought more severe than the previous norm, which may be the result of myriad environmental and anthropogenic factors (Pnevmatikos and Katsoulis 2006: 344). If meaningful climate changes can be observed in a thirty-year window, what variation is possible for the past five thousand years?

Many studies of the Early Bronze Age Mediterranean climate center on a possible period of prolonged severe drought and/or soil erosion between ca. 2300 and 2000 BCE (Weiberg and Finné 2013: 12; Wiener 2013: 581), which may correspond to the so-called 4.2 ka drought event, a phenomenon observable on an arguably global scale (Booth, et al. 2005; Mayewski, et al. 2004; Finné and Holmgren 2010; Wanner, et al. 2008). The degree of impact, geographic scope, and ultimate cause(s) of this period of increased aridity are widely discussed in archaeological scholarship.[43] Finné, et al. (2011: 3163-3166) review several climatological studies of the 4.2 ka event from the eastern Mediterranean, but as Manning (2013: 105) notes, these studies have widely varying data in terms of type, quality, and resolution. Moreover, their conclusions differ significantly, and the resulting noise makes it unclear what are regional climate variations and what are natural or anthropogenic complications (or a combination thereof).

The scarcity of high-resolution records for the period is a major challenge

43 See Weiss, et al. 1993; Dalfes, et al. 1997; Cullen et al 2000; Finné and Holmgren 2010: 48-9; Finné, et al. 2011; Rapp and Jing 2011: 125; Butzer 2012: 3633-34; Weiss 2012.

facing archaeological reconstruction of the 4.2 ka event in the Mediterranean (see Manning 2013; 2017). In terms of what can be said, the general timeline for major climatic events leading up to and during the Bronze Age is as follows:

Beginning ca. 6000 BCE, rainfall variability begins to increase. Around 4500 BCE, herbs and steppe vegetation increase, rendering the landscape more erosion-prone. However, limited human impact on the landscape during the Neolithic, combined with relatively high vegetation cover, led to no significant changes in sediment dynamics on a regional scale (Dusar, et al. 2011: 152) Between 4000 and 3400 BCE, rainfall was higher than average. The subsequent period from 3400-2600 BCE was still wetter than average, but less so than the preceding period (Finné, et al. 2011: 3169).

Around 2600/2500 BCE, a period of drier conditions and landscape instability begins; there has been a scholarly consensus that this instability was exacerbated by more widespread human impact than in previous periods and the increased sensitivity of the landscape to erosion due to a decrease in vegetation in more arid conditions (van Andel, et al. 1986, 1990; Zangger 1993; Whitelaw 2000: 144; Weiberg and Finné 2013: 10). Extreme rainfall events occurring on a less well-protected land surface would have increased sediment dynamics (Dusar, et al 2011; 152; Finné, et al. 2011: 3169).

Around 2200 BCE "a period of widespread and pronounced aridity" (Finné, et al. 2011: 3169) is evident—the so-called 4.2 ka drought event. However, this is not as clearly indicated in datasets from the Aegean as those from the Near East. During approximately the same time, there is widespread evidence for the destruction and sudden abandonment of many sites on the Greek mainland and on the islands, in addition to the sudden appearance of entirely new forms of material culture. Based on their apparent contemporaneity (though the chronology should not be taken for granted—see below), the 4.2 ka event and changes in material culture and settlement patterns seem intertwined, causing archaeologists to hypothesize about the nature of their relationship.

Maran (1998), for example, argues for a *Kulturwandel*, or cultural change, in the years surrounding ca. 2200 BCE that includes multiple variables. According to Maran's model, both changes in climate (e.g. increased aridity and landscape instability) and anthropogenic factors (e.g. the intensification of agricultural systems causing stress on the landscape) led to breaks in societal structure.

In a critique of Maran's model, Weiberg and Finné (2013: 15-16) suggest that the most critical development during this time period may not have been the transition itself but the preceding increase in centralization—both in terms of socioeconomic factors and consolidation of populations in fewer, larger settlements. This change, they argue, was what disrupted the patterns of dispersed populations that had been developing since the Final Neolithic.

Maran (1998) and Weiberg and Finné (2013) were concerned with the Greek mainland. To what extent are these models applicable to the Cyclades, and in particular, to Naxos? In order to apply the modified *Kulturwandel* model proposed by Weiberg and Finné to Naxos, several criteria that need to be met:

- Evidence for climate and environmental change, in particular signs of increased aridity and landscape destabilization
- Evidence for settlement nucleation, demonstrated by the decrease in overall settlement number but the increase in settlement size
- Evidence for increased social complexity
- Evidence for significant change in social structure and material culture
- Chronological correspondence between changes in the archaeological evidence and the environmental changes

First, there is no direct evidence for climate and environmental change ca. 2200 BCE because geological studies such as those undertaken in mainland Greece (e.g. van Andel, et al. 1986; Weiberg and Finné 2013) have not been conducted in the Cyclades. The closest thing to direct evidence for demonstrated landscape instability during this time comes from analysis at Markiani, Amorgos (French and Whitelaw 1999: 176) where there is evidence for a major erosion episode immediately following the abandonment of the site in ca. 2200 BCE. Given the current lack of direct evidence for climate changes during the Cyclades, it can only be assumed that the broader patterns of increased aridity and subsequent landscape destabilization due to both climate and anthropogenic factors followed a similar pattern to the rest of the East Mediterranean.[44] However, recent studies (Finné and Holmgren 2010; Finné, et al. 2011) caution against the practice of using climate data from other regions to posit climate-based explanatory models (Weiberg and Finné 2013: 12).

Second, while there is evidence for decrease in the overall number of settlements throughout the EBA period (see figure 5.2), there is no decisive evidence for an increase in settlement size that would suggest a pattern of nucleation. Grotta, the largest settlement on Naxos during the EC period, suffers from major postdepositional disturbances which make the establishment of a chronological sequence difficult (Kontoleon 1949; Hadjianastasiou 1989; Broodbank 2000: 220). While the material culture excavated at Mikre Vigla demonstrates that the site was occupied through EC III, the architecture has not been securely dated to show a clear sequence of expansion or change in form (Barber and Hajianasasiou 1989). At

44 Moody (2009) argues for a correlation between an increased period of aridity in the Early Minoan III/Middle Minoan I periods and changes in the Minoan cultural landscape. However, Manning (2017: 452-453) notes several issues with the chronology of Moody's study.

Panermos, the construction of a centralized building—potentially used for storage and/or defense, as discussed above—during the Kastri phase is possible evidence for nucleation, especially given that the underlying EC I stratum contains a much smaller and less robustly constructed building. Spedos is as yet unexcavated and therefore the chronological sequence for the site is not established. In general, the lack of well-established chronological sequences for EBA sites on Naxos in addition to destructive and occluding postdepositional factors make the discussion of changes in site size over time difficult.

Third, as discussed in chapter 3, the evidence for increased social complexity throughout the EC period—in particular, the "big man" model proposed by Broodbank (2000) and others—is problematic. Regardless, in Maran's model, it is not merely increasing social complexity, but increasing social complexity *that results in an unstable and expensive social structure* which contributes to *Kulturwandel.* In the Cyclades, there is little evidence for investment in organizational and administrative structures as there is on the mainland, which peaked ca. 2300 BCE (Weinberg and Finné 2013: 2). If there was an increase in social hierarchy in the Cyclades during this time, there is no evidence that it took the form of expensive-to-maintain social structures as it did on the Greek mainland.

Fourth, however, there is a change in the material culture which is often associated with emerging social complexity. As Steinmann (2015: 235) notes, by 2000 BCE the production of Cycladic figurines seems to end entirely, and the production of other marble prestige goods, such as frying pans, ended by the end of EC III. There is a cessation of lead seals and clay seal impressions found during this phase, which are objects traded from or influenced by Anatolia (Wiener 2014:

S7).[45] Rahmstorf (2015: 151) argues that turmoil in the Anatolian peninsula—due possibly to climatic stress and Akkadian military incursions—may have disrupted trade networks in the Aegean.[46]

During the EB II, there is also an increase in architectural fortification (see Ch. 4), which was followed by the abandonment or destruction of these structures ca. 2300 BCE. Panermos represents an example of this phenomenon, which occurs throughout the Cyclades at this time (Steinmann 2015: 235).

Fifth, there does seem to be a dramatic change in the archaeological evidence for the Cyclades at the end of the EBA, which Rutter (1983) first identified as an Early Cycladic "gap." The chronology, length, nature, and very existence of the gap are still debated among Aegean archaeologists, as evidenced by the recent *AJA* forum in Rutter's honor (Davis, et al. 2013) dedicated to the subject. Rutter's argument was simple: there was no site in the Cyclades with demonstrable stratigraphic, occupational, and cultural continuity from the EB II Keros-Syros culture through to the early Middle Bronze Age habitation of the islands (Davis 2013: 528). Evidence for ceramics, burial customs, and settlement patterns in the early MBA (the Phylakopi I cultural-historical phase) differ dramatically from the EB II Keros-Syros phase. The question of when precisely this "gap" occurs leads to the fifth and final point.

There is still debate about the dating of the EC "gap" in large part due to the broader issue that the relationship between the absolute chronology of the Early Cycladic period and the relative chronologies of Renfrew's original cultural

45 See Massa and Şahoğlu (2015) for a discussion of the 4.2 ka cal BP event and its effects in Anatolia.

46 See Hsiang, et al. (2013) for a discussion on how a major climatic stress event in one critical area can set a population in motion, interrupt trade networks, and have cascading effects including warfare.

phases is unresolved in Aegean archaeology. How one assigns absolute dates to EC cultural phases has a major affect on the potential impact of broader climate and environmental changes during the EBA.

Rutter's initial assumption for the absolute dating of the "gap," which he argued occurred between the Kastri phase in the late EB II period and the start of the Middle Cycladic, placed it in final centuries of the third millennium, and 2200 BCE became the conventional date of the EB II-III transition. More recently, Renfrew, et al. (2012) dated the EB II-III transition to 2300 BCE based on radiocarbon evidence from Dhaskalio. Furthermore, they found no evidence for Rutter's gap.

However, Manning (2017: 459-461) has noted several issues with both Renfrew, et al.'s (2012) radiocarbon dates and the logic of their argument in the relative chronology of EC material culture. In terms of the latter, Renfrew, et al. (2012: 157) state that the evidence at Dhaskalio indicates continuity between successive phases and that it does not indicate a gap. As Manning (2017: 460) notes, the gap would have occurred after the Dhaskalio sequence and before evidence from early Middle Cycladic sites, such as Phylakopi or Akrotiri. Furthermore, Renfrew, et al. (2012: 157) assume that because their radiocarbon dates from Dhaskalio overlap those from Phylakopi I, the end of the Dhaskalio sequence (Phase C) corresponds with the start of the Middle Cycladic. Manning (2017: 460) points out that there is minimal, if any, overlap with the Phylakopi dates in the most statistically probable parts of the respective date ranges.

Manning (2017: 460-461) re-runs the Dhaskalio data with a modifier to account for the long-lived wood samples and places the end of Dhaskalio Phase C in the twenty-fourth century BCE, concluding that the Rutter gap was a period of seventy-five to eighty years in the twenty-third century, and that the Middle Cycladic starts from around ca. 2200 BCE.

With Manning's revisions to the Dhaskalio radiocarbon dates, which place the EC III/MC I transition at ca. 2200 BCE, then the significant changes in late EC II/EC III material culture roughly correspond with the 4.2 ka event, assuming that this environmental change is felt in the Cyclades at approximately the same time as on the mainland. However, the dating of the material culture in conjunction with the dating of the 4.2 ka event is simply not refined enough to say whether the apparent hiatus in cultural material occurred before or after the climatological effects were felt. Therefore, it is not possible to conclude whether the environmental changes in the Cyclades were a contributing factor to the contemporaneous cultural changes. Moreover, it is impossible to say to what extent the Cyclades would have been affected by these environmental changes, which as evidence from other regions has shown, were felt at different times and to different degrees depending on local conditions.

While the direct effect of climate change on life at the end of the EC period is not possible to reconstruct with the present data, evidence for the 4.2 ka event's effects in other areas may have had a large impact on the trade networks that passed from Anatolia through the Cyclades and to the Greek mainland. Turmoil in the Anatolian peninsula—exacerbated by unfavorable environmental conditions—may have caused the collapse of Anatolian-Aegean trade networks (Rahmstorf 2015: 151) and led to the cessation of trade goods from Anatolia found in the Cyclades (Wiener 2014: S7). Therefore, even though the relationship between the 4.2 ka event and the cultural changes surrounding the end of the EC period in the Cyclades are still uncertain given current data, archaeological evidence does support at least a second-order effect from the impact of the 4.2 ka event elsewhere in the Mediterranean. While more geological data is needed to discuss the 4.2 ka event in the Cyclades, one should remember that there is no simple linear relationship between environmental conditions and the trajectory of human cultural change (Wilkinson 2003: 32).

Human Mobility within the Landscape

In this section, I assess different variables pertaining to human movement through and interaction with the landscape in an attempt to both quantify and qualify the environmental affordances of the southeastern part of the island. These variables include: hillslope, potential agricultural land, travel times between sites, agricultural catchments of sites, viewsheds and site intervisibility, and least-cost paths through the landscape.

Hillslope

Figure 5.5 shows the hillslope topography of Naxos as it relates to human pedestrian movement. As a general rule, terrain that is above 15˚ in slope is very difficult to traverse. Slope as variable has the potential to affect a wide array of landscape factors, which are discussed subsequently, including the travel times between sites and the agricultural catchments of sites.

When EBA sites from Naxos are overlain on the hillslope layer, some preliminary observations may be made (see figure 5.6). Naxos is roughly divided between east and west by steep slopes that run from the southwest to the northeast the length of the island. Sites to the west of this mountain range are located in a relatively open lowland area, and movement between them seems relatively

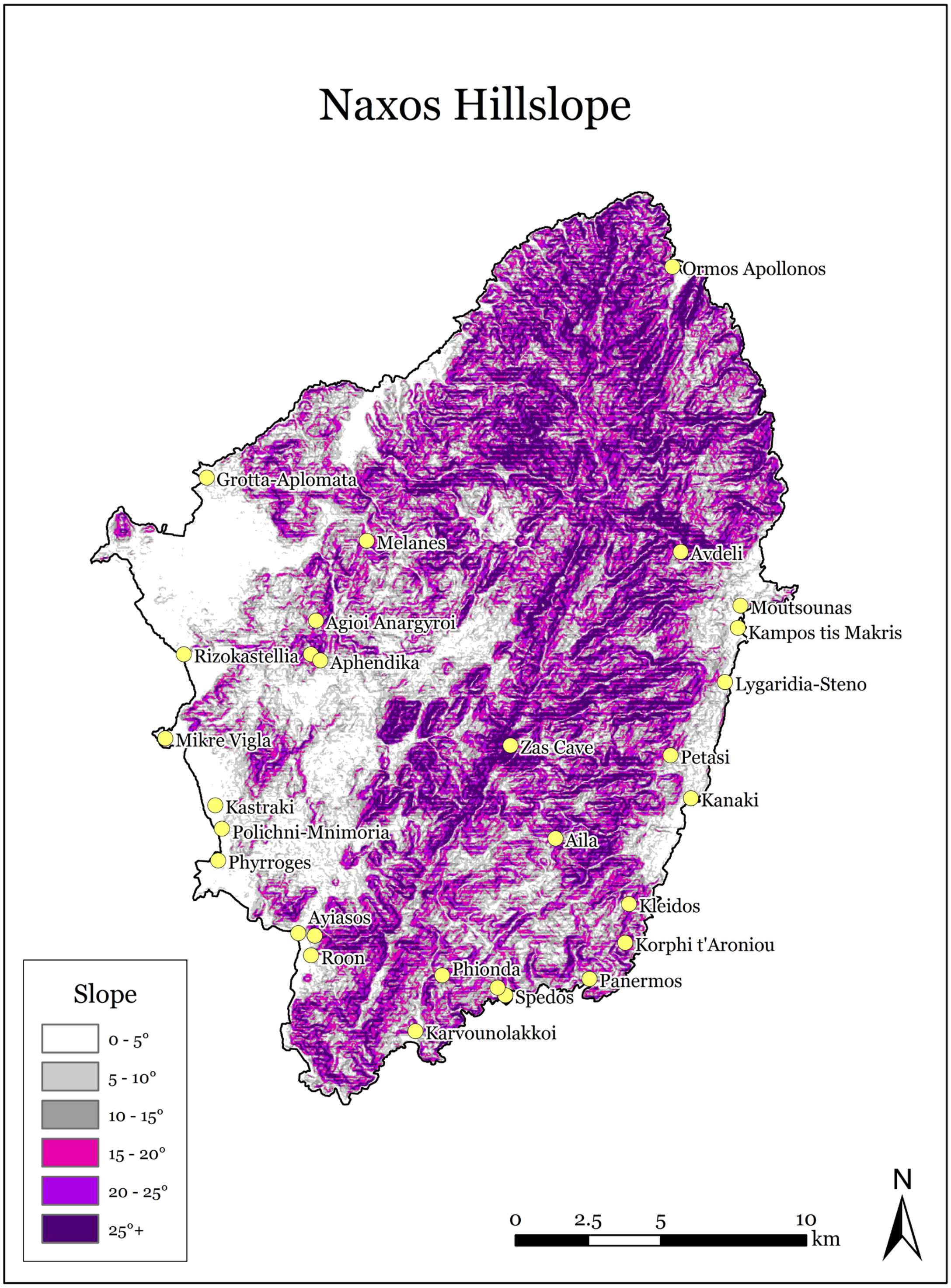


Figure 5.5. Naxos Hillslope
This map shows the hillslope of Naxos. Slope greater than 15° is very difficult for humans to traverse on foot.

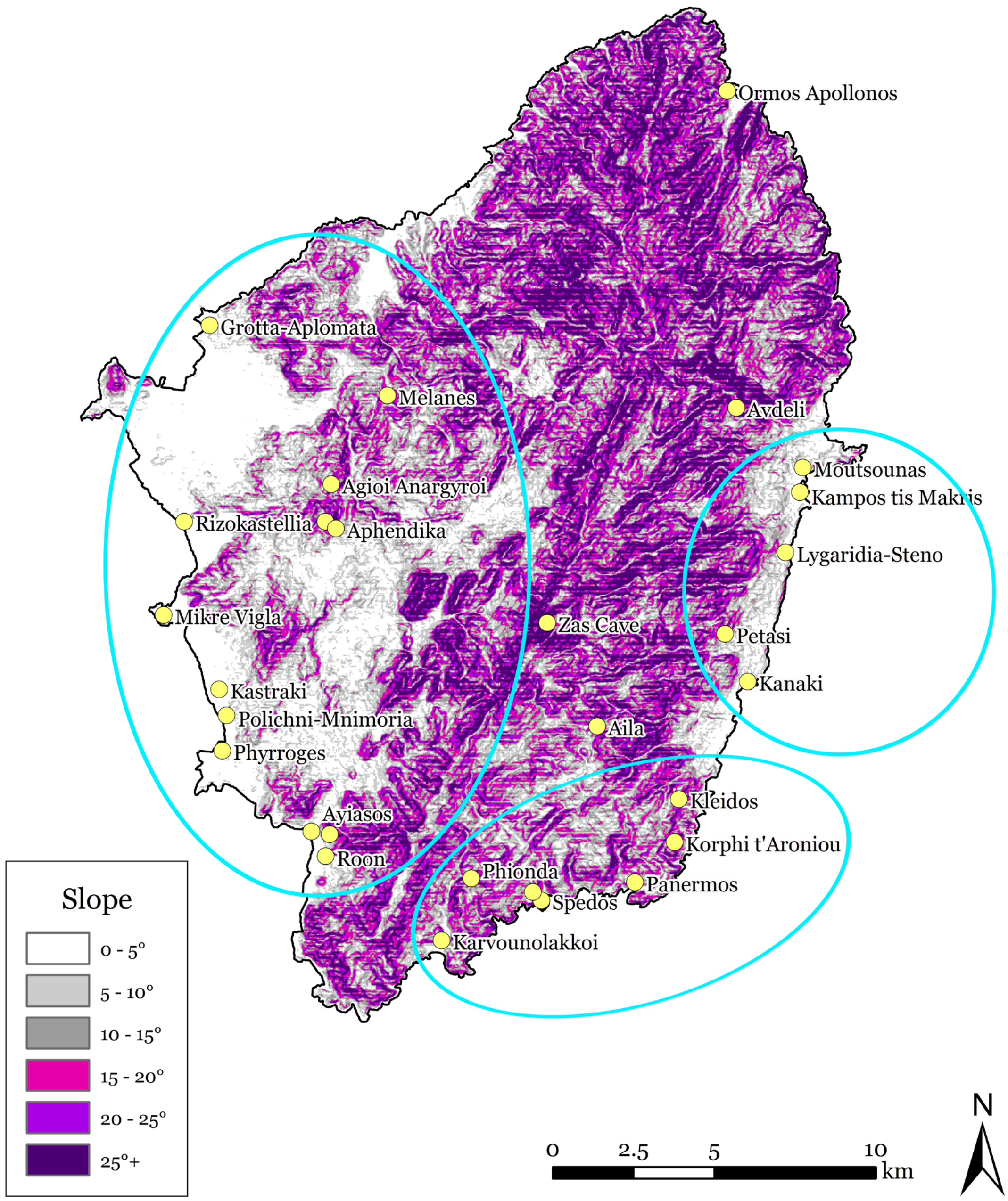


Figure 5.6. Areas of Naxos Grouped According to Hillslope
This figure hypothesizes site clusters based on areas of high, inaccessible slope that would create barriers for land-based travel.

unimpeded. Likewise, the sites on the eastern coast of the island—from Kanaki in the south to Moutsounas in the north—lie along a low-slope access corridor. The cluster of sites on the southeastern coast of Naxos—from Karvounolakkoi to Kleidos—may also form a cluster, though the greater changes in slope and topography indicates this is a region with lower permeability. Zas Cave—and to a lesser extent, Aïla and Avdeli—are unusual in their montane location, both for being situated in very high slope terrain and for their inland locales. Ormos Apollonos on the northeastern coast appears the most isolated site at first glance, and the explanation for its location may be related to other variables, in particular those related to maritime travel and interisland connectivity.

<u>Potential Agricultural Land</u>

The potential agricultural land for EBA Naxos is directly related to slope. In order to plow agricultural land without terracing, the maximum hillslope is somewhere between 10˚ and 12˚. In previous archaeological work on Keos, Whitelaw (1991; 1994; 1998) hypothesized that plowing is possible on slopes greater than 10˚ only if they are terraced (Price and Nixon 2005). On Kythera, Krahtopoulou and Frederick (2008: 558-9) found that slopes above 12˚ were preferentially terraced and south facing slopes were particularly attractive.

Figure 5.7 compares the land area covered by slope <10˚ and slope <12˚, which demonstrates the maximum potential agricultural land on Naxos, assuming that terraces were not in use during this time (though the adoption of terraces during the Bronze Age in the Cyclades is likely). This is a high estimate of potential agricultural land, since slope is the only factor under consideration. Other factors, such as available water, soil quality, vegetation, and proximity to settlements, would all limit the potential agricultural land further.

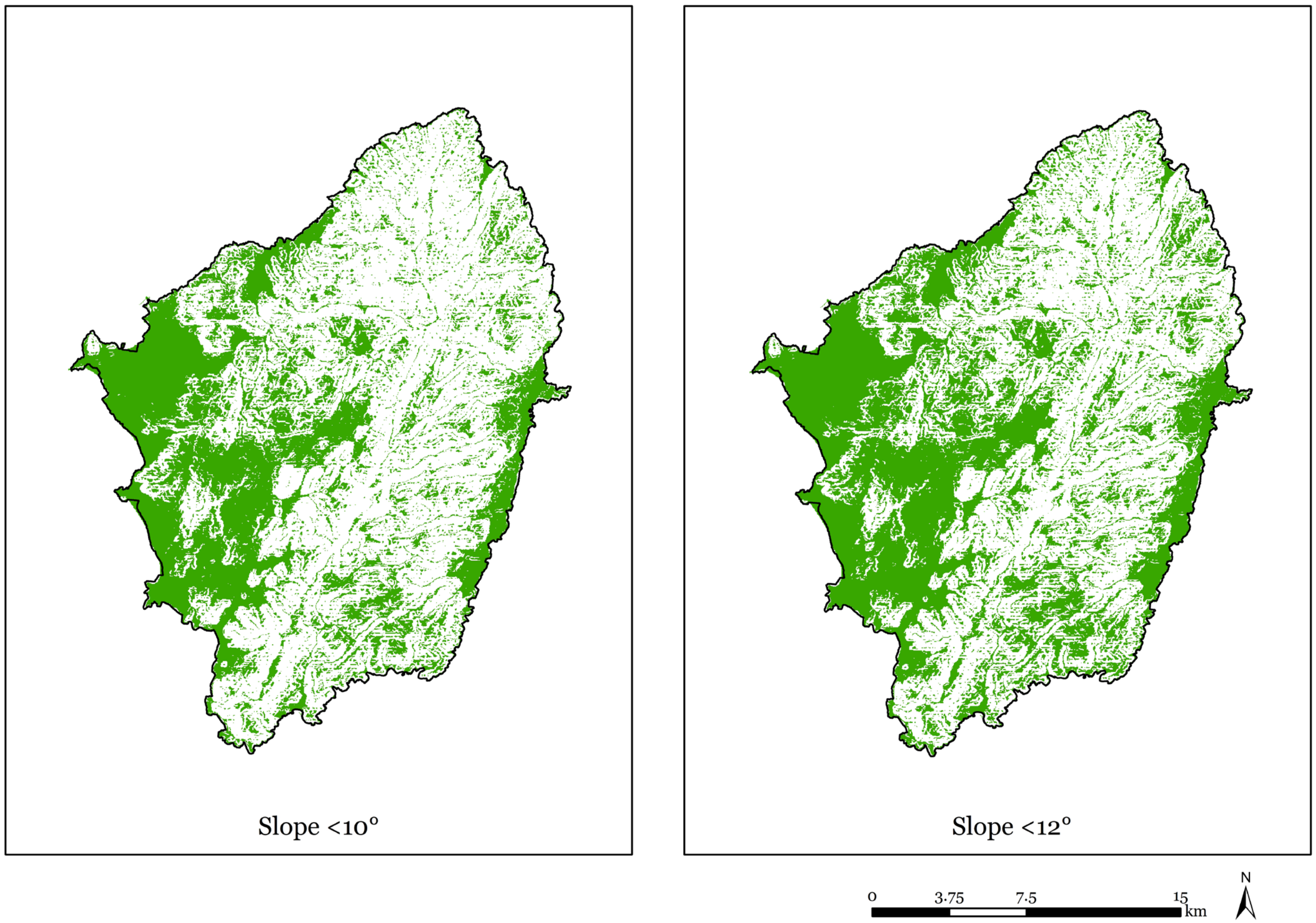


Figure 5.7. Naxos Potential Agricultural Land
This figure shows a comparison of the potential land area of Naxos that could be farmed without methods of intensification such as terracing.

Human Movement through the Landscape

The examples above—hillslope and potential agricultural land—are derived from a single environmental factor: the physical slope of the land (though implied in the analysis of potential agricultural land is the difficulty of humans to plow in steeply sloped areas). In order to better understand variables such as travel time and site catchments, we must analyze how the physical variable of slope relates to how humans move through and across landscapes.

In order to determine how much time it takes to move through terrain of different slopes, each slope range is assigned a different movement cost. The cost of movement is determined via Tobler's hiking function, a representation of anisotropic distance over time which estimates walking speed (km/h) via slope (degrees). The areas in gray on the map indicate relatively easy terrain for pedestrian movement (i.e. <15° slope), while the purple areas on the map indicate steep slopes (>15° slope) that from an optimization standpoint require a high cost of movement.

A cost raster was created by assigning values from Tobler's hiking function[47] to each cell of the slope raster of Naxos. The rules for classifying the raster are shown in table 5.2. The average walking speed for a range of slope degrees was calculated in seconds/meter. Since ArcMap requires an integer for reclassifying rasters, the average walking speed was multiplied by 200.

GIS cannot account for directionality when creating a cost raster, so the resulting costs for movement according to slope in the GIS model differ from Tobler's hiking function somewhat. In Tobler's function, a person walks the fastest

47 Tobler's hiking function (Tobler 1993) is a mathematical formula that estimates travel time on foot relative to the slope of the physical landscape. The equation is where W equals walking velocity and equals slope.

when walking slightly downhill (approximately a -2° slope). However, due to the limitations of GIS, only positive slope values can be taken into account. Once the cost raster is created, it can be applied to the further landscape analyses of agricultural catchment and travel time across the landscape.

Table 5.2. Reclass Rules for Naxos Slope Cost

Slope (°)	Walking Speed (sec/m)	Index Value (*200)
0 - 1	0.71474773	143
1 - 3	0.711423519	144
3 - 5	0.731655901	146
5 - 7	0.82737428	165
7 - 10	0.965258765	193
10 - 15	1.238977868	248
15 - 20	1.771792714	354
20 - 25	2.486743467	497
25+	4.429883363	886

Agricultural Catchments of Southern Naxos Areas of Interest

Figure 5.8 shows the maximum agricultural catchments for each of the four areas of interest on the coast of southern Naxos. It was created by clipping the slope layers with an area of extent that represents a two-hour walking time from each datum point. (Karvounolakkoi was used as the datum point of the Kalandos valley due to its central location.) Based on ethnographic data, two hours represents the maximum time a farmer is willing to walk from their home to their fields to work (Halstead and Jones 1989). Table 5.3 summarizes the maximum agricultural catchments for each area of interest.

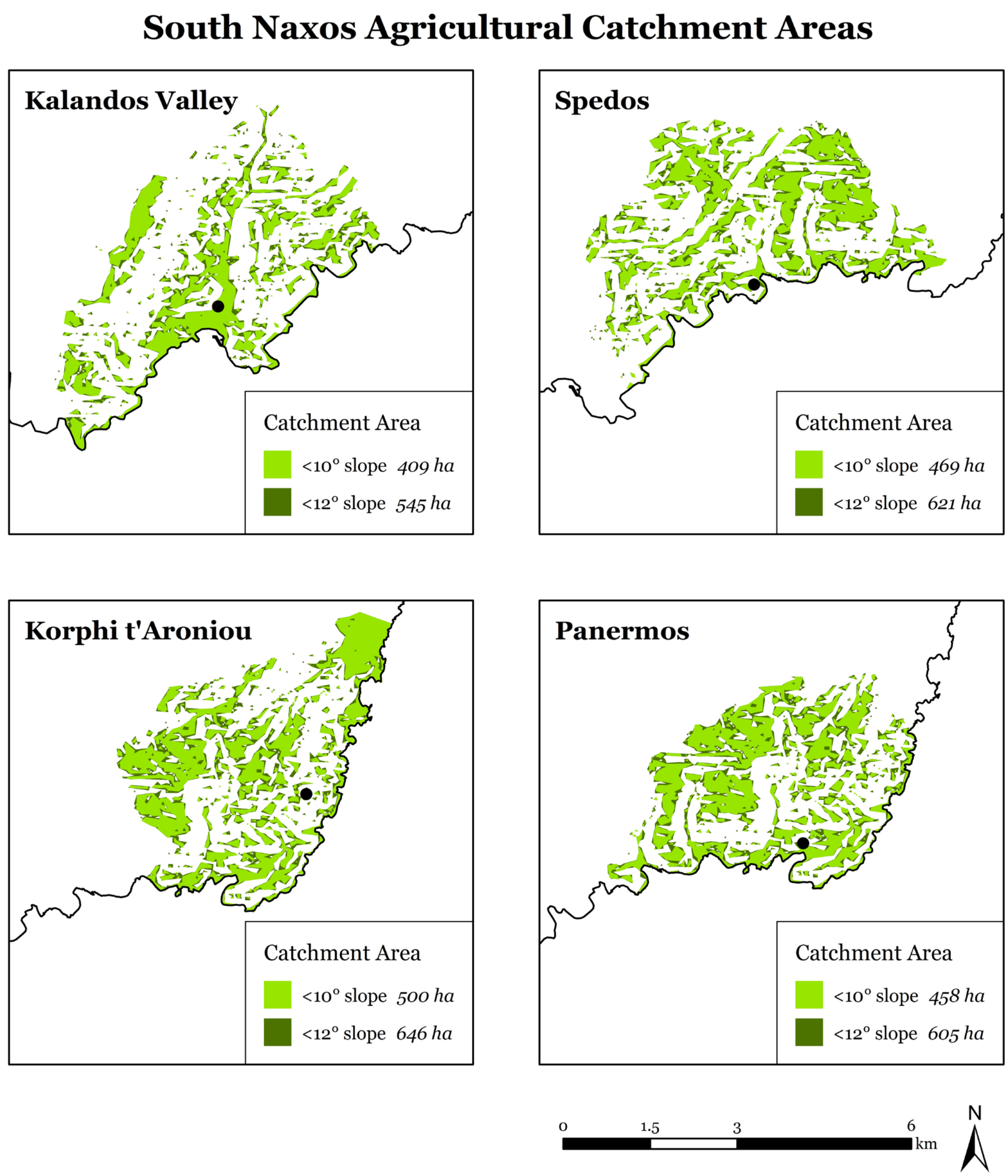


Figure 5.8. South Naxos Agricultural Catchment Areas
This figure shows approximate catchment areas for the four areas of interest in southern Naxos. The geographical extent of the catchment is determined by a maximum distance of two hours' walking time.

Table 5.3. Maximum Potential Agricultural Catchments for Southeastern Naxos		
Area of Interest	**<10° Slope**	**<12° Slope**
Kalandos Valley	409 ha	545 ha
Korphi t'Aroniou	500 ha	646 ha
Panermos	458 ha	605 ha
Spedos	469 ha	621 ha

While the Kalandos Valley has the lowest potential catchment of all four areas, it has the greatest area of potential agricultural land in the immediate vicinity of the datum point, indicating that ease of access to low-slope land may have been an advantage for farmers residing in this area.

The total area (both agricultural and non-agricultural land) of the 2-hour catchments of southeastern Naxos is 37.2 km^2. Based on the maximum populations listed in table 5.4, this would indicate a maximum population density of between 54 and 87 persons/km^2.

Table 5.4. Agricultural Carrying Capacity					
Catchment Area	**Hectares**	**Maximum population**		**Labor Requirements for Harvest**[a]	
	<12° slope	*0.75 ha/person*[b]	*1.2 ha/person*[c]	*10 labor days/ha*[d]	*30 labor days/ha*[e]
Kalandos Valley	545	727	454	181	545
Korphi t'Aroniou	646	861	538	215	646
Panermos	605	807	504	202	605
Spedos	621	828	414	207	621
TOTAL[f]	**2418**	**3224**	**2015**	**806**	**2418**

[a]Assumes a 30-day window for harvest (Halstead and Jones 1989).
[b]Sanders 1984.
[c]Halstead and Jones 1989.
[d]ibid.
[e]ibid.
[f]The total area of southeast Naxos removes the overlap between catchments of each of the sites and is therefore less than the sum of all four areas of interest.

Previous archaeological research based on the survey data from Melos has estimated the average population density of the EBA Cyclades at between 0.5 and 1.5 persons/km^2 for the EB I period and between 1.5 and 3.0 persons/ km^2 for EB II (Wagstaff and Cherry 1982). With a total land area of 37.2 km^2 for the entirety of southeastern Naxos, the minimum population estimate would fall between 18 and 56 persons for the EB I period and between 56 and 112 for EB II. If the population of the EB period on southeastern Naxos were indeed this low, it is unlikely that these communities would have been self-sustaining.

Historic census data serves as a feasibility text for maximal population estimates (table 5.5). The historic census data for Naxos between the years 1861 and 2011 indicates that the population density on the island varied between 23 and 56 persons/km^2. This indicates that the maximum population density of 54-87 persons/km^2 derived from the GIS models is achievable, but without modern support systems of water and food from the mainland to supplement subsistence production, it is unlikely that such levels were ever realized in the EBA. Nevertheless, as an absolute maximum estimate of population levels to cap the previously estimated population minimums, it shows that the actual population levels of southern Naxos during the Early Cycladic period could have varied widely. Previous population estimates based on archaeological settlement remains or cemetery size—both of which suffer from postdepositional degradation in the Cyclades—can only offer a bare minimum of population levels. The marginality of the Cycladic environment is often cited as a reason for this small population size; however, maximal estimates of settlement populations based on site catchment shows that if populations were indeed as low as archaeologists have estimated (see chapter 1), factors other than the constraints of the environment need to be considered.

Furthermore, Renfrew's (1972) hypothesis that the adoption of Mediterranean polyculture at the end of the Neolithic—which he argues is a necessary step in the emergence of social complexity—relies on the olive and vine allowing expansion into more agriculturally marginal, upland areas. The implication is that arable land was limited to hinder surplus production. If population levels for the Cyclades were indeed as low as has been estimated, catchment analysis shows that there was plenty of arable land available to support the population. Scarcity of agricultural land is not a sufficient motivation for the production of surplus, though it may have facilitated spatial diversification of crops to reduce risk (see chapter 3).

Table 5.5. Naxos Historical Population Size and Density (persons/km^2)

Year	Total	Density
1861	19,473	31
1871	20,582	33
1896	23,944	38
1907	25,185	40
1920	25,549	41
1928	34,553	55
1940	20,132	32
1951	18,593	30
1961	16,703	27
1981	14,465	23
1991	14,838	24
2001	18,188	29
2011	20,837	33

Small World Travel Times

As discussed in chapter 2, the definition of "small worlds" relies on human movement between settlements. The maximum areal extent of a small world is the distance a person can travel in a day (Tartaron 2013). Using Tobler's hiking function, I calculated the distance of traveling from each area of interest in one-hour intervals.

In the hilly landscapes of the Cyclades, it is especially important to use travel time and not distance as measured from a map to calculate maximum movement. While ethnographic studies have shown that the maximum distance an average person can travel on foot in a day is 20-30 km (Ames 2002; Kelly 1995; cf. Binford 2001: tables 7.10-7.13), Euclidean distance on a map does not account for the additional distance created by changes in elevation.

As discussed above, two hours is the farthest extent that farmers are willing to walk to their fields from their place of residence. Ethnographic evidence shows that for pedestrian land-based travel, six hours represents the maximum travel time for a single days' journey.[48][49] Therefore, three hours is how far a person could travel from a site and return home in a single day, and six hours—the time a person could travel in one day and return the next day—represents the extent of a small world network from a given node (figure 5.9). These times signify time spent walking and do not account for rest stops along the way or the slowing of pace due to fatigue, so actual travel time is likely to be higher than indicated.

48 Halstead and Jones's (1989) estimate of a two-hour round trip to agricultural fields represents a maximal figure; other transportation researchers (e.g. Marchetti 1994; Ausubel, et al. 1998) find that mean daily travel time averages around 1 hour per day. This average may be somewhat higher in small-scale cultivator communities. Hipsley and Kirk (1965) estimated the mean travel times of the New Guinea highlanders in the Pari area at 1.64 hours, while the Yapu women of the Amazon average 1.42 hours (Dufour 1984: 44). While commuting times are culturally, spatially, and temporally variable, there is evidence for some stability of mean commute times across time and space (Mokhtarian and Chen 2004). For further discussion, see Roscoe 2016: n. 1.

49 For example, in coastal Ghana women may walk three hours carrying their goods to market, sell them, and then make the return journey in a single day (Porter 2002: 289).

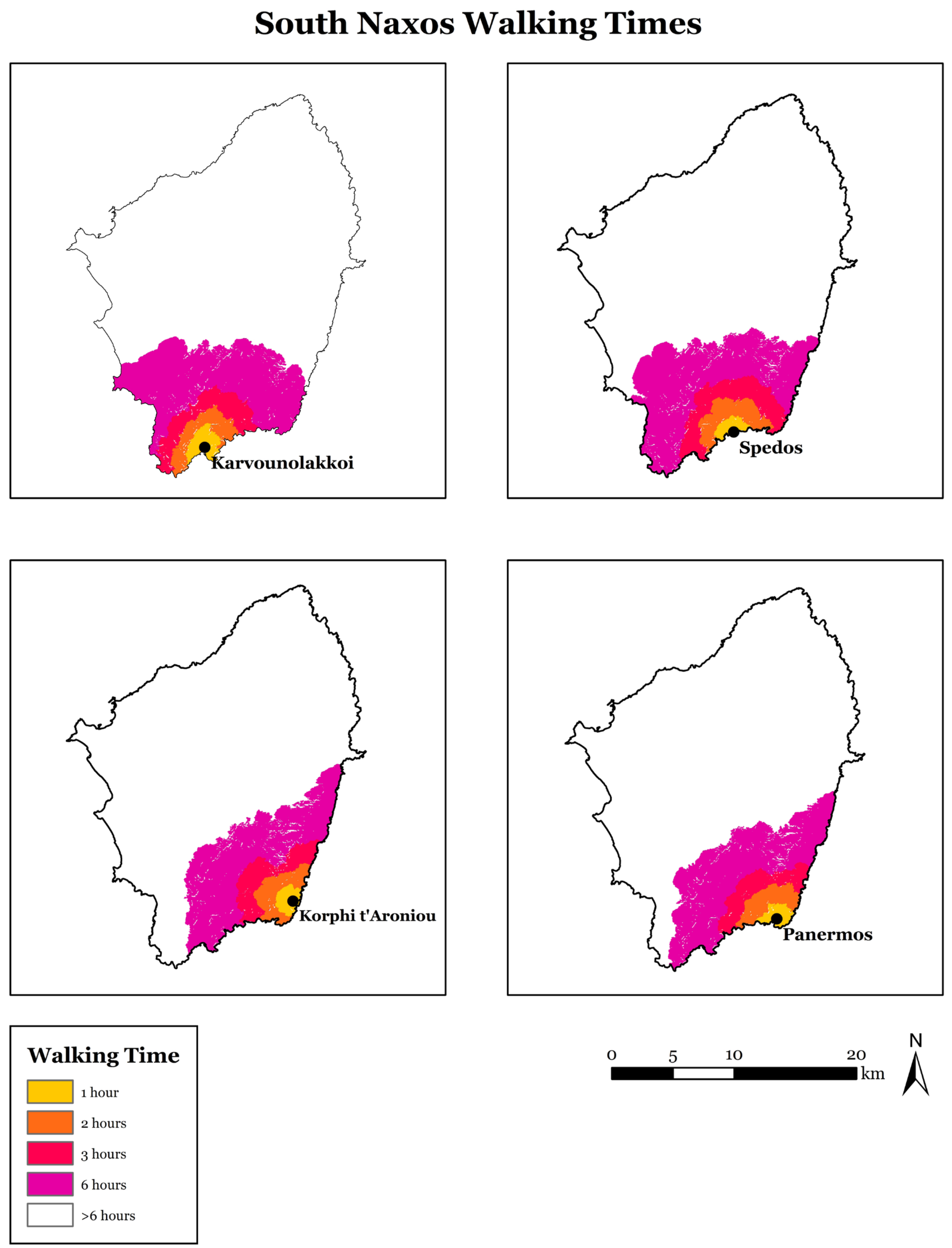


Figure 5.9. South Naxos Walking Times
These maps show how far a person could walk from each of the sites in the study area in a number of hours.

Each of the four areas of interest fall within the extent of each others' small world network (figure 5.10). Relative to each other, Spedos is most centrally located, being able to reach any of the other three areas of interest in three hours' walking time. Panermos and Korphi t'Aroniou are situated approximately one hour from each other, and a person walking from either settlement could reach the Kalandos valley in a day.

Three settlements outside of the area of interest are situated along the maximum extent of a days' travel from southeastern Naxos. First, Mt Zas in the center of the island is approximately one days' travel from any of the four areas of interest, reaffirming the hypothesis that its central position linked sites in different areas of Naxos while it was still inhabited during the FN-EBA transition. Along the western coast, Phyrroges—a settlement with an associated cemetery that was inhabited from the Grotta-Pelos through the Keros-Syros phases—sits just along the edge of the Kalandos valley's six-hour travel limit. Finally, along the eastern coast, Moutsounas—a settlement and cemetery of indeterminate EBA date—is at the precise edge of Korphi t'Aroniou's small world.

The analysis for the travel times between sites in EBA Naxos strengthens the hypothesis that the four areas of interest—Spedos, Panermos, Korphi t'Aroniou, and Kalandos—represent a small world. First, their close proximity and the relatively short travel time between them indicates the potential for frequent contact that could establish relationships based on trust. Second, the fact that the nearest settlements outside this small world lie on the very edge of the small world network both highlights their closeness to one another and yet demonstrates that these communities were not entirely isolated from the rest of the island by the harsh environmental characteristics of the landscape. During the Grotta-Pelos

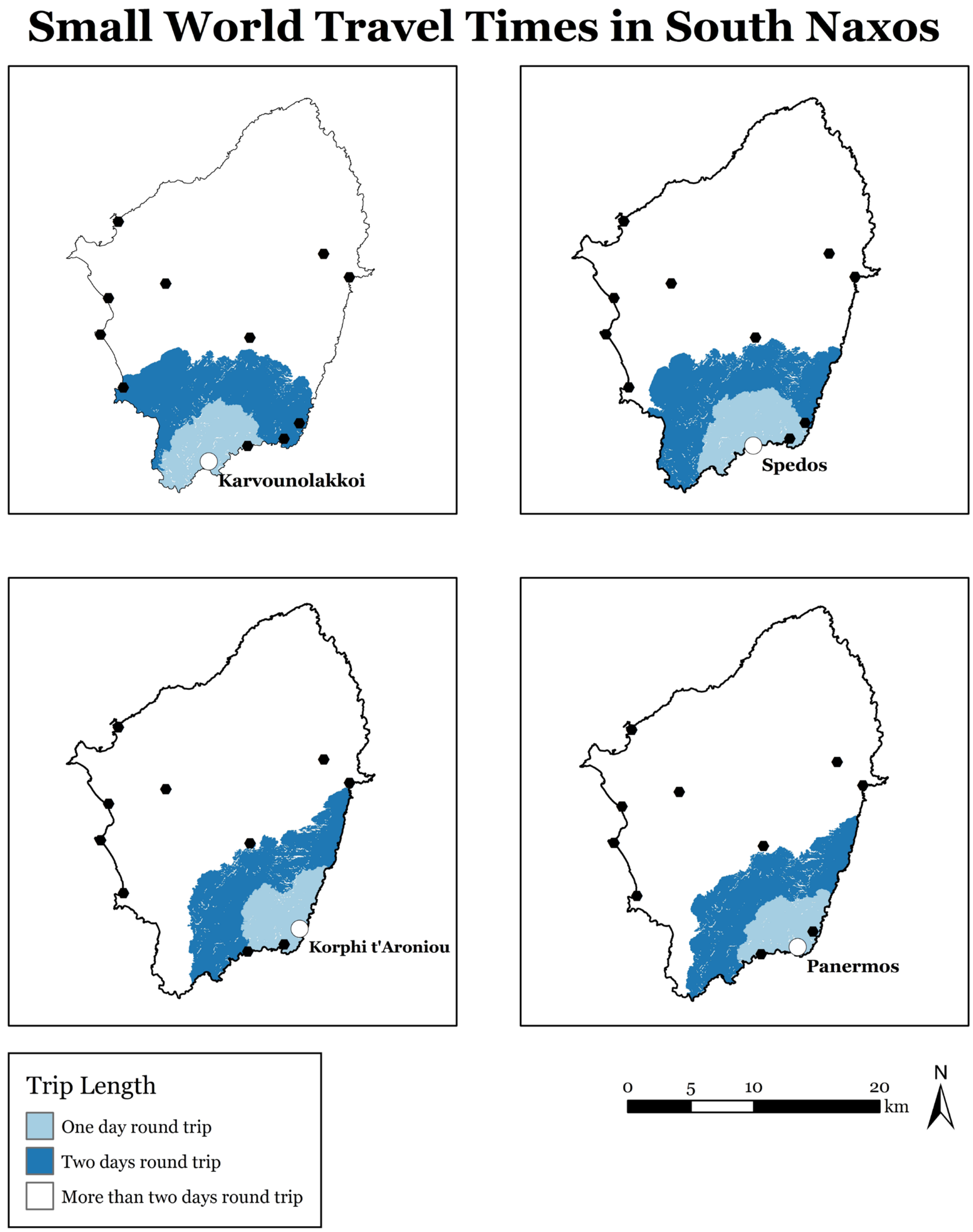


Figure 5.10. Small World Travel Times in South Naxos
This figure shows the settlements that could be reached from each of the areas of interest in one or two days' round trip travel.

through Keros-Syros phases, people residing in southeastern Naxos could have had regular contact with settlements in different parts of the island. However, with the abandonment Mt Zas and Phyrroges during the EBA, the settlements of southeastern Naxos may have become isolated from the rest of the island, and potentially strengthened their contacts with one another or with settlements on nearby islands (discussed further below).

Potential Action Spaces

Many of the GIS analyses that archaeologists regularly use are descended from the field of time-geography, developed by Torsten Hagerstrand in the mid-1960s (Lenntorp 1999), which is defined as:

> …a theoretically informed conceptual approach for analyzing and describing human behavior and movement in space and time; time-geography builds on an empirical set of temporal constraints, needs, and possibilities for human mobility: e.g. all human lives are constructed of activities carried out in space and time and every act is preceded and guided by the earlier acts (Leary 2014: 81).

Using time-geography definitions, the isochrones that I created for the walking times and agricultural catchments around sites in southern Naxos are called action spaces[50], which cover the space that can be reached within an allocated time-budget from a starting point (Seitsonen, et al. 2014: 81).

Cumulative action spaces, which assume that people spend the most time in the areas nearest to their place of residence, show the areas that are reachable from multiple starting points given the same time budget. The places where these areas overlap demonstrate higher potential for interaction, while places where there is

50 Action spaces are more commonly known in time-geography as Potential Path Areas (or PPAs). To avoid confusion with Proximal Point Analysis (also abbreviated PPA), I opt to use "action spaces" in the present project.

little to no overlap indicate potential barriers for interaction (Leary 2014: 82).

As demonstrated by the cumulative action spaces in figure 5.11, the greatest overlap (1 hour walking time from each site) occurs on the upslope area between Panermos and Korphi t'Aroniou. There is a second, smaller concentration of overlap between Panermos and Spedos. The next level of frequency in overlap (1-2 hour walking time from each site) shows that the action space around Spedos has an east-west orientation in the lowland areas along the coast. Korphi and Panermos are both centrally located within areas of this level of frequency, while the Kalandos valley experiences a 1-2 hour overlap only in the northeastern portion, which is located in a valley between Karvounolakkoi and Spedos.

Overall, the Kalandos valley experiences little overlap in action spaces, as does, interestingly, the inland area north of Spedos. The latter potentially indicates a high concentration, but limited geographic extent, in interaction near Spedos. The former is likely due to the Kalandos valley's relatively high distance from any neighboring sites as well as its location in a valley surrounded by upslope areas which would be more difficult to traverse than the relatively less steep areas around Panermos and Korphi.

<u>Least-Cost Paths</u>

In terms of human movement, a least-cost path represents the path of minimum effort in terms of energy expenditure to move from point A to point B. From a GIS perspective, a least-cost path is the cheapest route available between two points relative to the cost units defined by the original cost raster that was input into the weighted-distance tool. This cost raster might contain variables such as slope, vegetation and land use, and water crossings that would be weighted by the analyst to

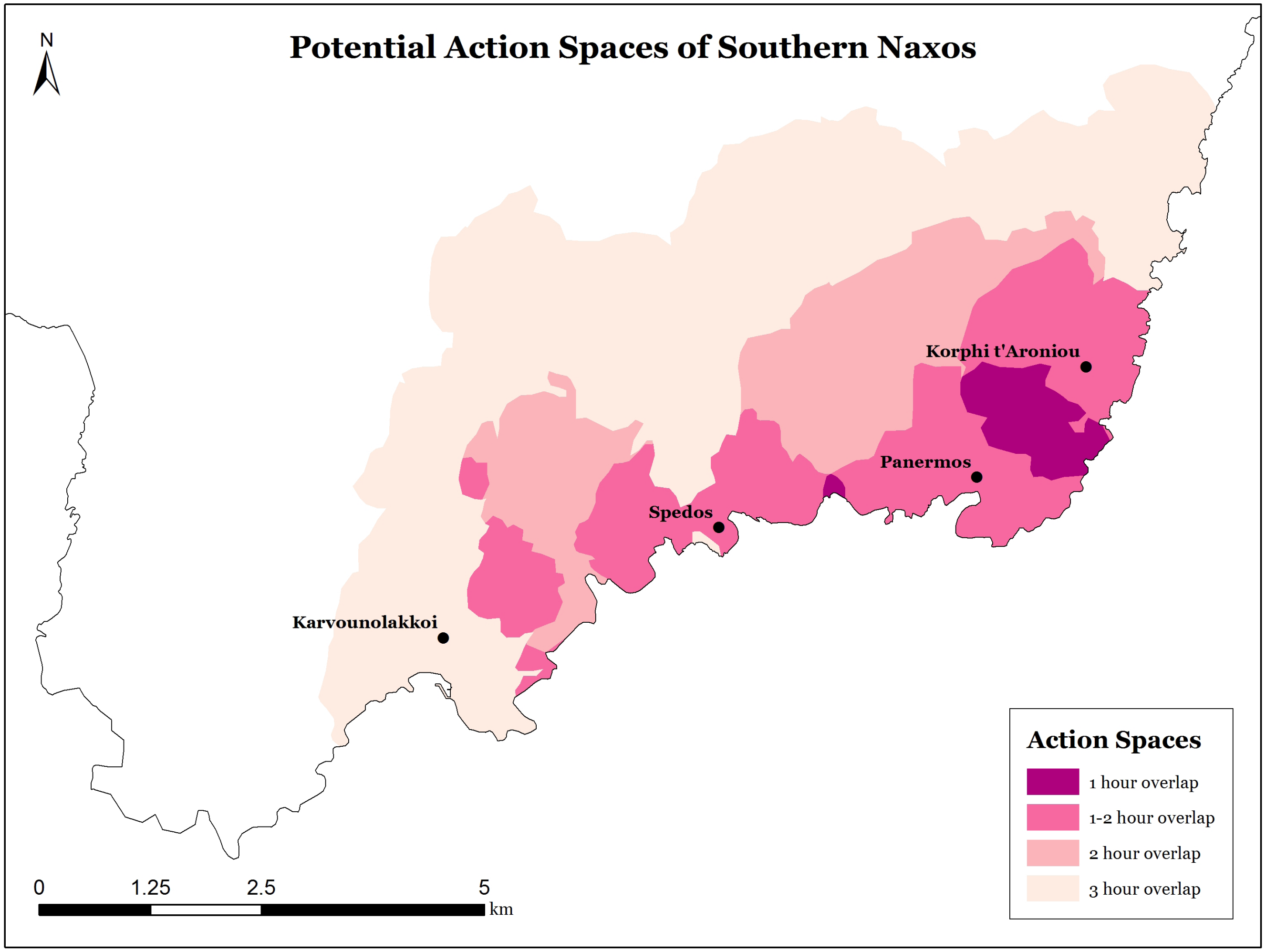


Figure 5.11. Potential Action Spaces of Southern Naxos

have different costs associated with moving across them. The underlying assumption of least-cost analysis is that human actors within a given environmental context will choose the path that minimizes their energy expenditure. Human beings are rarely, if ever, purely rational actors, and least-cost analysis does not take into account cultural factors that might influence movement choices. Nevertheless, as Kosiba and Bauer (2013: 64) write, "By delineating the contours of regional environments, econometric approaches offer sound foundational evidence that may be tested with additional archaeological data."

Figure 5.12 shows a cumulative view of least-cost paths from all of the sites of EBA Naxos—including both settlement and cemetery sites—leading to the four locations in my study area. These paths are overlaid on the previously discussed map of action spaces from southern Naxos. Figure 5.13 shows the least-cost paths from all of the EBA Naxos sites leading to the individually-mapped locations in the study area. When considered in conjunction with the action spaces, some patterns and questions emerge.

First is the importance of the coastal corridor in connecting the Kalandos valley, Spedos, and the Panermos/Korphi area. Some portion of this pathway exists in every individual least-cost path map, indicating a high degree of overlap in the movement between these sites.

Within the southeast Naxos coastal area, the rest of the paths are more dispersed, creating a web-like network of potential pathways that intersect in the inland catchment areas of the study sites. In a predictive sense, the nodes of intersection of these potential paths indicate areas where archaeological investigation should be conducted to see whether the distribution of material culture corroborates these places as areas of human interaction.

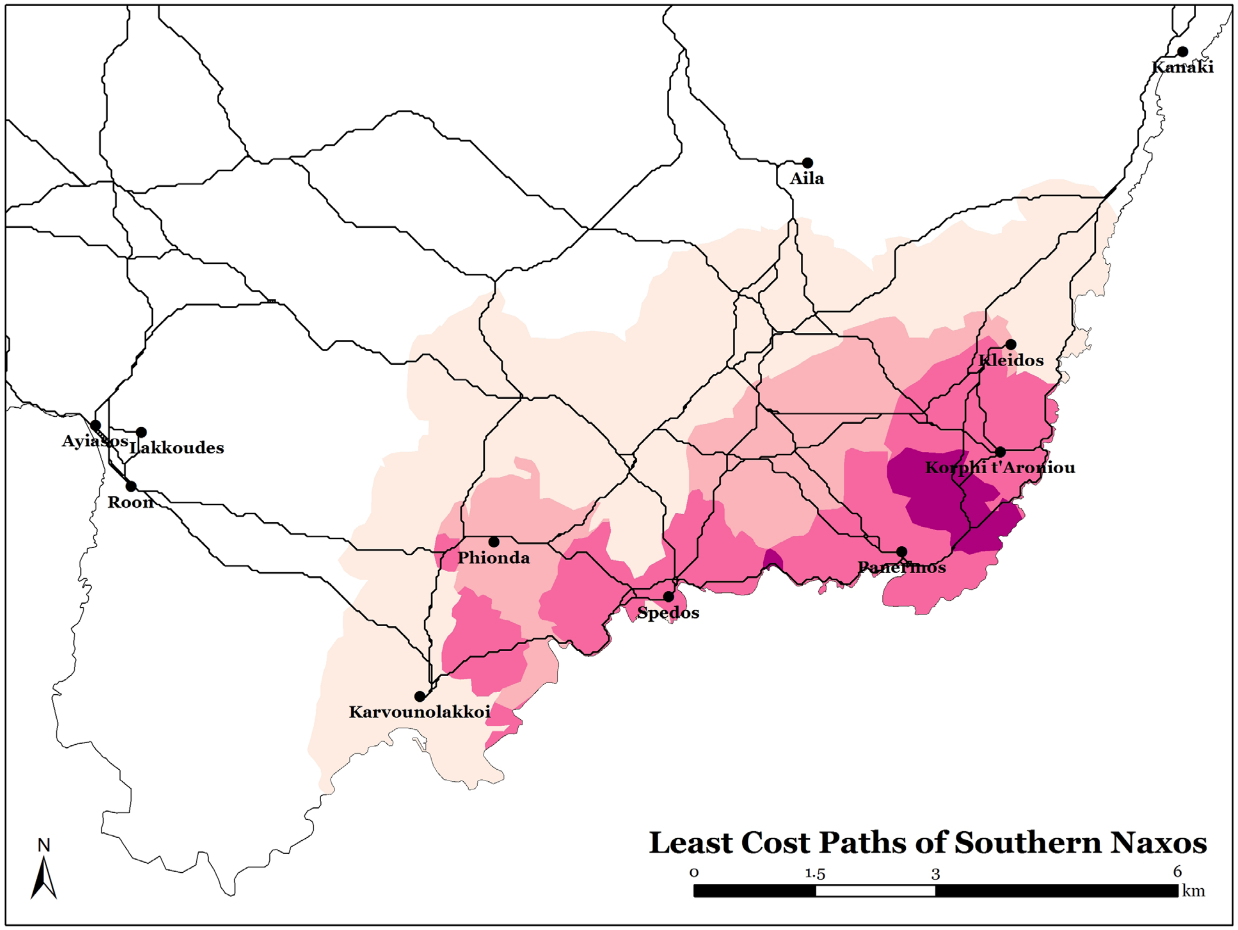


Figure 5.12. Least Cost Paths of Southern Naxos
This figure shows a cumulative view of least-cost paths from all of the sites of southern Naxos in the Early Cycladic period--including both settlement and cemetery sites--leading to the four locations in the study area.

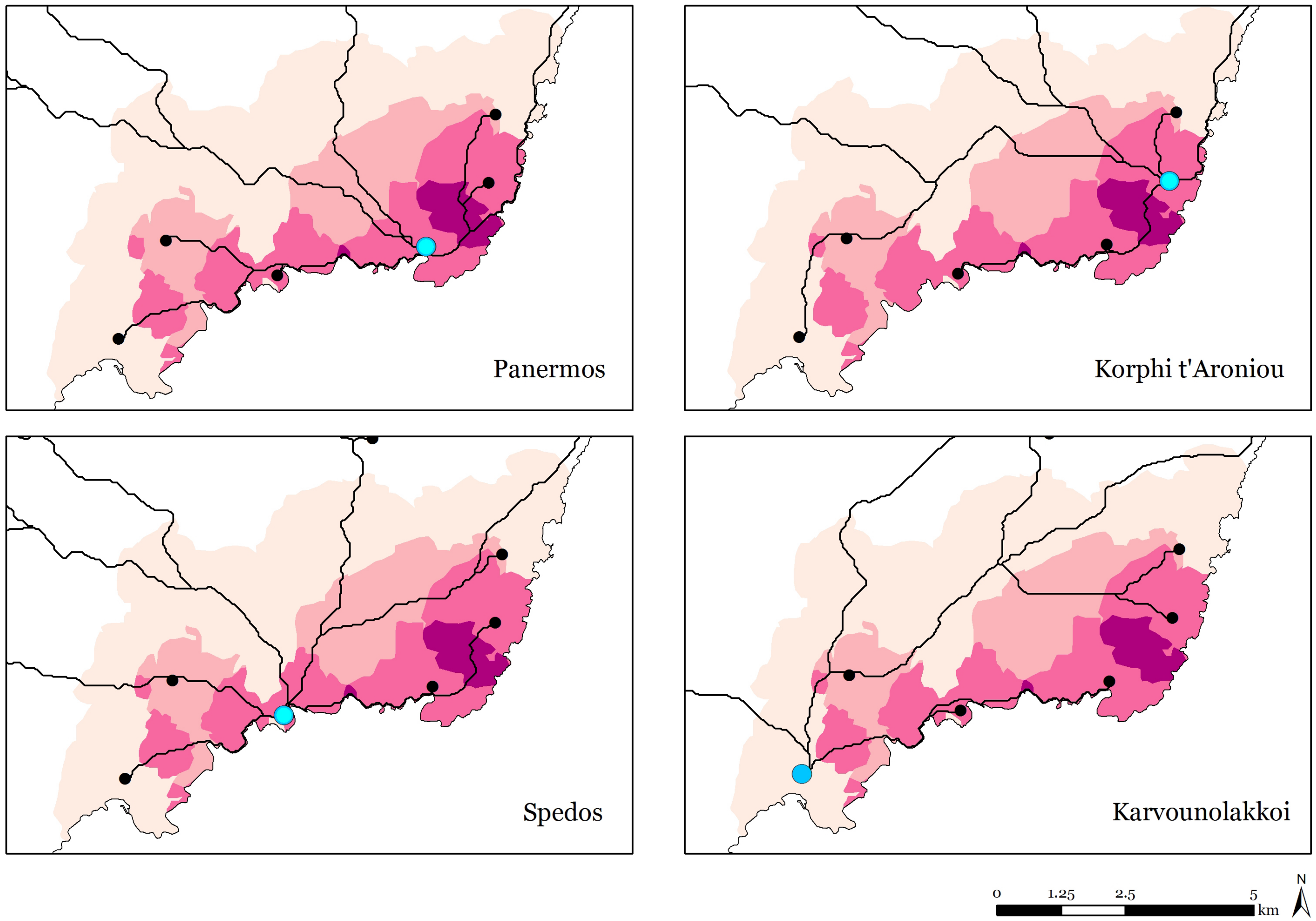


Figure 5.13. Least Cost Paths of Southern Naxos (Individual Sites)
This figure shows the least-cost paths leading to each of the four sites in the study area.

Finally, the least-cost paths show how the people residing within the study area might have traveled to the rest of the island. There appear to be many dispersed paths crossing the Mt Zas massif to reach sites on the west coast. These reflect potential mountain passes. In contrast, there is only one major path to the central part of the island, where Zas Cave is located, and only one major path to the sites along the east coast.

While least-cost paths offer a model for potential pathways between sites, optimization represents only one variable in the decisions for humans to create and maintain paths within the landscape. Therefore, least-cost paths should be used as a starting point for investigating movement that may be grounded, so to speak, in archaeological data and other types of models, such as visibility analyses.[51]

The future publication of the Cambridge Southeast Naxos Survey will facilitate the comparison of these least-cost paths with the distribution of artifacts. Therefore, the present project offers only a preliminary glimpse at what may be done with the GIS modeling of pathways in southeastern Naxos.

<u>Viewshed Analysis</u>

Viewsheds represent the cumulative lines of sight if a person were to turn 360° from a given point. Having a dominant view of a landscape is often associated with places which are designed to control routes and points-of-entry within a landscape

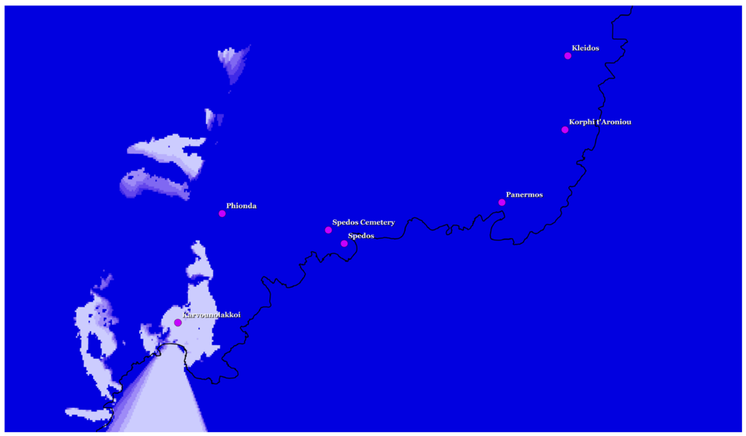
51 A research topic for future investigation would be how the location of settlement-associated cemeteries compares with the paths of access to those settlements. Are cemeteries preferentially located along access routes? For Spedos this seems to be the case, since the associated cemetery overlooks located in the valley leading up to the site. However, a) the incomplete availability of cemetery and settlement maps and b) the abundance of cemeteries attested in the EC period that are unaffiliated with settlements mean that further archaeological investigation is necessary to draw valid conclusions.

or to be highly visible to travelers moving through the landscape. Previous archaeological studies have shown that high visibility of a site may correspond to military applications and defensibility (Kay and Sly 2001; Jones 2006; 2010; Sakaguchi, et al 2010), resource acquisition (Krist and Brown 1994; Bauer, et al 2004; Llobera, et al 2011), and the solidification of social power (Bradley, et al 1993; Chapman 2003; Lambers and Sauerbier 2006; Howey 2007; Bongers, et al 2012). Whether motivated by these or other factors, the decision on the part of a settlement's inhabitants to increase or decrease visibility is a conscious one (Wright, et al 2014: 5).

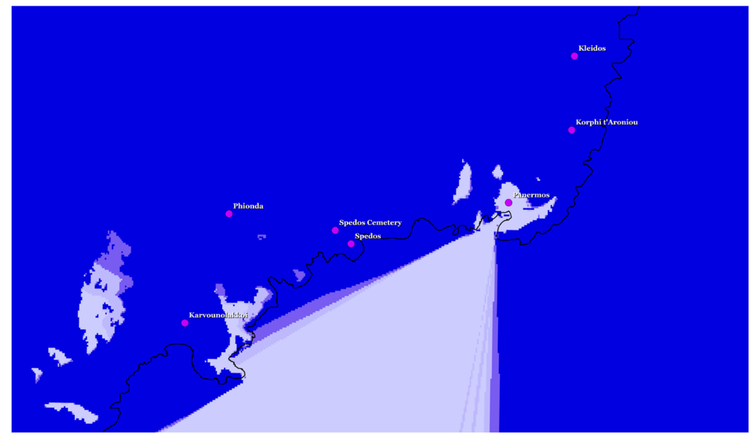
Viewsheds of sites on the coast of southeastern Naxos (figure 5.14) were calculated by first creating a 100m radius buffer around each site, and then creating a polyline of approximately 20 viewing positions along the circumference of the buffer. The results above are the cumulative viewshed of the polyline points, which represents more comprehensively a viewer's movement through a site. The viewer height is set to 1.6 meters.

In addition to being intervisible, the sites of Kleidos and Korphi t'Aroniou show a clear orientation toward the eastern coast of Naxos and overlook the seascape. While Korphi t'Aroniou has been described as an inland site, being located approximately 300 m from the coast, the viewshed of the site demonstrates a clear maritime orientation.

Panermos and Spedos appear oriented toward each other. Spedos in particular offers a commanding vantage point over the southern seascape of Naxos (figure 5.15). Both Spedos and Panermos appear to be situated so as to overlook the bay at Panermos, which is a quiet harbor that is accessible in all meteorological circumstances. The viewsheds generated by ArcGIS are imperfect, as the settlement

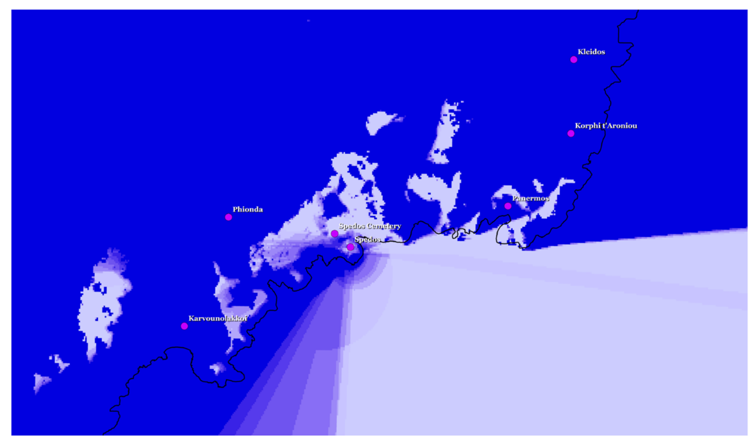


Karvounolakkoi



Panermos

Korphi t'Aroniou



Spedos

Figure 5.14. Site Intervisibility Comparison of Southern Naxos

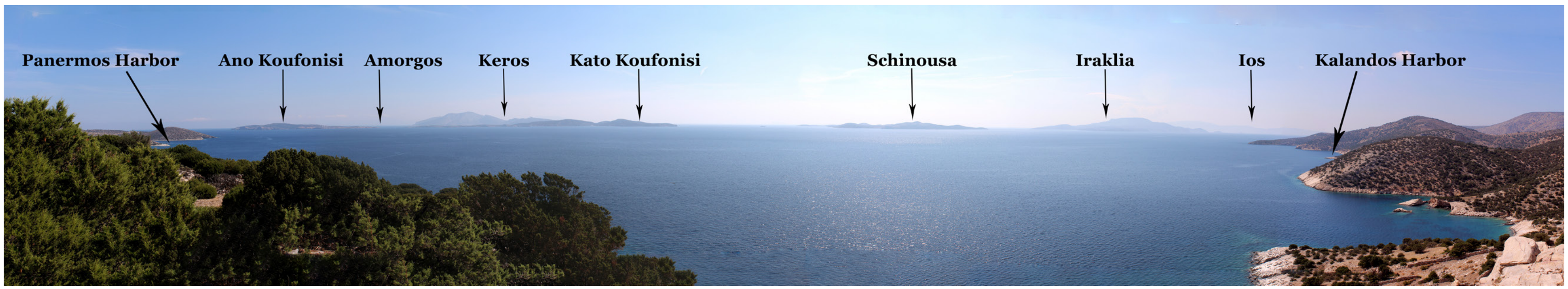


Figure 5.15. Panorama from Spedos
This image shows the sites and islands that are visible from the settlement at Spedos.

at Spedos is just barely visible from the so-called acropolis at Panermos (see figure 5.16). This is likely due to fuzziness in the ASTER Global Digital Elevation Map[52] used to create the model, which is only accurate to 30 m.

Karvounolakkoi overlooks the bay at Kalandos, which is another natural harbor. Both Karvounolakkoi and Phionda have extensive views of the Kalandos valley. The Kalandos valley contains the greatest potential agricultural land of the catchments of the settlements of southern Naxos. However, these sites are not intervisible.

Spedos is situated to have commanding views over the harbors at Panermos and Kalandos. The intervisibility between Panermos and Spedos might indicate connectivity and community cohesion, and it might support the interpretation of Spedos as a defensible settlement (see chapter 4) controlling access to nearby ports from the sea. The fortification walls at Panermos and Spedos (discussed in detail in chapter 4, see also appendix A) demonstrate a defensible aspect to these sites which would have been enhanced by Spedos's superior visibility.

The maritime orientation of all of the coastal sites both indicates the importance of the harbors at Kalandos and Panermos and suggests connectivity with settlements on the islands of the nearby Erimonisia. Therefore, in addition to the considerations of land-based travel and connectivity presented thus far in this chapter, it is imperative to consider maritime travel as a major aspect of small world analysis in the Cyclades (see chapter 6).

52 The ASTER satellite Global Digital Elevation Map (GDEM)—obtained from the USGS Earth Explorer web service—is a publicly available, three-dimensional raster model of the Earth's surface. It was used as the basis for all raster models in the present study.

Figure 5.16. Panorama from the "Acropolis" at Panermos
The so-called "acropolis" at Panermos overlooks the harbor near the site. Additionally, the hilltop where Spedos is located is visible on the right side of the image.

Cumulative Viewshed

In order to determine how prominently located the sites of my study area are from the vantage point of the broader landscape, I conducted a cumulative viewshed analysis (figures 5.17, 5.18, and 5.19). To do this, I used the Interactive Visibility plugin for ArcMap created by Xuguang Wang. I created the cumulative viewshed by placing thirty observer points randomly throughout the study area. The resulting viewsheds were added together to calculate the number of observers who can see a particular raster cell. The more observers that could see a particular raster cell, the higher its visibility. The results of these calculations were classified by natural breaks (jenks) into five classes, ranging from low to high visibility. The observer height (offset A) was set to 1.6 m, and the object height (offset B) was set to 0 m. The latter figure could in future iterations be set to a height that would represent the height of a building. Since the heights of buildings in the EC period are largely unknown, I performed this analysis with no alterations to object height.

Figure 5.17 shows the cumulative viewshed for the entire southeastern Naxos region, while figure 5.18 shows a closer (1:30,000 scale) view of the cumulative viewsheds for each of the study area sites. Generally speaking, the areas of highest visibility correspond with the highest elevation points, such as those in the southernmost end of the Mt Zas massif on the left-hand site of figure 5.17. Of the study area sites, Spedos has the highest visibility; as is shown in figure 5.18, the top of the hill on which Spedos is located has a moderate-high visibility. The entirety of the Kalandos valley has approximately a moderate visibility, while both Panermos and Korphi t'Aroniou are situated in low visibility locations.

Figure 5.19 shows the cumulative viewshed for the southeastern coast of Naxos when the observer points are located in the sea. This is to simulate how

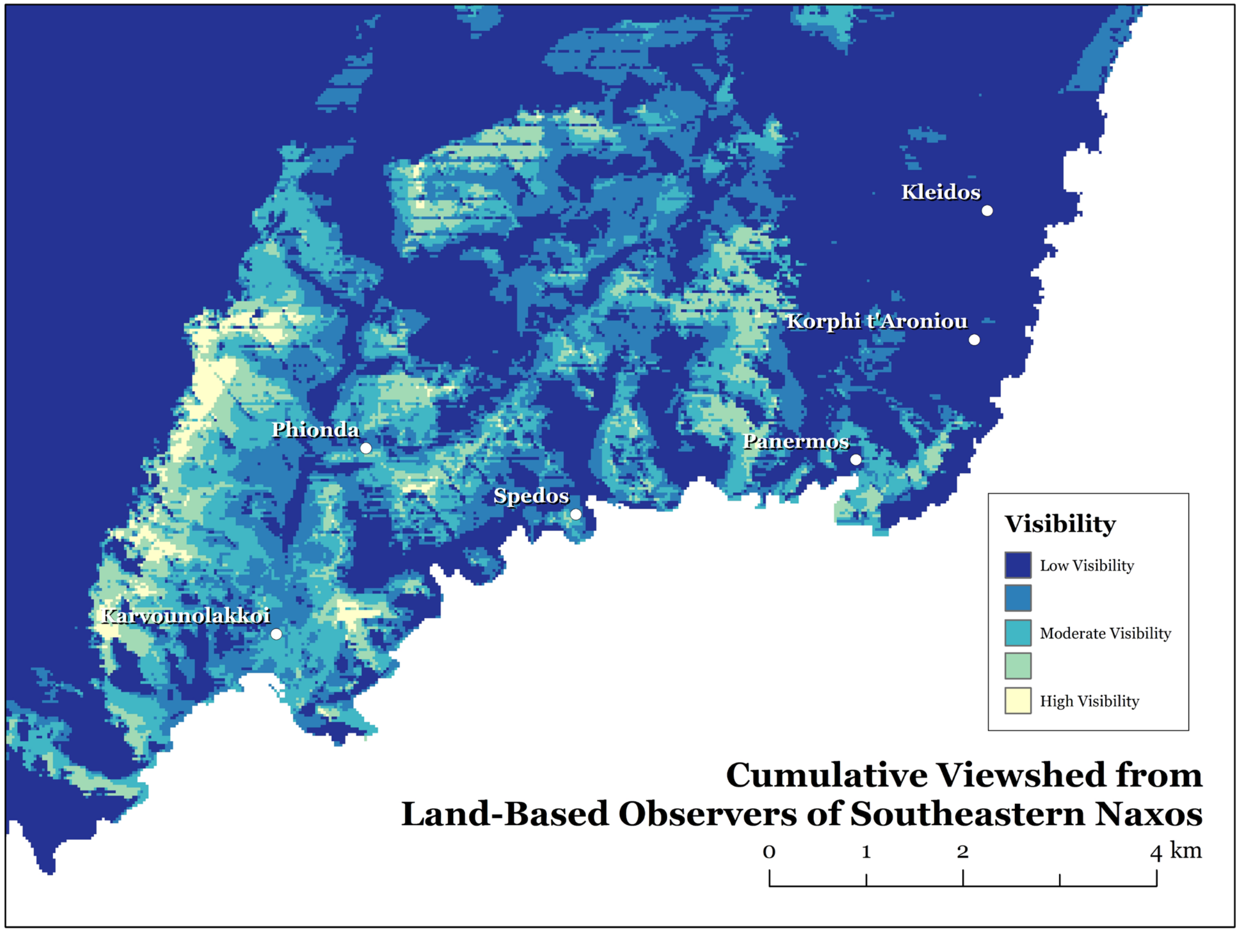


Figure 5.17. Cumulative Viewshed from Land-Based Observers of Southern Naxos
This cumulative viewshed was created by placing thirty observer points randomly throughout the study area of southern Naxos. The more observers who can see a particular raster cell, the higher the visibility of that location.

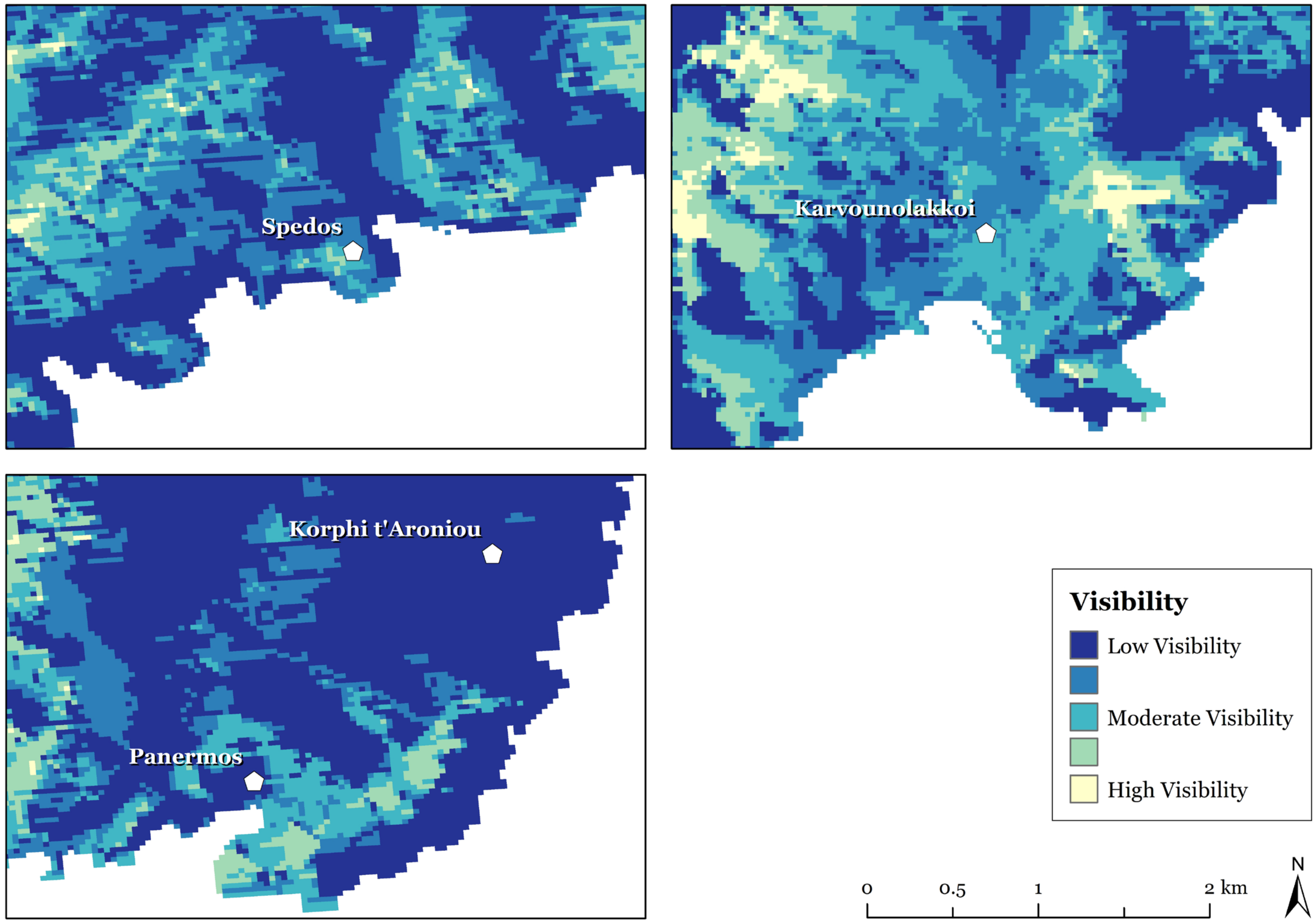


Figure 5.18. Cumulative Viewshed from Land-Based Observers from Each Study Area Site of Southern Naxos

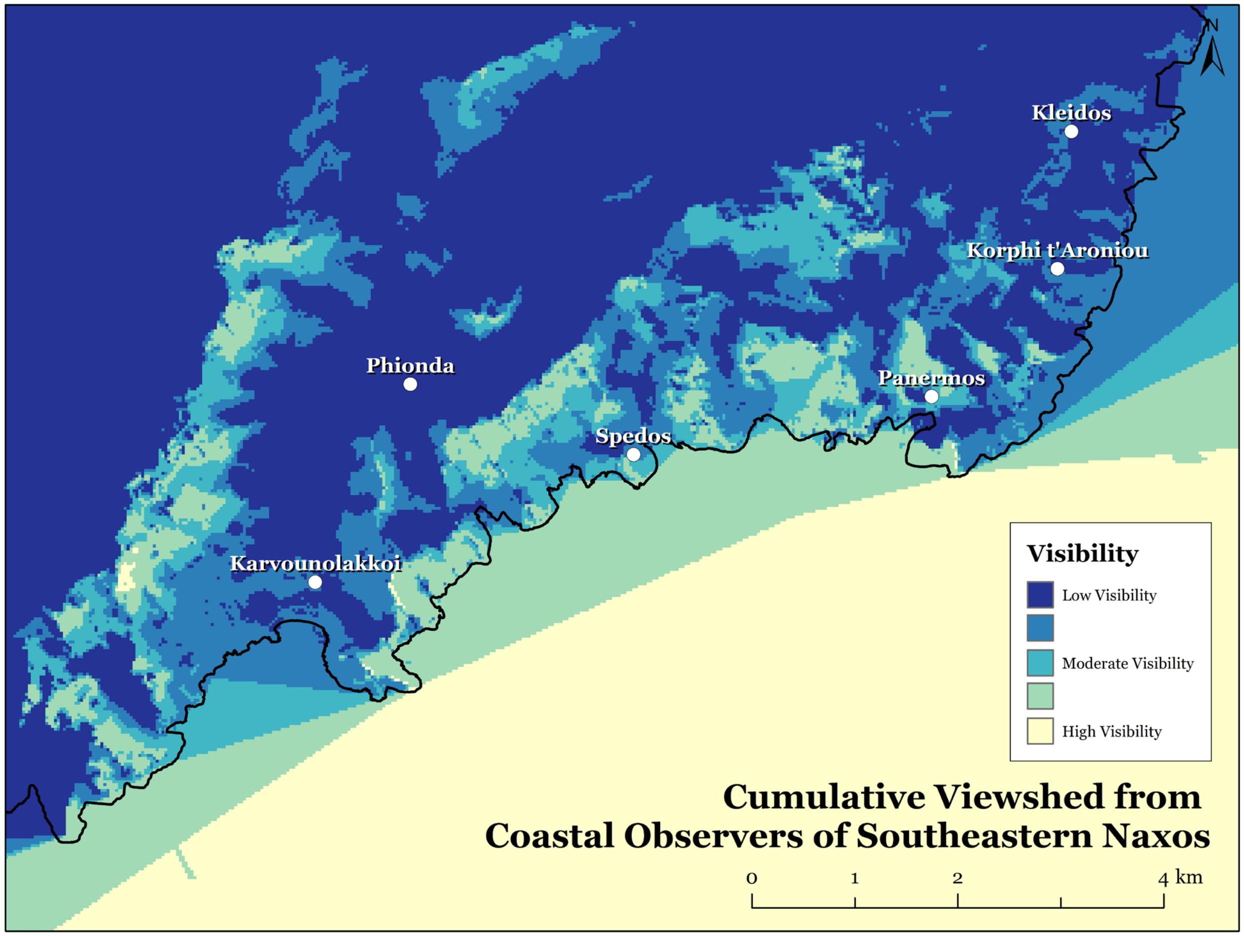


Figure 5.19. Cumulative Viewshed from Coastal Observers of Southeastern Naxos
Cumulative viewshed of coastal observers was created by creating random observer points in the water along the shores of southern Naxos to show visibility of the landscape from the perspective of maritime travel.

visible the sites of southern Naxos would have been from a viewer approaching via maritime transport. Again, the visibility for Spedos is moderate-high. Panermos is slightly more visible from sea than from land, while the Kalandos Valley and Korphi remain at relatively low visibility.

When considered with the viewsheds from the vantage points of the sites described above, not only does Spedos have controlling views over the landscape and the access points to the island from the sea, it also would have been a prominent visual marker on the southeastern coast. This would have been a useful visual waypoint for sailors navigating the stretches between Naxos and the Erimonisia.

The Kalandos Valley, Panermos, and Korphi t'Aroniou are less visible from land than Spedos and are markedly less visible from sea. However, all three sites have good visibility over access to the island from the sea. As potential locations of agricultural production (in the case of the Kalandos valley) or agricultural storage (in the case of Panermos), it may have been important for the residents of these areas to be able to see incoming seaborne threats and retreat to more defensive locations. In addition to Spedos's defensive fortifications (discussed in chapter 4), the viewshed analysis shows that the site held visual oversight and control of the harbors on this stretch of the southern coast of Naxos, highlighting the settlement's defensive function and strategic value in the Early Bronze Age.

Furthermore, the maritime visual orientation of the settlements in this small world points to the importance of maritime travel in the Early Cycladic period. In addition to the terrestrial mobility discussed in this chapter, seaborne mobility is also important to consider, as will be discussed in chapter 6.

Summary of GIS Models

Ethnographic evidence demonstrates that among hunter-gatherers, pastoralists, and horticulturalists, there is a huge variety in how, when, and to what extent people move for subsistence (Kelly 2013: 77-78) and on the time-frame of daily and habitual interaction. Based on the GIS models presented above, what can we now say about how Early Cycladic people residing on the southeastern coast of Naxos moved, and how might these patterns of movement have constructed a sense of community?

In terms of movement for subsistence, the agricultural catchment models show the area from settlements within which people would have made fields, the potential field locations based on hillslope, and the maximum potential catchment for those areas. The maximum population that could have been supported without agricultural intensification for southeastern Naxos (between 54 and 87 persons/km^2) sharply contrasts with previous archaeological estimates of population density for the EBA Cyclades (e.g. Wagstaff and Cherry 1982). This indicates that the availability of arable land was not a determining factor in EC population size, and it suggests the importance of spatial diversification as a subsistence strategy (see chapter 3).

The potential action space models offer evidence for how people might have moved to and from fields, the ranges for foraging and pastoralism, and intersections where moving people might have met during the course of their daily lives. The areas of highest intensity are locations where further archaeological investigation should be conducted to determine the corroboration of movement with the archaeological record.

The least-cost paths modeled here demonstrate the optimal routes between the settlements of southern Naxos during the EBA. Paths with a greater confluence of individual routes indicate potential high-traffic—and therefore, high interaction—zones as people move between settlements on a habitual basis. However, further grounding in archaeological data is needed to draw valid conclusions about path-making during this period.

The high visibility shown by the viewshed models of southern Naxos—in particular from Spedos—indicates functions of the settlement that may have been related to defensibility and the cohesion of power, especially given its oversight of the harbors at Panermos and Kalandos. Furthermore, its high visibility from the sea would have created a valuable waypoint for maritime navigators.

The GIS models presented here not only offer new evidence for human-environment and the building of communities in the EBA Cyclades, they also allow the formulation of new, testable hypotheses concerning the archaeological data. However, they represent only a preliminary step in the understanding of the landscapes of the EBA Cyclades. Models such as isochrones and least-cost paths—which fall under the umbrella of "econometric" approaches to GIS modeling (Kosiba and Bauer 2013: 63)—have been critiqued by archaeologists for treating humans as completely rational actors who optimize their interactions with—and exploitation of—the local environment. Given a choice, according to these models, an actor will always choose the path of least energy expenditure (i.e. the least-cost path). Sites are located to benefit the social group in the monitoring of the landscape—overlooking agricultural fields and other important spaces (Kosiba and Bauer 2013: 63). As they are typically deployed in archaeology, these types of models do not take into account differing mobilities within a population and they tend to generalize environmental variables.

In future research, the GIS models of the present chapter can be compared with the SENS survey data, once it is published, and with material culture from the Cyclades, which is beyond the scope of the present project. More detailed geological and climatological studies can illustrate changes to the physical environment over time. Therefore, the models presented above should be considered as laying the foundation upon which additional archaeological data can be tested. The GIS analyses employed here detail the physical environmental context of the EBA Cyclades in light of extant settlement data.

By modeling the action spaces and least-cost paths between the areas of interest in the study area, my analysis is able to move away from the "site" as an analytical focus. These models emphasize the importance of considering inter-site landscapes that may seem "hidden" archaeologically. An emphasis on mobility, situated within a small worlds framework, reveals dynamic places of habitual social interaction that would appear as undifferentiated space on a typical archaeological map of the region.

Southeastern Naxos - An Early Cycladic Small World?

Recalling the discussion of what comprises a "small world" in chapter 2, does the study area of southern Naxos represent an Early Cycladic small world? If so, how can it be characterized?

Shared Time and Place

In the absence of secure dating from the settlements and sites of southern Naxos, the contemporaneity of this small world should not be taken for granted. Furthermore, even if these settlements were contemporaneous, it should not be assumed that their structures or uses remained unchanged for a time period spanning more than a millennium.

It is likely that the three settlements at Spedos, Panermos, and Korphi were in use at the same period during the Kastri phase. The multi-room building at Panermos may be securely dated to this time period by its destruction layer and the evidence of pottery from excavations at the site. The underlying smaller structure at Panermos is dated to an earlier phase of occupation, and based on its size and building techniques is more likely a house or domestic structure rather than a more centralized building. Panermos, then, may have only emerged as a central gathering point for the dispersed farmsteads in the region toward the end of the EBA. The pottery at Korphi likewise dates it to the Kastri phase, and there were no previous occupation levels. It is impossible to predict, however, whether the building at Korphi during the Kastri represents an expansion of population for this region or simply a continuation from earlier periods.

Spedos is currently dated by the artifacts excavated from the nearby cemetery, which indicate its use by at least the Keros-Syros and Kastri phases. The footprint of an apsidal building at the apex of the settlement itself seems to mimic the larger apsidal building at Dhaskalio dated to the earlier Keros-Syros phase in EB II. The diagnostic pottery found during SENS also indicates an early date for the settlement.

At the cemetery at Karvounolakkoi, the finds from the cist-graves were dated to the Grotta-Pelos and Keros-Syros phases (Papathanasopoulos 1961-2: 109). The purported cemetery at Phionda, located at the northern end of the Kalandos valley, has not been excavated. There are currently no known associated settlements from this area; while we would typically expect a nearby associated settlement, there is currently not enough archaeological data to speculate about its location.

Figure 5.20 shows the changing extent of this small world in southeastern Naxos through the different chronological phases of the Early Cycladic period. We must await the results of ceramic analysis from SENS to gain a better understanding of the land use during different phases of the EBA for the Kalandos Valley and the broader landscape of this region. As a preliminary statement, however, it is noteworthy that during the Kastri phase, the settlements of southeastern Naxos persist and even potentially expand, which runs counter to the overall pattern of settlement decline in at the end of the EBA in the Cyclades. I propose that one reason for this persistence might have been the closeness of ties within this community, allowing its members to sustain one another during times of hardship. Though relative to the rest of Naxos, the agricultural land in the southeast is hilly and marginal, and the connecting paths from this region to the rest of the island are limited, it is often the case that ties in marginal areas are stronger and more persistent than ties in more centralized areas (Horden and Purcell 2000). It is possible that the communities of southern Naxos during the end of the EBA created these kinds of sustaining ties among one another, allowing endurance in a period of seeming decline in the rest of the islands.

Habitual Interactions

The coherence of small worlds relies on the face-to-face interaction of their residents at the temporality of habitual interaction. The isochronic models of travel time shown in this chapter demonstrate that all four of the areas of interest accessible from any of the other areas of interest by a there-and-back journey of one day, indicating the potential for the types of habitual interaction that facilitate relationships based on trust and shared identity.

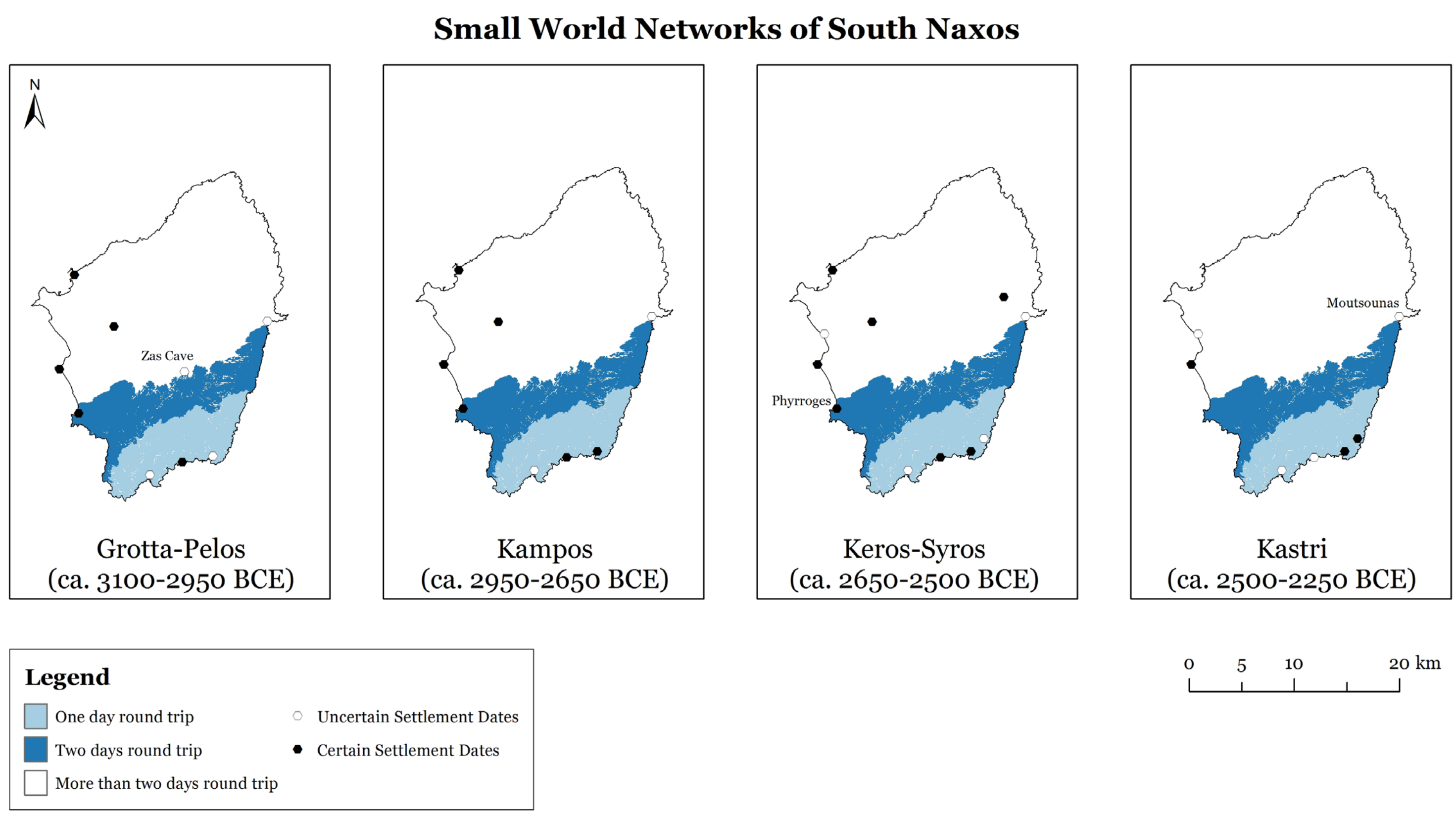


Figure 5.20. Small World Networks of South Naxos
This figure shows the changing geographical extent of the small world along the southeastern coast of Naxos through the different chronological phases of the Early Bronze Age.

If small worlds cohere based on habitual interactions, it follows that the spatial extent of a small world is constrained by how far its residents can travel on a habitual basis. The geographical extent of the small world should not be imagined as undifferentiated space, however, but as a varied landscape with places of greater and lesser interaction depending on the patterning of daily practice. Based on ethnographic data of how far farmers in modern Greece are willing to walk to their fields on a daily basis, as well as more generalized ethnographic comparanda on daily walking distance, I calculated potential action spaces that not only demonstrate the geographical extent of southern Naxos communities but also those spaces in which more intensive interaction likely occurred (figure 5.11).

Mobility is a key factor in community *praxis*, and place emerges from the meshwork of paths of movement (Ingold 2009, 2011; Lee and Ingold 2006: 78). These places are additionally characterized by the types of activity that occur in them as well as the daily and seasonal patterns of intensity of their use. Most obviously, this includes settlements or places of residence. This also includes cemeteries, where periodic gatherings to commemorate the dead would have occurred. For southeastern Naxos, the archaeologically known settlements are located at Panermos, Spedos, and Korphi t'Aroniou. However, significant portions of the island's population may have lived in dispersed farmsteads, which can be revealed through intensive survey.

Based on the analysis of potential action spaces, least-cost paths, and visibility studies, Spedos is both the most centrally located settlement and the one with the greatest surveillance over the southern coast of the island. Its location high on a prominent hill, as well as the nearby associated cemetery indicate Spedos as a place both highly visible within the community as well as a location of ritual activity for interring the dead.

Panermos and Korphi, in contrast, are more oriented toward domestic agricultural and pastoral activities. I postulate that due to its somewhat fortified walls, as well as its location near to a natural harbor and easy accessibility from land that Panermos represents a central site where the residents of the surrounding landscape could have gathered to possibly store agricultural materials or process animals remains. Korphi likely represents the farmsteads of these more dispersed members of the community. More archaeological work is necessary, however, to corroborate or disprove these hypotheses. Neither Korphi nor Panermos has the same degree of visibility or of surveillance as Spedos, which further emphasizes Spedos as a point of control for the landscape more generally, and especially from maritime contact.

More archaeological investigation is necessary to examine the role of the Kalandos valley, as well. While the GIS analyses above indicate this area as having potentially high agricultural importance for this community, the relationship with the patterns of material culture remains to be corroborated.

In addition to settlements and cemeteries, places of interaction for EBA communities would also have consisted of subsistence areas, socially maintained boundaries, and regularly traversed paths. Subsistence areas might include fields, threshing floors or other locations for the processing of crops, pastures for grazing, and locations of seasonal subsistence activities, such as gathering wood or fishing. These types of areas are not directly recoverable archaeologically; however, the GIS models above can help indicate where subsistence activities may have occurred. Agricultural fields were likely located in low-slope areas near to settlements or farmsteads, as demonstrated by the catchment areas in figure 5.8.

Potential paths are modeled by least-cost analysis of the landscape, using slope as a primary factor. Figure 5.12 indicates that the locales in the study area were highly interconnected, with many concentrated paths overlapping to connect the settlements via the coast and more dispersed paths intersecting in the inland areas to form potential nodes of interaction and activity. Relatively few paths connect the southeastern Naxos region to the rest of the island, indicating that there may have been known routes for traveling to the west, central, and eastern portions of the island over land.

Shared Identities

Given the current nature of the archaeological evidence, it is difficult to determine whether the settlements of southeastern Naxos during the Early Cycladic period had a shared collective identity. Renfrew (1972) identified various cultural phases, which form the common parlance for temporal periods in the Cyclades (e.g. the Keros-Syros culture, the Kastri group), but it does not follow that this shared material culture indicated shared identity. Furthermore, it is impossible to separate southern Naxos out in terms of material expression as distinct from other areas in the Cyclades.

However, based on the sheer persistence of sites on southern Naxos throughout the EBA, even during periods of overall decline, I posit that ties between these settlements were long-lived and stable. The marginality of the southern coast of Naxos, as it is geographically distinct from the rest of the island, might have enhanced these inter-settlement ties rather than detracting from them. As Horden and Purcell (2000) demonstrate for the mountainous communities of South Etruria, ties in marginal areas are often longer-lived and more stable than those in central areas.

While this chapter has focused solely on land-based analyses, in order to better understand the intercommunity interactions and small world networks of the central Cyclades during the Early Bronze Age, it is necessary to assess habitual maritime interaction. With this in mind, I turn to the development of a model to map sailing patterns in order to better situate Early Cycladic communities within their maritime environment.

Chapter 6
Maritime Mobilities

Introduction

The sea that surrounds the Cyclades exhibits at least as much variability as the terrestrial environment (Broodbank 2000: 92). Therefore, when considering community interactions for the Early Cycladic (EC) period, it is important to take into account the nuances and affordances of maritime travel. In the previous chapter, I introduced a methodology for modeling habitual interaction between Early Cycladic settlements via land-based travel. However, due to the steep and rocky terrain of the Cyclades—which also affords high intervisibility between islands—and the relative nearness of the islands to one another, it is likely that connections between islands would have been in many cases stronger and more frequent than connections between communities on the same island (Broodbank 2000). Previous attempts to quantify ancient maritime travel (e.g. Broodbank 2000; Knappett, et al. 2008, 2011) have been hindered by a number of factors: the aforementioned lack of direct evidence for sailing vessels, the need to account for the varying winds and currents that occur in the southern Aegean, and technological issues in creating cost-surface models for marine surfaces.

The present chapter resolves some of these issues. With the increasing availability of environmental data and new features in GIS that allow for the inclusion of horizontal factors in creating cost surfaces, it is possible to build a model that offers a more nuanced understanding of the affordances of the Early Bronze Age (EBA) seascape. Such a model treats the sea not as a constant expanse, but as a varied and varying surface affected by changes in season, weather, and time.

While most scholarship on Early Cycladic seafaring concentrates on the Cycladic longboats that journeyed on a regional scale, the present discussion focuses on the smaller spheres of interaction—those of everyday and habitual temporality—which I established in chapter 2. In a maritime context, a journey on an everyday scale would entail sailing out to the destination and returning again in a single day's time, while habitual journeys would involve sailing out and back in two days' time. As discussed in chapter 5, the threshold for a single day's travel is approximately six hours, so temporally an everyday journey would consist of a maximum of three hours' travel to reach the destination, and this is doubled for a habitual journey.

When considering both everyday and habitual interaction together, I refer to them as "local" spheres of interaction. Local interaction is differentiated from broader interaction spheres by several factors. First, journeys may be conducted by non-specialists. While long-range travel is conducted by individuals who specialize in sailing, local journeys might also have been undertaken by unskilled individuals (Tartaron 2013: 186). Short-range journeys would have moved between points that were most likely intervisible, and therefore they would not have required specialized knowledge of long-range navigation. Additionally, local journeys could be undertaken opportunistically during favorable conditions, so knowledge of how to handle seacraft in adverse weather conditions would not have been as vital, except, perhaps, in the case of a sudden storm. Second, seacraft would have been small, requiring fewer people to crew and thereby reducing the labor requirements for sailing as well as the cost of owning such a vessel. Finally, local interactions between settlements are distinct from broader travel ranges because they could occur with enough frequency so that relationships based on trust could be established between members of the visiting communities (see chapter 2). These smaller spheres of interaction are those most important to the practices of daily life and would have been the ties that sustained communities during periods of hardship in the marginal Cycladic environment.

The basic analytical unit of local interaction is the community. As discussed in chapter 2, "community" may be defined in different ways, and an individual may belong to multiple communities simultaneously. Due to the nature of the archaeological evidence, which for the Early Cycladic period focuses on the distribution of sites, in this chapter I consider community in the sense of coresidence, and therefore the settlement forms my primary analytical unit. One of the advantages of the methodology I implement is its ability to identify potential areas of activity and interaction that might not manifest via typical means in the archaeological record, and so it offers the ability for future prospection. In the present discussion, in order to keep the model grounded in the archaeological evidence, I use known settlements as a starting point for modeling intercommunity interaction.

Chapter Outline

In the present chapter, I first consider some of the ways in which network analyses have been previously applied to the Aegean Bronze Age, in particular Cyprian Broodbank's (2000) use of proximal point analysis in discussing site interaction for the Cyclades and Knappett, et al.'s (2008, 2011) maritime network interaction model, which they test with a case study of the collapse of Minoan trade networks following the Theran eruption. After assessing the strengths and weaknesses of these two models, I examine new methodologies of modeling maritime interaction applied by archaeologists working in other regions. I propose a least cost model[53] that incorporates environmental, technological, and cultural variables to understand patterns of habitual interaction between Early Cycladic communities. Finally, I implement this model to examine the Early Bronze Age seascapes in the central Cyclades. The creation of a least cost model for the Early Cycladic period allows me to address the following questions:

1. How do estimates based on the inclusion of environmental data compare with previous estimates of travel time?
2. What areas of the EBA Cyclades may have been interconnected by maritime travel on a local scale?
3. How does seasonality affect local seafaring and maritime connections?
4. How does directionality of travel affect local interaction?
5. How does maritime interaction change throughout the Early Cycladic period?

While previous models of Aegean seafaring have emphasized the importance of settlements as central nodes to attract connections, the present application of a cost surface model enables me to consider Early Cycladic settlements not merely as points in space but as embedded within a contiguous surface of land and sea. Most cost surface models of seafaring focus on regional scales of interaction, but here I consider local movement which would have created the ties most fundamental in sustaining intercommunity relationships (see chapter 2). Finally, I consider change between seasons and over time, highlighting the complex and ever-changing conditions facing the Bronze Age seafarer.

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53 The principle of least cost (Zipf 1949) assumes that humans tend to economize many aspects of their behavior, thereby maximizing profit and minimizing cost (see White and Surface-Evans 2012: 2). Such an approach can be problematic when variables are included where it is unclear that the people in question valued them to a certain degree. This tends to occur when either too few variables are considered or the archaeological evidence is not tied closely to the model using least coast analysis (LCA). Therefore, in the model I propose, I am careful to include a variety of cultural, environmental, and technological variables.

Evidence for Early Cycladic Seafaring

The available evidence, while largely indirect, indicates that maritime travel was an integral part of life for Early Cycladic islanders, but unfortunately no direct archaeological evidence of sailing technology survives. To reconstruct ancient seafaring, archaeologists must rely on depictions of Early Cycladic sailing vessels such as the images on the so-called Cycladic 'frying pans' (Wedde 2000: cat. 401-411)—those which are securely provenanced come from Chalandriani, a large EC II cemetery on Syros—on petroglyphs, such as those found at Korphi t'Aroniou on Naxos (figures 6.1 and 6.2), or in the form of models, such as the one excavated at Markiani (Brodie 2006).

It is difficult to draw firm conclusions based on the representation of vessels during this period, but it is possible to distinguish between two major types. While both vessel types usually exhibit a flat hull and vertical stern (Wedde 2000: 50)[54]—which was possibly a tiller for steering—they are distinguished by scale. The first type, the Cycladic longboat depicted on the frying pans, would have been a vessel holding a crew of twenty-five or more sailors (Broodbank 1989: 329)[55][56]. The cost of producing such a vessel, the larger crew required to sail it, and social restrictions make it likely that longboat ownership would have been restricted to a small group

54 For alternative interpretations of the vertical structure depicted on early Aegean sailing vessels see Tsountas 1899; Evans 1928; Marinatos 1933; Casson 1971; Gray 1974; and Basch 1987.

55 Scholars have noted the similarities between the sorts of craft depicted in the EC II period and ethnographic parallels in canoeing societies, in particular those used by the Trobriand islanders for kula ring exchange. Therefore, given the limited nature of the archaeological evidence, ethnographic comparison proves useful in understanding the technological limitations and affordances of inter-island canoe sailing. For a review of the ethnographic literature on sailing technologies, see Broodbank's synopsis (2000: 101-106).

56 Four lead models purported to be from a cist grave on Naxos (their provenance is far from certain) have also been interpreted as representing Early Cycladic long boats, as has a clay model from Palaikastro from the Early Minoan II period (Davaras 1984).

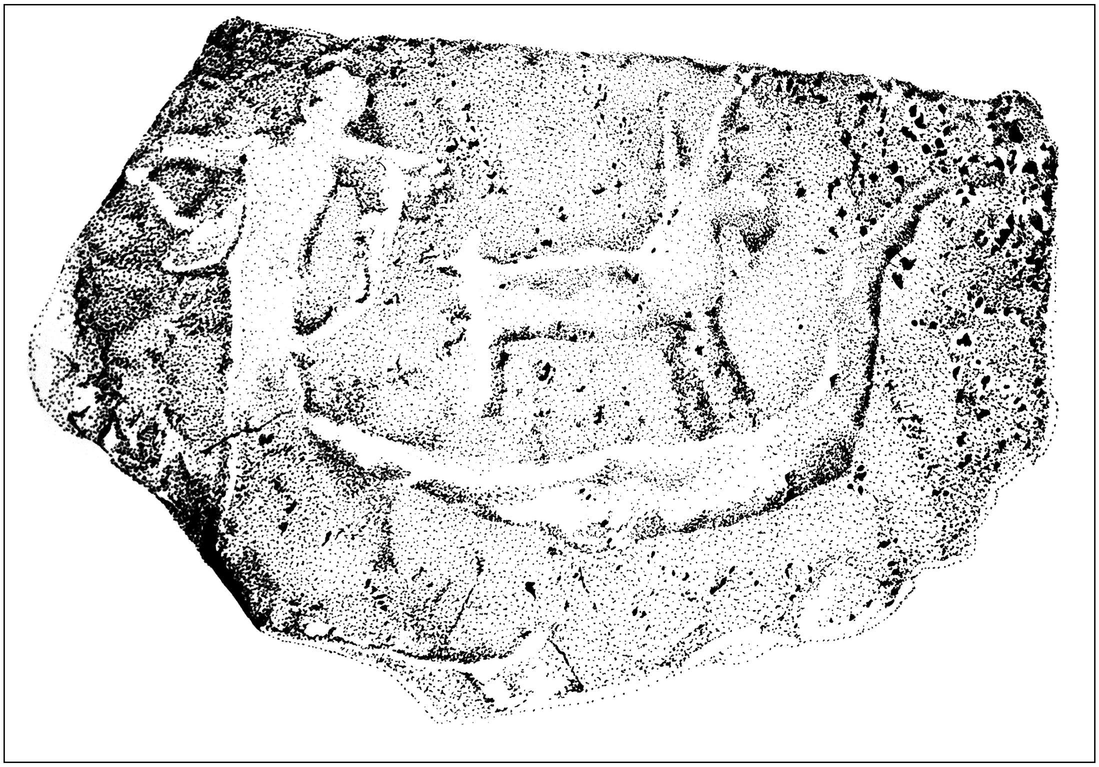

Figure 6.1. White Marble Fragment Depicting a Small Vessel, a Human Figure, and an Animal Figure
An Early Cycladic petroglyph from Korphi t'Aroniou (Wedde cat. 413), likely dating to the EC II period through analogy with the "frying pan" vessels from Chalandriani (Wedde 2000: 314). The small vessel depicted has a flat hull and vertical stern that is surmounted by an aft-facing appendage. Two projections from the hull are interpreted by Wedde (2000: 313) as tholes, which function as pivots for oars. To the left of the vessel, a human stands with one foot on the bow of the vessel; the figure appears to be holding tools in both hands. Above the vessel, an animal—likely a caprine—is depicted (Doumas 1965:48-50; 1970; Wedde 2000: 314).

Figure 6.2. Gray Marble Fragment Depicting Small Vessel and Two Human Figures
An Early Cycladic petroglyph from Korphi t'Aroniou (Wedde cat. 414), likely dating to the EC II period (cf. Figure 6.1). The small vessel depicted has a flat hull and vertical stern. Two human figures stand aboard the vessel (Doumas 1965: 52-53; 1970; Wedde 2000: 314).

of people (Broodbank 1989: 330). The longboat's owner may have been an individual who would marshal a crew for longer-distance voyages using personal charisma. Given the small population size estimated for most of Early Cycladic sites, a crew of 20-25 may have represented a substantial portion of a settlement's—or even an entire island's—adult population, and therefore it is doubtful that small Cycladic settlements could sustain the depletion of the workforce that longboat voyaging would entail (Broodbank 1989: 330-331).

The second type of vessel, small boats such as those depicted on the petroglyphs from Korphi t'Aroniou (Figures 6.1 and 6.2) or the terracotta model from Markiani, might have been operated by a single person or few people and used for short-haul trips or for fishing (see Brodie 2006: 210). Broodbank (1989: 332-333) suggests that livestock and bulk goods might have been more easily transported by these small boats than by longboats.

Longboats were probably built out of dugout logs or wood planks (Basch 1991: 47, 51; Brodie 2006: 210; Broodbank 1989: 329; Marinatos 1933: 173). However, the overall shortage of trees on the islands would mean that larger vessels such as longboats would have been rare and expensive to produce. Paleoenvironmental evidence suggests that some islands had large enough trees to allow the production of longboats. With the exception of Naxos, which would likely have been forested due to its size and higher elevation,[57] the islands with the potential resources for boatmaking tend to be those on the edge of the Cyclades. The wood charcoal data from EBA Akrotiri (Thera) indicates the presence of pine (*Pinus*)

57 Pollen analysis on Naxos indicates that by the EBA there was a reduction in tree cover, so the availability of lumber for boatmaking is unclear (Dalongeville and Renault-Miskovsky 1993; Broodbank 2000: 71; cf. French and Whitelaw 1999 for similar vegetation disturbance on Amorgos during the EBA).

and possibly oak (*Quercus*) which, depending on the species, might have been suitably large for boatmaking (Asouti 2003: 473), and evidence from Late Bronze Age Phylakopi III shows the presence of beech marten, which would have also been usable (Broodbank 1989: 329; Renfrew and Wagstaff 1982: 97). Due to their marginal location relative to the other Cycladic islands, these islands might rely on longer-range connections, necessitating the use of larger boats (see below). Islands with potential mainland connections such as Syros may have been able to acquire boats or their construction materials that they could not produce with the available natural resources, a possibility which merits further archaeological investigation.

Smaller vessels, on the other hand, could be skin-on-frame boats constructed of branches, bark, hide, and other less costly materials,[58] making them accessible to more members of society. Bosanquet and Welch (1904: 206) interpret a clay boat model from Phylakopi, which dates to the Mycenaean period and has painted vertical stripes, as representing a wooden frame pressing against a skin hull (see also Brodie 2006: 211).

Tools recovered from the material record indicate that Early Cycladic islanders had the technological capabilities for shaping planks for boat-making:

> Shaped planks would be well within the capabilities of shipwrights using polished stone or metal adzes; indeed, it is of interest to note by way of comparison that our knowledge of Keros-Syros tool kits shows them to be superior to those of many of the most accomplished boat-building cultures of the Pacific and elsewhere. (Broodbank 1989: 329)

The controlled, special deposition of metal objects (Nakou 1995) indicates that woodworking for boats would have likely been a restricted and/or prestigious activity requiring special knowledge limited to the few.

58 Analogous vessels include skin-on-frame or bark kayaks (e.g. Tappan Adnay and Chappelle 2007), qaffas, and coracles (e.g. Peacock, et al. 2009).

Early Cycladic islanders likely embarked on a variety of types of voyages, including short-range travel, long-range trade, raids (see chapter 4), and ritual voyages. Different segments of the population would have taken part in these types of voyages, and differential knowledge would have been required to complete them. The most inclusive type of voyage would have been short-range travel, which is the focus of the present chapter. No specialized knowledge of seafaring or wayfinding is required for such voyages (Tartaron 2013), nor would specialized vessels have been necessary. Longer-range travel would have necessitated larger vessels such as longboats. For raiding and war, as discussed in chapter 4, only a small portion of the population—most likely young adult males—would have participated. Trade, likewise, probably involved a small segment of the population who had specialized knowledge about the location of far-flung settlements and natural resource extraction sites. Broodbank (1993) proposed that only a few sites would have dominated long-range trade in the region, since only a few settlements would have had great enough resources and population to fund such voyages.

Evidence for ritual voyaging is attested at Dhaskalio-Kavos (Renfrew, et al. 2012; 2013). The sanctuary at Dhaskalio-Kavos functioned as a regional center for the region, and travelers brought artifacts for ritual deposition at Kavos and white pebbles for placing in the central altar at Dhaskalio (Nymo, et al. 2013). On such a voyage, one might imagine many or all members of one or several communities gathering at staging sites to embark, guided by those with specialized sailing knowledge.

Previous archaeological models of maritime interaction

Previous methods for modeling maritime interaction networks in the Mediterranean have treated the sea surface as undifferentiated space (Leidwanger 2013: 3302). By relying solely on geographical distance as the determining factor of nearness, these models ignore the practicalities of ancient sailing. For past sailors, the time it took to travel between places would have been of greater logistical importance than distance (see Di Piazza, et al. 2007; Leidwanger 2013; Di Piazza 2014). Furthermore, the overemphasis on known archaeological sites as nodes in these networks leads to ignoring less archaeologically visible places that may have held meaning to past inhabitants and/or served as visible references for navigation. What is needed is a methodology for assessing ancient maritime networks that considers the marine surface as varied and dynamic, taking travel time as the defining factor of nearness.

Two particularly influential models of maritime interaction in Aegean archaeology are Broodbank's (1993; 2000) proximal point analysis and Knappett, et al.'s (2008; 2011) diachronic network analysis of maritime trade in the southern Aegean. In the broader context of studies of Bronze Age Aegean interaction, Broodbank's model (discussed in depth in chapter 2) is a major step forward because it refutes the notion of "island laboratories" that was prevalent in earlier processual scholarship (e.g. Renfrew 1972; Renfrew and Wagstaff 1982; Cherry, et al. 1991). Proponents of the "island laboratory" model held that islands are inherently bounded and isolated due to their geographical nature. However, Broodbank showed that there could be greater connectedness between islands than there was on the same island. This is due to the steep, fragmented terrain, which separates settlements on the same island and causes communities to turn toward external connections, and the geographic nearness of the Cycladic islands, as well as the ease by which EC vessels could make landfall since they did not require harbors (2000: 75).

The model Broodbank uses is proximal point analysis (PPA), which takes a series of points distributed in space and predicts interactions between them based on a factor of distance. Broodbank's initial (1993) publication of the results of this analysis predates the widespread adoption of GIS technology in Mediterranean archaeology. The model assumes that each point will connect with the other points nearest to it. This web of interactions produces a network, which can be analyzed in terms of regional communication (Broodbank 2000: 180-1). Broodbank's input data consist of known settlement sites at different chronological time periods. By assessing the various reconfigurations of relationships between the sites as they come into being or disappear, he evaluates how network interactions changed diachronically from the Neolithic through the Bronze Age (2000: 195).

A more recent model developed for site interaction of the southern Aegean during the Bronze Age is Knappett, et al.'s (2011; 2008) diachronic network analysis for maritime trade. This model takes a series of settlements and evaluates them within the overall trade network according to a series of variables, such as carrying capacity, attraction to visitors from other settlements, physical distance, and the social potential for cost/benefit. The underlying assumption is that larger or more important sites will have both greater incentive for maintaining relationships between other sites and will also have greater draw for external contact. The authors subsequently present a case study that asks how the eruption of Thera affected the collapse of Minoan palatial trade networks, even though these networks persisted up to 100 years after the volcanic eruption (2011: 1009).

Both of these network models assume an undifferentiated seascape, where the nodes of the network are known archaeological sites, the edges are direct lines between them, and these connections are measured by geographical distance. As such, they ignore the temporal elements of ancient travel which would have had a greater impact on the logistics of a journey than nearness. They also do not take into consideration the differential availability of ships, technology, and labor to people in Aegean communities, which if considered would allow the authors to investigate social difference in the maritime network. Finally, both rely on assigning relative weight to settlements, where centrality is assumed to equal the strength and importance of connections. A cost surface model of maritime travel, which takes into account the nuances of the marine surface and privileges travel time over geographical distance, can resolve these issues.

The application of cost surface models to maritime travel in archaeology is a relatively new endeavor, due, in part, to technological limitations. Archaeologists must either rely on the existing capabilities of GIS software or create their own software applications. In some cases, archaeologists have to shoehorn their research models into GIS functions created for entirely different purposes. For example, Indruszewski and Barton (2007; 2008) use the r.spread function in GRASS, which was originally created by Xu (1994) for analyzing the spread of wildfires, to create a cost surface model for Viking sailing routes. Creating unique software applications to model maritime interaction, such as one used to model early sailing routes in the Polynesian islands (Di Piazza 2014; Di Piazza, et al. 2007) can be cost prohibitive and limit comparison with other network models.

Some scholars have also attempted to weight maritime least cost paths with cultural variables—such as preference for certain types of coastscape, intervisibility and navigational markers, locations of protected water, and site aspect—as cost factors in their GIS models, such as Gustas and Supernant's (2017) model of least cost paths between islands in the Pacific northwest. Thus far the inclusion of cultural variables precludes the creation of a cost surface raster of the marine surface itself, and therefore these least cost paths do not account for travel time.

The suite of path distance tools implemented in ArcGIS version 10.3 offers the most promising avenue for maritime interaction because they allow for the creation of multi-variable cost surface rasters, including horizontal factors such as wind direction. Earlier cost surface tools in ArcGIS were ill suited to modeling marine surfaces because they were unidirectional. For overland travel (see chapter 5) this is not a problem because humans take approximately the same amount of time to travel upslope as down. However, maritime travel is significantly affected by directionality. Sailing into the wind results in very different travel times than going with it. It is necessary for the cost surface model to be capable of accounting for different travel costs depending on the direction of movement.

Leidwanger (2013) successfully applied the Path Distance function to model the sailing ranges of a Roman shipwreck in the eastern Mediterranean. By accounting for the variation in the distance a ship was capable of sailing in a day due to its relative position with respect to the prevailing wind, he concludes that earlier estimates of sailing distance based on ancient literary sources and archaeological evidence are not particularly useful. While the average sailing distance of all directions was comparable to earlier estimates, the range of sailing distances among all directions was so great as to render the average meaningless.

To model local maritime interaction of the EBA Cyclades, I incorporate some successful methodologies implemented by the previous archaeological applications above: the use of isochrones, the creation of cost surface rasters, and the consideration of the contiguous seascape over site-centered analysis. While all of the aforementioned models consider travel on a regional or greater scale, I focus on local temporalities of travel. Whereas the models listed above that utilized cost rasters all use cost factors associated with ships that have sails, I create cost factors based on the performance of sail-less vessels, which would have been used until the appearance of the masted sailing ship in the EBIII period (Papadotos and Tomkins 2013: 353-355).[59] Finally, I take into account the changes in sailing patterns based on seasonal variation in wind and wave patterns.

Building an interaction model

To address the research questions outlined at the beginning of this chapter, I created a least cost model for maritime travel. The inputs of the present model consist of environmental variables, known archaeological sites, and sailing vessel performance data.

Environmental Variables

The first step in creating a least cost model for maritime travel in the Early Cycladic period is the compilation of environmental variables that would have influenced sailing to create a cost surface raster, which contains the cost of moving to and from each cell on the raster map. The primary environmental variable that would have affected maritime travel in the Early Cycladic period was wind.

59 Currently there is no evidence to indicate that sails were used during the first part of the Early Cycladic period, and the choice to create a model for sail-less vessels is based on the inherited wisdom of a century's archaeological work in the Aegean. The earliest known archaeological evidence for the use of the sail comes from Mesopotamia during the Ubaid period (c. 6000-4300 BCE) (Carter 2012: 348), so it is feasible that sails were adopted in the Cyclades earlier than the extant archaeological evidence shows. Should that be the case, the present model could be expanded to include cost factors based on the performance of vessels with sails.

The speed and direction of wind are the main factors in the creation of sea surface circulation in the Aegean. Sea surface circulation—the circulation of wind-generated and geostrophic currents—would have been a decisive element in early sea-faring (Papageorgiou 2008: 201). Prehistoric rowboats would have been affected by the combined effects of wind pattern and current flow, and unlike later sailing boats, they would have been less resistant to adverse weather conditions (Papageorgiou 2008: 202).

There are two predominant currents that flow throughout the Aegean: the north-east Aegean current and the east Mediterranean current. The former flows in a counter-clockwise direction from the Black Sea all the way down the coast of the Greek mainland to Crete. The main input of water into the North Aegean comes from the Black Sea (Kourafalou and Barbopoulos 2003: 251-2) and is of lower salinity—and therefore lower buoyancy—than the waters of the south Aegean, where the primary in-flow comes from the east Mediterranean (Olson, et al. 2007: 1909). This current is powerful and throughout most of the year is aided by winds flowing in the same direction. Although this current would have been navigable for rowboats year-round, the current is most powerful in the summer, when the parallel Etesian winds would have aided in sea craft propulsion.

The east Mediterranean current brings high salinity water into the Aegean from, as the name implies, the eastern Mediterranean, and it flows northward. This current is not as powerful as the north-east Aegean current, which is probably due to generally opposing wind patterns. The combination of the two currents produces a cyclonic (counterclockwise) flow that circulates the entire Aegean. The predominant flow of the northeast Aegean current divides the northwestern-most Cycladic islands—which would include the Bronze Age settlements at Ayia Irini, Kastri and Chalandriani, Mt Kynthos, and Strophilas—from the rest of the island chain. This tentatively suggests that the natural current might have privileged interaction of these sites with the Greek mainland over the other Cycladic islands.[60]

So much for the generalized Aegean currents—what can we say about current and wind patterns in the Cyclades more specifically? The first factor it is important to note is the extreme variability of the wind and current pattern in the region. In contrast with the very regular pan-Aegean currents, subsidiary sea-lanes would have only been open during certain weather patterns or at certain times of year. Mariners would have probably used various alternative pathways (Broodbank 2000: 92-4; Papageorgiou 2008: 212), which would likely result in outgoing and return journeys following different routes.

To create a cost surface raster for the south Aegean, I derived the wind speed and direction data from windfinder.org, which tabulates average monthly wind data for various points throughout the Mediterranean, dating from 1999 to the present. Once I had collected the information for each month from data points around the Aegean, I interpolated them in ArcGIS to produce wind maps for each month (see appendix B for maps and detailed methodology). Wind patterns in the southern Aegean vary significantly from month to month, indicating that seasonality might very well be a major factor in sailing patterns.

It is likely that early Aegean sailors faced wind conditions similar to those of the present day (Mantzourani and Theodorou 1989; Papageorgiou 2009; see also Leidwanger 2013: 3304). McGrail (2001: 89) notes that in the absence of

60 Cherry, et al. (1991) note in their survey on Keos that early centralization at Ayia Irini and the lack of dispersed EC I settlements may have been due to relationships with the mainland, unlike the more "typical" EC settlement pattern described in Renfrew and Wagstaff's 1982 survey of Melos.

more detailed knowledge of earlier Mediterranean environments, it is valid to use modern data on winds, currents, tides, and coastlines to assess the context of early Mediterranean maritime voyages. McGrail's assessment is borne out by subsequent climatological (Enzel, et al. 2008; Kuhlemann, et al. 2008) and geological (Roskin, et al. 2011a; 2011b) studies. Moreover, comparison between modern wind tables and ancient historical references suggests that prevailing wind patterns have not changed markedly (Murray 1987).Therefore, using modern wind data is likely to yield valid results. Furthermore, since Mediterranean currents are generally minimal in comparison with the surface currents caused by wind directionality and speed (Leidwanger 2013: 3304), they are excluded from the present model for simplicity.

The inherent risk and variability of seafaring, given the volatile weather conditions, might have manifest in several ways. It is possible, as Broodbank (2000: 92) has interpreted, that sailors might have limited their journeys to a favorable season of travel. Long-range voyages might have been undertaken primarily during the summer months when the north winds prevailed. An alternate interpretation, (see Papageorgiou 2008) is that the variability of the weather patterns might have facilitated year-round voyaging. Such a model would require sailors to be flexible in their sailing patterns—both in terms of routes and obligations to their home communities—and it would require knowledge of safe havens and sheltered harbors (Papageorgiou 2008: 204). Given the analysis of the agricultural cycle in chapter 3, Papageorgiou's (2008) hypothesis seems more likely as there was no particular season during the year when labor requirements would have encouraged travel. Short-range voyages in smaller vessels mean more opportunities for travel throughout the year since they would be less reliant on stretches of good weather.

Travel by longboats or smaller vessels did not have any specific requirements for harbors. Ships could be pulled ashore anywhere that was not a steep cliff (Broodbank 2000: 101). I analyzed the modern coastlines of the islands and blocked off any portions of the coastline too steep for a longboat to pull ashore as barriers to travel. The coast lines of the Cyclades in the Bronze Age were probably similar to the modern coast[61], as the major rise in Mediterranean sea levels had occurred by the Neolithic (Broodbank 2000: 70; Papageorgiou 2008: 201). The coastline in the Bronze Age would have been between 2 and 18 m lower than at present, and bays would have been deeper, since sediment has gradually built up in the modern era (Papageorgiou 2008: 201). However, it is unlikely that the slope of the coast has changed dramatically, allowing the use of modern slope data to assess barriers to ancient maritime travel. Figure 6.3 shows the coastal zones of the Cyclades where a boat would have easy access to land. I found that a large portion of the Cycladic coastline would not have been suitable for pulling boats ashore (i.e. is greater than 20° slope) (contra Broodbank 2000: 101), and therefore knowledge of beaching locations would have been important for early seafarers, especially when traveling between locations that were not intervisible.

Archaeological Sites

The Path Distance function in ArcGIS requires inputs for a starting point or points which serves as the destination locations(s) for the model. In other words, the starting point is actually the location *to which* the least accumulated cost dis-

61 The major geographical differences between the islands in the Bronze Age and today are the presence of a land bridge between Paros, Antiparos, and Despotikon (Bent 1984: 47; Morrison 1968) and that the eruption of Thera deepened and widened the existing caldera (Druitt 2014; cf. Heiken and McCoy 1984).

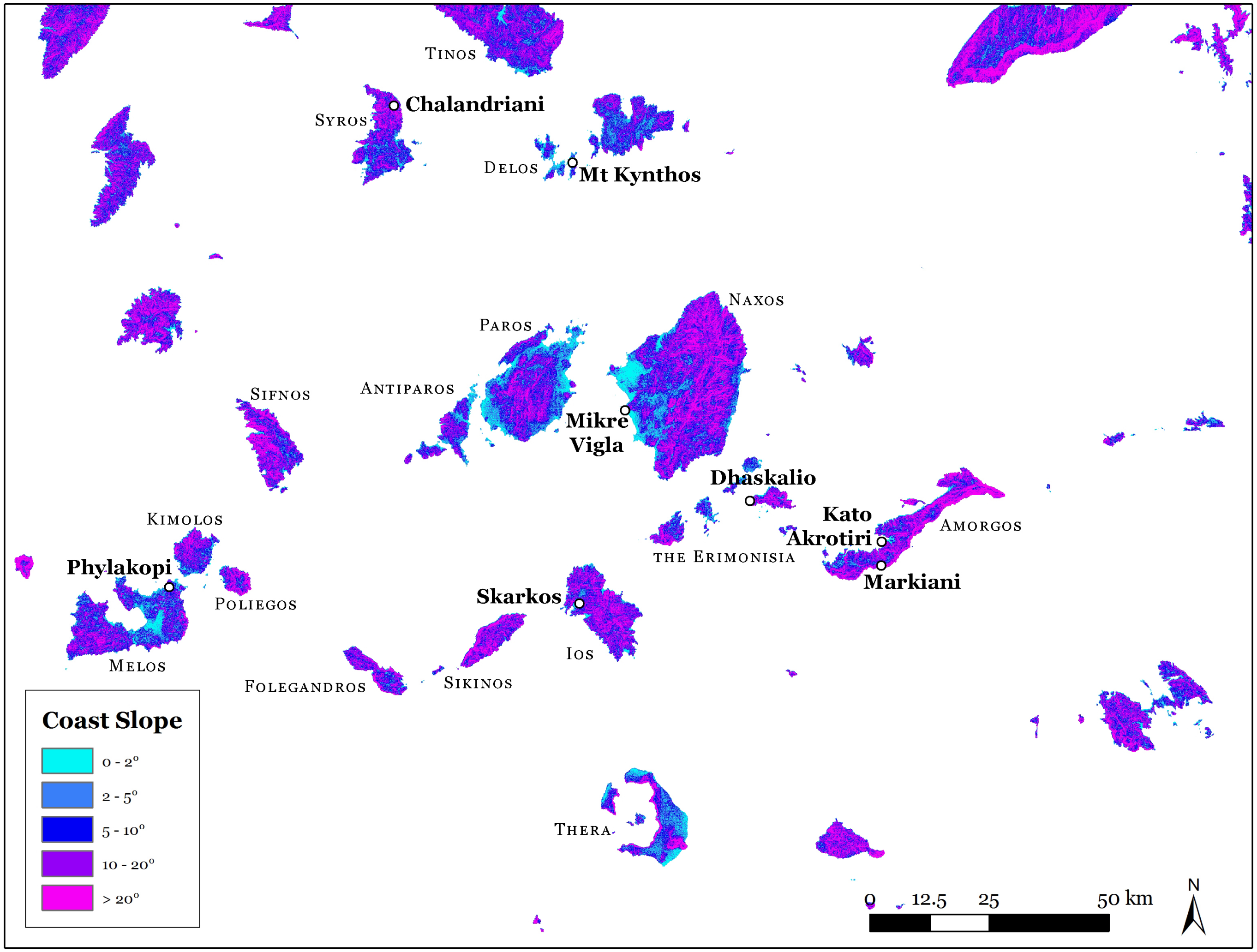

Figure 6.3. Major Early Cycladic Sites and Coast Slope

tance is calculated. In this case, I used shapefiles of the locations of known Early Cycladic coastal sites with the idea that at a later point potential beaching spots or likely locations of human activity could be identified and later incorporated. These shapefiles had to be modified so that the starting points were not located on a null location on the raster file. Since I categorized all land values as null so that they appear as absolute boundaries in the Path Distance model, this meant that the Early Cycladic sites in the starting point shapefiles were "relocated" to the nearest raster cell in the sea to the site's actual location.

Sailing Vessel Performance

To create the cost factors to be included in the least cost model, I had to estimate vessel speeds and assess the performance of vessels under various sailing conditions. I calibrated the cost of sailing in different wind speeds first to neutral conditions, which would be sailing perpendicular to little wind (Beaufort 0). I determined a base rate of 7 km/hr for a cruising speed that could be maintained for several hours. In optimal conditions, with an advantageous breeze and traveling directly downwind, this came to an 11 km/hr cruising rate, and in very adverse conditions (a Beaufort 5 going straight into the wind), this resulted in 2 km/hr. (Given a choice, it is unlikely that someone would undertake a journey in the last conditions.) The costs associated with sailing under various wind conditions are listed in table 6.1, where traveling in Beaufort 2 conditions has the lowest associated cost of 0.4.

Table 6.1. Costs for Sailing in Various Wind Conditions

Beaufort	Wind (km/h)	Classification[a]	Conditions	Cost
0	<1.8	Calm	Sea surface smooth and mirror-like	1
1	1.8 - 5.6	Light Air	Scaly ripples, no foam crests	0.7
2	5.6 - 11.1	Light Breeze	Small wavelets, crests begin to break, scattered whitecaps	0.4
3	11.1 - 18.5	Gentle Breeze	Large wavelets, crests begin to break, scattered whitecaps	0.7
4	18.5 - 29.6	Moderate Breeze	Small waves 1-4 ft becoming longer, numerous whitecaps	1
5	29.6 - 40	Fresh Breeze	Moderate waves 4-8 ft taking longer form, many whitecaps	10
6+	40+	Strong Breeze+	Large waves, many whitecaps	150

[a] According to the World Meteorological Organization

In addition to estimating how EC vessels would have performed under different wind speed conditions, I also had to estimate how vessels would have performed relative to the prevailing wind direction, which formed the horizontal factor—or H_factor—of the least cost model. Most comparanda deal with vessels that have sails, even if they are single sails like early Polynesian outrigger canoes (see Di Piazza 2014; Di Piazza, et al. 2007). Vessels without sails, such as those from the Early Cycladic period, behave very differently relative to the prevailing wind. They travel the fastest when sailing directly downwind, which is called leecocking, and conversely, they move slowest when sailing directly into the wind, called weathercocking (figure 6.4).

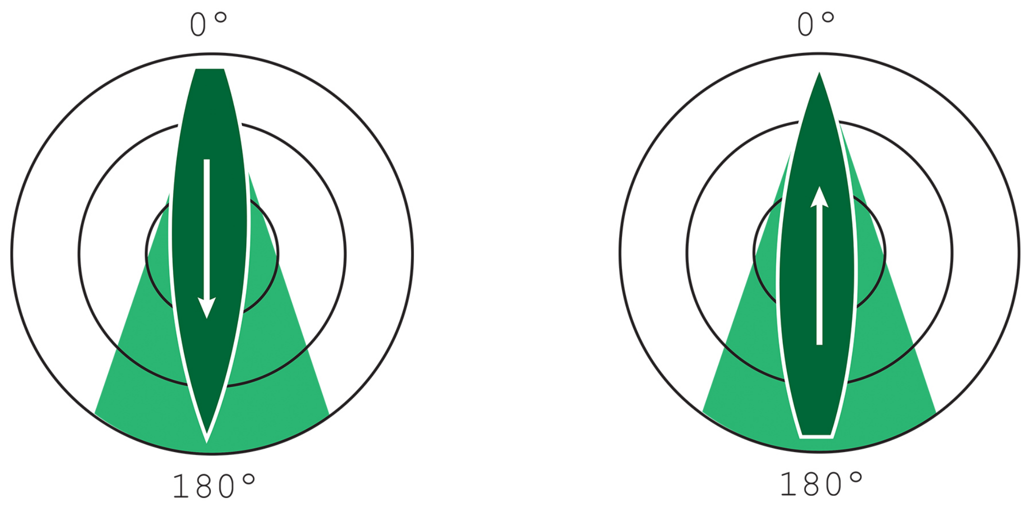

Figure 6.4. Vessel Performance Relative to Wind Direction
Early Cycladic vessels would experience optimal sailing speeds when traveling directly downwind, called leecocking, while the most adverse conditions would entail traveling directly into the wind, called weathercocking.

Figure 6.5 shows the calculated costs of the horizontal relative moving angle (HRMA), which is the direction of traveling relative to the prevailing wind direction. Traveling into the wind (0°) has the highest cost of 5, while traveling with the wind (180°) has the lowest associated cost of 0.9.[62]

Modeling Interaction with the Path Distance Function

With the data gathered and the various cost factors determined, I used the Path Distance function in ArcGIS to create a model of maritime movement for the Early Cycladic period. The Path Distance function multiples the cost raster—i.e. the

62 The degrees measured range from 0 to 180 due to input requirements from ArcGIS's Path Distance function. Path distance measures HRMA on a scale of 0 to 180 because it assumes the graph of costs is symmetrical. Therefore if a vessel was traveling at 350° relative to the prevailing wind, the function would assign it the same value as a vessel traveling at 10° relative to the prevailing wind.

wind speed reclassified by the cost table shown above—by a horizontal raster—i.e. prevailing wind direction, which was modified by the H-factor table shown above. The result is a cost surface raster that takes into consideration the costs associated with traveling at different wind speeds and with traveling at different angles relative to the prevailing wind direction. While most applications of GIS cost surfaces assign a static cost value per cell (Conolly and Lake 2006: 221-224), the Path Distance function assigns each cell a dynamic cost that varies in accordance with a second independent factor. In this case, the Path Distance function "defines sailing capabilities relative to wind direction: here it reflects the difference in angle between prevailing wind and vessel heading" (Leidwanger 2013: 3305).

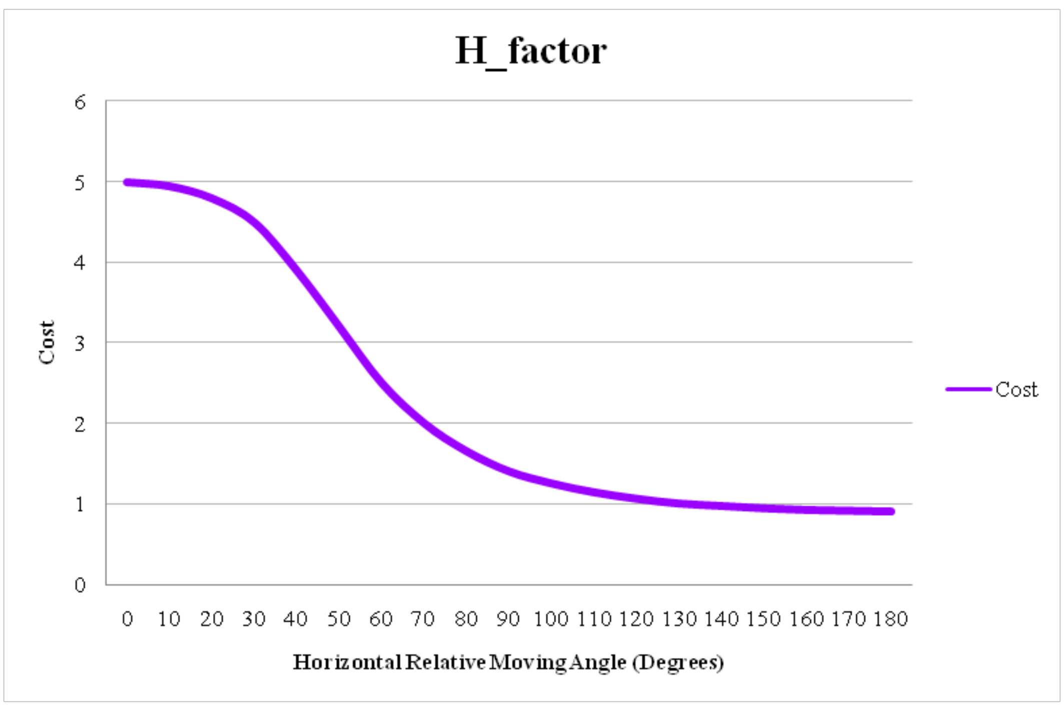

Figure 6.5. Horizontal Factor
The horizontal factor, or H_factor, measures the cost of a vessel traveling relative to the prevailing wind direction.

The Path Distance function measures the costs of traveling *to* a place, not outward from it. Unlike previous models based on geographic distance, this model has the ability to differentiate between outbound and inbound travel times, which depending on weather conditions, almost certainly would not have been equal.

Figure 6.6 shows one particular example of running the function for a single site during a specific month of the year; in this case it shows the distances from which one could sail to the site of Dhaskalio on the island of Keros in one and two days' time. The concentric circles on the map represent Broodbank's original 10 km, single day travel distance estimate (Broodbank 2000: 103, fig. 24).

Starting from this map, it is possible to test several variables of the model. For example, since it is so difficult to estimate the base rate of speed for an Early Cycladic vessel due to the lack of direct archaeological evidence, figure 6.7 compares different base rates to see how much travel ranges change. On the left is shown an average travel distance of 21 km/day—this is derived from a cruising speed of 7 km/hr by modern kayaks in neutral conditions. For an out-and-back journey in a single day, the maximum threshold for travel time on one leg of a journey seems to be about three hours based on various ethnographic comparanda, and this is doubled for a 2-day round trip (see chapter 5 for further discussion). Shown in the middle of figure 6.7 is a more moderate base rate of 15 km/day, and on the right is Broodbank's conservative 10 km/day estimate. In the present model I opt to be more conservative estimating travel ranges, so the 10 km/day range is what I use henceforth.[63] However, this comparison shows that the model is flexible in accounting for different base rates of travel pending new evidence.

63 This base rate of sailing is also comparable to the base sailing speed identified for canoe travel in the Pacific Northwest by Ames (2012: 30-31; see also Gustas and Supernant 2017: 45).

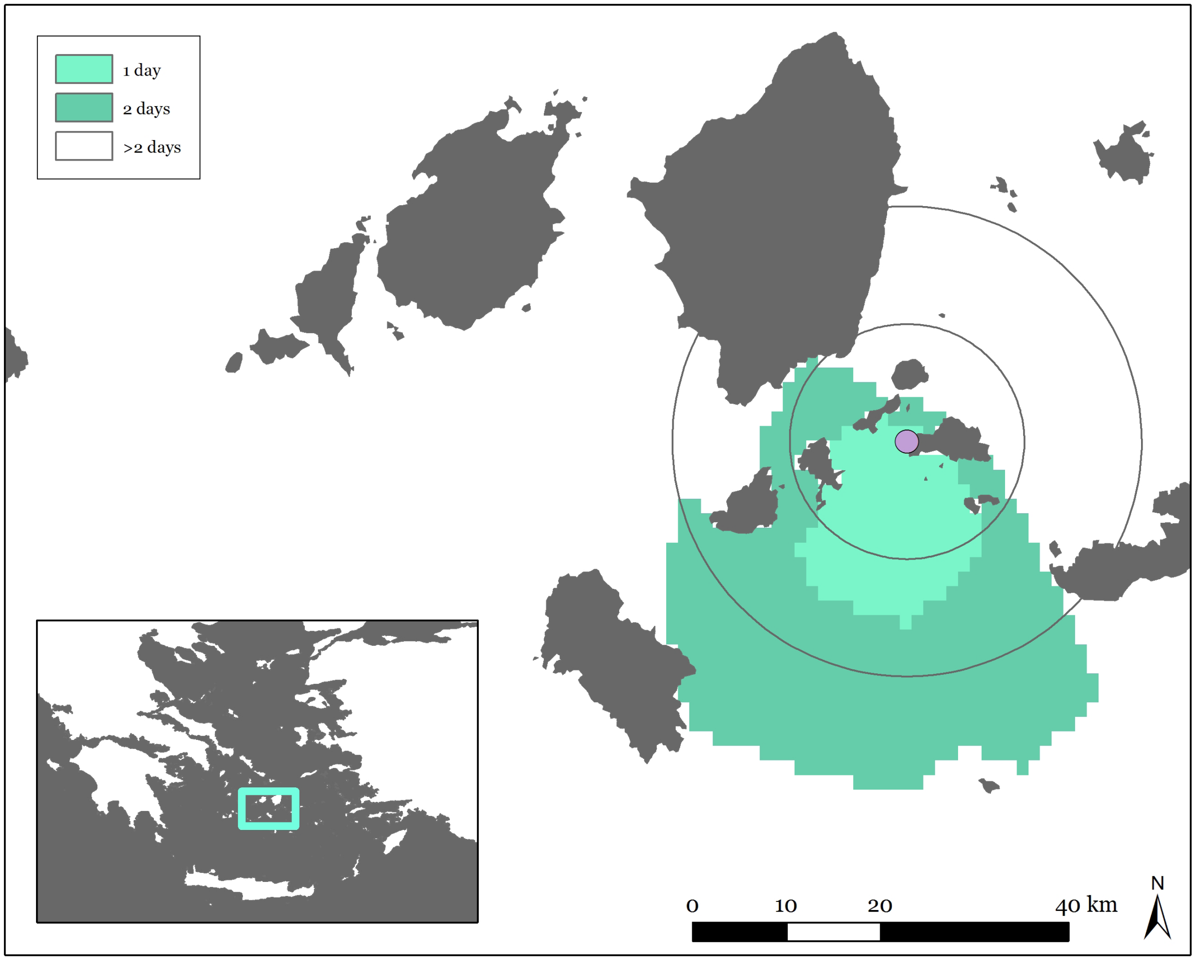

Figure 6.6. Path Distance Function for Dhaskalio, Keros (June)
This map shows the distance from which a person using a small Early Cycladic vessel could sail in one and two day's time to the settlement at Dhaskalio on the island of Keros during the month of June.

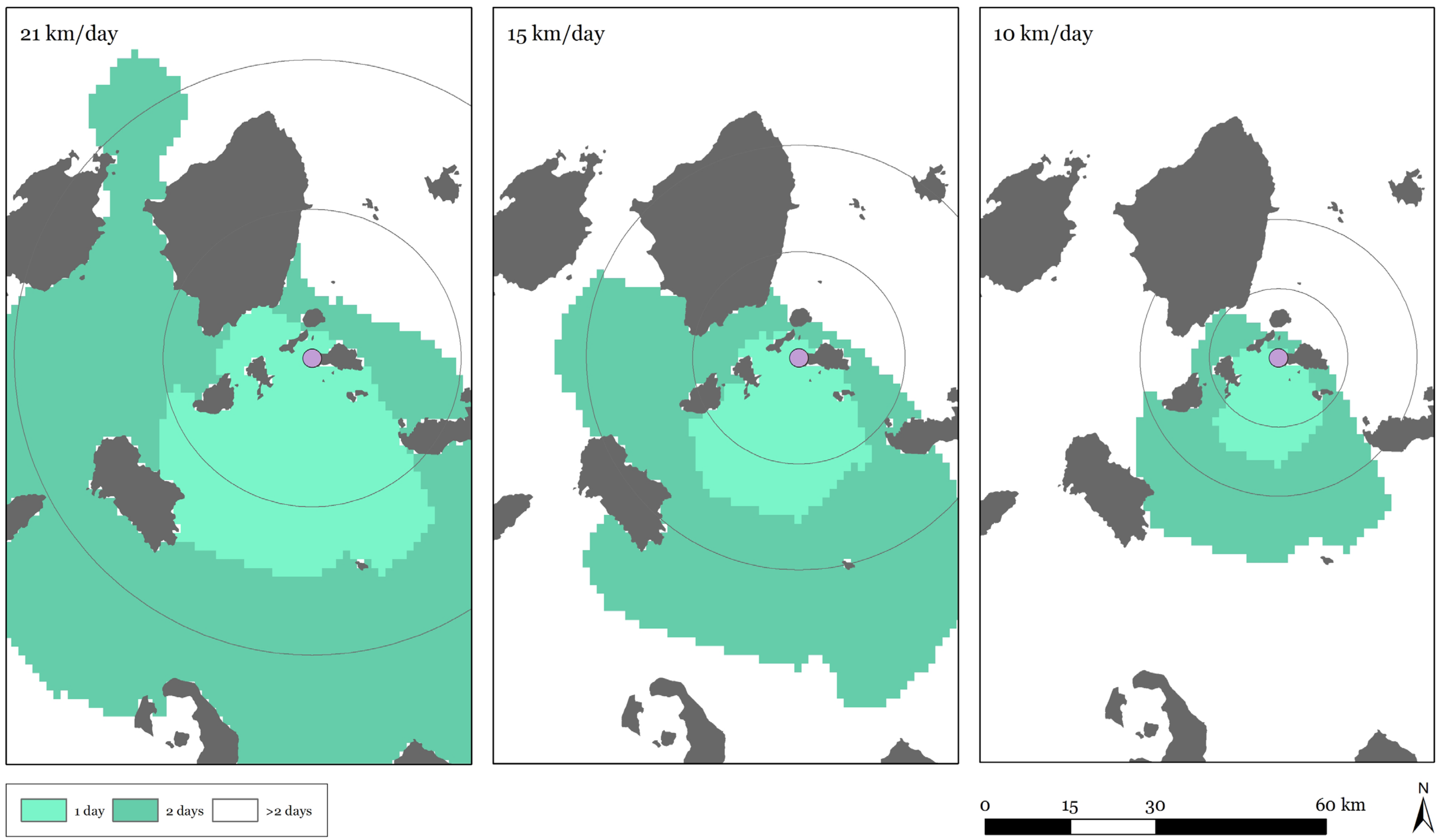

Figure 6.7. Base Rate of Speed Comparison for Dhaskalio, Keros (June)
This map compares different base rates of speed from which an Early Cycladic islander could have sailed to Dhaskalio on the island of Keros during the month of June.

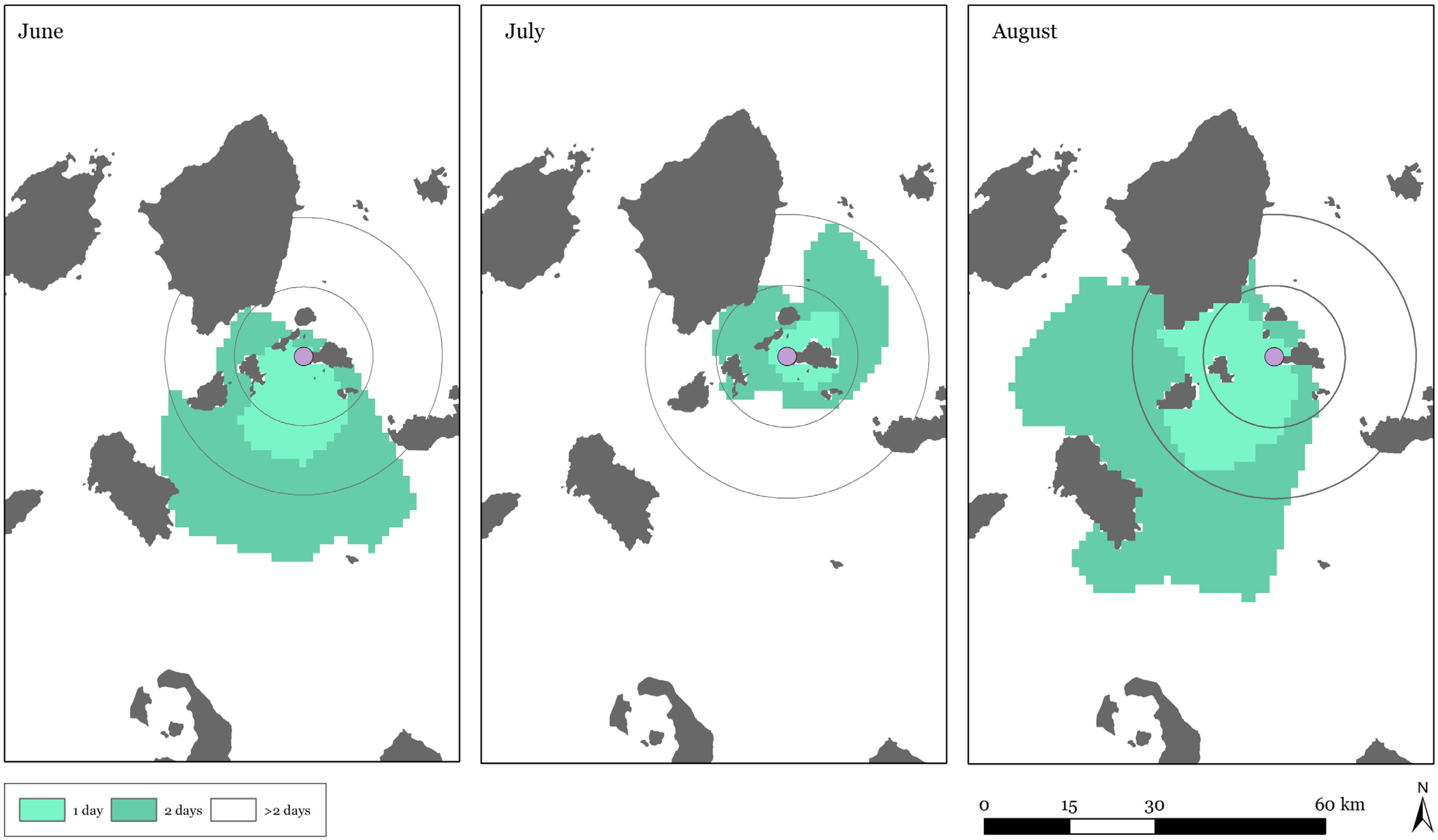

Figure 6.8. Seasonal Comparison for Sailing to Dhaskalio, Keros
This map compares the different sailing patterns of the summer months for an Early Cycladic islander sailing to Dhaskalio on the island of Keros.

It is also possible to see how sailing rates change depending on the prevailing wind speed and direction for each month. As an example of this, figure 6.8 shows the differences between June, July, and August. The summer months have previously been posited as the "sailing season" of the EBA Cyclades due to weather conditions and their relationship with the agricultural cycle (Broodbank 2000: 92-96). Here it is evident that the affordances of the seascape vary significantly from month to month.

Analysis

Returning to the four research questions I identified at the outset of this chapter, what can this model tell us about sailing patterns in the Early Cycladic period, and what information about environmental effects on sailing can a cost surface maritime model reveal?

<u>1. How does the inclusion of environmental data compare with previous estimates of travel time?</u>

When compared with previous archaeological estimates of traveling time in the Cyclades, my findings corroborated Leidwanger's (2013: 3306) conclusion about Roman ships in later antiquity; in previous studies of the daily range of maritime travel in antiquity, while *average* estimates were fairly accurate, the *range* of sailing distances was much more extreme, to the point where average estimates are not particularly meaningful.

Returning to the example of Dhaskalio (Keros) in June (figure 6.6), when considering sailing distances from the cardinal and ordinal directions (not including the east because it is blocked by the island of Keros itself), the average sailing distance for a single day's journey in June was 9.2 km. Accounting for the fact that these maximum ranges are occasionally shortened by running into a land mass, this is close to Broodbank's 10 km/day estimate. However, the range of distance for a single day of travel varies from an extremely short 1.6 km to over 20 km due to the prevailing southern wind.

While previous archaeological estimates have technically been accurate, these results should caution archaeologists against relying on averages pertaining to geographical distance, what Leidwanger (2013: 3306) calls "static figures," when considering ancient travel. Moreover, it calls attention to the importance of distinguishing geographic distance from the experiences of travel based on time that would have shaped past maritime interaction. To optimize their journeys, ancient seafarers would have required knowledge about wind and weather patterns, as well as skill to navigate various sailing conditions.

2. What areas of the EBA Cyclades may have been interconnected by maritime travel on a local scale?

On a local scale, some areas of the central Cyclades seem to be much more connected by maritime travel than others. Figure 6.9 shows coastal sites clustered with other sites within reach via less than two days' journey. Using a cost surface model allows me to quantitatively distinguish geographical closeness and temporal closeness; the lived experiences of ancient travel would have been much more closely dependent on the time it took to travel to a place, rather than on its geographical distance from a starting location.

Certain sites are geographically close to one another, but in terms of maritime travel, do not have the potential for frequent maritime connections. These

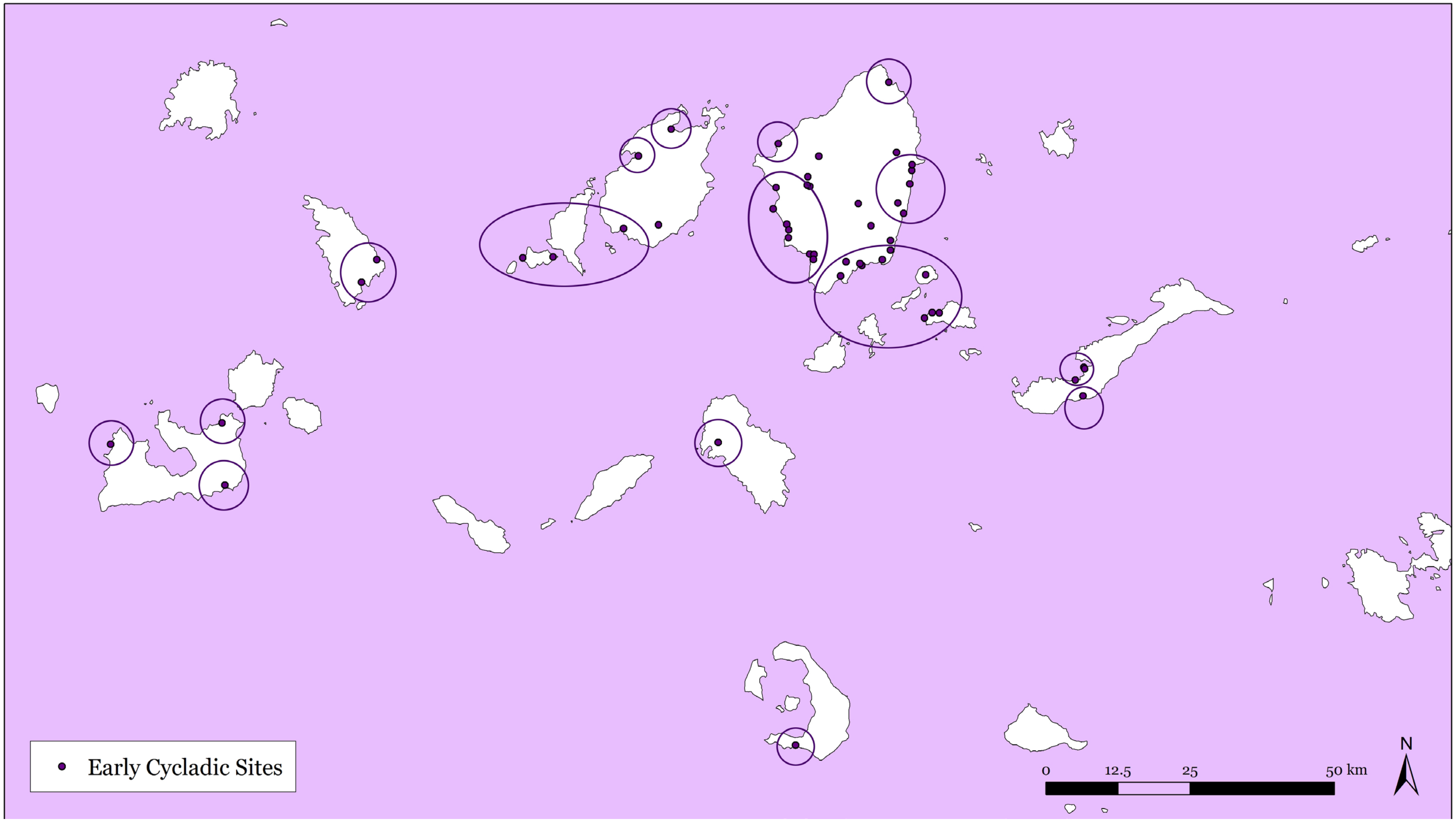

Figure 6.9. Early Cycladic Maritime Connectivity
This map shows the sites in the central Cyclades that would have been connected via maritime travel on a local scale during the Early Bronze Age.

include sites on Melos to the west, the northwestern coast of Paros, the northern coast of Naxos, and sites on Amorgos. Markiani on Amorgos, for example, at first glance appears to be a coastal site that is geographically near the settlement of Kato Akrotiri just north of it. However, because of Markiani's positioning on a steep section of coastline as well as differing wind patterns on the northern and southern sides of the island limit its potential for maritime connectivity. It is more likely that someone venturing forth from Markiani would have traversed to the north side of the island on foot before departing. Other islands, such as Thera and Ios, have single settlements that would have only been able to connect to settlements on other islands via longer-range maritime voyages.

There are two clusters of sites—the Paros/Antiparos cluster and the Erimonisia/south Naxos cluster—which seem to have high degrees of inter-island maritime connections. Finally, the west and east costs of Naxos represent zones of potential high connectivity along the coast of a single island.

In terms of individual Early Cycladic coastal settlements or major cemetery sites, maritime connectedness varies widely (figure 6.9). Dhaskalio on Keros enjoys high connectivity with multiple islands and sites throughout the year. Likewise Mikre Vigla on Naxos is easily reachable from northern Paros and the entire western coast of Naxos.

Other major settlements, such as Ios on Skarkos have very limited connectivity. For most of the year, Skarkos is reachable from Sikinos via a one-day journey, and during the winter and summer months it is reachable from Folegandros. However, both of these islands have very steep coastlines and few usable beaching points. Skarkos may have enjoyed some connections with the northern coast of Thera to the south. From a maritime perspective, Skarkos is oriented toward the southwest, rather than toward the more intensely connected Erimonisia and southern coast of Naxos to the northeast. On the northeastern coast of Ios—near present-day Theodotis—the low-slope beaches on the may have been launching points for local maritime interaction between Ios and the Erimonisia.

The cemetery at Chalandriani on Syros—the largest cemetery during the Early Cycladic period, notable for many artifacts such as the "frying pans" that include marine iconography—is isolated in terms of local maritime interaction. While it is possible that during certain parts of the year the cemetery was reachable from Tinos, the southern coast of Tinos is very steep and offers few launching points. Mt Kynthos on Delos experiences similar isolation. In general, the islands of the northern Cyclades are poorly connected via local maritime interaction, suggesting the importance of regional contacts for those settlements. The need for longer-range maritime connections may have empowered local leaders to construct longboats and recruit crews for more distant voyages, which could partially explain the emphasis on longboat and maritime iconography at Chalandriani.

Finally, Phylakopi on Melos is very isolated, despite Melos's geographical proximity to the small islands of Kimolos and Poliegos. Adverse winds during most of the year prevent Phylakopi from being accessed on a local scale. It is noteworthy that Phylakopi's prominence as a Cycladic settlement occurs during the Middle and Late Bronze Ages, which suggests the possibility that changing sailing technologies might have increased the settlement's ability to interact with other Cycladic sites more frequently. Melos was a known source of obsidian, having been exploited since the Late Pleistocene/Early Holocene (Carter 2016), and therefore culturally transmitted knowledge of this resource may have incentivized long-range voyages and the maintenance of less frequent connections from other Cycladic settlements.

Because of the nature of Aegean survey—with archaeological projects concentrating on single islands or portions of islands—some islands—such as Naxos—have received more thorough investigation and publication than others. At this stage in Aegean scholarship, it is more likely that the distribution of sites shown in figure 6.8 represents archaeologists' emphasis rather than meaningful distribution of past settlements, so I hesitate to draw firm conclusions. However, it seems that the maritime connections of sites in the central Cyclades varied greatly, ranging from single, isolated sites to corridors of intense coastal connectivity; the latter seems to be concentrated around the islands of Paros, Naxos, and the Erimonisia.

3. How does seasonality affect local seafaring and maritime connections?

The results of the model show that the variation in wind speed and direction over the course of the year did not have much effect on the number of islands from which a particular site was able to be reached. Under perfectly even circumstances, one would expect that the number of islands from which a site could be reached via habitual interaction would be four times the number of sites from which a site could be reached via everyday interaction. (Since the radius of habitual interaction in neutral circumstances is double that of community interaction, the resulting area for habitual interaction would be four times that of community interaction.)

Returning to the earlier example of Dhaskalio, table 6.2 shows the island connections for everyday and habitual interactions throughout the year. On average, 3.67 islands were able to reach Dhaskalio for each month via one day's journey, while 6.25 islands were able to reach Dhaskalio for each month via two day's journey, resulting in a ratio of approximately 0.6.

Table 6.2. Dhaskalio Seasonal Connections

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Everyday Scale												
Kato Koufonisi	■	■	■	■	■	■	■	■	■	■	■	■
Ano Koufonisi	■	■	■	■	■	■	■		■	■		■
Naxos		■	■	■	■			■			■	■
Schinousa		■		■		■	■	■	■		■	■
Iraklia								■			■	■
Ano Antikeri	■									■		■
Ios												
Amorgos												■
Habitual Scale												
Kato Koufonisi	■	■	■	■	■	■	■	■	■	■	■	■
Ano Koufonisi	■	■	■	■	■	■	■	■	■	■	■	■
Naxos	■	■	■	■	■		■	■		■	■	■
Schinousa	■	■	■	■	■	■	■	■	■	■	■	■
Iraklia		■		■		■	■	■	■	■	■	■
Ano Antikeri	■	■	■	■		■	■	■	■	■	■	■
Ios		■				■		■	■	■	■	■
Amorgos										■		■

■ (shaded cell) = Keros is reachable from this location

Table 6.3 shows the seasonal connections for Skarkos on Ios, a settlement which in optimal conditions could be reached from only three other islands. The averages are nearly identical to those from Dhaskalio; on average one island could reach Skarkos per month via a single day's journey, while 1.67 islands reach it via two days' journey, also resulting in a ratio of approximately 0.6.

Furthermore, sites that are well-connected via maritime interaction on a local scale tend to be well-connected year-round, while sites that are isolated tend to be isolated year-round, as discussed in the section above. Figure 6.10 (see also appendix C) shows path distance calculations for the entirety of the central Cyclades

Table 6.3. Skarkos Seasonal Connections

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Everyday Scale												
Sikinos	■	■	■	■		■	■	■	■	■	■	■
Folegandros												
Thera												
Habitual Scale												
Sikinos	■	■	■	■	■	■	■	■	■	■	■	■
Folegandros	■	■	■			■		■	■			
Thera	■	■		■	■			■				

■ = Skarkos is reachable from this location

for each month of the year. The exceptions to this general rule are some islands where there are no extant Early Cycladic sites, such as Folegandros—which can access Skarkos during the summer months—and Kimolos and Poliegos—which have access to sites on Sifnos and Melos for roughly half the year and are otherwise isolated.

These results support the hypothesis that the varying winds in the Cyclades created more affordances than hindrances and that wind variance was not impactful, meaning that short-range journeys could be completed year-round (see Papageorgiou 2008). There is little evidence of a "sailing season" as Broodbank (2000) and others have posited, at least in terms of the affordances of the environment alone, though it is possible that other factors may have contributed to a particular "sailing season," such as storms or the relationship of sailing to seasonal labor requirements.

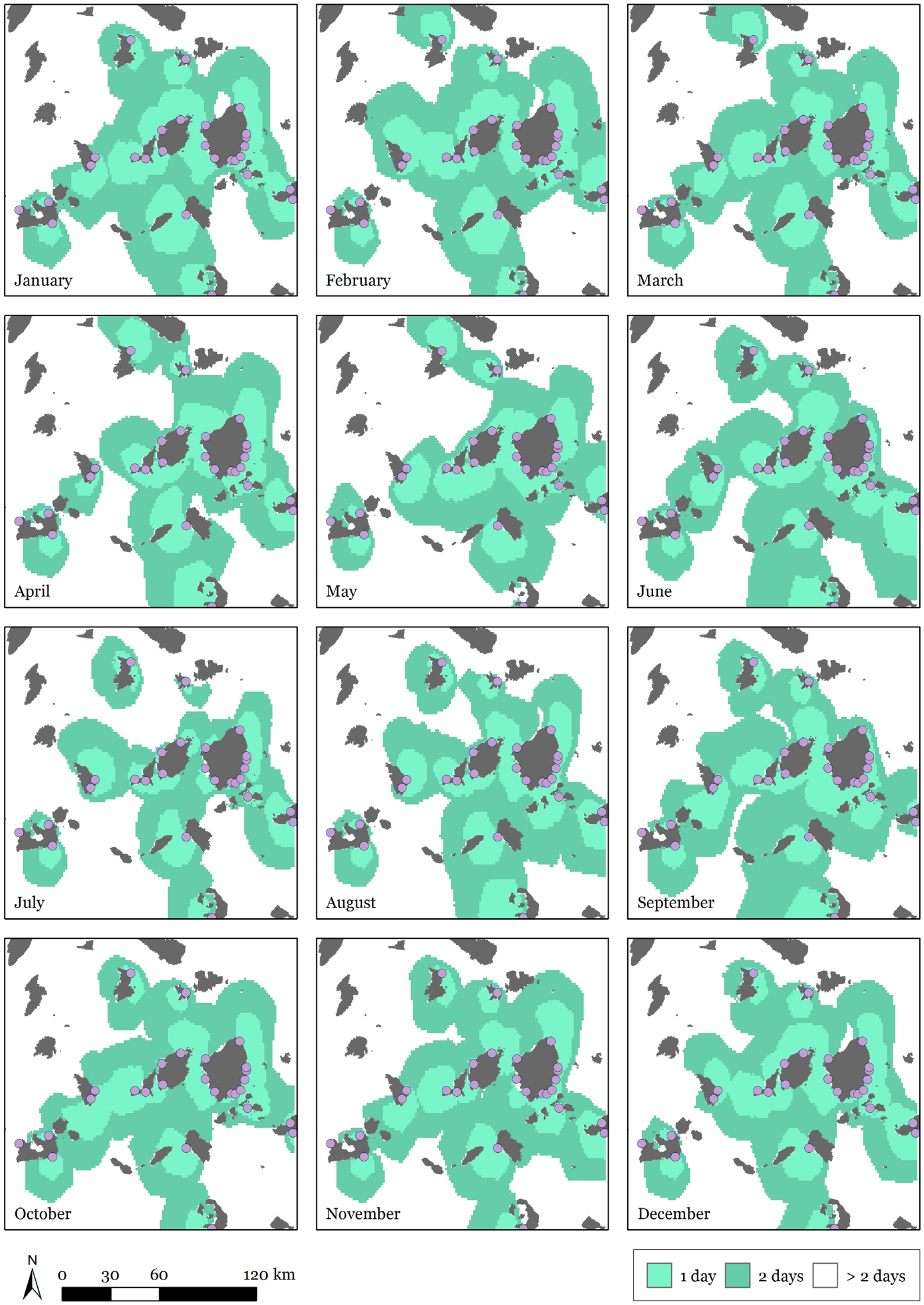

Figure 6.10. Central Cyclades Path Distance by Month
This map shows the Path Distance calculations for every site in the central Cyclades for each month of the year to demonstrate the seasonal variation in sailing patterns due to varying weather conditions.

In chapter 3 I examined the seasonal labor requirements for subsistence in the Early Cycladic period. Based on those results, there does not seem to be a specific time of year during which the abatement of agricultural production, animal husbandry, foraging, and hunting would indicate an optimal sailing season. The months which, according to Broodbank's (2000) speculation, would be the best sailing time (May-September) are in fact marked by the highest intensity of agricultural production, as well as increased labor requirements to tend pregnant sheep/goats. It is possible that some combination of sailing and subsistence activities were divided along gendered or other demographic lines, whereby only one portion of the population participated in sailing.[64] More archaeological evidence is needed to investigate this possibility, however.

4. How does directionality affect local interaction?

One of the major advantages of this model is that it allows for the consideration of directional movement. Because travel time and distance are primarily affected by wind patterns, it follows that a trip traveling against the wind would not take the same amount of time as a trip sailing with the wind. In terms of local interactions, this means that an outbound voyage that would be classified as "everyday" or "habitual" interaction might have a return voyage that is classified differently, requiring different levels of preparation and planning on behalf of ancient mariners.

To test how directionality affects voyaging times, I selected four Early Cycladic sites located in the central Cyclades, which is the corridor that enjoys the

64 This is the case in later Aegean iconography, where sailing is almost an exclusively male activity (Broodbank 1989: 330). When women are depicted in association with boats, they are either shown as passengers of larger craft—where their garb differentiates them from sailors—or as punters in small boats, which would further indicate that local range seafaring was a nonspecialized activity.

most interisland connectivity in the region. These sites are Dhaskalio (Keros), Avyssos (Paros), Grotta-Aplomata (Naxos), and Panermos (Naxos). First I executed the Path Distance function for each site, using the month of June as a test case. Then I selected four random coastal points within the range of local distance of each site. Each of these test points is located on a low slope area of the coast and is therefore a feasible landing spot. Then I calculated Path Distance for each point.

Figures 6.11-6.14 show the results of these calculations. Overall, directionality made a major difference in whether or not an out-and-back journey on a local scale was possible between two locations. In all cases except Dhaskalio (Keros), only one of the four tests sites exhibited two-way local connectivity. Dhaskalio (figure 6.11), possibly due to its location in the Erimonisia where wind patterns are less severe, experienced two-way local connectivity with three of its four test sites. This relatively high two-way local connectivity might explain Dhaskalio's centrality during the Early Cycladic period.

The low occurrence of two-way local connectivity highlights the importance of distinguishing maritime travel from terrestrial travel. In the majority of cases, an Early Cycladic islander would not have been able to rely on making an out-and-back journey in a single day and would expect to spend at least one night at the destination. This implies that it would have been crucial for islanders to maintain social ties between communities in order to depend on the hospitality of others while traveling.

From the archaeologist's perspective, this indicates that methodologies which have been used to create least cost models for terrestrial movement (such as in chapter 5 of the present project) are not appropriate for modeling maritime travel. The incorporation of directionality is imperative for the accurate archaeological reconstruction of ancient sailing routes and maritime networks.

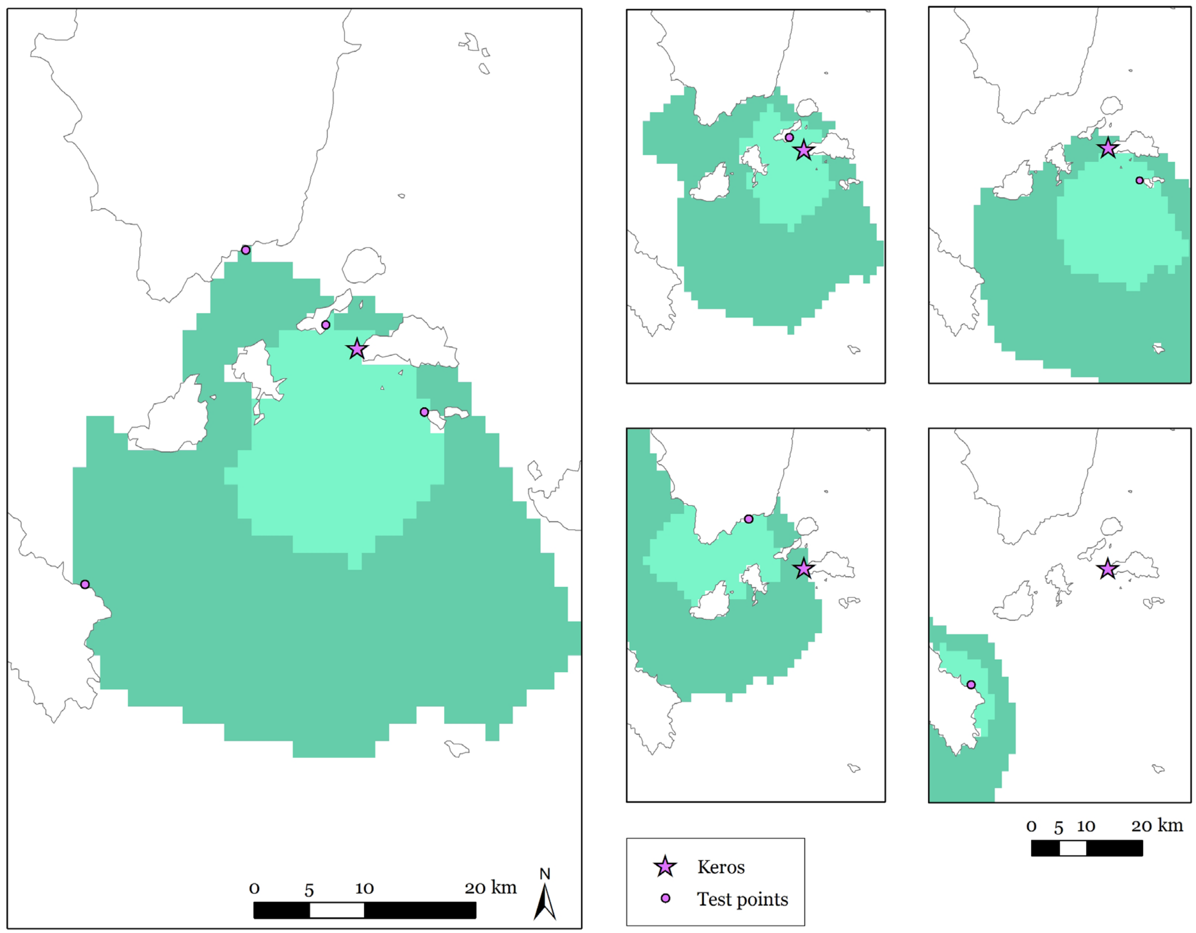

Figure 6.11. Directional Connectivity for Dhaskalio, Keros
The left-hand map shows the Path Distance of one and two days' travel time from which the island of Keros can be reached during the month of June. The four smaller maps on the right show four test points showing one and two days' travel time in the opposite direction.

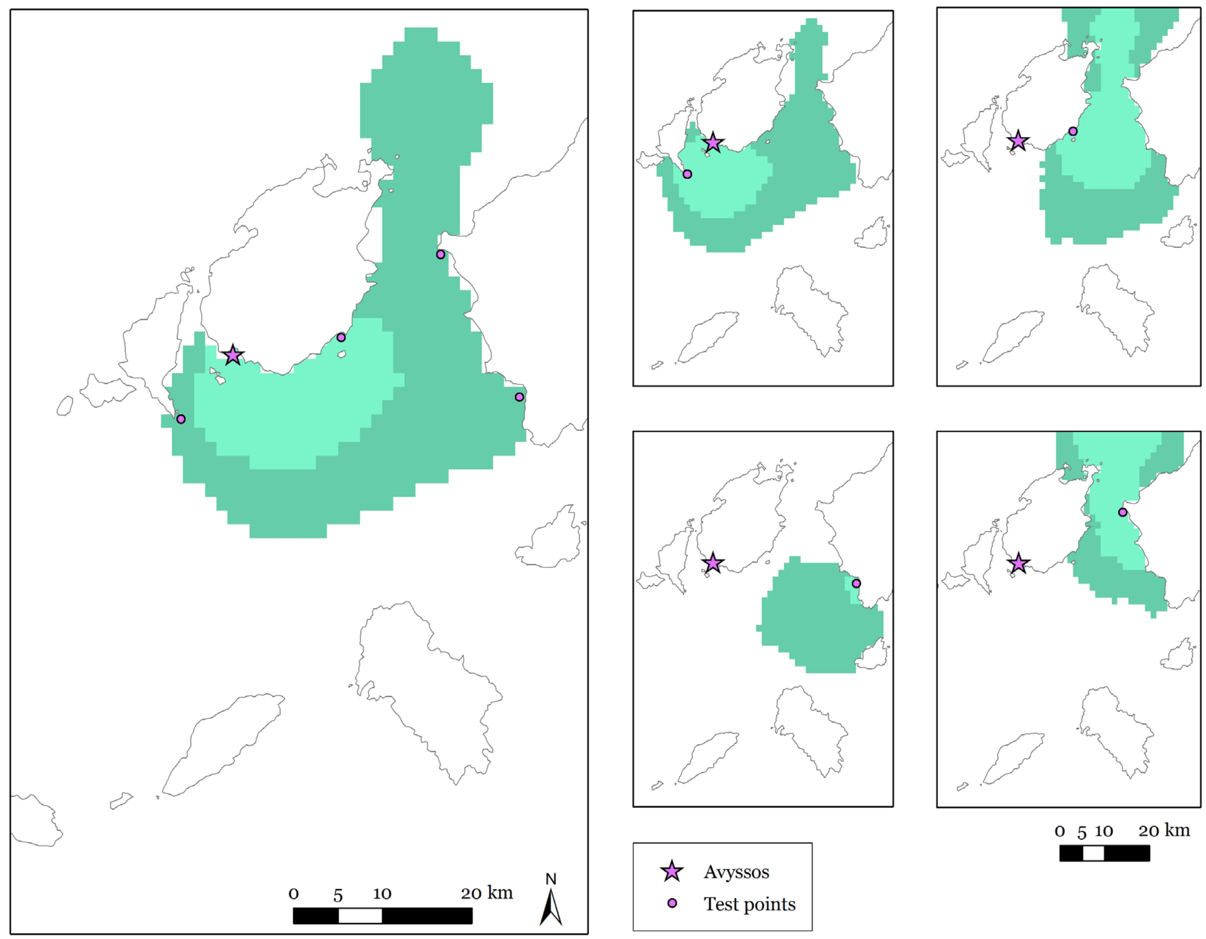

Figure 6.12. Directional Connectivity for Avyssos, Paros
The left-hand map shows the Path Distance of one and two days' travel time from which the site of Avyssos (Paros) can be reached during the month of June. The four smaller maps on the right show four test points showing one and two days' travel time in the opposite direction.

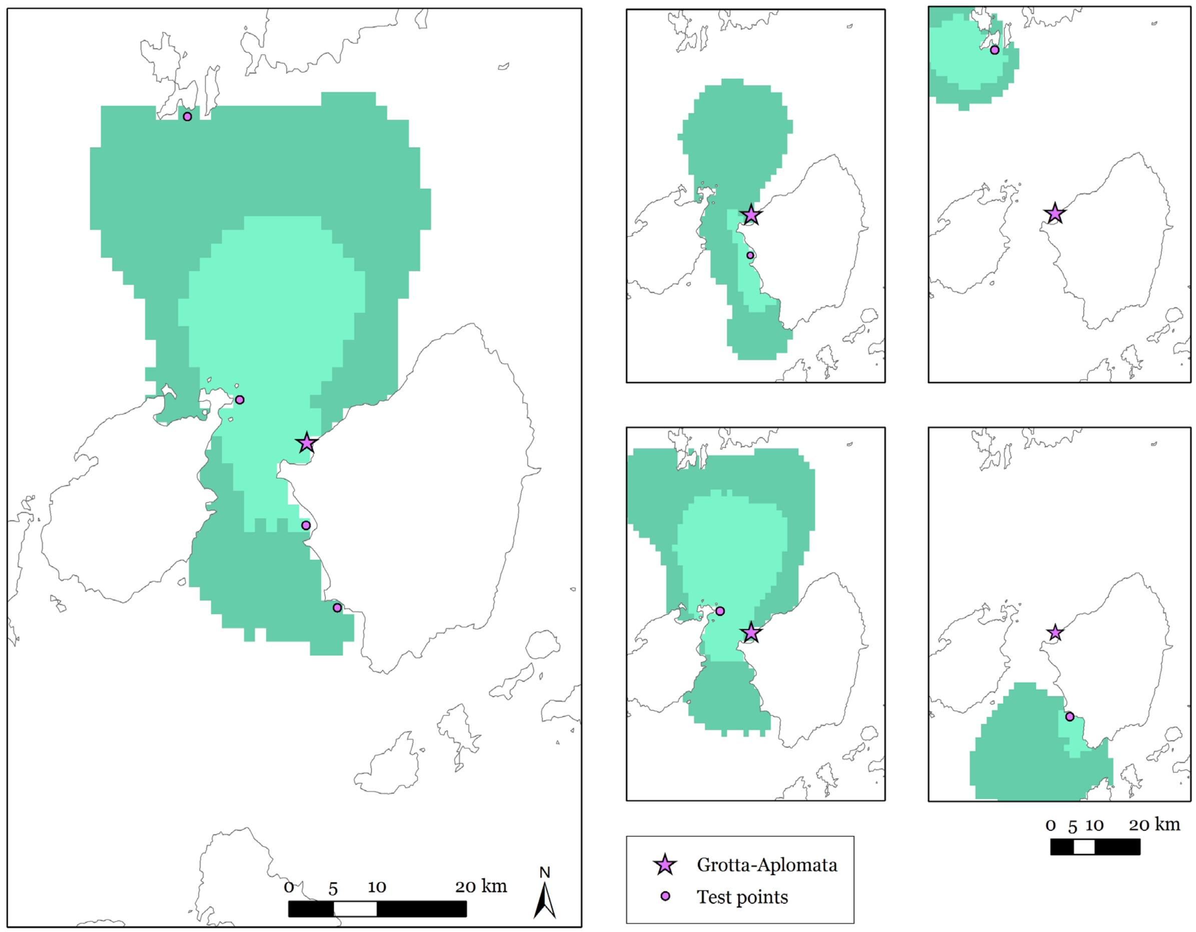

Figure 6.13. Directional Connectivity for Grotta-Aplomata, Naxos
The left-hand map shows the Path Distance of one and two days' travel time from which the site of Grotta-Aplomata (Naxos) can be reached during the month of June. The four smaller maps on the right show four test points showing one and two days' travel time in the opposite direction.

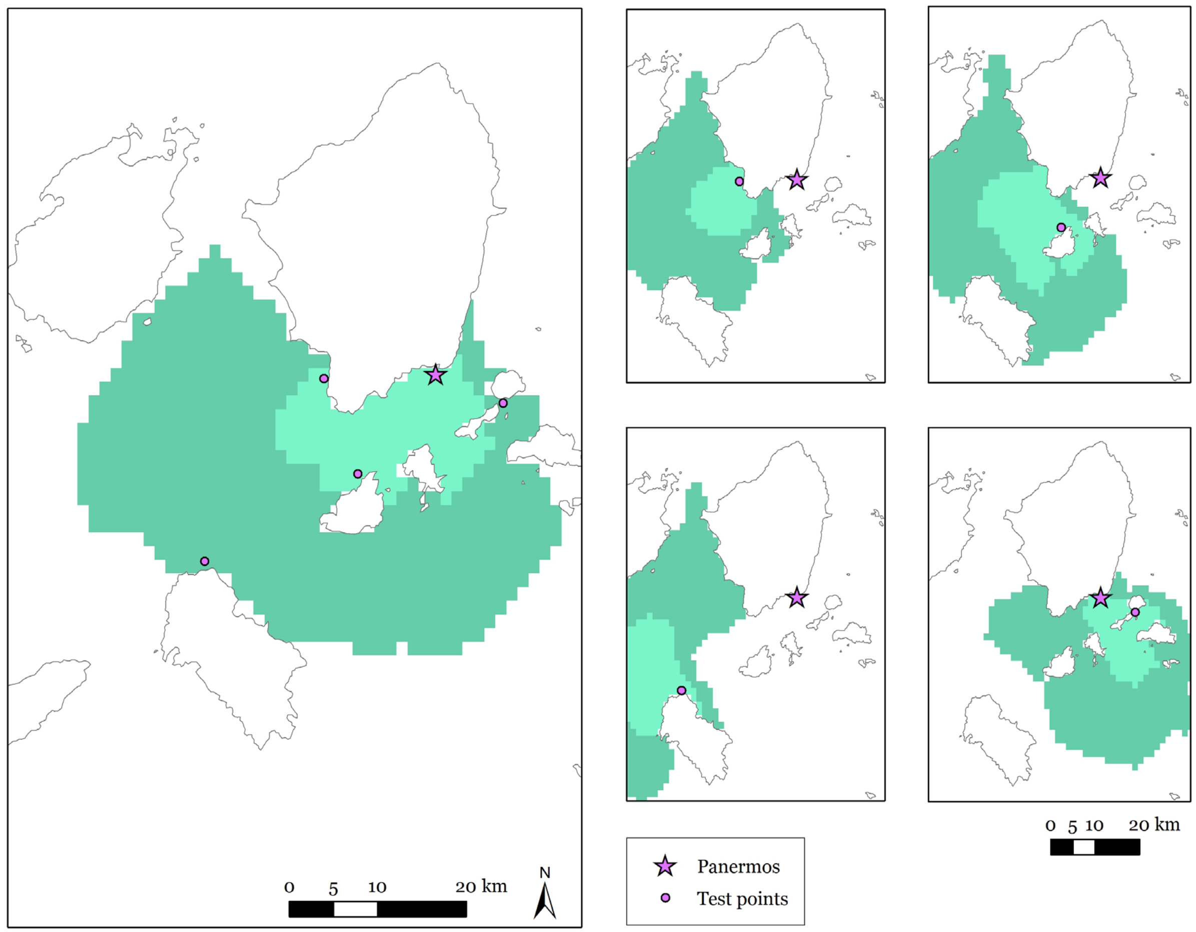

Figure 6.14. Directional Connectivity for Panermos, Naxos
The left-hand map shows the Path Distance of one and two days' travel time from which the island of Keros can be reached during the month of June. The four smaller maps on the right show four test points showing one and two days' travel time in the opposite direction.

5. How does maritime interaction change throughout the Early Cycladic period?

Based on changing site distributions for each of the phases of the Early Bronze Age, the Path Distance model also allows the analysis of changing patterns of maritime activity over time. Figure 6.15 shows the maritime connections for Cycladic sites of the Grotta-Pelos phase (ca. 3100-2950 BCE). Seasonal variation in site connectivity is much more apparent for the Grotta-Pelos phase. During summer and early autumn, the central Cyclades (consisting of Naxos, Paros, Antiparos, the Erimonisia, northern Ios, and western Amorgos) form a distinct cluster from the western Cycladic islands of Melos and Sifnos. However, during the winter months, local connections are possible, bridging the divide between Sifnos and Antiparos.[65]

Figure 6.16 shows the maritime connections for the Keros-Syros phase (ca. 2650-2500 BCE). Seasonal variations in sailing patterns are less marked here, and there is a north-south orientation to local travel, with a major corridor of activity running between Naxos and Paros. While Chalandriani on Syros, Mt Kynthos on Delos, and Akrotiri on Thera are isolated in terms of local travel, they might have made maritime connections with the central islands via slightly longer journeys. It is also possible that Ios, Keros, and Delos served as stopping over points for travelers journeying to the central islands from Thera, Amorgos, and Syros, respectively.

During the Kastri phase (ca. 2500-2250 BCE), Thera and Melos are isolated from the central Cyclades during all seasons (figure 6.17). The central Cyclades, and in particular the western and southern coasts of Naxos, remain areas of high potential connectivity, though on a more restricted scope than in the preceding Keros-Syros phase.

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65 Because many early surveys of Cycladic sites did not recognize the Kampos phase (ca. 2950-2650 BCE) as a distinct period, it is not possible to create a representative map of that phase.

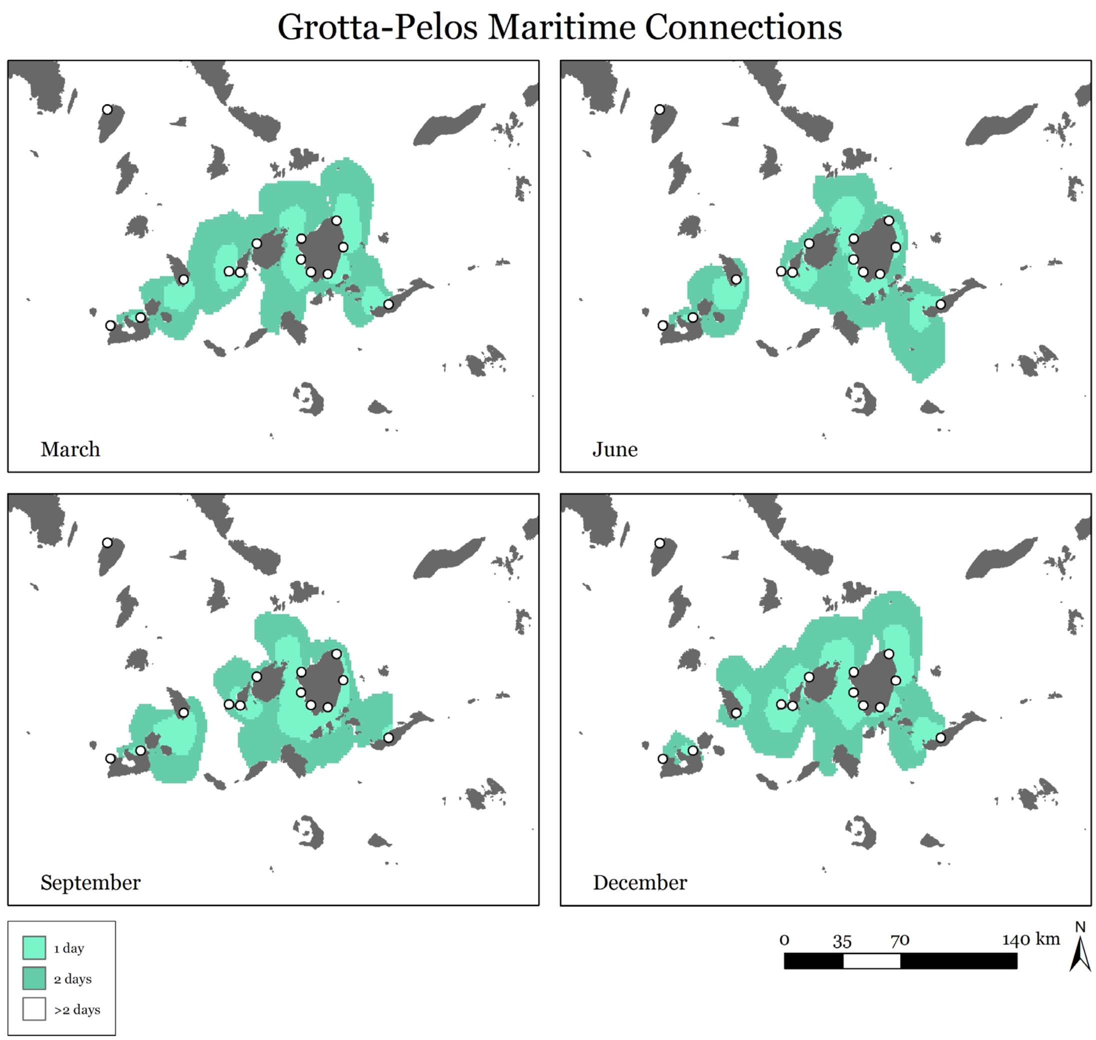

Figure 6.15. Grotta-Pelos Maritime Connections

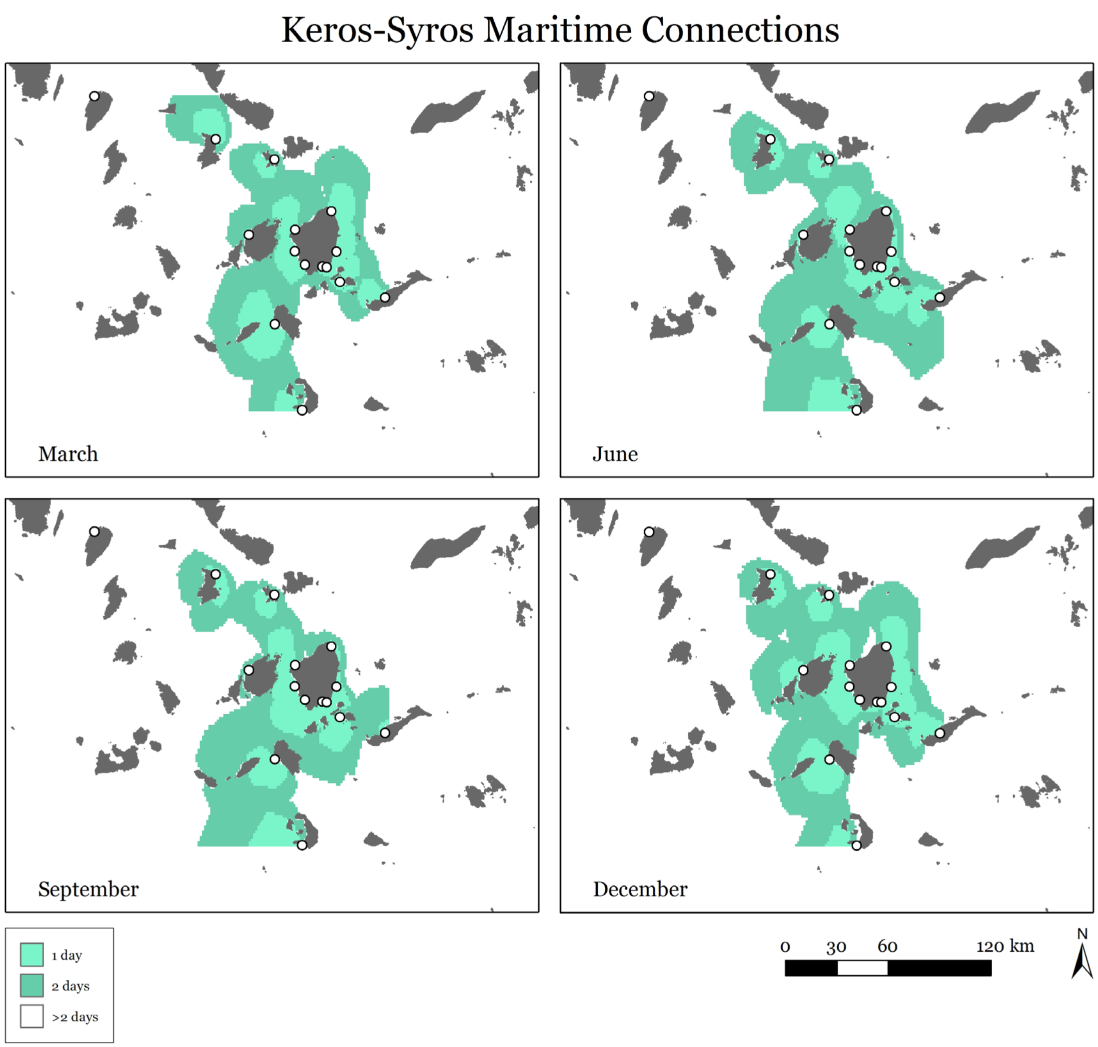

Figure 6.16. Keros-Syros Maritime Connections

Kastri Maritime Connections

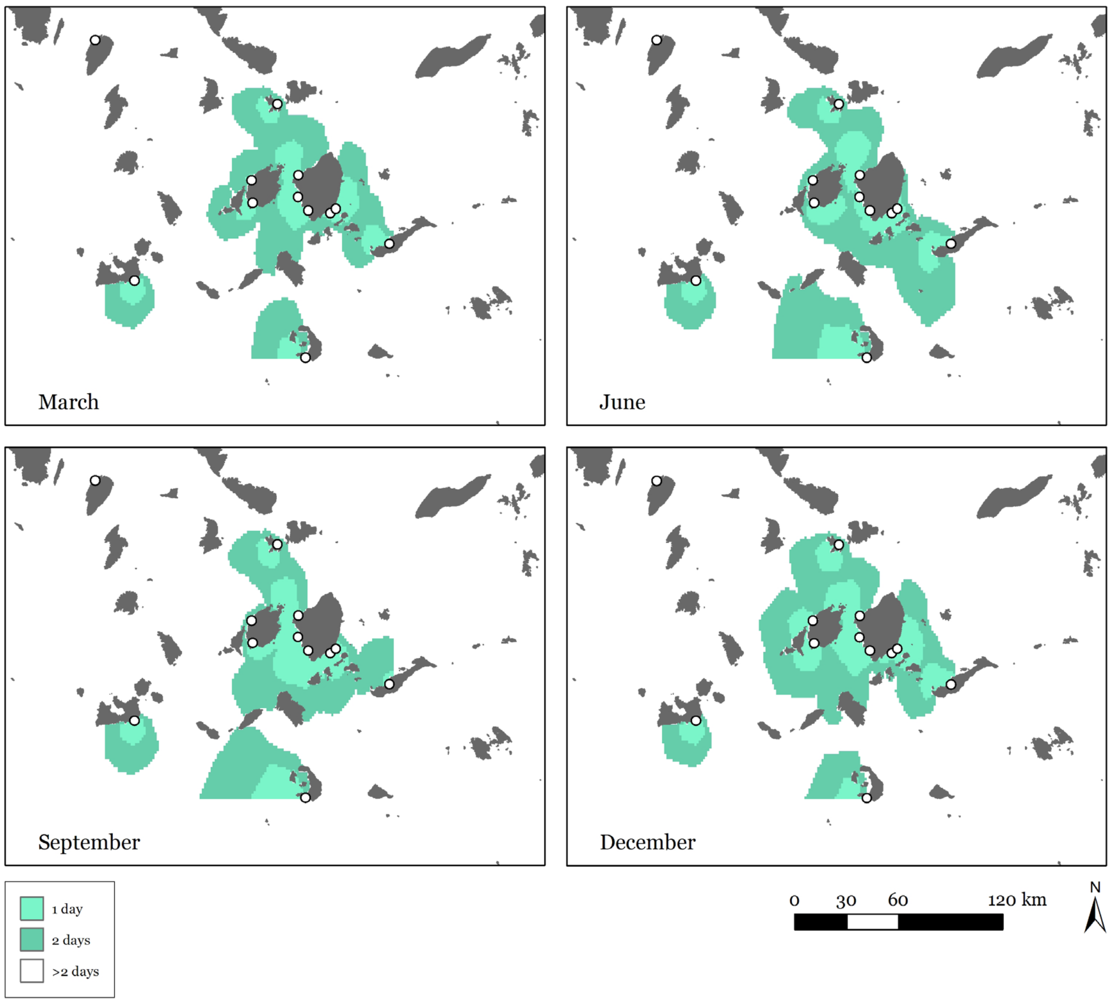

Figure 6.17. Kastri Maritime Connections

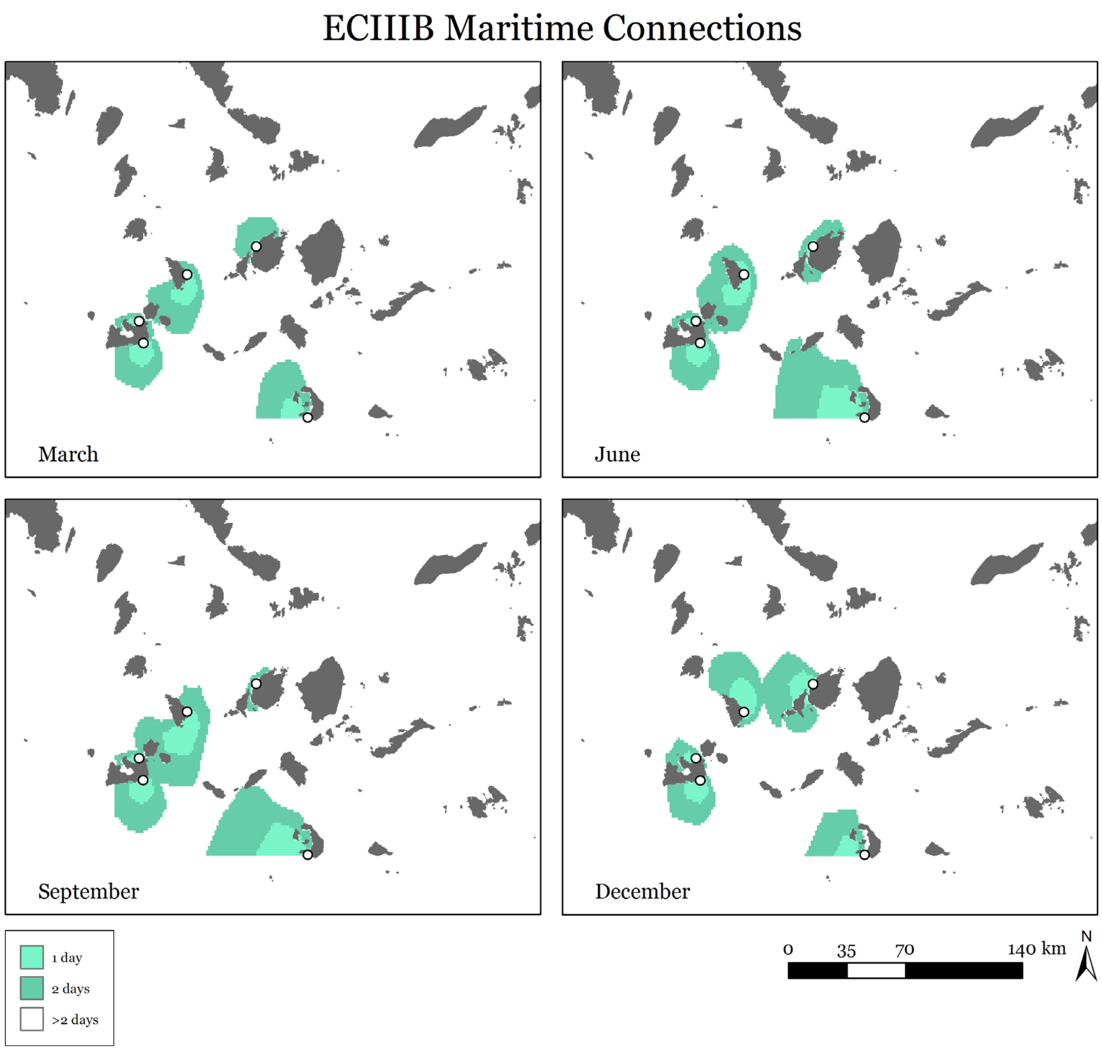

Figure 6.18. ECIIIB Maritime Connections

Finally, with the overall decline in site numbers during the ECIIIB phase (ca. 2250-2050/2000 BCE), figure 6.18 shows drastically reduced connectivity and increased isolation. Melos and Sifnos are just barely connected in all seasons except winter, when the affordances of the seascape allow connections with western Paros. Thera remains isolated year-round.

More broadly, the effects of seasonal weather patterns on maritime travel are exacerbated during time periods and in areas where there are fewer sites. The short window of opportunity islanders in remote sites would have had to interact with other communities might lead to a particular sailing season—though there seems to be no correspondence with the May-September season suggested by Broodbank (2000: 92)—or year-round opportunistic voyages in favorable weather.

Conclusion/Future Directions

By creating a multivariable cost surface raster of the sea surface that takes into account variation by season and over time, the model presented here allows for a more nuanced understanding of maritime interaction during the Early Cycladic period than previous archaeological estimates based on geographical distance alone. First, I found that comparing average daily sailing distances, while they approximated the estimates of earlier scholarship, would not have been particularly meaningful in practice due to the extreme range of distances it would have been possible to sail in a given direction on a given day.

Second, when considering the Cyclades as a region, the corridor between Naxos and Paros and the area around the Erimonisia emerge as areas of potential high connectivity, while Melos to the west, Thera to the south, and Delos and Syros to the north exhibit few local maritime connections during the EC period.

However, the persistence of major EC sites on poorly connected islands requires explanation. While centrality and ease of access may have contributed to the cultural importance or longevity of some sites such as Dhaskalio on Keros, high connectivity is not the only variable that indicates a site's success. My analysis indicates that there are two very different modes of maritime connectivity in the Early Cycladic period. On one hand, there exist spatially defined local worlds, like southern Naxos and the Erimonisia. Renfrew's (1972) analysis of small cemetery groups also shows a degree of material similarity within settlements at a small worlds scale. On the other hand, certain locations—such as Chalandriani and Phylakopi—need to reach beyond that scale due to their lack of local connections. Higher investment in longboats, as at Chalandriani, or knowledge of the location of valuable natural resources, such as at Phylakopi, may have encouraged persistent, yet infrequent, interactions at a regional scale.

This model does indicate that network models based on centrality are ineffectual for analyzing Early Cycladic maritime connections. Archaeological centrality models equate "nearness" with distance, rather than frequency of connection based on travel time. Furthermore, centrality models assume that a) linkages exist between settlements based on distance and b) that these linkages are equally likely in all directions. For example, in Broodbank's (1993; 2000) PPA model, settlements are assigned links to the nearest three settlements, and those settlements with the most linkages are considered the most central, and therefore as having the most connections. But, as the present model has shown, not all Early Cycladic settlements show signs of maritime connections to other settlements, and when connections are present, directionality is very influential.

This highlights a major issue with applying social network models in archaeological contexts. Archaeological data is inherently spatial, yet geographical space is rarely a component of social networks, largely due to the fact that network theory derives largely from the discipline of sociology (Brughmans 2014: 24). The conflation of social nearness with geographical distance results in the disregard of the landscape as a contiguous entity which shapes physical movement and social connections.

Finally, variations in wind patterns due to seasonality and directionality indicate that everyday travel—i.e. out-and-back journeys in a single day—would have been possible only rarely and only under optimal travel conditions. Early Cycladic voyagers would likely expect to stay the night in the settlement they were visiting, which would require knowledge of other communities and the establishment and continuation of on-going social relationships. One might imagine a system of reciprocal hospitality in place that was maintained through habitual relationships based on trust. For example, several archaeologists (e.g. Broodbank 1992: 543; 2000: 173; Carter 2008: 119; Hoffman 2000: 534, 545; Sherratt 2000: 135-6) posit the necessity for exogamy among Early Cycladic communities. If this is the case, travelers might initially establish kin relations in other communities through marriage, which could be maintained through regular connection.

While the present model has allowed me to create a more nuanced picture of Early Cycladic maritime connections, its flexibility allows for the inclusion of additional variables in future research. For example, the inclusion of cultural and additional environmental variables such as bathymetric data, lading, and intervisibility might indicate preferences for certain routes and illuminate the lived experience of ancient sailing. Once available, the inclusion of finer-grained environmental data such as diurnal and nocturnal current changes would allow for finer-resolution sailing patterns. Finally, this model could easily scale up to larger areas of focus, allowing the consideration of maritime connections at the regional scale and beyond.

Chapter 7
Conclusions

In this dissertation I have reexamined and reframed some of the persistent questions of Early Cycladic (EC) archaeology:

1. What role did surplus play in EC social organization?
2. To what degree were EC settlements self-sustaining?
3. What was the role of maritime travel in EC society?

By investigating these questions through the lens of small worlds—a bottom-up approach that examines habitual intercommunity interaction— I have eschewed the ambivalences that have characterized Cycladic research as a result of tensions between the local and regional scale of analysis (see chapter 1). This has allowed me to draw several conclusions about community interaction and social organization during the Early Cycladic period:

> **Conclusion 1**. Early Cycladic islanders employed a variety of strategies to minimize risk in subsistence production that would have encouraged shared production among communities.

Chapter 3 shows that islanders during the Early Cycladic period employed a variety of strategies to minimize risk. Based on recent archaeobotanical and zooarchaeological evidence, islanders planted diverse crops that in the event of a bad year could be harvested twice. It is likely that—like ethnographic comparanda from traditional island farming—the Early Cycladic islanders took advantage of environmental microdiversity by diversifying spatially as well as temporally.

Site catchment analysis in chapter 5 shows that the potential agricultural area for the settlements on the southeastern coast of Naxos could support a much larger population than archaeologists have estimated for Early Cycladic settlements. For this area, at least, spatial diversification of crops would have been a feasible risk management strategy.

Spatial and temporal diversification of production, lack of archaeological evidence for centralized storage facilities, and a high degree of uncertainty resulting from a semi-arid environment with highly fluctuating interannual rainfall indicate that Early Cycladic communities might have cooperated to ensure mutual survival, and social organization likely encouraged shared production. Occasionally, a power imbalance might occur in which some individuals gained a reputation for managing trade deals or benefited from sustained inequality, thereby achieving authority within their social groups.

Chapter 4's discussion of warfare between Early Cycladic communities showed that—due to the presence of fortified sites during the Early Cycladic period—raiding and warfare might have been a regular feature of island life. However, due to social nearness and the precariousness of life for small communities in marginal environments, it is likely that warfare tactics would aim to limit casualties and property damage. Furthermore, due to the limited capacity of boats, warfare for the purpose of stealing bulk goods or animals would be unlikely; more probable would be the stealing of prestige goods or the kidnapping of people.

> **Conclusion 2**. Time and habitual interaction are much more important measures of community "nearness" than geographical distance.

Chapter 6 shows the importance of using travel time, rather than geographical distance, as the primary variable for considering the "nearness" of communities.

Previous estimates of average daily sailing distance in archaeological scholarship tend to be accurate, but the range of daily travel can vary widely depending on the prevailing wind patterns and on the season. Parts of the Cyclades were well connected by maritime travel, including the corridor stretching between Naxos, Paros, and the Erimonisia. Communities on other islands—despite the location of major settlements (e.g. Chalandriani-Kastri on Syros) or natural resources (e.g. obsidian on Melos)—exhibit few maritime connections within the Cyclades during the Early Cycladic period. In the case of natural resources, such as on Melos, memory may have played an important role in return visits to the island. In the case of major, isolated settlements like Chalandriani-Kastri or Phylakopi, islanders may have needed to invest in longer-range forms of travel, such as longboats, that allowed infrequent, but persistent, interactions at a regional scale.

Likewise, chapter 5 describes a small world in southeastern Naxos that persisted throughout the Early Cycladic period. This region is geographically distinct from the rest of the island, and the longevity of this small world indicates that the communities that comprised it likely enjoyed strong and stable ties throughout the Early Bronze Age. The use of action spheres to model community interaction shows that places of habitual interaction were not limited to settlements but occurred in subsistence areas, socially maintained boundaries, and regularly traversed paths. These places of interaction were where social ties based on trust were established and maintained.

Conclusion 3. Cycladic land- and seascapes were major actors in constructing the relationships between Early Cycladic small worlds, and ties between marginal areas could be longer-lived and more stable than central ties.

Fragmented landscapes, marginal soil, and frequent years of drought meant that diversification strategies, rather than intensification, were more effective for subsistence production. While the seascape created affordances in communication, meaning that communities frequently enjoyed closer contacts with communities on other islands than those on the same island, it also created barriers for the expansion of settlements. Small, dispersed communities formed close relationships with other communities forming close-knit small worlds.

In the case of southeastern Naxos presented in chapter 5, the persistence and stability of the small world of the case study highlights the importance for archaeologists to consider network models that assess marginal ties. Centrality models assume that connections are equally likely in all directions and that the importance of connections is based on distance. However, as chapter 6 shows, directionality is a major factor in the connectedness of EC maritime small worlds. Furthermore, the equation of “nearness” with geographical distance (discussed above) disregards the importance of the physical environment as a contiguous entity that shapes human movement and social connections. Social network models used by archaeologists need to account for the physicality of the environment, as the present project has demonstrated.

> **Conclusion 4.** Small world interaction was more important to the shaping of Early Cycladic life than the regional-scale activities that have received a disproportionate amount of archaeological attention.

The disproportionate focus in the archaeological literature of the Early Cycladic period on the distance that voyagers traveled via longboat or the range that artifacts traveled via trade has led to a dearth of study at the scale of intercommunity interaction/the small world. As I discuss in chapter 6, artifactual evidence of longboat/regional travel exists only at a handful of exceptional sites, it is possible that only a few communities participated directly in this type of long-range trade. Furthermore, the analysis of site fortification and settlement patterning in chapter 4 shows correlation between fortified sites and sites with evidence of longboats and long-range trade, in particular at Chalandriani-Kastri.

The constraints on travel beyond the small world due to the intensity of the production cycle, seasonal fluctuations of sailing conditions, and ruggedness of the Cycladic landscape indicate that travel beyond the small world would have been an infrequent and opportunistic event. My analysis of the subsistence production cycle in chapter 3 reveals that there is no "sailing season"—a dip in agricultural production that would have freed up labor for long-range voyages—during the Early Cycladic period (*contra* Broodbank 2000). The reconstruction of sailing conditions in chapter 6 also indicates no clear sailing season due to high variability in wind and wave patterns between months. Optimal sailing conditions for longer-range travel would have occurred at varying times of the year depending on site location.

Finally, analysis of terrestrial movement in chapter 5 and maritime movement in chapter 6 confirms the hypothesis (Broodbank 2000) that interisland connections (at least via short-range maritime travel) may have been more frequent than intraisland connections. The ruggedness of the Cycladic terrain fragmented the landscape so that on islands such as Naxos, small-world clusters were separated from one another by difficult terrain. Furthermore, the frequently changing weather patterns mean that opportunistic sailing might occur during any part of the year.

Travelers ranging beyond the small world might only be able to take voyages to certain locations during particular seasons, when the winds were favorable, as shown in chapter 6. At any time of year, maritime travelers might be hindered by adverse weather. An example from Pausanias's *Description of Greece* (1.21.13) offers an example of the notoriously tricky sailing among the Aegean isles: the Alexandrian boxer Apollonius Rhantes gives being delayed in the Cyclades by adverse winds as his excuse for lateness to the Olympic Games.[66] Though this is later proven false, chancy weather when sailing the Cyclades was a plausible excuse for delay in antiquity.

Analysis of the seasonal activities of Cycladic islanders and the degree of connectivity between communities via both maritime and terrestrial travel highlights the importance of small world interaction in shaping everyday life. The solidarity and mutual understanding that emerge from shared habitual action within a shared landscape can create a sense of group identity (Gerritsen 2004:147; see also Yaeger 2000).

66 Pausanias's *Description of Greece* (1.21.13): ἀφίκετο οὐκ ἐς τὸν εἰρημένον καιρόν, καὶ αὐτὸν ὑπὸ Ἠλείων πειθομένων τῷνόμῳ ἐλείπετο τοῦ ἀγῶνος εἴργεσθαι τὴν γά οἱ πρόφασιν, ὡς ἐν ταῖς Κυκλάσι νήσοις ὑπὸ ἀνέμων κατείχετο ἐναντίων, Ἡρακλείδης γένος καὶαὐτὸς Ἀλεξανδρεὺς ἤλεγχεν ἀπάτην οὖσαν: ὑστερῆσαι γὰρ χρήματα ἐκτῶν ἀγώνων αὐτὸν ἐκλέγοντα τῶν ἐν Ἰωνίᾳ.

Conclusion 5. Small world interaction facilitated the emergence of charismatic "big men" as community leaders.

Broodbank (2000) conceptualizes leadership during the Early Cycladic period as being comprised of "big men"—a reference to Sahlins's (1963) oft-quoted ethnographic study of Melanesian islanders—charismatic individuals who achieved status through social and economic interaction. Manning (1994: 226-227) has argued that Early Cycladic community interdependence created opportunities for individuals to gain power as leaders of particularly advantaged sites seized control over access, trade, communication, and prestige items. Small worlds analysis offers an explanatory framework for *why* certain individuals succeeded and others failed in the particular social context of the Early Cycladic period. Personal charisma was a key component of successful small world interaction.

Small world interaction kept people from neighboring communities in frequent, sustained contact. While some Early Cycladic individuals would have enjoyed sustained success in production, through either foresight or luck, it was the successful individuals *with personal charisma* who had an edge in becoming negotiators and leaders in interdependent community interaction (see chapter 3). In negotiations about whether to go to war, when individuals' opinions could hold significant weight, persuasive speakers would have had a disproportionate effect on the decision of the group (see chapter 4). In the few communities engaging in longboat voyaging, those successful individuals who could not only afford a boat but who could convince others to crew with them would, through their leadership, gain knowledge about extracommunity places, people, and resources and return with exotic prestige goods that physically marked their importance. The small world was the crucible in which big men were forged.

Conclusion 6. The Cyclades cannot be considered a single analytical unit.

Although archaeologists frequently consider the Cyclades to be a cohesive analytical unit, there is no evidence that prior to the first millennium BCE the islands were conceptualized as a group (Broodbank 2000: 69). In literature of the classical period, writers emphasize the sacred geography of the islands as forming a *kyklos* around Delos, as in the example of Callimachus's *Hymn to Delos* discussed in chapter 1. Even in ancient literature "the Cyclades" were hardly a consistent unit; the islands which comprised the Cyclades varied among ancient sources. For example, not only does Strabo's (10.5.2-19) list of Cycladic islands differ from that of the present day, it also does not line up with the politico-ethnic division of the classical period into Ionian and Dorian spheres, including the southern Dorian islands of Melos and Thera among the northern Ionian majority (Broodbank 2000: 60)

When considered in geographical terms, the modern island group makes sense—the islands are closer to each other than any neighboring land mass. However, from the perspective of travel via Early Cycladic maritime technology, clustering the islands by "nearness" fragments the Cyclades and varies according to the dominant weather conditions throughout the year, as shown in chapter 6. My analysis of community interaction via maritime travel in chapter 6 indicates the likelihood that some Early Cycladic communities would have had more frequent interaction with areas beyond the Cyclades than within them. For example, islands like Syros, Delos, Kea, Kythnos, Tinos, Andros, and Mykonos are isolated from the southern Cyclades during most parts of the year and might have had more opportunity for connections with the mainland to the northwest. The islands of the southern and central Cyclades might have sought extra-regional connections with the Dodecanese and western coast of Anatolia, as archaeological research in the Izmir region of modern Turkey suggests (e.g. Şahoğlu 2005). Expanding the model from chapter 6 to encompass the southern Aegean would reveal more about the frequency of connections at the regional scale and offers a promising area of future research. Regional contextualization of Early Cycladic maritime interaction might also illuminate the role of voyagers coming into the Cyclades from Anatolia, the Greek mainland, and later, Crete. The GIS analysis of settlement patterning and habitual terrestrial movement in reveals small world groups within the Cyclades that may have enjoyed more frequent connections, as I demonstrate in chapter 5 for the small world located in southern Naxos.

Homogenization of the islands is misleading at best and actively harmful to archaeological interpretation at worst. The terrain of the Cycladic islands varies significantly from island to island, and their microdiversity means that interpretations of results from one island/part of an island cannot be generalized across all of the islands, as has been done in the past, especially by intensive survey projects. Failure to account for island microdiversity has led archaeologists to ignore other strategies of agricultural risk management in favor of surplus, which has received the bulk of scholarly theorization due to surplus's perceived importance in the formation of complex society in the Aegean. Recent archaeobotanical and zooarchaeological evidence from the Cyclades, combined with ethnographic comparanda, indicate that Early Cycladic islanders would have adopted an entire suite of risk management strategies to contend with poor soil and inconsistent rainfall. The microdiversity of the islands would have been key in increasing the survivability of Early Cycladic communities. As chapter 3 shows, spatial diversification of crops and the cooperation of communities in subsistence production were two strategies that minimized risk in the Early Cycladic period.

The sea surrounding the Cyclades is also highly variable. While previous network models (e.g. Broodbank 2000, Knappett, et al. 2008; 2011) have assumed an undifferentiated seascape and have used geographical distance as the primary cost variable for analyzing ancient travel, the cost-surface model I create in chapter 6 demonstrates the importance of considering the temporal elements of ancient travel that would have had a greater impact on maritime travel. Corridors of high potential connectivity emerge from the cost-surface model, primarily surrounding Naxos, Paros, and the Erimonisia. Important but more temporally distant settlements such as Chalandriani and Phylakopi may have needed to invest in less frequent, longer range travel, as exemplified by the depictions of Cycladic longboats at Chalandriani. The memory of obsidian on remote Melos might have spurred opportunistic travel to the island when possible, highlighting the choice of islanders to undertake risky voyages if they considered the outcome reward enough.

For the future of this project, I plan to expand the maritime cost-surface models outward to encompass the southern Aegean, southeastern Greek mainland, and western coast of Anatolia to better understand the potential for Early Cycladic maritime connections within the greater region. I hypothesize that this will highlight variation within the Cycladic islands. As the results of recent excavations and survey projects are published, in particular the Southeast Naxos Survey and excavations at Skarkos, I plan to compare the GIS models more closely with emerging material culture data. One major aim is to identify moments where the optimized view of interaction presented by GIS models is challenged by the material evidence. Such tension reveals choice by ancient islanders and can reveal ancient values and priorities.

Appendix A
Site Gazetteer

In chapter 5, I identified four locales along the coast of southern Naxos as particular areas of interest for the modeling of small world interactions in the Early Bronze Age. These are Spedos, Panermos, Korphi t'Aroniou, and the Kalandos valley.

Spedos

Spedos is a fortified settlement located on the top of a 65 m high hill on the coast of southern Naxos. The visible remains of the Early Bronze Age settlement on the surface consist of part of a large fortification wall and the walls of several rectilinear architectural structures (Economidou 1993: 123, 131). The settlement has not been excavated; it was originally investigated by Stephanos (1904: 53), and it was subsequently surveyed and the surface remains were mapped by the Cambridge Southeast Naxos Survey in 2015, which is at present unpublished.

The hilltop on which the settlement is located has a commanding view over the islands to the south, as well as over two natural harbors on the southern coast of Naxos: Panermos and Kalandos (see figure 5.15).

The settlement is associated with Spedos cemetery, a collection of Early Cycladic graves located in the valley north of the settlement. It was excavated by Papathanasopoulos (1961-2: 114), and contained Keros-Syros ceramics as well as lending its name to the most common type of Cycladic figurines[67]. While the excavators did not record the precise geographical location in the original excavation, the cemetery was re-discovered and mapped by the Cambridge Naxos Survey (forthcoming).

Spedos settlement and cemetery are believed to date from the Grotta-Pelos period through the Keros-Syros period, possibly extending into the Kastri phase.

Gazetteer entries: Hope Simpson & Dickinson 330; Renfrew 22, 518.

Panermos (Korfari ton Amygdalion)

The site at Panermos (Korfari ton Amygdalion) was originally investigated by Doumas (1964: 411; 1972: 166; 1988: 25-6). Panermos is situated advantageously: it commands a view of the natural harbor and nearby valley, but it is hidden from the sea by surrounding higher hills (Angelopoulou 2008: 150). The fortified architectural remains at the site consist of twenty-odd connected rooms surrounded by thickly-built walls (up to 1.8 m thick), bastions, and towers. Narrow entryways and passages, rarely over 0.60 m wide, restrict access to the rooms. This architectural style is characteristic of the EC IIIA period. While the ceramic material from the EC IIIA layer indicates short habitation during this time—which ended with the destruction of the site by fire and possible enemy attack—an earlier stratum shows that the site was occupied by EC I-II transition, if not earlier (Economidou 1993: 42, 137). This layer, excavated by Doumas (1972: 156) consists of a small one-room house or temporary shelter with 25 cm thick walls.

67 For two examples of EC figurines excavated from the Spedos cemetery see the figurine from tomb 14, National Archaeological Museum, Athens, no. 6140.20 (Hendrix 2010: 423-4); and the figurine from grave 13, National Archaeological Museum, Athens, no. 6140.21 (Zervos 1957: 112, pl. 114).

Early scholars interpreted Korfari ton Amygdalion as a fortified settlement, but more recent excavation makes its status as a settlement unclear. The material evidence from the site was comprised of a narrow range of ceramic vessels and rough stone lids, both of which are primarily associated with storage functions. Angelopoulou (2008: 151) concludes that Korfari ton Amygdalion was likely a fortified storage facility used by the households living on the slopes of the hill. In addition to providing centralized storage space, the fortification at Korfari ton Amygdalion would have sheltered the occupants of the area in the event of an attack.[68]

In order to test Angelopoulou's interpretation, I performed a spatial syntax analysis (Hiller and Hansen 1984) of the architectural remains at the side. The results confirmed Angelopoulou's assessment of the site as a defensible complex. Figure A.1 shows the depth of each of the features within the complex (comprised of rooms, corridors, and towers), which may be defined as the least number of syntactic steps needed to reach a feature from the outside. With the exception of features 5, 3, and α, the complex at Panermos may be best defined as having a tree-like structure. While the entrances into the complex are restricted by features 22 and 18, once further into the complex, movement is relatively free and the degree of connectivity high.

Restricted access from the outside, towers, bastions, and high exterior wall thickness all indicate a defensive function for the complex at Panermos. If this were a residential compound, one might expect to see groups of rooms separated by corridors (as is the case for nearby Skarkos on Ios; cf. Economidou 1993: 137). However, the overall spatial pattern at Panermos—single rooms connecting to common

68 Cf. Tsountas's (1899: 78, 127-9) similar conclusion about the fortified acropolis at Kastri on Syros.

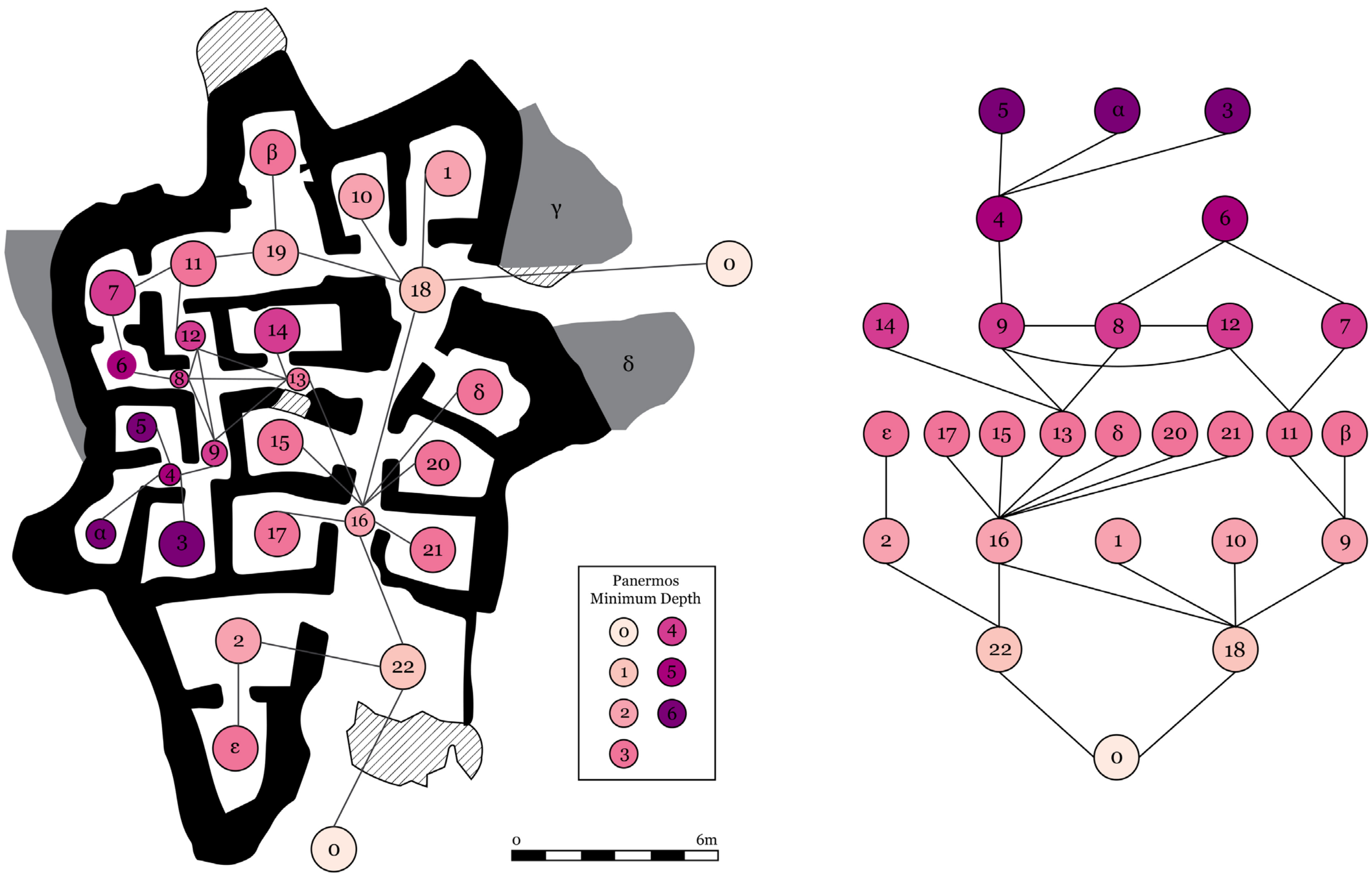

Figure A.1. Spatial Syntax Model of Panermos (Korfari ton Amygdalion)
Site plan after Angelopoulou (2008: fig. 16.1).
The spatial syntax model of Panermos shows the minimum depth for each room in the building.

corridors—when combined with the material evidence supports the hypothesis that this building was used as a storage facility and defensive structure.

This is an important conclusion because evidence for centralized storage facilities in the EBA Cyclades is virtually nonexistent. If the architecture at Panermos represents a centralized storage facility during the Kastri period, this may indicate a significant shift in socio-political structure, as is discussed in detail below.

Gazetteer entries: Hope Simpson & Dickinson 330-331; Renfrew 23

Korphi t'Aroniou

Korphi t'Aroniou is a settlement on the eastern coast of Naxos encompassing a maximum of 0.08 ha on a prominent hilltop (Broodbank 2000: 177). It is situated approximately 300 m from the sea and has been described as "inland" (Economidou 1993: 129), but a viewshed analysis from the hilltop that the site is situated to overlook the sea (see figure 5.14). The settlement was occupied during the Kastri phase, and may have also been occupied during the Keros-Syros phase.

The buildings of the settlement (figure A.2) have neatly-built walls which are of slightly greater thickness (50-60 cm) than Cycladic average (see chapter 4), straight, and joined at right angles. Some of the buildings have paved floors, and sometimes slabs were used for roofing, indicating a high standard of living relative to contemporary settlements (Economidou 1993:133). The attempt at a regular layout of the settlement—where houses are divided into small groups with roads, alleys, or passages running between them—is also unusual for this time period (Economidou 1993: 137).

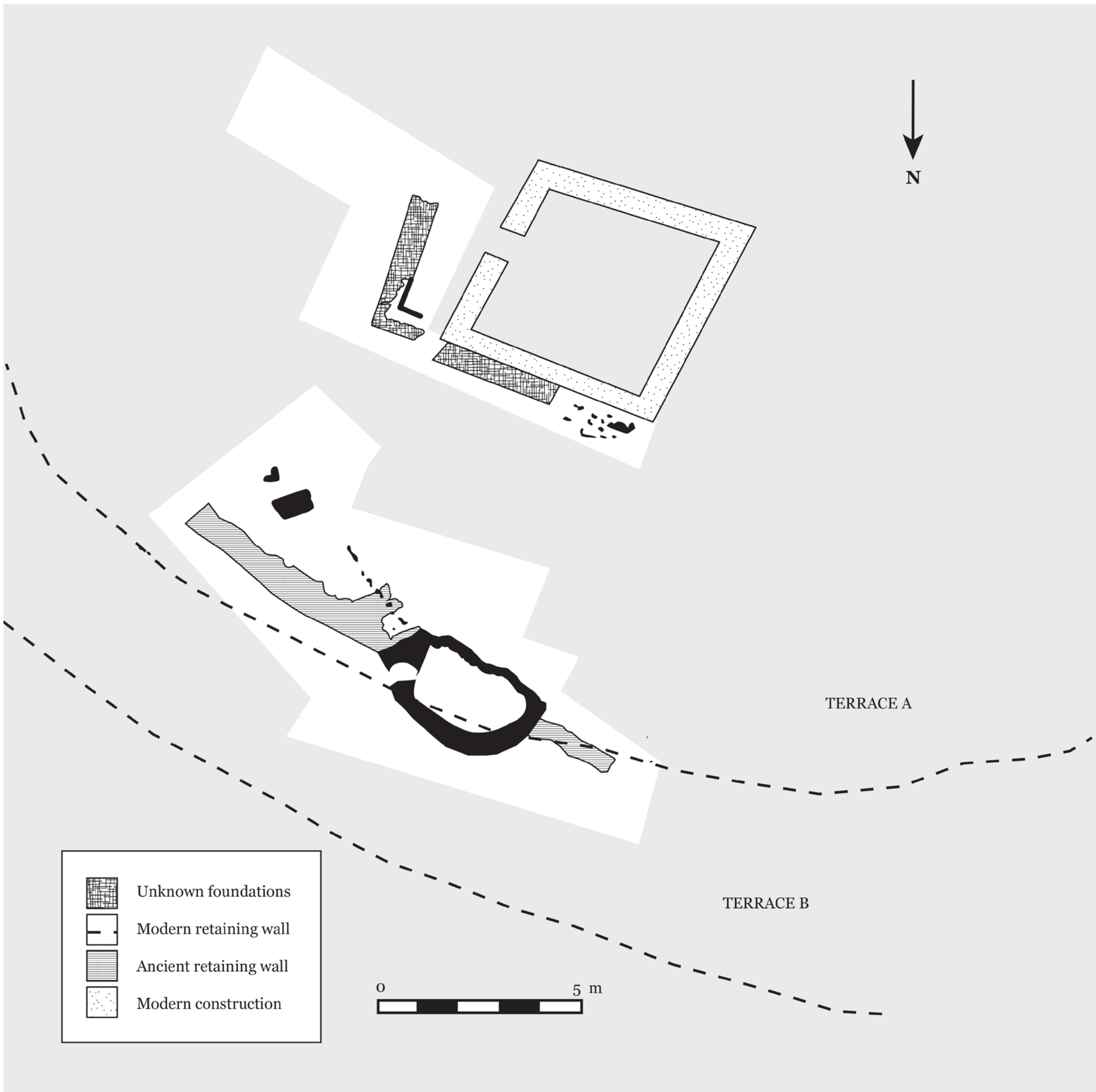

Figure A.2. Site Plan of Korphi t'Aroniou

After Doumas (1964; 1965).

The site plan of Korphi t'Aroniou shows the trenches excavated by Doumas and the elliptical building.

Some of the buildings of the settlement were excavated by Doumas (1965) (figure 5.6). Unique among these is an elliptical structure whose unusual construction and isolation from the rest of the buildings of the settlement indicate its potential function as a storage building, paralleling similar structures used by Cycladic farmers in modern times to store agricultural tools or produce (Economidou 1993: 138). A vertical slab was placed in front of the door to prevent water from seeping in, since the floor is 30 cm below ground level (Economidou 1993: 135). Mill-stones and grinders were excavated from the site, indicating grain processing activity (Economidou 1993: 138-9).

Most notable of the finds from Korphi t'Aroniou are ten stone slabs, engraved with different scenes, including a famous pictograph of a human with a quadruped (possibly a goat) being loaded onto a small vessel with a flat hull and prominent bow (W413). This has been interpreted as a representation of the short-distance transport of an animal or two to grazing lands or for trading with other coastal communities (Broodbank 2000: 127-128; Cherry 1985:20), but it has also been seen as depicting early colonizing expeditions in which many people and animals set out on ships to sail and settle in distant lands (Tartaron 2013:78). No associated cemetery has been found for the settlement at Korphi t'Aroniou.

Gazetteer entries: Hope Simpson & Dickinson 330; Renfrew 22

Kalandos Valley

While no settlement sites have been discovered yet in the Kalandos valley, it is the largest contiguous stretch of promising agricultural land in southeastern Naxos (see figure A.3). Two cemetery sites—Karvounolakkoi in the central part of the valley

Figure A.3. The Kalandos Valley of Southern Naxos

and Phionda to the north—have been attested, and the Cambridge Naxos survey's preliminary results indicate a high degree of human activity in the area during the Early Bronze Age, in particular on the upper part of the western slopes of the valley.

Stephanos (1904: 53; 1905: 216) excavated 82 cist graves from the extensive cemetery at Karvounolakkoi (Renfrew 1972: 518). Finds were dated to the Grotta-Pelos and Keros-Syros phases (Papathanasopoulos 1961-2: 109).

No published excavation has taken place at Phionda; the cemetery's existence was reported by locals to Renfrew in 1963 (Renfrew 1972: 519). Local inhabitants reported a so-called 'Royal Family' grave with marble finds, but neither the location of the cemetery nor the associated dates can be verified. It is possibly that the marble finds are a group from the Goulandris collection that has been associated with Spedos (Doumas 1969: nos. 308, 309, 312, and 328).

Gazetteer entries: *Karvounolakkoi* - Hope Simpson & Dickinson 330; Renfrew 20; *Phionda* - Hope Simpson & Dickinson 331; Renfrew 27

Appendix B
Seasonal Wind Patterns for the Southern Aegean

To create cost surface rasters for modeling maritime interaction I first needed to create wind maps of the average monthly wind speed and direction for the southern Aegean. I obtained average monthly wind speed and prevailing wind direction information from windfinder.org, an open-source website that aggregates data from various observation points around the Aegean dating from 1999 to the present. I created a shapefile containing all of these observation points and linked it to a table that contained the data for wind speed and direction from each month. From this, I used the Interpolation tool in ArcGIS to create two maps for each month using inverse distance weighted interpolation (IDW), one containing average wind speed and the other containing prevailing wind direction.

Once I had created two interpolated maps for each month, I generated a mesh of regular points across the study area using the Create Fishnet (Data Management) tool in ArcGIS, making sure the "Create Label Points" option was selected. This resulted in two map layers, a grid layer and a point layer. The latter was connected to the direction and speed rasters for each month using the Extract Multi Values to Point tool.

I symbolized the resulting layer—which now contained average wind speed and direction values at points across the study area in a regular grid—using graduated symbols where the magnitude of the symbol varied according to wind speed, and the rotation of the symbol varied according to wind direction. Because wind direction is measured by the direction *from* which it is flowing, it is important to symbolize the map with a downward facing arrow in order to achieve the correct representation. I classified the data according to Natural Breaks (Jenks) with five categories. This process was repeated for every month (figures B.1-12).

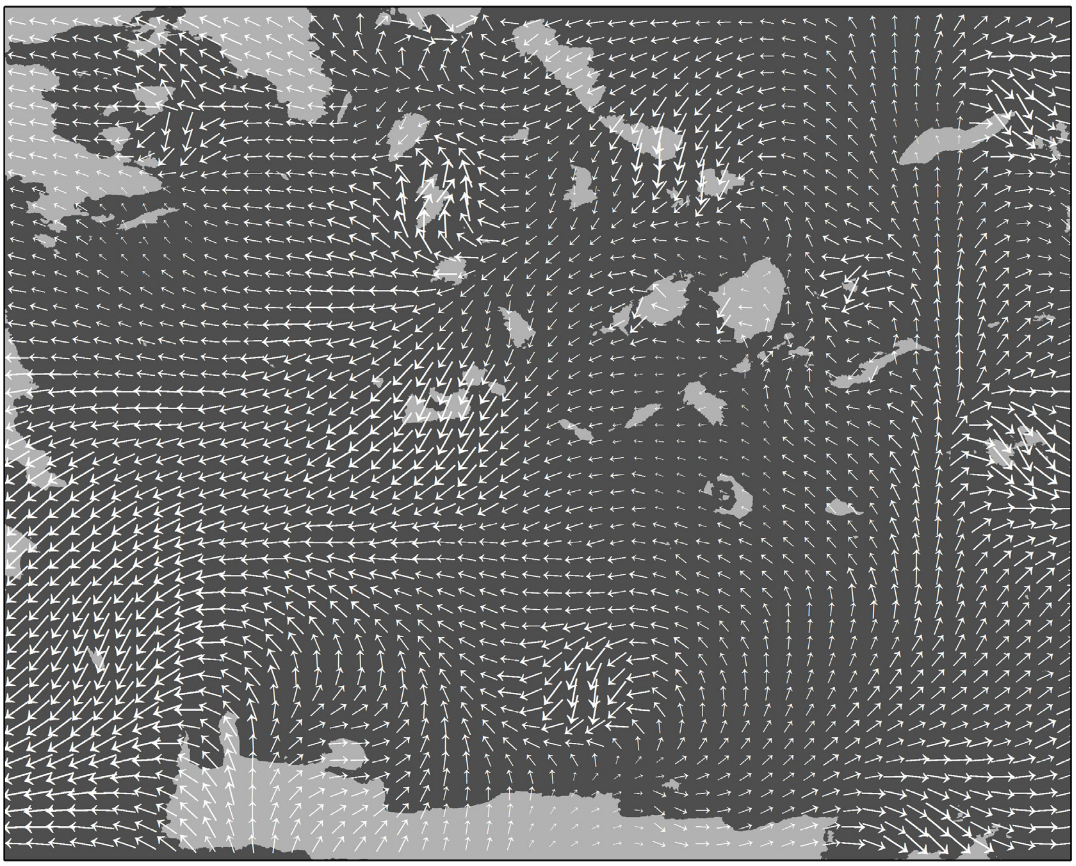

Figure B.1. January Wind Map

Figure B.2. February Wind Map

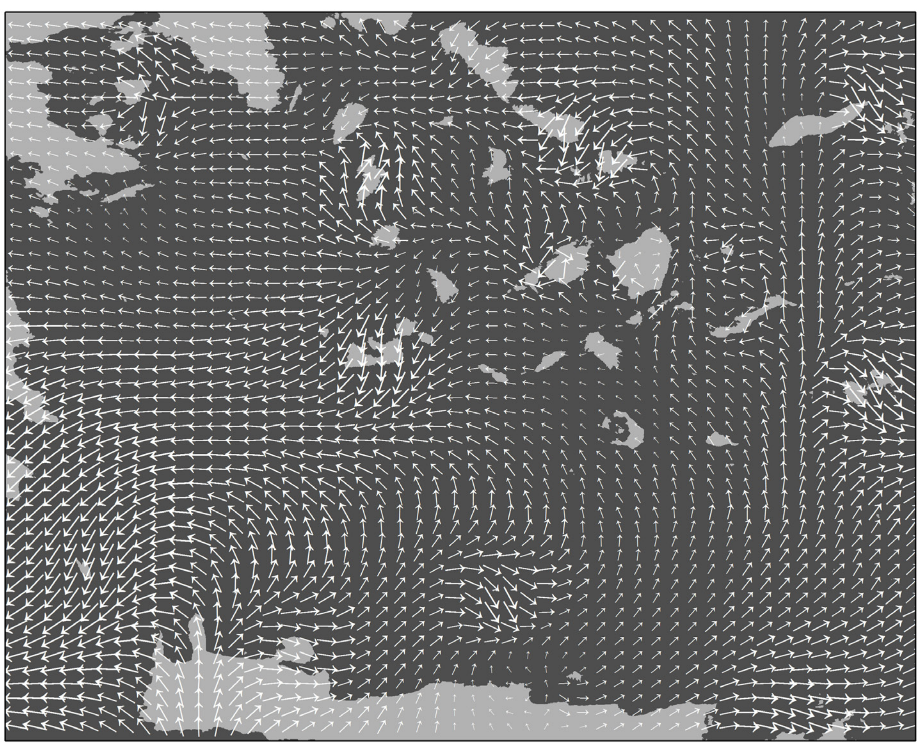

Figure B.3. March Wind Map

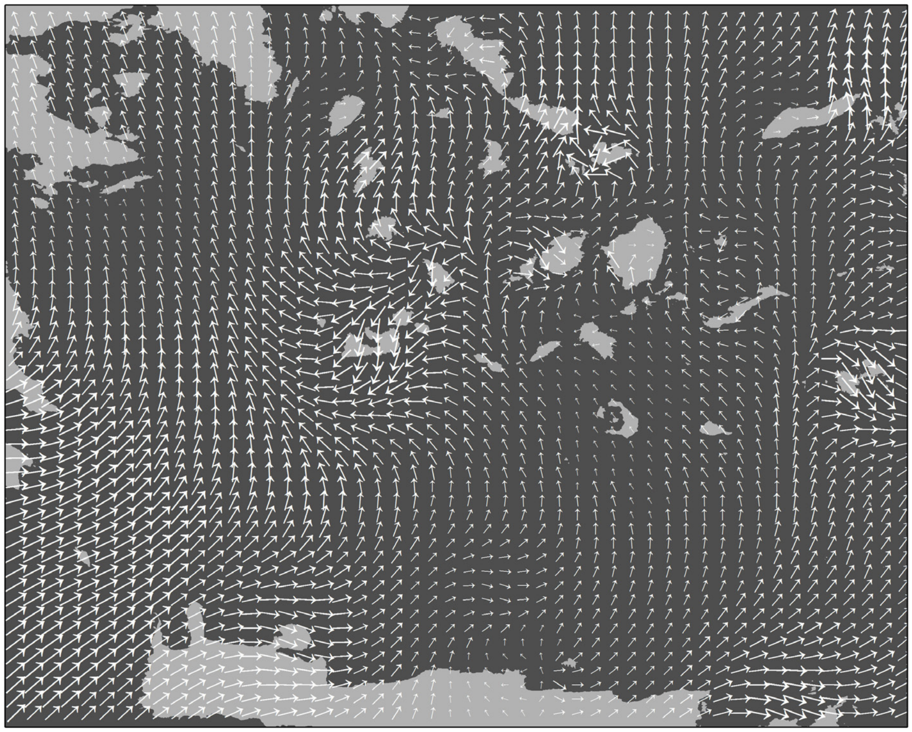

Figure B.4. April Wind Map

Figure B.5. May Wind Map

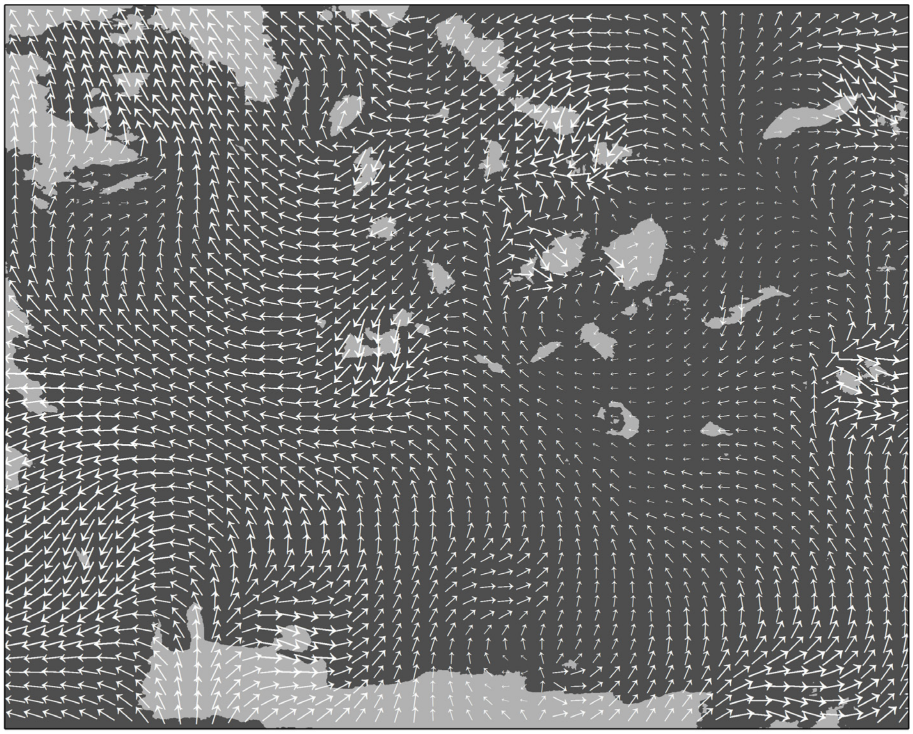

Figure B.6. June Wind Map

Figure B.7. July Wind Map

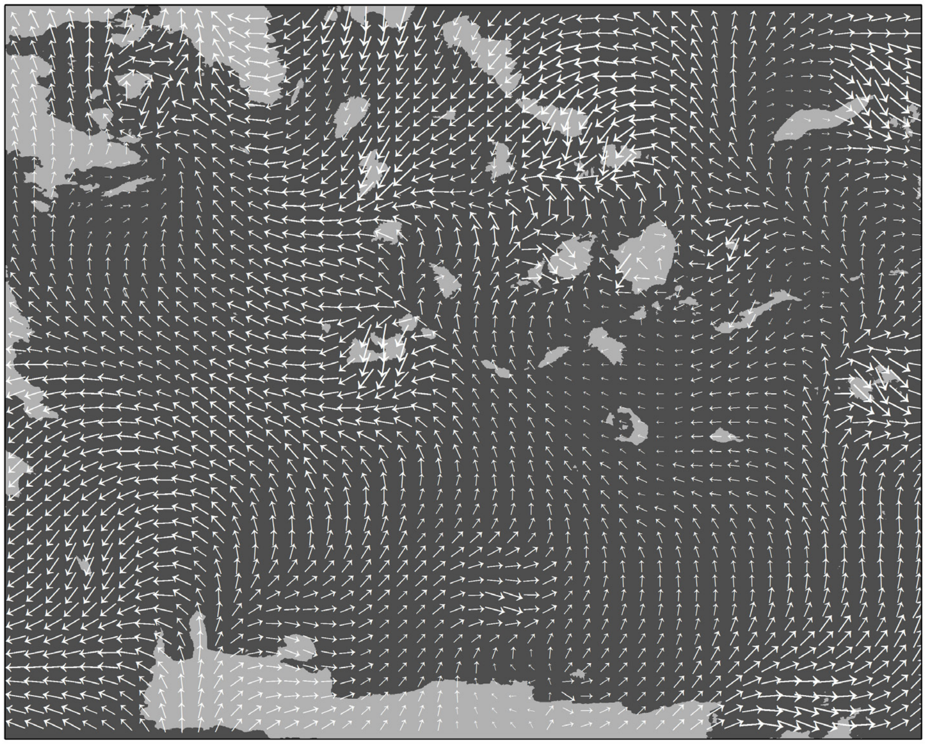

Figure B.8. August Wind Map

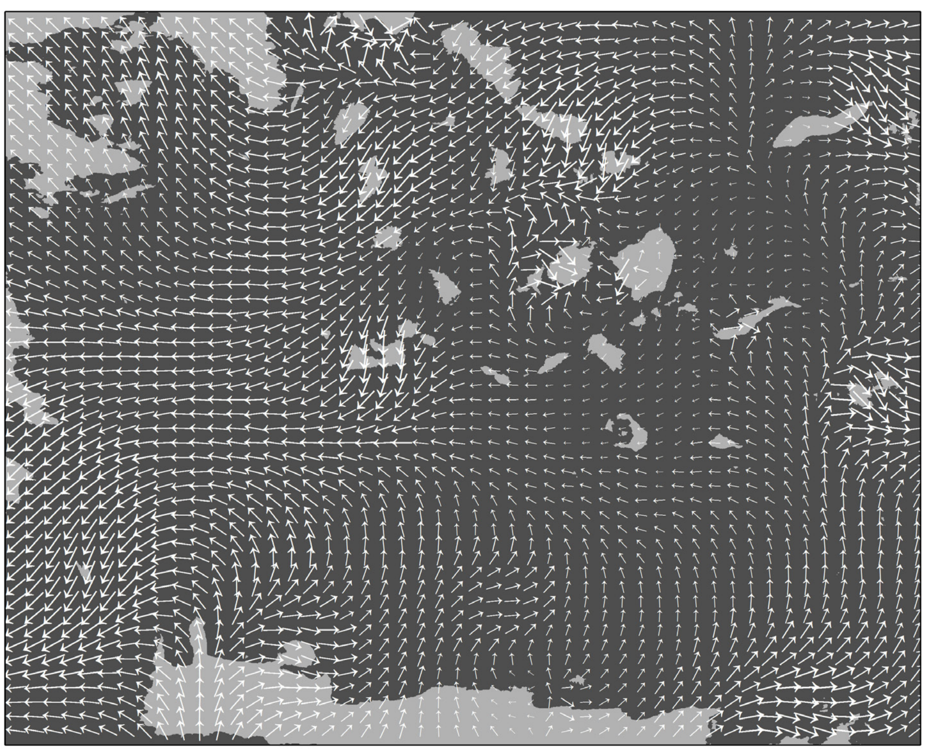

Figure B.9. September Wind Map

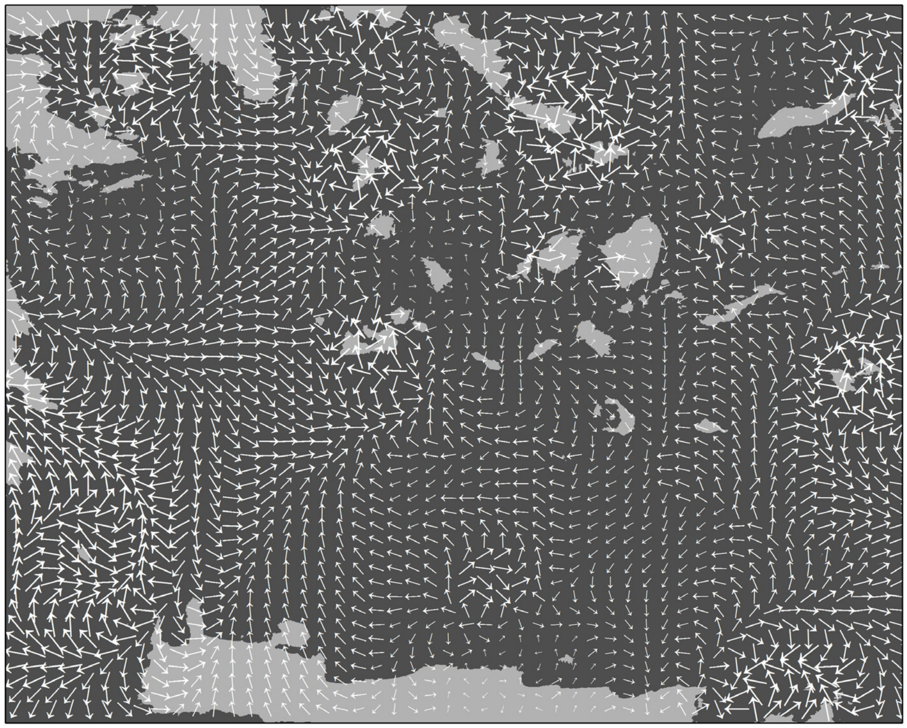

Figure B.10. October Wind Map

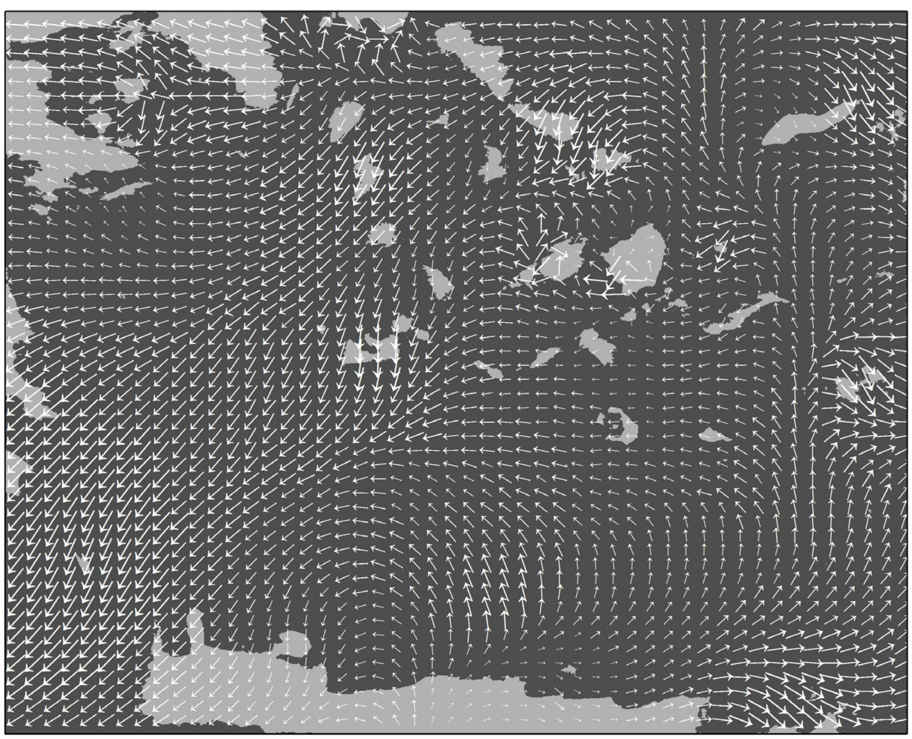

Figure B.11. November Wind Map

Figure B.12. December Wind Map

Appendix C
Cyclades Path Distance by Month

To measure travel ranges for Early Cycladic sites by month (figures C.1-12), I used the Path Distance function in ArcGIS. The locations of known Early Cycladic coastal sites form the input for the model, which measures travel time *to* each of these points. Cost factors for the Path Distance model included average wind speed and direction for each month (see appendix B). The costs associated with sailing under different wind conditions may be found in table 6.1.

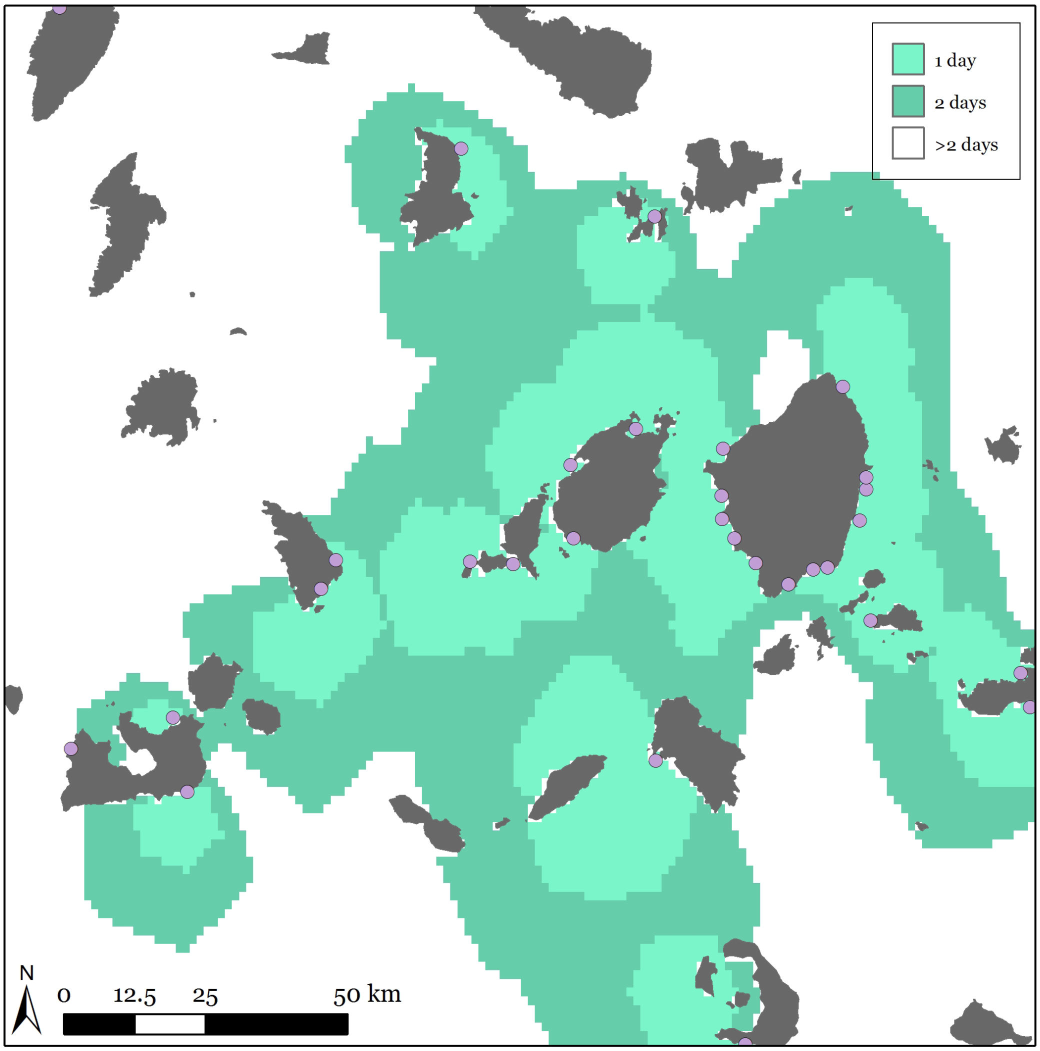

Figure C.1. Cyclades Path Distance (January)

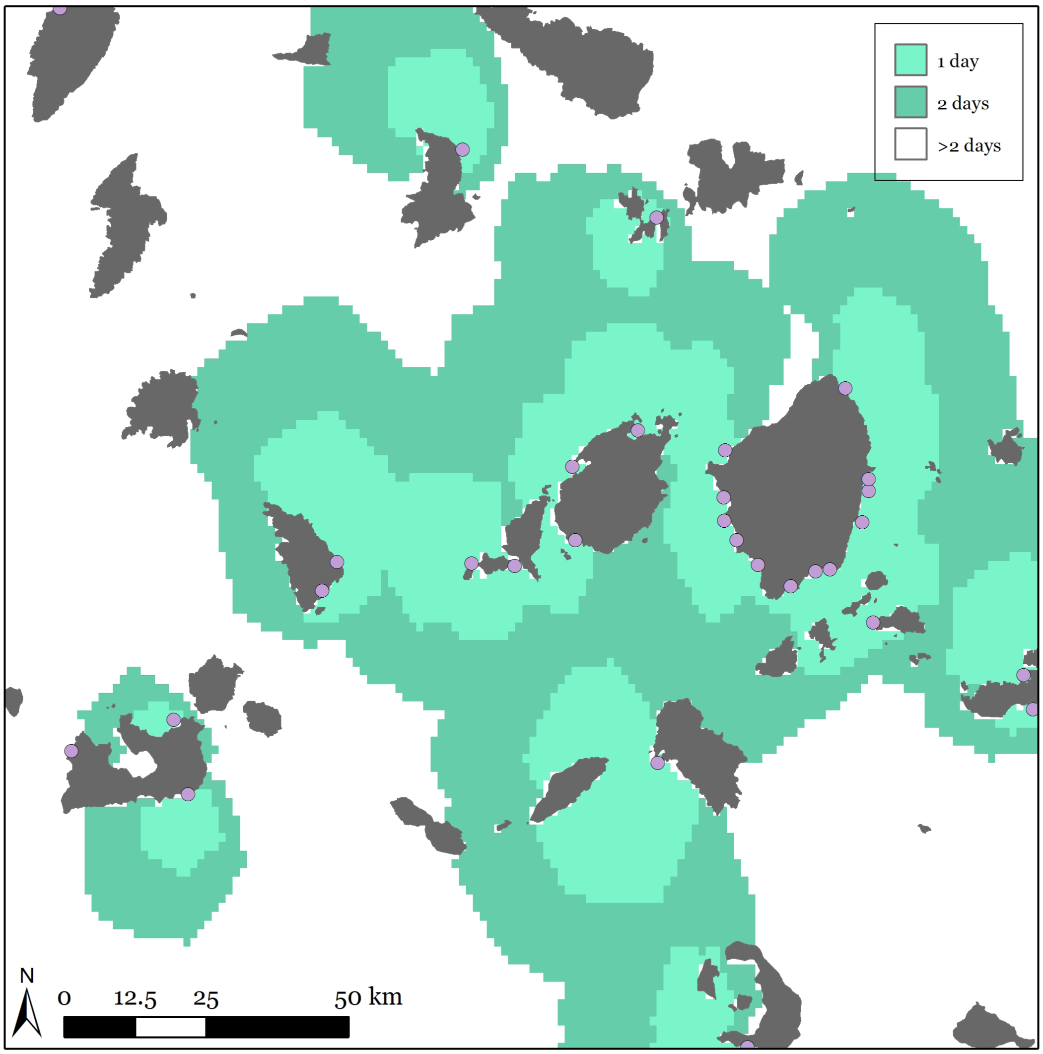

Figure C.2. Cyclades Path Distance (February)

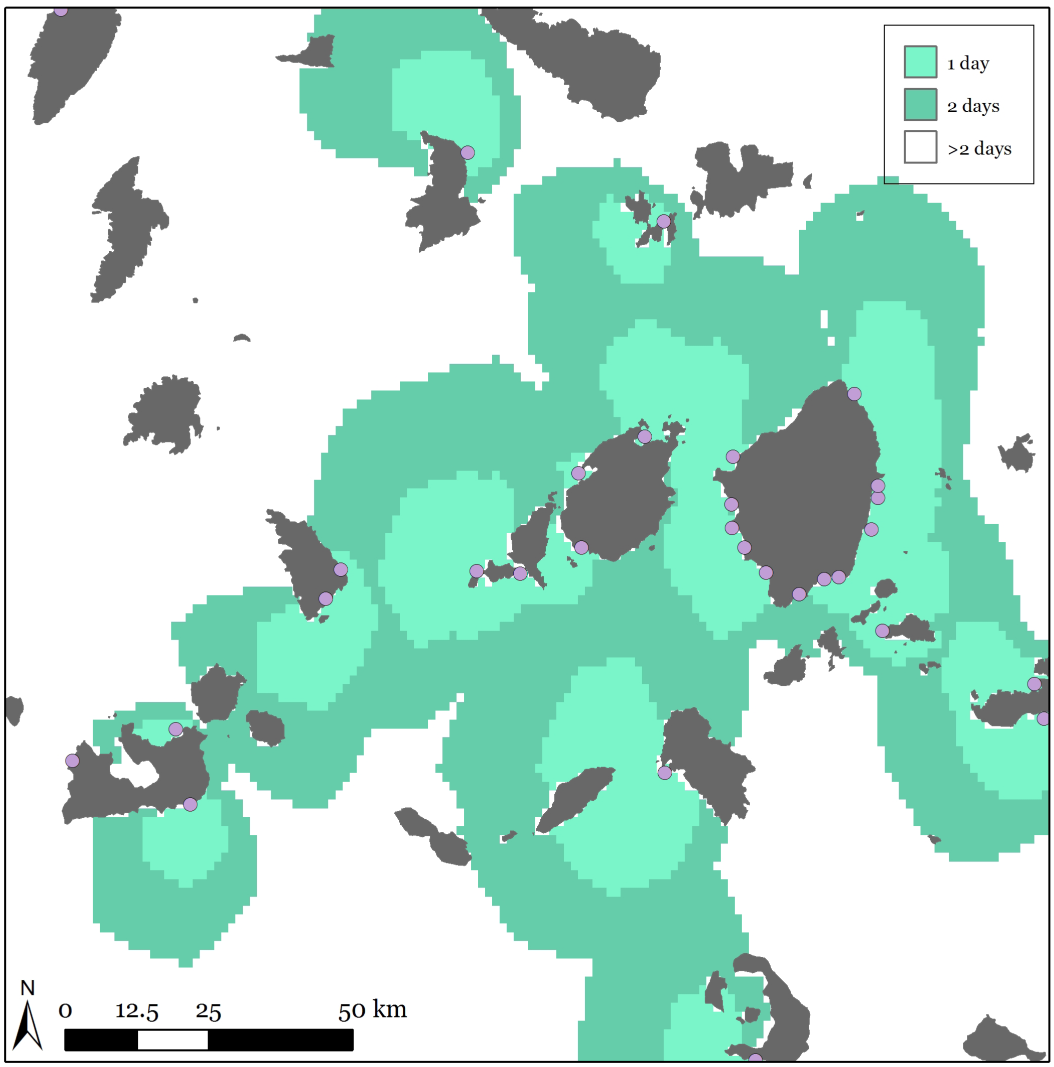

Figure C.3. Cyclades Path Distance (March)

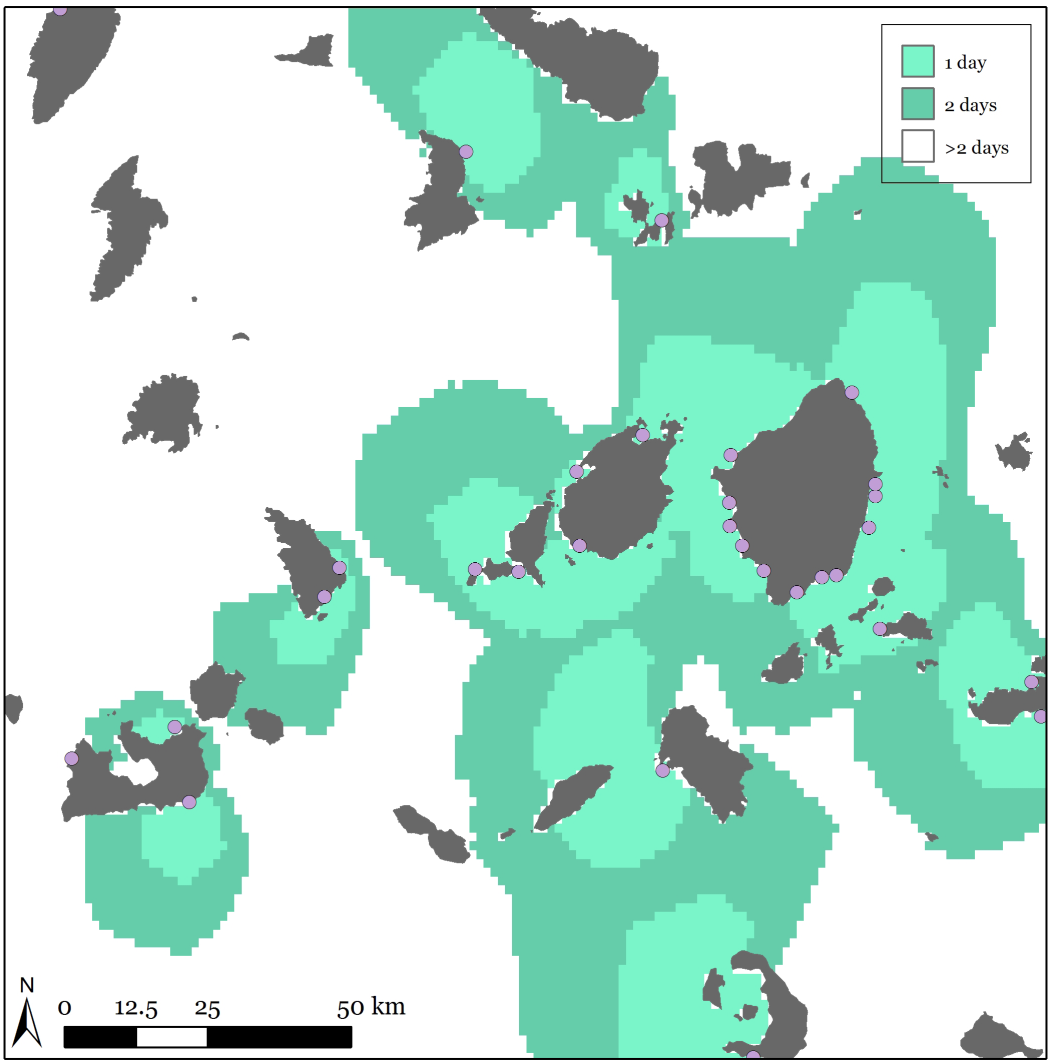

Figure C.4. Cyclades Path Distance (April)

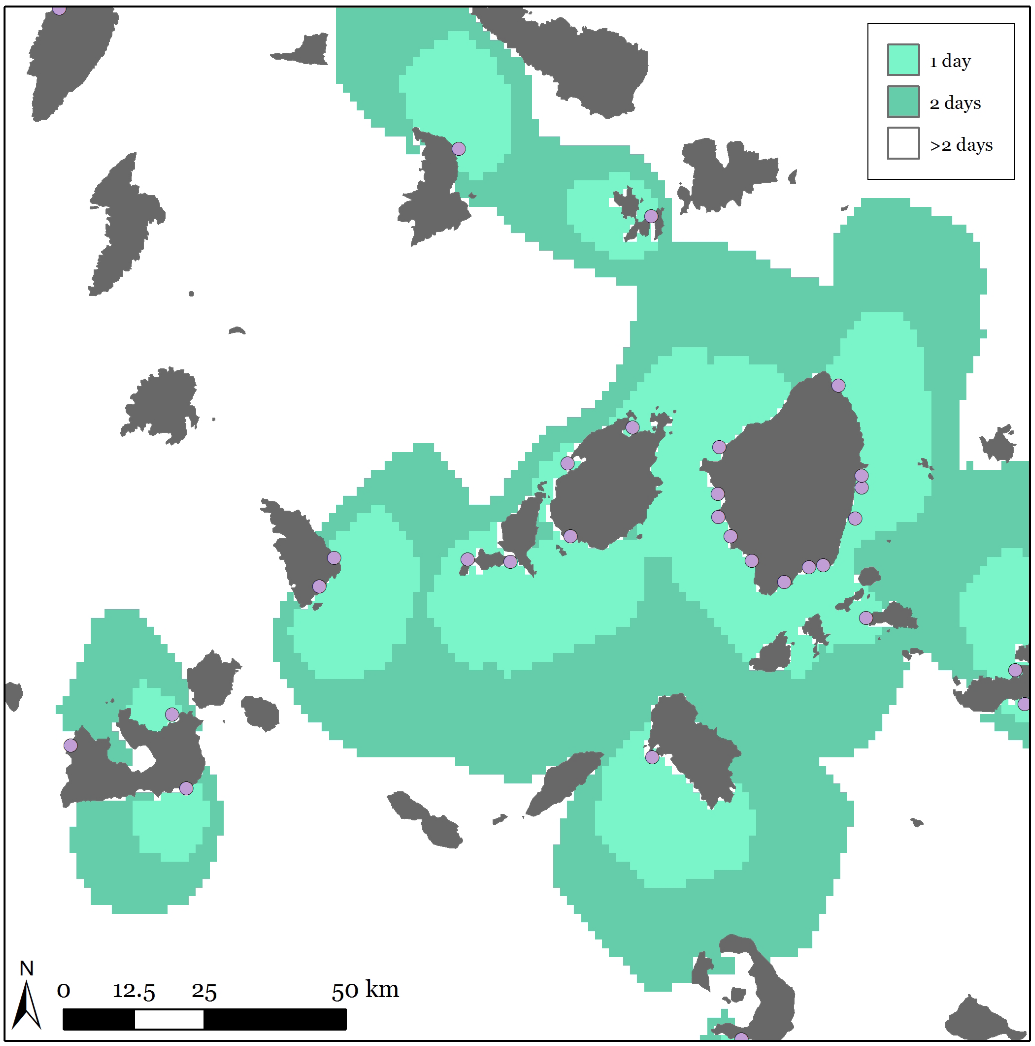

Figure C.5. Cyclades Path Distance (May)

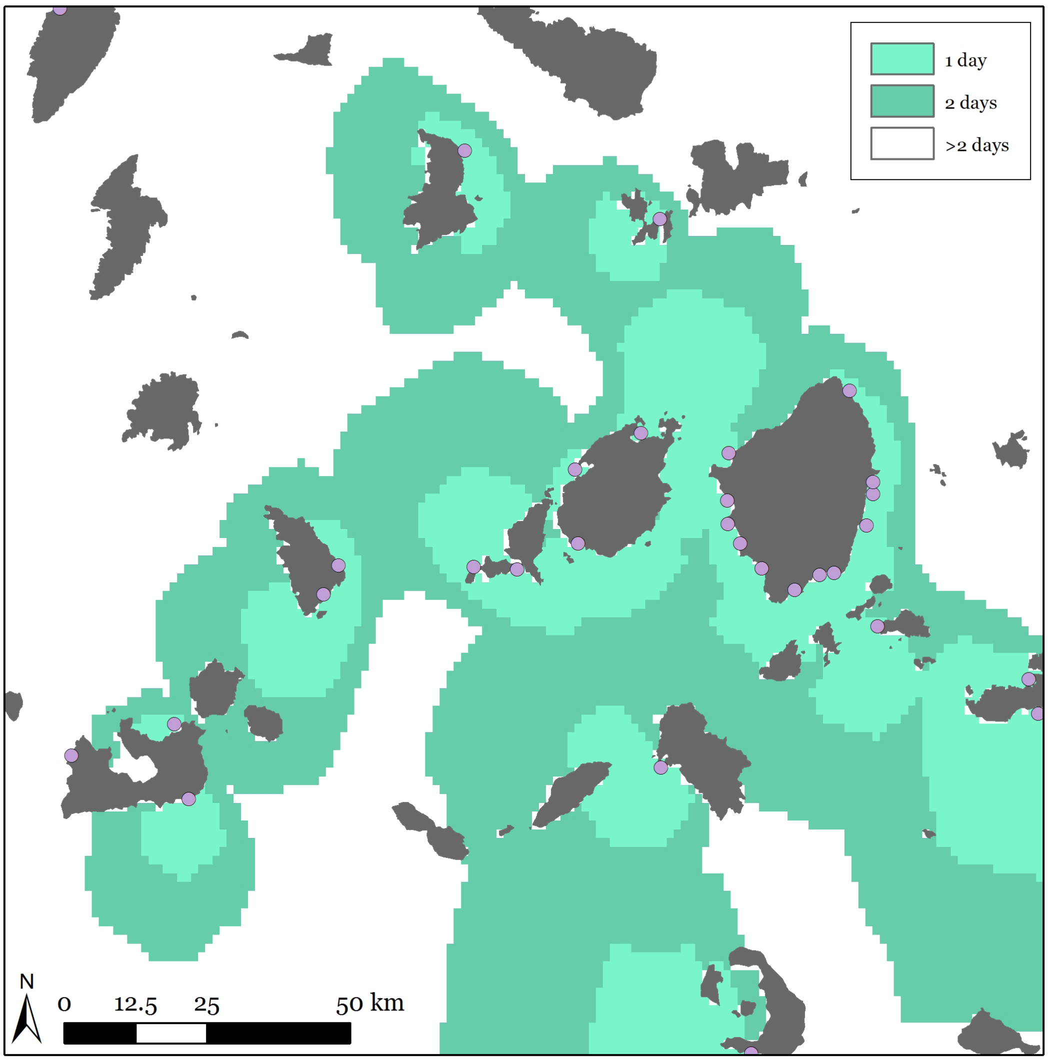

Figure C.6. Cyclades Path Distance (June)

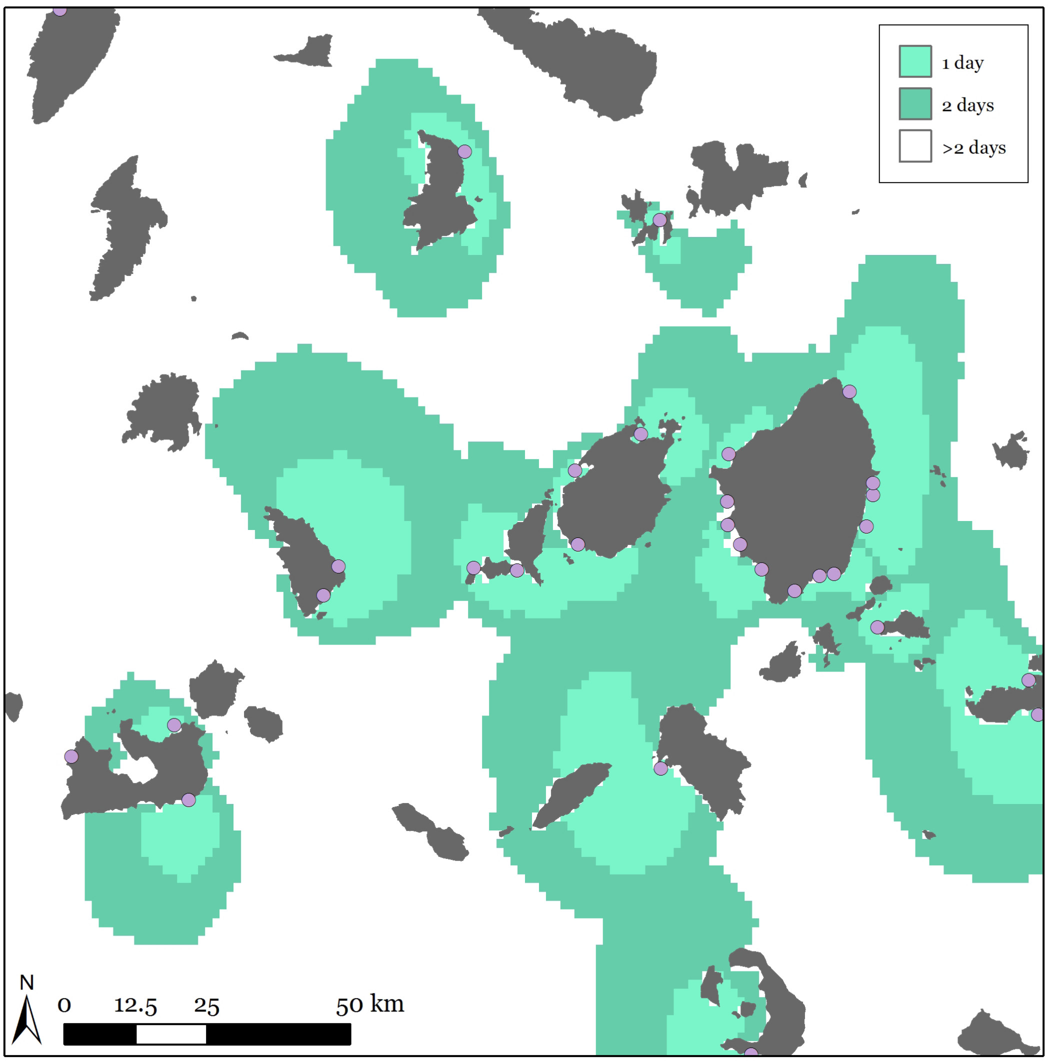

Figure C.7. Cyclades Path Distance (July)

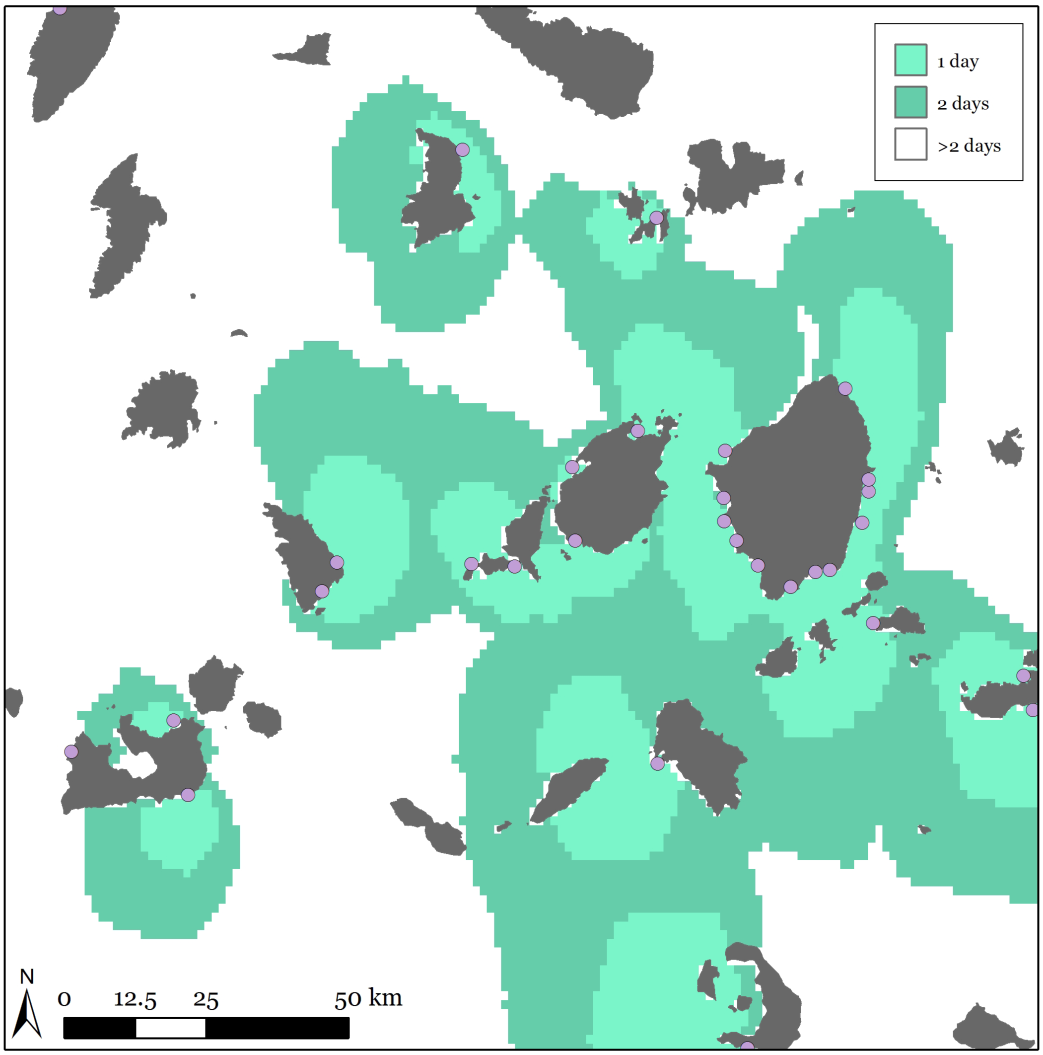

Figure C.8. Cyclades Path Distance (August)

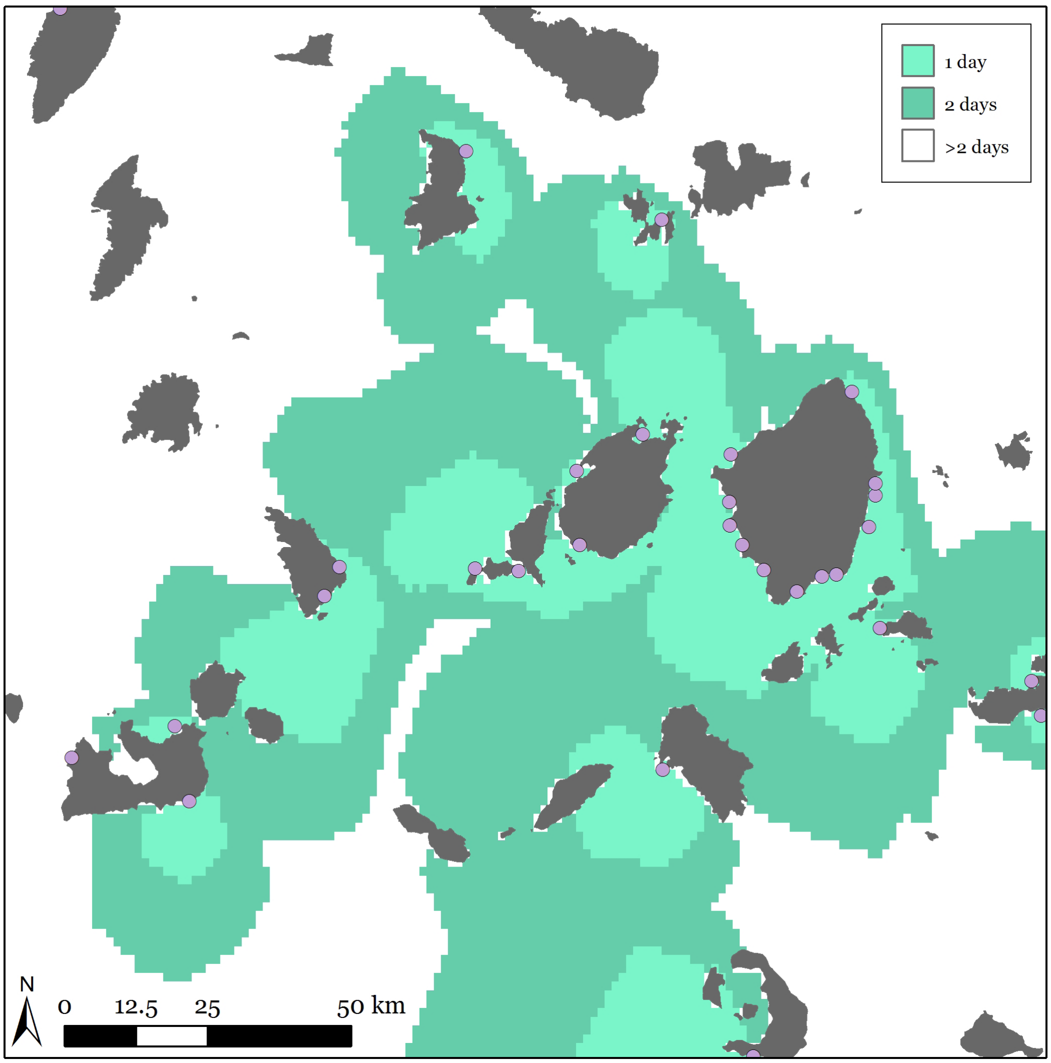

Figure C.9. Cyclades Path Distance (September)

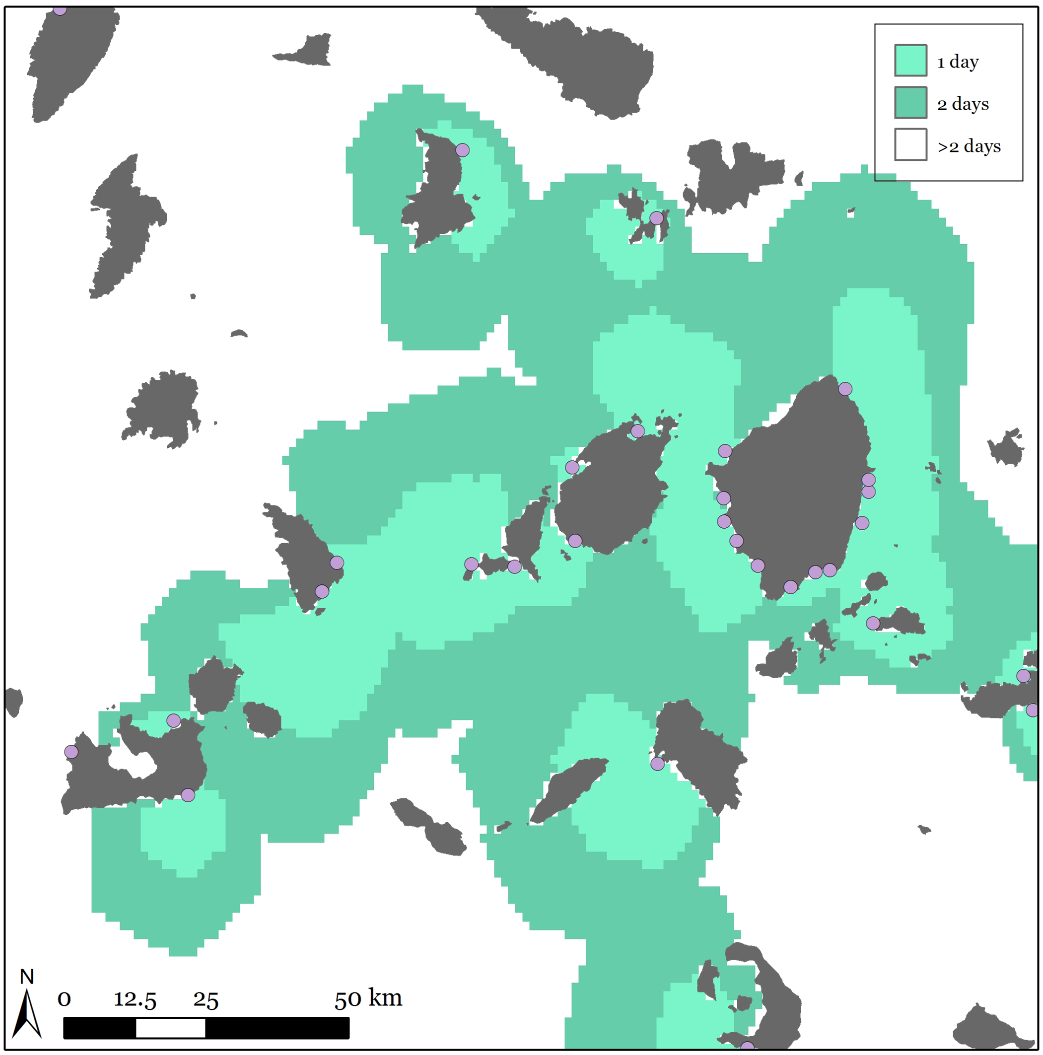

Figure C.10. Cyclades Path Distance (October)

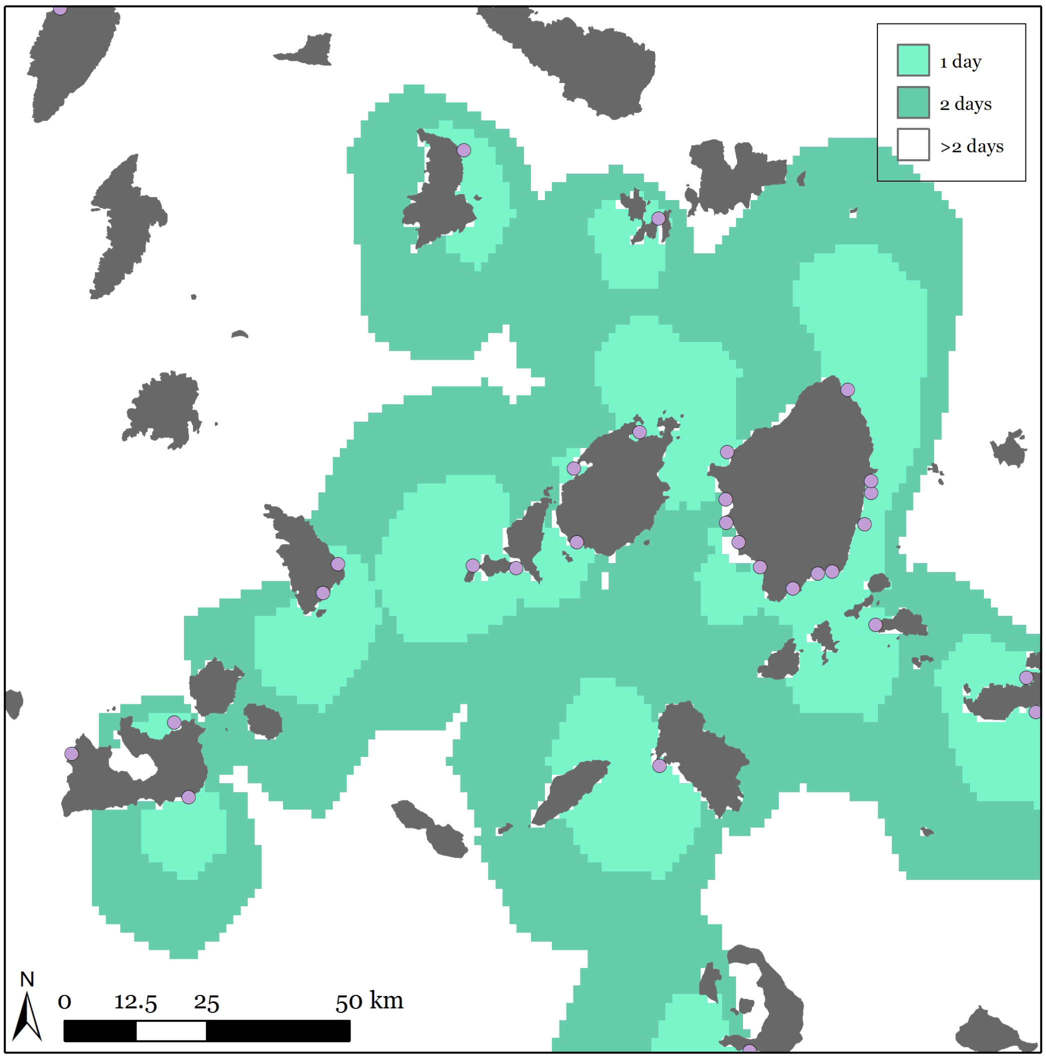

Figure C.11. Cyclades Path Distance (November)

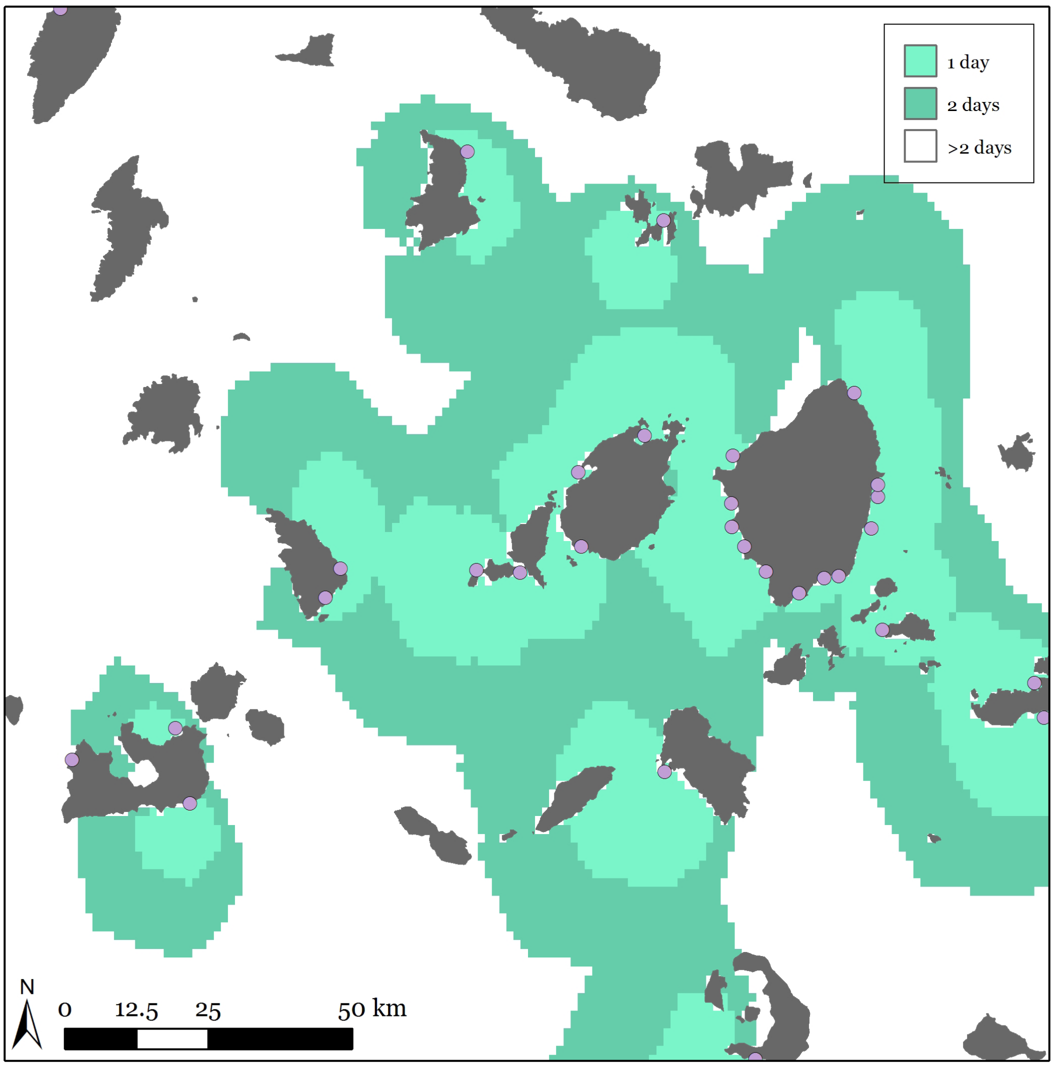

Figure C.12. Cyclades Path Distance (December)

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