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Master’s Thesis

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Coastal landscape and maritime context of Neolithic settlement of Paralimni *Nissia*, Cyprus

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Supervisor: Dr. Stella Demesticha

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ABSTRACT

Title: The Coastal Landscape and maritime context of the Neolithic settlement of Paralimni *Nissia*, Cyprus
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Abstract:
The Ceramic Neolithic site of Paralimni *Nissia* is located on a small hillock, right on the coast of Kaminoudhia Bay, Famagusta Bay, Cyprus. Owning to its location and considerable amount of marine-related artifacts, Paralimni Nissia is considered as a neolithic harbour site. However, fluctuation in sea levels through the Holocene has not been taken into consideration, thus it is possible that because the sea level was lower than today when the site was occupied. The following research has been thus aimed to hypothetically reconstruct the coastal landscape in the vicinity of Paralimni Nissia, based on different data sets: geomorphological observations, field underwater survey, sea level studies and bathymetry generated from LiDAR data, as well as the mollusc assemblage excavated at the Neolithic site. Further quantitative and spatial analysis was conducted on the molluscs in order to investigate their archaeological and environmental context.

During the survey, 16 geomorphological markers were identified. Taking into consideration their depths, at least five palaeocoastlines can be proposed in various depths, between – 2 m and -7.60 m. Quantitative analysis revealed that the prevalent quantity of shells was probably collected alive, for consumption purposes, while the minority, and only specific species, were modified into ornaments and tools. Finally, the assemblage contains a considerable quantity of fresh deep-dwelling molluscs, indicating that these shells were probably collected alive offshore. As such, this thesis proposes the coastal character and positions of sea levels during the timespan of the settlement as well as its maritimity based on geography and distribution of shells and other marine-related finds.

Keywords: Ceramic Neolithic Cyprus, Maritime Archaeology, Paralimni *Nissia*, Palaeocoastline reconstruction, Molluscs

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1. Introduction

The coast is a dynamic zone, constantly formed by both marine and land processes. Coastal changes depend on various factors of both local and global scale, including the geology and the topography of the coasts, climate conditions, and the range of hydrodynamics, isostatic and eustatic changes. Since the last glacial maximum, the sea level has risen by tens of meters, leading to the inundation of prehistoric coastal zones, and the present-day sea level which was reached approximately 4 ka years BP (Gomez and Pease 1992; Galili et al. 2005, Bailey and Flemming 2008).

The Ceramic Neolithic settlement of Paralimni *Nissia* is located in southeastern Cyprus (Flourentzos 2008), in Famagusta Bay, on the small hillock situated right next to the coast of Kaminoudhia Bay (Fig. 1). The sea is easily accessible from the modern Vyzakia beach on the north, a stone's throw from the site. To the north/northwest, the hillock is bordered by a dried channel of the small river Potamos tou Lombardi which had flowed into the sea on the north, before the modern beach was established. Besides its geographical position, the site yielded a rich assemblage of marine molluscs and sea-related artifacts, such as net sinkers, a stone fishhook, shell jewellery as well as tools and stone figurines depicting marine animals (Flourentzos 2008:85,87,89,120,123, Knapp 2020: 430). In total, 21 species of molluscs (913 individuals) have been discovered at *Nissia* site (Reese 2008:119-153). Each species of molluscs requires a specific habitat and natural conditions. Their analysis thus can provide

Figure 1: The location of Paralimni Nissia (modified Google Earth)

information about coastal and environmental changes, as well as the exploitation strategies and daily life in the past (Karali 1999; Bar-Yosef Mayer 2005a:1-4).

The concept of maritime cultural landscape, first introduced by Westerdahl (1992), has a broad definition concerning the human utilization of maritime space, including economy, connection, and trade, as well as the human understanding of the sea, reflected in toponyms, symbolism, or mythology. Ten years later, Galili et al. (2002) introduced the 'Mediterranean Fishing Village' (MFV) model, taking into consideration not only the subsistence strategies but also geographical aspects, i.e. distance from the sea. Bearing this in mind, this thesis addresses the maritimity of Paralimni *Nissia* through the environmental approach, taking into consideration the local geography as well as the influence of the sea on the daily life of the villagers via subsistence strategies of marine resources and spatial distribution of molluscs and marine related artifacts. Therefore, the focus of this thesis is on the reconstruction of the coastal landscape in the vicinity of Paralimni *Nissia*, based on geomorphology, bathymetry, sea level studies, and analysis of the mollusc assemblage. At the same time, quantitative and spatial analysis of shell distribution is used to gain an insight into procurement strategies, processing methods, and deposition practice.

To this end, the first chapter discusses the Ceramic Neolithic period in Cyprus (the fifth millennium BCE) and its maritime context. The chapter contains the review of the research at Paralimni *Nissia*, with emphasis on the spatial distribution of the dwellings, as it is essential for further spatial analyses. The second chapter is dedicated to palaeocoastline reconstruction. Geomorphological markers are combined with bathymetry and sea level changes in Cyprus and the eastern Mediterranean. The last chapter covers the archaeomalacology and shell assemblage of Paralimni *Nissia*. Shells are used for bothenvironmental reconstruction and as an indicator of the maritime context of the settlement through quantitative and spatial analysis.

The main research questions which is thesis is attempting to answer are:

1) How far was the site situated from the sea in the period of occupation?
2) What can the material culture of Paralimni *Nissia* reveal about the environmental settings of the coast?
3) What can the material culture of Paralimni *Nissia* reveal about the marine adaptation and exploitation by its inhabitants?
4) What are the similarities and differences among Paralimni *Nissia* other contemporary coastal sites in Cyprus and the rest of the Eastern Mediterranean?

The objectives of this Master thesis are to:

1) place the settlement in its archaeological context, with a focus on its connection to the sea
2) hypothetically reconstruct the palaeocoastline in the vicinity of Paralimni *Nissia* based on sea level studies, field survey data, and bathymetry generated from LiDAR data
3) Understand the use of seashells in the settlement, via quantitative analysis spatial analysis
4) discuss possible similarities and/or differences among Paralimni *Nissia* and other contemporary coastal sites in Cyprus and the rest of the Eastern Mediterranean

2. Ceramic Neolithic period and maritimity in Cyprus

2.1. Ceramic Neolithic in Cyprus

The Late Aceramic Neolithic (LAN) ended around the mid-6th millennium BCE, probably as a result of the collapse of the Khirokitian culture, and was followed by a gap in the radiocarbon sequence of up to 500-1,000 years (Legrand-Pineau 2009:114; Clarke 2007:22; Clarke 2014:187). When the archaeological record resumes, the following Sotira culture (named after the site of Sotira *Teppes*) is characterized by the turn to sedentary life with animal domestication and farming, the abandonment of most of the LAN settlements, and the establishment of new sites - some of which are in previously unoccupied areas. This resumption in the archaeological record also sees the introduction of pottery and the use of sub-rectangular buildings. As it follows the Late Aceramic Neolithic period, this period is called the Ceramic Neolithic (CN) (Knapp 2013:159-160). The extent of this period is still debated but the widest range of the available data points to a timespan of about 1,000 years, from about 5200/5000-4100/4000 Cal. BCE; the main phases of all excavated settlements date to the second half of the 5th millennium BCE (Kloukinas and Voskos 2013:315; Knapp 2013:158).

The earliest evidence comes from the site of Dali *Agridhi*, located in central Mesaoria Valley, where stratigraphic layers revealed occupation in the late sixth millennium BCE with no pottery evidence and then another occupation in the early fifth millennium BCE, when pottery finds

Figure 2: Location of Cypriot sites mentioned in the text: 1) Paralimni Nissia 2) Nissi Beach 3) Salamis 4) Enkomi 5) Cape Andreas Kastros 6) Akanthou Arkosyko 7) Klepini Troulli 8) Ayios Epiktitos Vrysi 9) Philia Drakos A 10)Petra tou Limniti 11) Peyia Elia tou Vatani 12) Stroumpi Pigi Ayios Andronikos 13) Kissonerga Mylouthkia 14 Paphos 15) Sotira Teppes 16) Kandou Kouphovounos 17) Akrotiri Aetokremnos 18) Amathus 19) Parekklisia Shiroulokambos 20) Kalavasos Kokkinoyia 21) Kalavasos Tenta 22) Khirokitia Vouni 23) Dromolaxia Vyzakia 24) Kition 25) Dhali Agridhi (modified Google Earth)

were located (Clarke 2014:187). Nearly 40 CN sites have been identified on the island, of which 10 have been fully or partially excavated (Knapp 2013:162). These sites are: Sotira *Teppes* (Dikaios 1961), Klepini *Troulli* (Peltenburg 1979), Ayios Epiktitos *Vrysi* (Peltenburg 1983), Philia *Drakos A* (Watkins 1972), Dhali *Agridhi* (Lehavy 1989), Kandou *Kouphovounos* (Mantzourani 2003), Kalavasos *Kokkinoyia* (Clarke 2004) and Paralimni *Nissia* (Fig. 2). In the west, trial excavations have been conducted at Stroumpi *Pigi Ayios Andronikos* (Ammerman and Sorabji 2005; Ammerman, Flourentzos and Noller 2009) and Peyia *Elia tou Vatani* (Baird 1985:341-343). Ceramic Neolithic occupation have been found in limited range also above LAN layers at Khirokitia (Dikaios 1953:274,321; Dikaios 1961:209, 216-217), Kalavasos *Tenta* (Held 1989:223,241; Clarke 2007:33,35,37-38) and Kissonerga *Mylouthkia* (Peltenburg 1991).

Small villages of approximately 100 habitants spread all over the island and sites have been located along the north and east coast (Ayios Epiktitos *Vrysi*, Klepini *Troulli*, Paralimni *Nissia*), in Mesaoria (Philia *Drakos A*), in the southern coastal plain (Sotira *Teppes*, Kalavasos *Kokkinoyia*, Kandou *Kouphovounos*) and in highlands along the west coast (Peyia *Elia tou Vatani*, *Pigi Ayios Andronikos*) (Clarke 2014:187; Knapp 2013:162-164,188). Most of the

The site	**Location**	**Distance from the sea**	**Type**	**Architectural features**
Sotira *Teppes*	Conical hill	5-10 km from the sea	village	Large dwellings, pebble floors
Ayios Epiktitos *Vrysi*	Headland	On or near the coast	village	Subterranean dwellings, surrounding wall and ditch
Klepini *Troulli*	Headland	On or near the coast	possibly village	(Possible) surrounding wall, (possible) large dwellings
Paralimni *Nissia*	Hill on the coast	On or near the coast	village	Large dwellings, pebble floors, *havara*, surrounding wall
Philia *Drakos A*	River flank	20 km from the sea	unknown	surrounding wall and ditch, *havara*, system of pits and shafts
Dhali *Agridhi*	River terrace	20 km from the sea	Small camp	No structures
Kandou *Kouphovounos*	Conical hill	5-10 km from the sea	village	Large dwellings
Kalavasos *Kokkinoyia*	Edge of a ridge	5-10 km from the sea	unknown	system of pits and shafts *havara*

Table 1: Ceramic Neolithic sites with their location, dinstance from the sea, type of settlement and architectural features

settlements are situated on the coast or in relatively short distance, up to 5-10 km from the sea, on conical hills (Sotira Teppes, Fig.3a) or remote headlands (Ayios Epiktitos Vrysi, Fig.3b), offering them protection and/or a lookout over coastal plain (Table 1). There is an apparent preference for settling the locations in close proximity to a river or a natural spring, to arable lands, and to areas with overlapping environmental zones where farming, hunting of fallow deer, and herding of sheep and goats can be practiced (Dikaios 1961:1; Mantzourani 2003:37; McCartney 2007:85; Knapp 2013:162-5,186-8). Philia *Drakos A*, Ayios Epiktitos *Vrysi* and Paralimni *Nissia* were bounded by walls or a ditch.

Ceramic Neolithic settlements consisted predominantly of freestanding single-room, single-entry houses of mostly sub-rectangular, but also elliptical or oval plans, with an average occupational area ranging between 14-30 m2 (Knapp 2013:167). Walls of the houses with up to a maximum height of 1m were constructed from locally available stones collected from

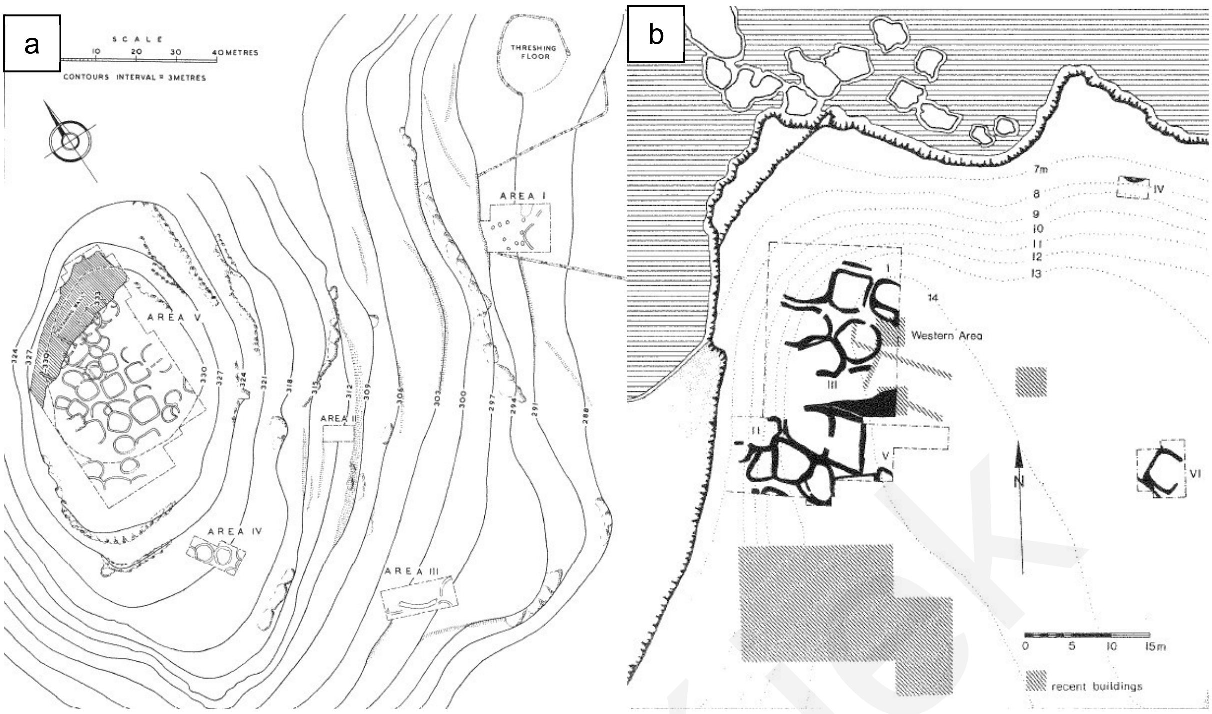


Figure 3: a) Site plan of Sotira Tepes (Dikaios 1961:Plate 4); b) Site plan of Ayios Epiktitos Vrysi (Peltenburg 1983:Fig.1)

surrounding areas, riverbanks or coasts; superstructure was made of *pisé* or mudbricks, with flat or conical roofs made of reed and mud, supported by timber posts as postholes identified in most of the dwellings (Mantzourani 2003:37; Kloukinas and Voskos 2013:315; Knapp 2013:162,167). The floors were made of beaten soils, although some houses also revealed partial pebble pavement or *havara*, beaten locally available soft limestone. Houses may also contain partition walls, probably dividing occupational space for different uses (Mantzourani 2003:37; Knapp 2013: 165,167). Some sites, which may represent ephemeral settlements or squatter encampments, lack these common architectural elements and instead they consist of pits and subterranean features (Clarke 2007:22; Knapp 2013:162).

One of the apparent features of the Ceramic Neolithic in Cyprus is homogeneity in the material culture, spatial organization and architecture, as well as ritual practices through the island. Such uniformity points to regular interaction among seemingly isolated settlements (Clarke 1992:3; Knapp 2013:188). The common repertoire includes chipped stone tools, a variety of groundstone implements, represented in a wide range of grinding (querns, pestles, grinders, pounders, mortars), and production of cutting tools and weapons (axes, miniature axes, adzes, chisels, hammerstones), stone vessels (although less frequent than in preceding period), anthropomorphic and zoomorphic figurines, bone and shell tools and ornaments and newly introduced pottery. Late Neolithic pottery is simple, handmade and coil-built, decorated in a monochrome or bichrome finish of red paint or the contrast of red and white, either in positive, Red-on-White design or negative, Combed design (Clarke 2007:38; Boness et al. 2015). It comes in a limited range of shapes: large and small bowls, with or without spouts, tall necked bottles, holemouth jars and a range of small thumb pots (Clarke 2007:38-39).

2.2. Maritime life of Ceramic Neolithic Cyprus

Compared to the earlier periods, the Ceramic Neolithic in Cyprus is associated with less evident maritime interactions, which led to the consideration of whether the island was isolated from the mainland (Knapp 2013:162; 2020:429). In contrast to earlier periods, obsidian from Anatolia was reduced in quantity, represented only by few individuals, which points to cease in transmarine exchange system. Despite the lack of direct evidence, links in material culture between Cyprus and the mainland have been proposed. Although chipped stone industry, groundstone tools, and bone tools reflect the continuity from Khirokitian culture (McCartney 2007:72,80-82; Legrand-Pineau 2009:120-121; Kloukinas and Voskos 2013:315; Knapp 2013:160), McCartney (2007:84) noted the parallels in chipped stone industry of Cyprus with contemporary sites in the central and southern Levant. Moreover, compared to the blade-based industry of Khirokitian culture, newly introduced flaked tools represent an anomaly and foreign influence has been proposed (McCartney 2007:82). Clarke (2007:97) considered the possible import of know-how of pottery making from the mainland. According to Knapp (2020:426), the decrease in transmarine contacts resulted from social changes connected with permanent occupation of the island, when Ceramic Neolithic fishermen may have not longer been involved in transmarine contacts.

Regarding the coastal and marine exploitation, Ceramic Neolithic sites yielded marine fauna remains, fishing gear, and marine fauna-shaped figurines. Considerable amounts of marine molluscs were unearthed at Paralimni *Nissia* and Ayios Epiktitos *Vrysi* while other contemporary sites yielded lower quantities, ranging from few individuals to several tens of shells (Table 2). Fish remains uncovered at Paralimni *Nissia* and Ayios Epiktitos *Vrysi* are sparce, counting only few individuals. Paralimni *Nissia* contained a considerable amount of perforated stones, interpreted either as stone weights, loomweights, or netweights (Fig. 4). Flourentzos (2008:89) further suggests that these finds are most likely associated with fishing activities as the earliest known loomweights on the island are dated some 1000 later (Knapp 2013:176). Possible net sinkers and bone fishhooks were found at Sotira *Teppes* and Ayios

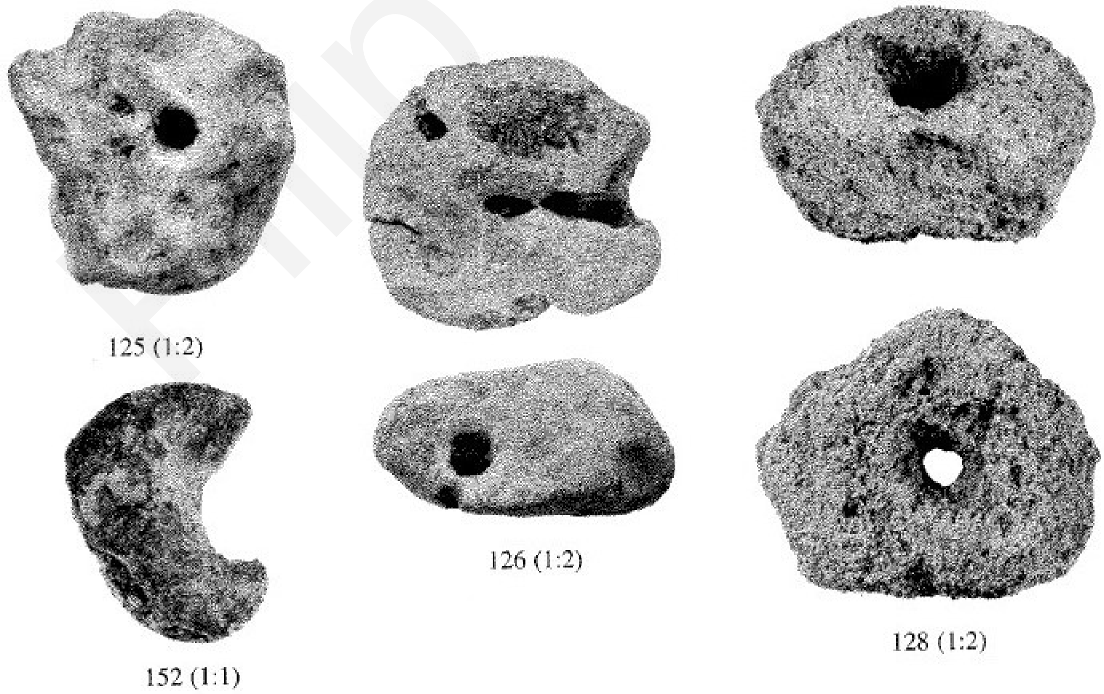


Figure 4: Marine-related artifacts from Paralimni Nissia: net sinkers (P.N.125 – unknown location; P.N.126 and P.N. 128 – from House 12) and stone hook (P.N.152 – from House 12) (Flourentzos 2008: Plate XLIV, XLVI)

Figure 5: Spearheads/daggers recovered from Atlit Yam (Galili et al. 2004b:7, Fig.5)

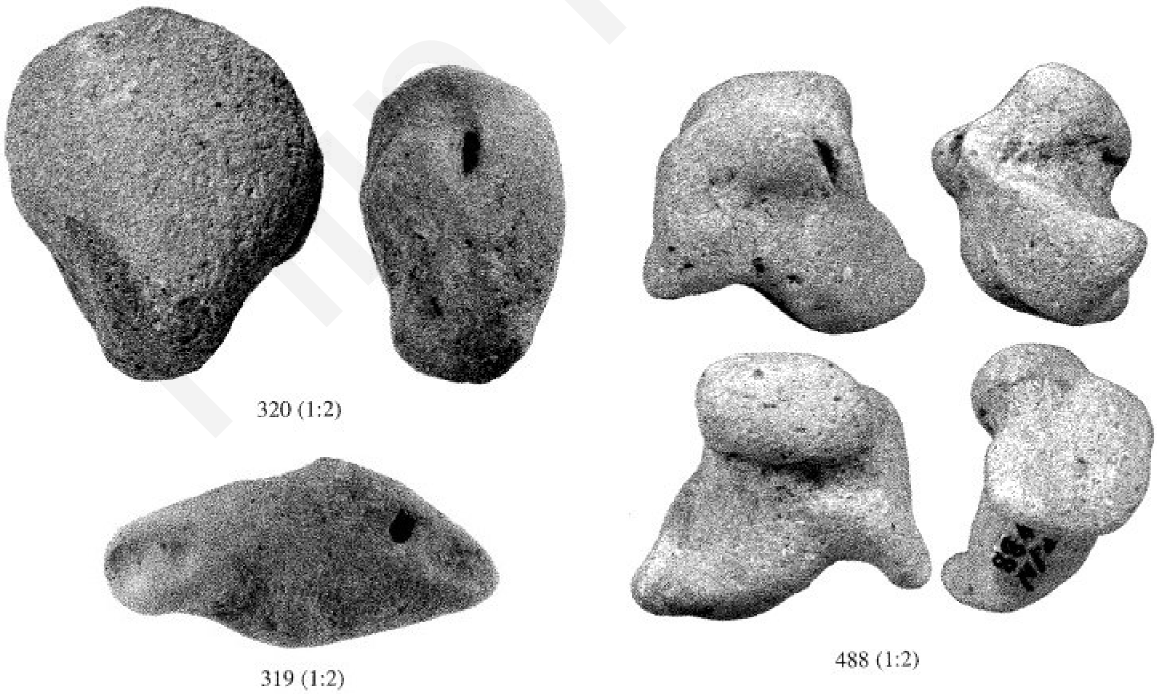


Figure 6: Figurines possibly representing marine fauna: fish (P.N.319), turtle (P.N.320), octopus (P.N.488) (Flourentzos 2008: PLATE LVIII, PLATE LXXVI)

Epiktitos *Vrysi* (Dikaios 1961:203; Peltenburg 1983:24,124) while Paralimni *Nissia* yielded a stone hook which may either represent a fishing gear or an amulet (Fig. 4) (Flourentzos 2008:85). Based on the presence of fishing gear, Croft (2008:115; 2010:136) proposed that fish must be seriously underrepresented due to the lack of wet sieving. Galili et al. (2002:177) proposed that fishing tools may involve long blades used as spearheads for fishing (Fig.5).

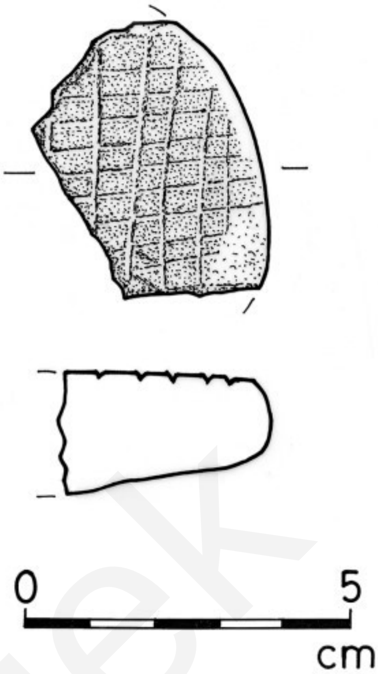


Figure 7: Incised cross-hatched stone from Kalavasos Kokkinoyia (Clarke 2010:201, Fig.23.2)

It has been proposed that notable proliferation of cutting tools, such as axes, chisels or flaked tools, may relate to woodworking and clearance of forests, perhaps to acquire more arable lands or open space areas for herding sheep and goats (McCartney 2007:82-83; Knapp 2013:186). Galili et al. (2002:177) suggested that high percentage of axes in the assemblage of the PPNC site of Atlit Yam, located along the Israeli coast, may indicate the exploitation of wood for the construction of seagoing vessels.

Paralimni *Nissia* yielded numerous stone anthropomorphic and zoomorphic figurines, three of which possibly represented marine animals: fish (P.N.319), turtle (P.N.320), and octopus (P.N.488) (Fig.6) (Flourentzos 2008:87). At least one engraved pebble was found on the

Site	**Marine-related material culture**	**Reference**
Paralimni *Nissia*	913 MNI marine molluscs, 2 crabs, limited number of fishbones, net sinkers, marine fauna-shaped figurines, stone hook, shell jewellery, ornaments from shark vertebrae	Flourentzos 2008:87; Reese 2008:119-153
Ayios Epiktitos *Vrysi*	1666 molluscs, 159 crabs, possibly marine turtle, limited number of fish bones, bone fishhook, possible net sinkers, obsidian	Ridout 1983; Reese 2008:122; Knapp 2020:430
Klepini *Troulli*	41 marine shells, shell jewellery	Peltenburg 1979:23-24,34
Sotira *Teppes*	68 MNI marine molluscs, bone fishhook, possible net sinkers	Dikaios 1961; Reese 2008:121
Khirokitia *Vouni*	6 marine shells	Reese 2008:122
Kandou *Kouphovounos*	162 MNI marine molluscs, 23 crab fragments and 2 sea urchins	Karali 2019:27; Mantzourani 2003:98
Dhali *Agridhi*	two shells, shell jewellery, crab claws, fossilized fish teeth	Lehavy 1989:211
Kalavasos *Kokkinoyia*	30 marine molluscs (surface find), 2 triton shells,obsidian, engraved pebble (a surface find)	Knapp 2020:431
Nissi Beach	231 MNI marine molluscs	Ammerman et al. 2017

Table 2: Ceramic Neolithic sites with marine fauna remains and other marine-related artifacts

surface at Kalavasos *Kokkinoyia* (Fig.7) (Clarke 2004:59; McCartney 2007:89; Knapp 2020:429). Engraved pebbles, with a grid of incised lines on one or both sides, may represent either weights for net sinkers, a depiction of fishing net, tokens in a social storage system, or could have been used in exchange transactions (Stewart and Rupp 2004:168–171; Knapp 2020:429). These finds are reported from Aceramic and Ceramic Neolithic sites both of Cyprus and Eastern Mediterranean, which, according to McCartney (2007:89) points to transmarine interactions between Khirokitian and subsequently Sotira culture with Yarmoukian sites of central and southern Levant.

2.3. Mediterranean Fishing Village model

In 1996, Butzer proposed the traditional Mediterranean model of subsistence, characterized by the cultivation of legumes and grains, animal husbandry (sheep, goat, pig and cattle), cultivation of orchards, green vegetables, and condiments (Butzer 1996). As his definition is oriented towards terrestrial exploitation, Galili et al. (2002) proposed a model comprising also the exploitation of marine resources. The model of Mediterranean fishing villages (MFV) is based on their field research along the Carmel coast in Israel and is associated with permanent, sedentary settlements such as dwellings, storage facilities, production facilities, and ritual activities accompanied with subsistence strategy focused on both terrestrial and marine exploitation (Galili et al. 2002: 167-8, Galili et al. 2004: 93).

It is proposed that MFV emerged during the end of PPNB or in PPNC along the Levantine and Cilician coasts (Galili et al. 2002: 168). After the collapse of the PPNB socioeconomic systems at the end of the 9th and the beginning of the 8th millennium BP, new economic strategies were established to cope with different environmental conditions, resulting in either nomadic pastoralism combined with dry farming in arid and semi-arid areas or by the intense exploitation of coastal areas (Galili et al. 2002: 170, Galili et al. 2004: 97). They also argue that once established in PPNC, MFV spread relatively rapidly westward along the coasts of Europe (Galili et al. 2004: 97).

Galili et al. (2002) explain that compared to bones of terrestrial mammals, the fragility and poor preservation of small-sized fish bones impede the relative quantitative analysis of fish remains, resulting in relative paucity of ichthyological remains at most MFV sites. Therefore, they propose the assessment of the relation to other factors, such as 1) distribution of fish remains and fishing-related material culture within the settlement; 2) presence of a wide variety of marine species derived from numerous biological niches; 3) utilization of all ranges and sizes of marine species without signs of selectivity such as caused by trade considerations; 4) presence of various implements associated with fish procuring activities and indicators of fishing gear manufacturing; and 5) incorporation of marine species and fishing associated signs and artifacts into symbolic life of inhabitants of the settlement (Galili et al. 2002: 171).

They also propose that rather than on the coast, MFV are situated further inland, between a few hundreds of meters and five kilometres, as littoral zone soils are affected by ocean spray and thus are less fertile and less suitable for agricultural activities. It is likely that other satellite camps were situated within the littoral zone, focused only on fishing activities (Fig.8) (Galili et al. 2002: 171). MFV model helps to explain marine-resource exploitation, marine-related finds occurrence and, as McCarthney (2007:88-89) pointed out, the distribution of exotic goods between Cyprus and the mainland resulting from transmarine interaction during the Neolithic. Nonetheless, it is necessary to stress, that the definition of this model is based on Neolithic villages and their subsistence. Thus earlier prehistoric sites (even though scarce in the eastern Mediterranean) do not fit due to absent economy based on domestic plants and animals (Galili et al. 2004:97).

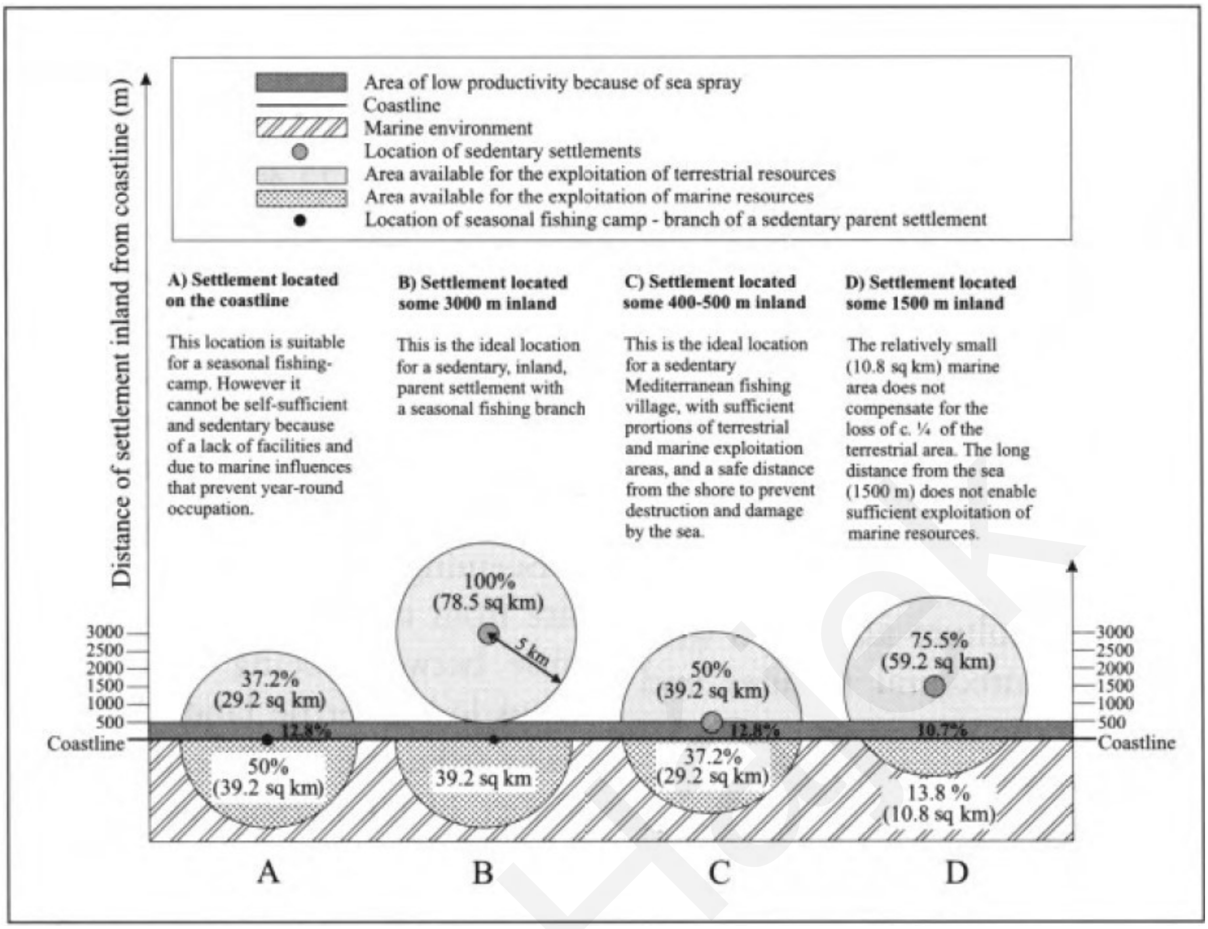


Figure 8: Location model of coastal settlements: the extent of marine and terrestrial exploitation areas as a function of distance from the coastline (Galili et al. 2002:172, Fig.3)

The submerged PPNC site of Atlit-Yam, possibly together with two terrestrial sites of Ras Shamra and Ashkelon Marina may represent the earliest occurrence of MFV in the Levant (Galili 2004a; 2017). Atlit-Yam, as the exemplary site, is situated 300-500 m offshore, in the north bay of Atlit, at water depth of 8-12 m. The site was most probably a permanent settlement extending over approximately 40, 000 m2 and thrived from c. 7200 to 6500 cal. BCE (Galili et al. 2002: 173; Galili et al. 2004b: 2; Galili and Rosen 2010: 272-3). Archaeological investigation revealed foundations of rectangular stone structures, paved floors, straight walls, 35 hearths, circular ritual installations, water wells and human burials. Deposits of animal and fish bones and charred and waterlogged seeds points to the village's economy based on hunting, herding, farming, and fishing (Galili et al. 2002; Galili et al. 2004b; Galili and Rosen 2010: 273). Intensive fishing is suggested based on numerous taxa of marine fauna as well as abundant fishing tools, such as netsinkers, fishhooks, and spearheads, while high frequency of stone axes may be related to boatbuilding activities (Galili et al. 2002: 177,185). Beyond the submerged Neolithic sites located along the Israeli coast, Galili et al. (2002:185-191) construed more Mediterranean sites as possible MFV, for instance, Mersin-Yumuktepe, located on the southeast Anatolian coast, the Cyclope Cave on Youra Island in the Aegean sea, Franchthi Cave in Argolid, Greece or even further west, such as Scamuso, in Puglia region, Italy. In Cyprus, Galili et al. (2002:187-188;2004a:97-101) marked more sites (Akanthou *Arkosyko*, Parekklisia *Shillourokambos*, Kalavasos *Tenta*, Kissonerga *Mylouthkia*, Cape Andreas *Kastros*) as possible MFV, while Knapp (2020:431) stated that none of CN coastal and near-coastal sites, except possibly *Nissia*, can be construed as an archetypal MFV.

2.4. The site of Paralimni *Nissia*

Immediately after the site discovery, the trial excavation was carried out by P. Flourentzos in January 1994 and was followed by five seasons of systematic excavation (1995, 1996, 1998, 2000 and 2001). The area of the settlement measured approximately 3,250 m2 of which 2,750 m2 were excavated (Flourentzos 2008:1,3). During the excavation, 40 dwellings and an extensive surrounding stone-wall were revealed (Fig. 9). According to Flourentzos (2008:3), the village follows a primitive urban plan as the dwellings were arranged in the form of a ‘spiral’, notably inside the surrounding wall with a small free area in the centre. The settlement is disturbed by a tourist pedestrian road constructed right along the seashore, which has cut through three dwellings (Nos. 26,27,28) and the surrounding wall. The construction work of a pedestrian road also affected the preservation of the House 20 and the House 5 together with the western corner of the surrounding wall is disturbed by recently built fence wall of modern villa (Flourentzos 2008:6,15,20).

The houses are sub-rectangular while some have irregular or oval plans. The average habitation space is 22 m2. The foundation walls were built with rubble or other rough rocky material, most probably cut from the nearby seashore, and superstructure was made of *pisé* or mudbricks (Flourentzos 2008:3, 23). The postholes located within the houses indicate a roof, probably consisting of the dark red soil of the area (Flourentzos 2008:3-4). The floors of the houses consisted of beaten *havara* and, in rare cases, an additional layer of pebbles or layer of pebbles or stones was recorded also in the outside area, more specifically in the entrance area of the House 3 and the passage between H19 and Pyre Γ (Flourentzos

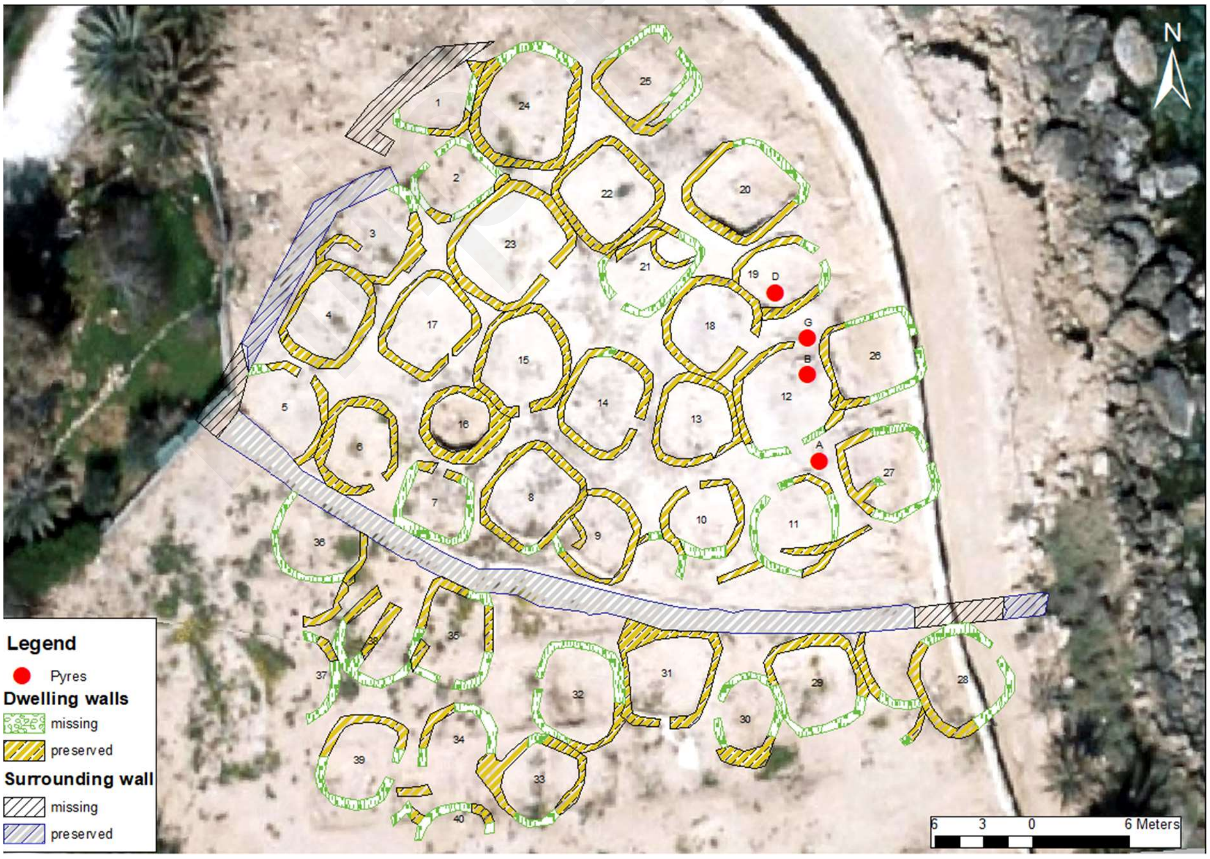


Figure 9: Digitalized settlement plan of Paralimni Nissia with locations of pyres A,B,Γ(G) and Δ(D) (after Flourentzos 2008: Figure B)

2008:5,14). Most of the houses are single-door and freestanding while several houses share a common wall. Besides, six pyres were found, located in the eastern part of the hillock. Four of these pits (Α,Β,Γ and Δ) contained ash and burnt material accompanied with artifacts, while the last three (Ε,Στ and Ζ) did not yield any archaeological material, probably because they were not excavated to the bedrock (Flourentzos 2008:19).

The settlement is dominated by the surrounding wall, extending from the seashore to the west and then curved to the north and then back seaward (Fig. 9). The wall contained the main gate in the south, next to the modern coastline and another side entrance was located in the northwestern part, providing direct access to the small river of Potamos tou Lombardi, which flew along the hillock with the Neolithic settlement atop in northwest and north (Flourentzos 2008:19-20). Twenty-seven dwellings are located within the surrounding wall (*intra-muros* occupation) and 13 other houses have been unearthed beyond the wall (*extra-muros* occupation). The excavation in the area of the main entrance revealed two distinct phases, during the first phase the entrance measured 2.20 m, and in the later phase the entrance was narrower with only 1.10m. Moreover, a pivot stone was found in the second phase context, indicating that the main entrance was closed with a presumably large wooden door. The wall also contains a small channel, presumably used for draining the *intra-muros* part and preventing the flooding of houses (Flourentzos 2008:20).

Figure 10: The location of lithics probably of preceding period (Red dot) and wall remains dated to the Greco-roman period.

Evidence of fire has been observed on the floor of destruction of the dwellings, notably in the northwestern part of the settlement (Flourentzos 2008:4). The layer of ash has been recorded only on the third floor of House 5 (Flourentzos 2008:6). Out of 46 pieces of axes, 13 were identified as unfinished, which led the excavator to the conclusion that the presence of so many unfinished tools of this kind is the result of some rapid abandonment of the site, likely due to some catastrophic event (Flourentzos 2008:81). There is evidence of fire in the stratigraphy, and most of the finds of this unfinished axe type (and amulets, loomweights) belong to the upper layer of the settlement, i.e. in its late phase (Flourentzos 2008:81,88-89).

Several houses point to special function. House 14 with a waterproof floor and a limited number of finds revealed a special stone installation: a limestone mortar nearly 1m in length had one stone on either side in a north-south direction and on the west the mortar was supported by a wall of 50cm width. It is believed that this installation was used for the production of salt (Flourentzos 2008:10). The concentration of three finished and two unfinished axes on the floor V in House 16 was interpreted as an axe-producing workshop (Flourentzos 2008:13) and a flint-producing workshop was suggested for House 26 due to the concentration of five flint blades of various types (Flourentzos 2008:18). Furthermore, some houses (Houses 16 27, 31) contained pits for supporting vessels, occasionally with additional

Figure 11: Settlement plan with recorded entrances (after Flourentzos 2008:3-24)

installation of rough stones, and sometimes with a ceramic vessel found in situ, interpreted as the holes for fixing jars or production of pottery (Flourentzos 2008:11,18,22). Another installation represented by a considerable number of red mudbricks located next the shallow pit outside of House 33 was interpreted as a mudbrick oven for pottery (Flourentzos 2008:23).

Radiocarbon analysis of burned bones located on the second floor of House 16 revealed dates ranging between 4250-4040 BCE/4330-4040 BCE. Taking into consideration that this house contains three preceding floors, it has been proposed that the actual relative initial date of the Paralimni *Nissia* site is the earliest phase of the 6th millennium BCE (Flourentzos 2008:96). House 16 is of oval plan which is atypical for the Ceramic Neolithic period but common in LAN. In an attempt to reveal whether preceding aceramic occupation existed at the site, it was decided to excavate House 16 to the bedrock and five successive floors were discovered, almost all of them having artefacts and pottery in situ, which presumably represent at least five chronologically different phases of Ceramic Neolithic period at the site (Flourentzos 2008:10). However, as only House 16 was excavated to the bedrock, it is possible that aceramic levels have not been discovered at the site yet (Flourentzos 2008:64). Moreover, a small number of lithic tools, discovered in the southeastern part of the excavated area, may represent a residual material relating to a lithic industry that precedes the Cypriot Aceramic Neolithic, indicating a very early temporary occupation at the site (Fig. 10) (Flourentzos 2008:64). Furthermore, the excavation also revealed pottery fragments chronologically ranging from the Late Hellenistic to the Late Roman period (Flourentzos 2008:96). These

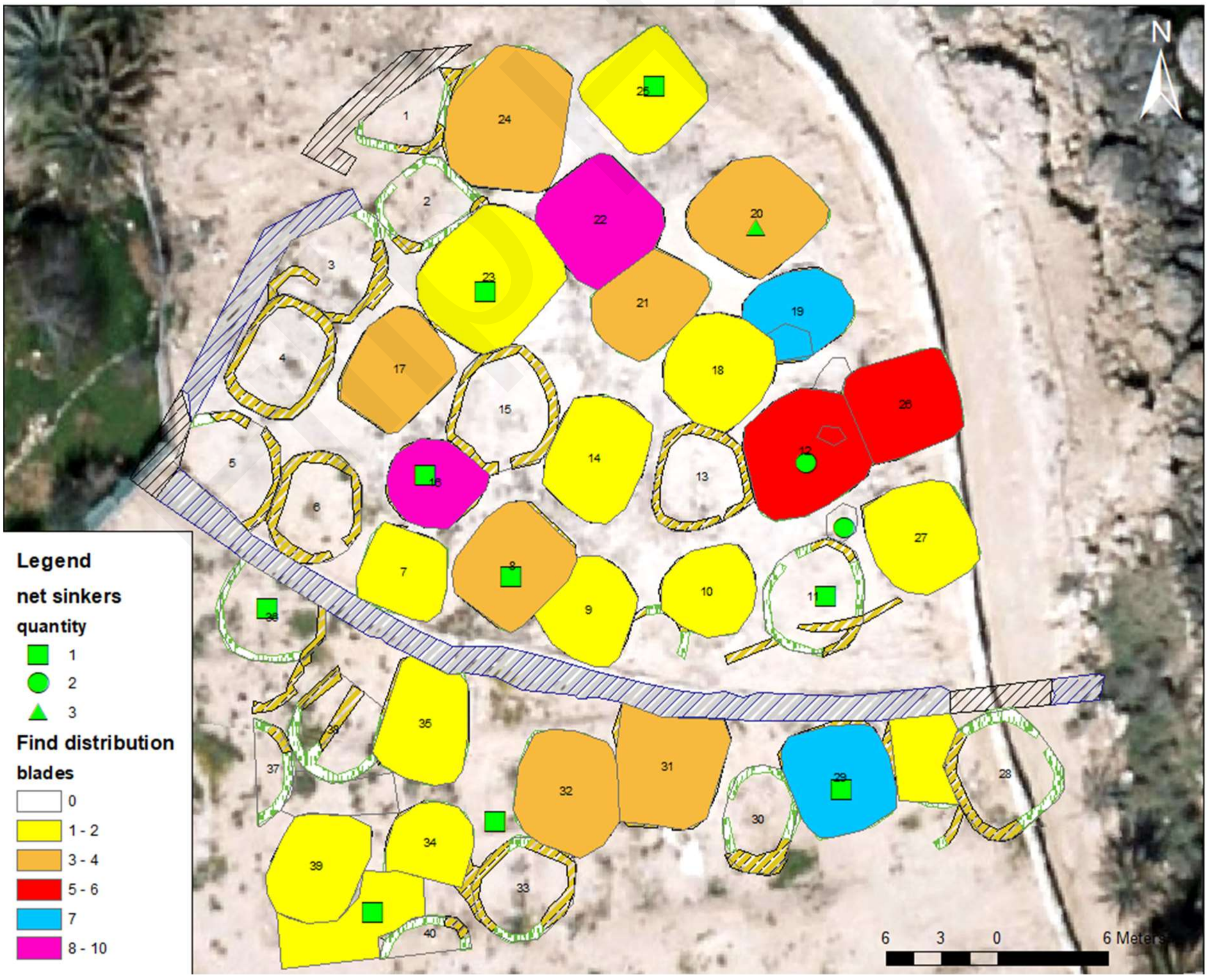


Figure 12: Distribution of blades and net sinkers

sherds were concentrated in the northwest, southwest, and in the centre of the excavated area, close to the surface and with almost no relation to the structures of Ceramic Neolithic settlement (Fig. 10) (Flourentzos 2008:96). Moreover, two walls, presumably of the same period were documented above Houses 10 and 11 (Flourentzos 2008:7,9). It has been proposed that during the Greco-Roman period the site was occupied in limited range, probably by fishermen, consisting presumably of few houses made of perishable material (Flourentzos 2008:96).

According to Flourentzos (2008:20,96), at least three phases of occupation existed at the site: the early occupation within the surrounding wall, and then the settlement expanded beyond the fortification. Several houses were utilized for more than one phase, as indicated by the blocking of original entrances and building new ones (Fig. 11), by the preservation of several successive floors (Houses 5 and 16) while other dwellings show the changes in ground plans, with either narrowing (Houses 16 and 30) or extending habitation area (House 25). (Flourentzos 2008:10-13,18,21). Some houses have walls running underneath under other houses (Houses 9-10 and 12-26) and notably Houses 28 and 29 are built above the debris of a house constructed during the preceding phase (Flourentzos 2008:21). Moreover, Pyre Δ was built in the House 19, apparently after the house had been abandoned for unknown reasons (Flourentzos 2008:14,19) and the east corner of House 12 was destroyed by Pyre Γ (Flourentzos 2008:12). Regarding the surrounding wall, the northern part of the wall overlaps the eastern wall of House 1, while House 35 blocks the drainage channel and Houses 28 and 29 block the main entrance. Finally, House 38 cut the foundation wall of House 35, indicating

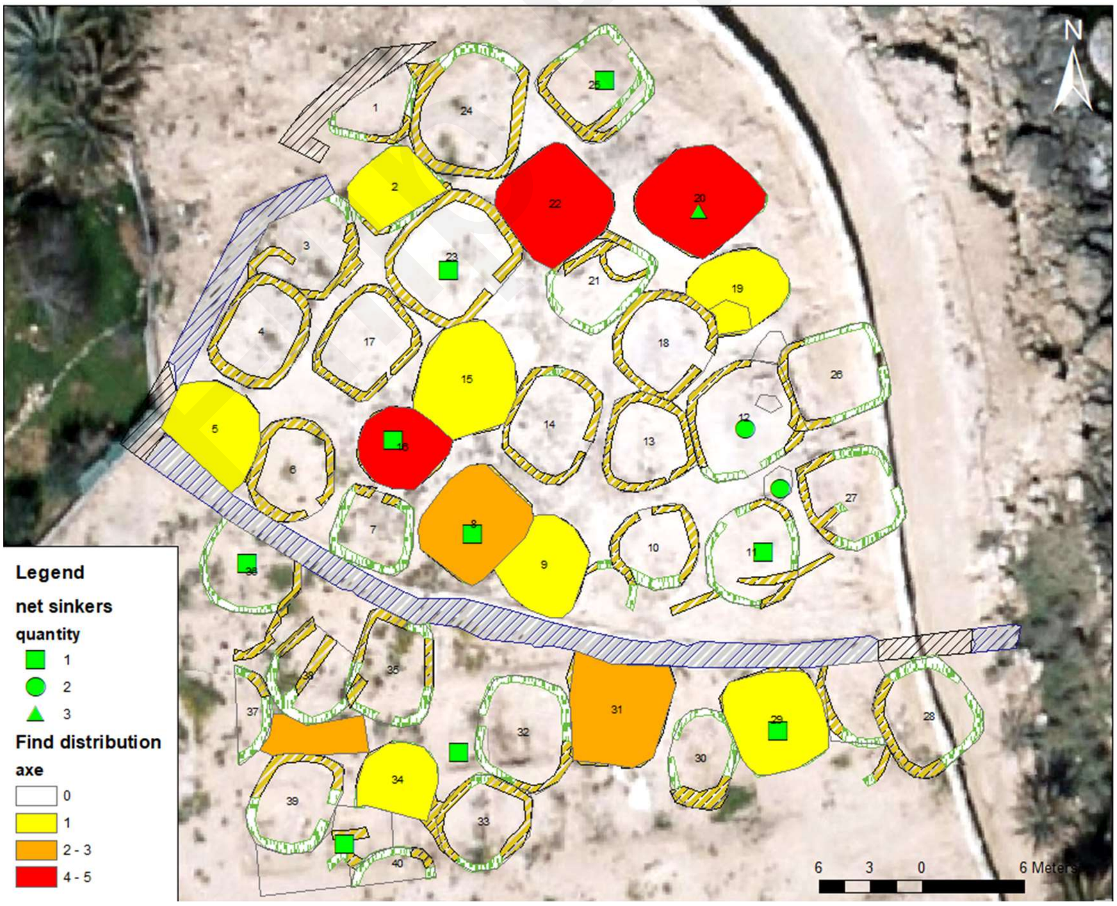


Figure 13: Distribution of axes and net sinkers

this House was also constructed during the later phase of the *extra-muros* extension (Flourentzos 2008:24).

2.5. Spatial distribution of marine-related artifacts

Paralimni *Nissia* yielded 36 net sinkers, and the location of only 16 pieces has been mentioned in the publication. Recorded artifacts are mostly single pieces spread all over the site, with apparent concentration in the eastern part of the settlement, where two weights were found in House 12 (P.N.126, P.N.128), one unfinished weight (P.N.426) was found in Pyre A and another one (P.N.424) between Pyre A and House 27, while House 20 yielded three weights (P.N.99, P.N.178, P.N.256) and the three fish bones, which is the largest concentration of larger fish bones documented at the site (Fig.,12,13,14) (Reese 2008:147). House 20 also contained a relatively large number of blades (four pieces), axes (six pieces) and one chisel. Blades are concentrated in the eastern area of the settlement and H26 have been interpreted as possible blade-production workshop (Flourentzos 2008:18). Another concentration of both blades and axes was documented in House 22 and a possible axe-production workshop also existed at Floor V of House 16 (Flourentzos 2008:13).

Fish and turtle figurines were found in House 32, where, besides other artifacts and large quantity of mollusc remains, two triton shells (*Charonia* sp.) were found (Fig.13). Additionally, a stone hook was located at House 12, where two above-mentioned net sinkers were found, together with a shark/ray vertebrae holed in the centre, which may represent an ornament (Reese 2008:147-148).

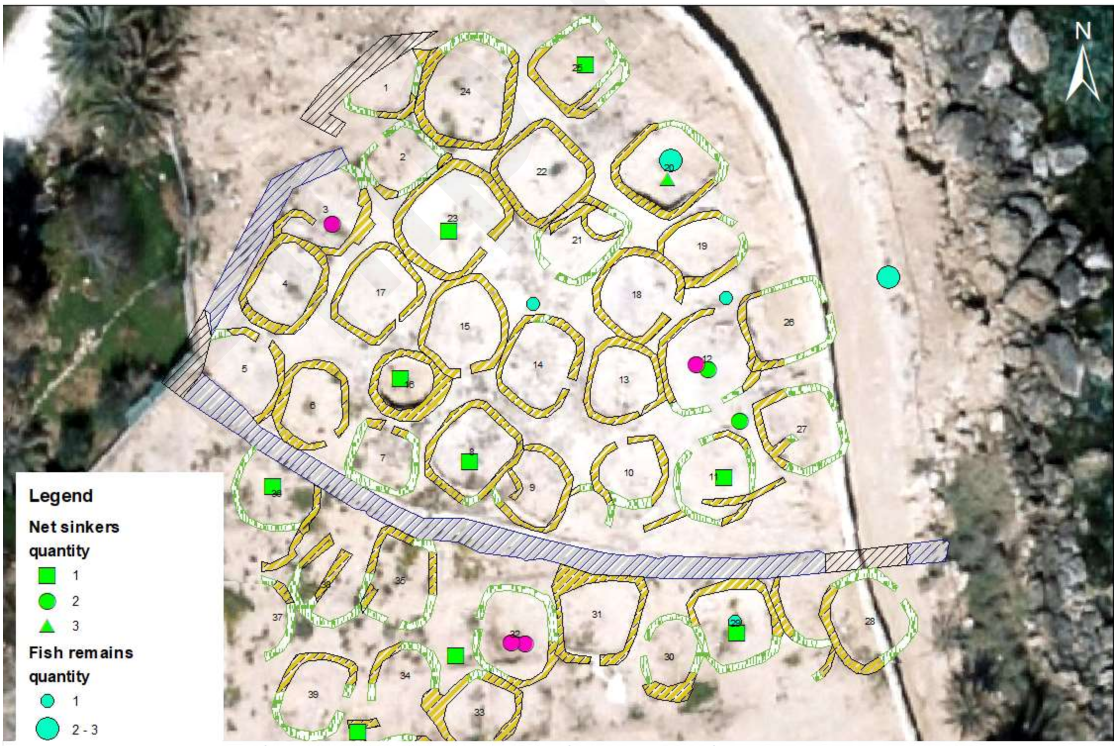


Figure 14: Distribution of net sinkers, marine-related figurines and fish remains

3. Palaeocoastline reconstruction

3.1. Introduction

Archaeological investigation does not only concern ancient settlement history through the study of excavated material, but may also involve palaeoenvironments of areas where the materialswere situated. The coastal areas are specific landscapes shaped by both land and marine processes. These constantly occurring processes involve wave operation, subaerial processes, sediment transport, and sea level changes. As such, the coasts are affected by erosion or deposition of sediments. The velocity of these changes depends on geology and the resistivity of rocks forming the shore, the isostatic and eustatic changes, the composition of and the topography of the shore and lastly, on climate which affects the wave energy and tidal range as well as vegetation growing in the area (Carter and Woodroffe 1994:8-10; Galili et al. 2005:80; Bird 2008:5-9; Davidson-Arnott 2010:13-15; Sherman 2013:1-4). Study of these phenomena reveals the current nature of the local coastal geomorphological settings as well as the coastal processes that occurred in the past. Geoarchaeology is the field of research that involves computer cartography, digital elevation models (D.E.M.) and Geographic Information Systems (GIS), and produces accurate topographic maps, palaeogeographic reconstructions or 3D views of palaeolandscapes, based on Satellite images, high resolution topographic surveys, and palaeo-environmental data (Ghilardi and Desruelles 2008).

Due to sea level changes, it is likely that the sea level was of different elevation than today and that the coastal area in the vicinity of Paralimni *Nissia* changed significantly since Neolithic times. Therefore, this chapter is dedicated to the palaeocoastline reconstruction in the vicinity of Paralimni *Nissia*. The palaeocoastline reconstruction is based on coastal geomorphology, field survey and sea level studies of Cyprus and the eastern Mediterranean, which were combined with LiDAR data, processed in ArcGIS. The chapter incorporates the basic principles of coastal geomorphology, sea level studies, the methodology of processing LiDAR data, and field survey.

3.2. Palaeocoastlines: Research review

During the 1970's, archaeologists aware of coastal changes and fluctuation of sea levels started to study the sea level changes at archaeological sites, attempting to better understand underwater sites (Marriner and Morhange 2007). At that time in Cyprus, Peltenburg (1983) considered palaeocoastal environment of Ayios Epiktitos *Vrysi*, based on sea level studies and geomorphological observations, in attempt to estimate the influence of marine transgression on the settlement and its inhabitants. Later, Gomez and Pease (1992) reconstructed the coastline of the whole island for the periods 7000 BCE and 3000 BCE based on British military bathymetric charts.

Morhange and his colleagues reconstructed the coast of Kition in Larnaca, based on the coring and biological, sedimentological, and radiometric approach. The study revealed that the sector of Kition Bamboula was situated on the open bay and the coastal transformation started after 2100 BP (Morhange et al. 2000). The palaeocoastline of Larnaca salt lake was reconstructed by Devillers and her colleagues (2015). The coring revealed that salt lakes were open lagoons during the second millennium BCE, corresponding to the development of harbour Dromolaxia-

Vyzakia, which was abandoned around 1200 BCE as the consequent of the enclosement of the lagoon.

Leidwanger and Howitt-Marshall (2008) mention the contribution of remote sensing techniques in studies of submerged landscapes, and they present a case study of reconstruction of the coastline around Kouklia in Palaeopaphos. Their reconstruction is based on pottery and anchor analyses, coring and remote sensing, and more specifically, sidescan sonar and sub-bottom profiler. In the same area, Zomeni (2012) emphasized the need to elucidate the landscape evolution and possible location of harbour site of Kouklia *Palaeopaphos*; she combined uplifted Quaternary marine terraces, historical sources and sea level data predicted by Sivan et al. (2001), Lambeck et al. (2004) and Galili et al. (2005).

The most recent case study has been performed by Miltiadis Polidorou et al (2021a), who reconstructed the evolution of Akrotiri salt lake. This reconstruction, based on coring and sedimentological, micropalaeontological and geochronological analyses, identified how the salt lake has changed during the last 6000 years. Moreover, Polidorou et al (2021b) reconstructed the sea level fluctuation around Akrotiri peninsula within the last 4000 years based on OSL dating of the beachrock.

Outside Cyprus, the coastal zone adjacent to Franchthi cave was reconstructed based on malacological data (Shackleton and Van Andel 1986) and remote sensing (Van Andel and Lianos 1984). Palaeocoastline reconstructions based on geoarchaeological approaches, i.e., sedimentological, biostratigraphical, and geochemical analyses of core samples, have also been modelled for the ancient harbours of Alexandria in Egypt (Véron et al. 2006; Flaux et al. 2017), Tyre (Marriner et al. 2005, Marriner and Morhange 2006), and Sidon in Lebanon (Marriner et al. 2006) or Tell Akko in Israel (Morhange et al. 2017). Ghilardi and Desruelles (2008) demonstrated the application of their approach on three case studies (Palaeo-lake Maliq in Albania, Thessaloniki plain and the site of Methoni in Greece), combining GIS and D.E.M. with archaeological, geological and palaeo-environmental data, and thus estimated and visualized the littoral evolution and sea level changes in different periods.

3.3. Sea level changes

3.3.1. Changes in mean sea level

The level of the land and the water body fluctuates ceaselessly. These changes are caused by various factors and occur periodically, in short-term such as tides which fluctuate in terms of hours or long-term which vary seasonally with the change of sea and wind currents or in scale of years and decades. The relative sea level is affected also by atmospheric pressure and storm surge (Davidson-Arnott 2010: 19). However, sea levels can change significantly, affecting the morphology of the coast, when the land is either exposed (marine transgression) or inundated (marine regression) and is affected by the topography of the shore and the rate of sea level rise (Flemming 2014:26). Long-term sea level fluctuation is caused by isostatic changes in the relative elevation of the land and eustatic changes in relevant elevation of the oceans. Tectonic changes are caused by the movement of tectonic plates which may cause either uplift, when land mass elevation rises or subsidence when land mass elevation decreases (Flemming 1974; Fleming and Webb 1987; Murray-Wallace 2007; Davidson-Arnott 2010:19-28; Flemming 2014:74).

These elevation changes occur particularly along tectonic plate margins resulting from long-term isostatic activity of the plates, or from short-term, sudden events, particularly in earthquake zones (Davidson-Arnott 2010:23; Flemming 2014:74). Eustatic changes are associated with the volume and distribution of water in the ocean basins, which may be caused by the growth and decay of ice sheets, changes in the volume of the ocean basins caused by tectonics, continental drift, sediment infill, or hydro isostasy and changes in ocean mass arising from changes in the earth's rotation, tilt, and gravitational distribution (Davidson-Arnott 2010: 27; Flemming 2014:74). Both tectonic and eustatic processes work simultaneously and it can be difficult to distinguish between them (Davidson-Arnott 2010: 19; Flemming 2014:74). Nonetheless, as already mentioned, isostatic changes occur predominantly along the plate margins, thus eustatic changes are recorded in tectonically more stable areas (Galili et al. 2005; Lambeck and Purcell 2005).

3.3.2. Sea level indicators

Sea level fluctuation caused by both eustatic and isostatic changes, result in re-deposition of palaeocoastlines. As such, emerged coastlines occur above the present sea level while coastlines formed during the low stand of sea level are submerged. Emerged coastlines are characterized by marine shells layers and marine (wave-cut) terraces above the sea level (Bird 2008:46). Terraces also occur underwater and staircases of marine terraces referring to different geological periods occur along several coasts around the world (Fig.15) (Bird 2008:52; Bilbao-Lasa et al. 2020). Geological coring may reveal palaeobeaches with

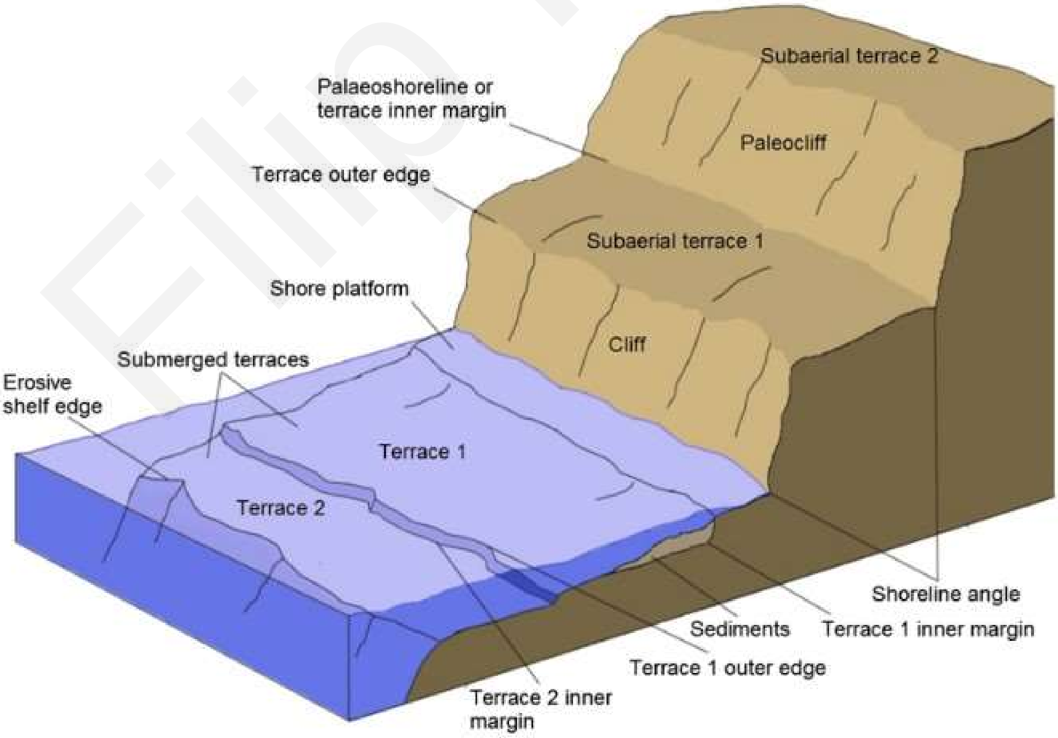


Figure 15: Sketch showing the emerged (subaerial) and submerged marine terraces (Ricchi et al. 2018:46, Fig.4)

nearshore fauna deposits, buried by sediments either on land and underwater (Marriner and Morhange 2007; Stewart and Morhange 2009:393).

Beachrocks are hard sedimentary formations consisting of lithified coastal deposits, cemented through within few decades through precipitation of (mainly) carbonate cements, often at the interface of the freshwater–marine phreatic flow (Lambeck et al. 2004: 1570; Vousdoukas et al. 2007; Mauz et al. 2015). Beachrocks consist of silt, sand, gravel, and other locally available substrates and may also contain shells or archaeological remains (Flemming 1978:393; Galili et al. 2016:195; Benjamin et al. 2017:12). Beachrocks are formed ìn or near intertidal zones, their deposition is not continuous and thus as a point in time and space, they are considered as realiable indicator of palaeocoastlines (Mauz et al. 2015).

Apart from wave-cut platforms and beach deposits, palaeo sea level can be indicated by the sea stumps with the flat top, abraded by wave action within the intertidal zone (Bilbao-Lasa et al. 2020). Sea stumps are the final stage of headland erosion, caused by sub-aerial processes and wave energy. In the course of time, cracks in the cliff face are widened by breaking waves, and hydraulic action together with abrasion by sand and disintegrated rocks leads to the development of sea caves. In cases of protruding promontories or headlands, further erosion may result in merging of sea caves with the opposite site of the headland, which forms an arch. An arch is getting bigger which subsequently leads to the collapse of the top of an arch with a rocky pillar, a sea stack, remaining offshore. Finally, further erosion will disintegrate the stack above the sea level and only isolated low reef, known as a sea stump, at the level of the sea will remain (Fig.16) (Balasubramanian 2011:5; Gilson 2020).

Other important sea level indicators are tidal notches and abraded faces of calcarenite rocks along the coasts, caused by wave action and tidal fluctuation (Antonioli et al. 2007; Evelpidou et al. 2012; Zomeni 2012). Tides are produced by the gravitational influence of the moon and sun and produce regular daily rise and fall of sea levels that may range from a few decimetres to as much as 15 meters in a few places (Davidson-Arnott 2010: 29). The height of tidal notches roughly corresponds to the tidal range of the area and is also affected by average

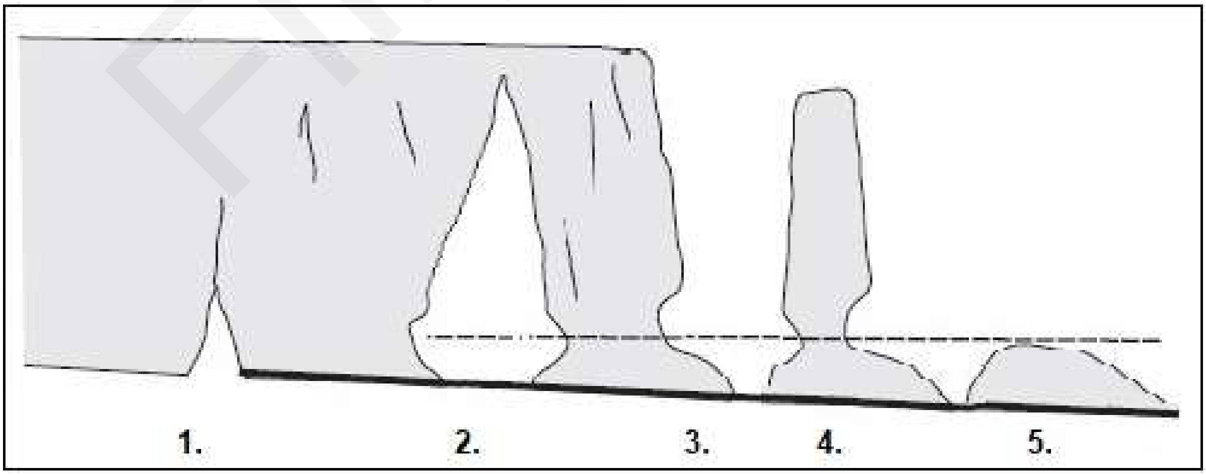


Figure 16: The evolution of cliff erosion: 1) cave 2) arch 3) collaps of arch 4) stack 5)stump (modified schematic model of Trenhaile et al., 1999)

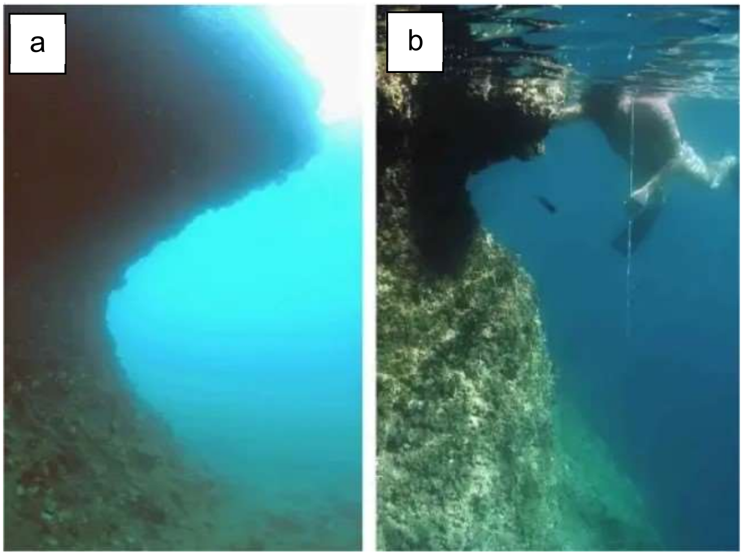


Figure 17: The submerged tidal notches: a) -2.2 m at Duino (Trieste, Italy); b) -0.8 m at at Rovinj (Croatia) (after Antonioli et al. 2007:2470,Fig.4).

wave height. Wave action abrasion predominately form V-shaped or U-shaped notches, with the deepest point located near mean sea level (Evelpidou et a. 2012:92; Benjamin et al. 2017:16). Tidal notches occurring above and below present sea level, point to stable palaeocoastlines followed by sudden change in sea level; gradual sea level change would form a taller single enclave as the basal ledge was cut down (Fig.17) (Bird 2008:47,52). Moreover, tilted submerged/emerged coastline points to tectonic vertical movement while linear coastlines indicate eustatic changes (Bird 2008:52).

Apart from geomorphological markers, sea level changes can be indicated by the deposition of archaeological structures and biological remains related to the sea level. Such archaeological indicators involve fishponds, harbour infrastructure, breakwaters, coastal wells, coastal quarries, or beached shipwrecks (Auriemma and Solinas 2009; Galili et al. 2016:213; Empereur & Kozelj 2017:127). Rise in sea level is marked by the inundation of the entrances of caves occupied during prehistory, and by the submergence of coastal pre- and protohistoric settlements (Galili et al. 2005; Marriner and Morhange 2007; Auriemma and Solinas 2009). Marine taxa, such as Balanus sp., Lithophaga lithophaga, Vermetus triqueter and Chama griphoides, are characterized with precise vertical relationship between species ecology and sea level, with accuracy ±5 cm (Marriner and Morhange 2007:182).

3.3.3. Sea level changes in Late Quaternary and Holocene

In Quaternary, alternating between glacial and interglacial periods affected the global sea-level fluctuation significantly. During the glacial periods, the global sea level may have fallen as low as 130 m below present sea level, while it may have reached up to 4-10 m above the present sea level, when continental-scale ice sheets retreated (Lambeck et al. 2004: 1570; Murray-Wallace 2007; Galili et al. 2016:183). After the Last Glacial Maximum, since about 17 000 BCE, the melting of glaciers in the northern hemisphere caused a rise in global sea levels for more than 100 meters to the present sea level, between 18 000 - 4 000 BCE (Zomeni 2012:259; Flemming 2014:26; Benjamin et al. 2017:42).

3.3.4. Sea level changes in Eastern Mediterranean

Sea level rates for the periods of Late Quaternary/Early Holocene are based on research conducted in countries, such as Greece or Israel (Vigne et al. 2014; Bar-Yosef Mayer et al. 2015). At that time, some 9 500 BCE, the sea level was ranging between -40 to -68 m below present sea level (Lambeck and Purcell 2005). Israel is considered a tectonically stable area as the present-day position of shallow marine MIS 5.5 sediments is consistent with little vertical tectonic movement during the past 120 ka years (Lambeck and Purcell 2005:1982). The submerged PPNC village of Atlit Yam was found at a depth ranging between 8-12 m, some 200-400 m offshore (Galili and Nir 1993). Located coastal wells in the settlement indicate that during the occupation of the village, between 6180 - 5550 BCE, the sea level was ca. 16 m lower than today (Galili et al. 2005:82). Furthermore, archaeological and sedimentological evidence from coastal and submerged sites shows that during 6900 - 5000 BCE the sea level dropped from -35 to -7 m, and between 5000 - 2000 BCE it reached the present sea level (Galili et al. 2005:85; Benjamin et al. 2017:45). Galili et al. (2016), who studied the position of Late Quaternary beach deposits along the Cypriot coast, proposed that this Israeli model is also suitable for Cyprus.

Pirazzoli (2005) and Morhange et al. (2006) elucidated that based on the biological indicators and geomorphological markers. The coast of eastern Mediterranean, from Hatay in southern Turkey, through Syria and up to Lebanon, was 1.2 m to 1.4 m above present sea level between 4000 BCE to 1000 BCE and then 0.8 m to 0.4 m between the fifth century BCE and the sixth century CE, due to the tectonic uplifts (Fig.18). Pirazzoli further concluded (2005:1996) that data from tectonic and non-tectonic areas from the whole Mediterranean points to the nearly stable global eustasy since 4000 BCE, and that sea level changes in the Levant during the Late Holocene are the result of local rapid tectonic vertical movement. On the contrary, the coast of southern Turkey, east of Cape Gelidonya and opposite of the coast of Northern Cyprus, was relatively stable during the last geological time and thus isostatic changes had negligible impact on sea level fluctuation (Peltenburg 1983:10).

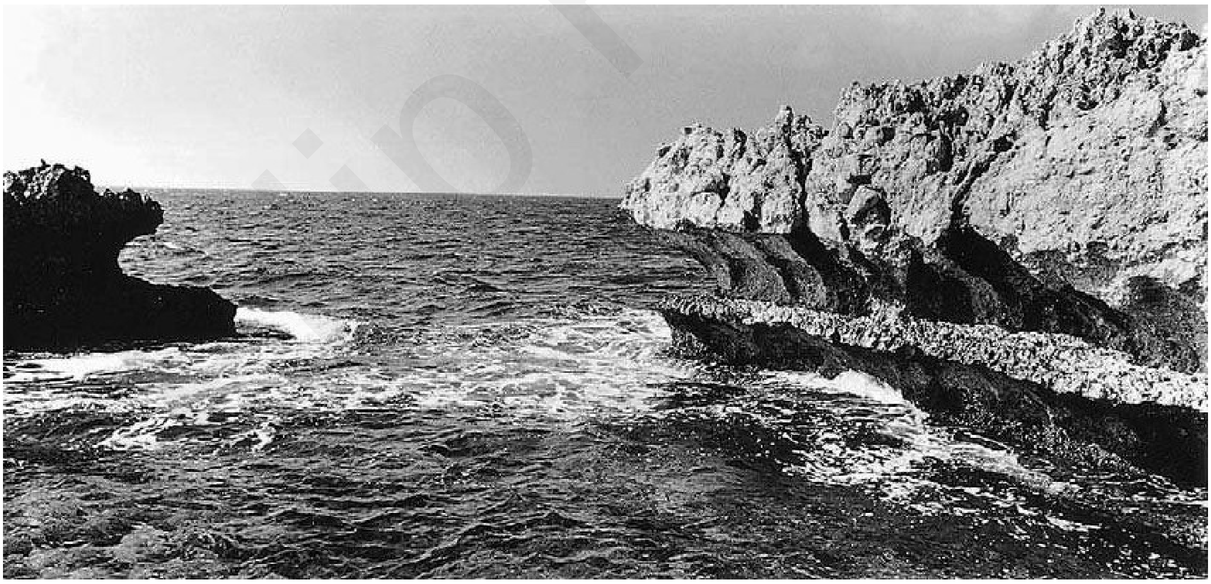


Figure 18: An elevated shoreline on Ile du Phare, Lebanon. Well recognizable notches are at about +0.8 to +1.0 m above the present sea level, while the upper part of the notch roof seems to be a remnant of previous slightly higher notch, corresponding to a higher sea level at ca. +1.3 m (Pirazzoli 2005:1998, Fig.9)

Several studies have been done in Cyprus, but nonetheless, variations in the results combined with poor palaeoenvironmental data impede the acquiring of accurate data of sea level rates in the Early Holocene (Vigne et al. 2014:159; Moutsiou and Agapiou 2019:8). Galili et al. (2016) observed several beachrocks along the coast of Cyprus. All of them are located within the intertidal zone, indicating that that these beachrocks have been embedded and consolidated during the last millennia. Furthermore, they propose that tidal notches and abrasion platforms together with beachrocks point to relatively stable conditions along the coasts of Cyprus during the last 4 000 years, with minimal fluctuation, but it could have been affected by tectonic uplifts and drops in local scale (Galili et al. 2016:210). On the other hand, Poole and Robertson (1991:918) stated that floodplain conglomerates in some coastal areas of south and west Cyprus, together with the coastal archaeological sites of Salamis, Amathus, Larnaca, and Paphos, shows the signs of partial submergence, indicating that some parts of the island subsided during historical times.

At the ancient harbour of Salamis, situated ca. 37 km northward from Paralimni *Nissia* as the crow flies, the survey revealed that harbour installations are 1.8 - 2 m below current sea level, which was caused either by tectonic movement or by erosion and liquefaction of sea bottom sediments (Flemming 1974:171-172). In the same area, coring samples revealed C14 dates in 7185+145 BP when the sea level was 7.7 m lower than today and that the ancient harbour was built on the shores of palaeo-estuary (Devillers et al. 2002). However, Harrison et al. (2014:575,579) report that stone blocks associated with ship mooring were located in Enkomi ca. 4 m above the present sea level and that without further archaeological work, the palaeo sea levels provided by Devillers et al. (2002) shall be considered as tentative.

Two ancient harbours of Kition and Dromolaxia *Vyzakia* are situated in Larnaca were examined by several palaeoenvironmental investigations. Sedimentological sequences in the ancient harbour of Kition suggested tectonic uplift of the coast when pottery from 13th century BCE, located in marine mud layer, was situated 40 cm above the present sea level (Morhange et al. 2000). Chronological data provided by Dalongeville et al. (2000) demonstrate a similar pattern at palaeo beach deposits close to Cape Kiti, which were ca. 1-1.5 m higher during the second millennium BCE and 2-3 m above the present sea level during the first half of the third millennium BCE (Devillers et al. 2015:75). Mapping of the Larnaca Lowlands by Harrison et al. (2014) revealed the bioindicated palaeo coastline was situated ca. 0.5 m above the present sea level around 3500 BCE and corresponds to archaeological data indicating that the Late Bronze age site of Dromolaxia *Vyzakia* was built on marine shore at approximately present-day sea level (Harrison et al. 2014:575). Coring carried out by Gifford (1978) and Geological Survey Department revealed C^{14} dates of organic material from lagoonal deposits at elevations between ca. 5.5 to 10.8 m below present-day sea level of 7217±267, 6921±391, 6083±200 and 4617±268 Cal. BP (Harrison et al. 2014:568-569, 575). Considering higher sea level, Gifford further proposed a subsidence of the harbour, which is in contrary with the results of Morhange et al. (2000:225) (Galili et al. 2016:212).

Figure 19: Rock-cut fish tank at Lambousa in Lapithos associated with the present sea-level (after Galili et al. 2016:211, Fig.37)

Lastly, in northern Cyprus, Green (1973:150) conducted a survey around Cape Andreas searching for ancient shipwrecks and reported on stable conditions in recent geological time

(Galili et al. 2016:212). Additionally, no ancient, submerged quarry has been located along the coast of northern Cyprus and fishponds from the Graeco-Roman periods in Lambousa are probably still functional, suggesting stable sea-level conditions and with minimal isostatic activity during the last millennia (Fig.19) (Nicolau and Flinder 1976; Dreghorn 1981:283-284; Galili et al. 2016:211-213).

Above-mentioned sea-level data points to great variability between regions of the eastern Mediterranean as well as between coastal sites in Cyprus (Fig.20). The eastern Mediterranean region is located on the margins of the African and Anatolian plates which results in increased tectonic activity in the region, and earthquakes have been documented through past based on numerous seismotectonic, archaeological, historical, and geomorphological data (Altinok et al. 2011; Evelpidou et al. 2022). As it is believed that sea levels and regional tectonic conditions have been stable during the Late Holocene, vertical changes are attributed to local effects of seismic shaking (Galili et al. 2016:211).

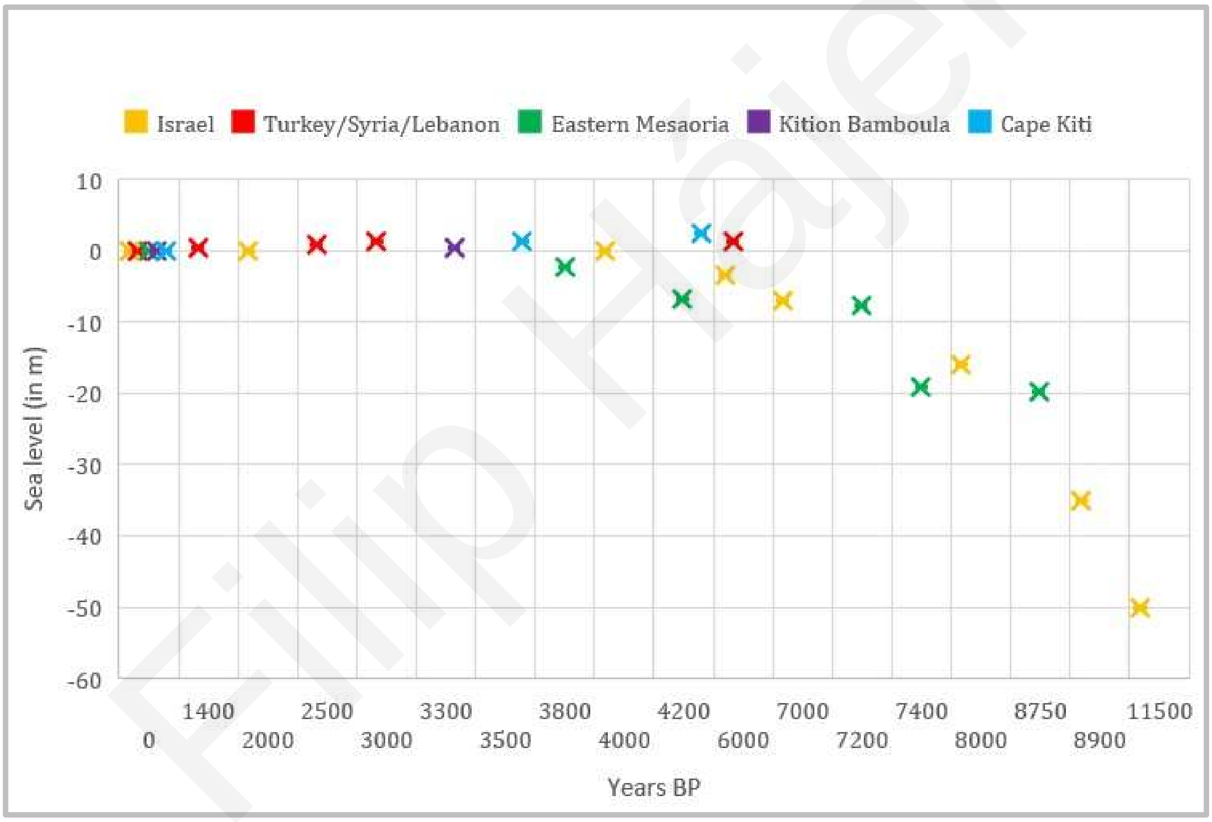


Figure 20: Relative sea level variations based on sea level data considered in this work

3.4. Palaeogeographic reconstructions, GIS, DEM and LiDAR

Palaeogeographic reconstruction can be derived from various data sources and approaches: geomorphological surveying, sediment coring and sedimentological and geochemical proxies, geophysical surveying, remote sensing, and archaeological data or analysis of bioindicators, such as pollen, charcoals, micro and macro fauna. In all these cases, the essential tool for the creation of georeferenced maps informed with additional data is Geographic Information Systems (GIS) (Ghilardi 2021).

GIS is the digital support capable of integrating, storing, editing, analysing, sharing and displaying of georeferenced data (Marble et al. 1984). In archaeology, GIS was introduced 30 years ago and nowadays it is used extensively as an essential tool to explore, analyse, and interpret spatial data, in both site and regional scales (Ghilardi and Desruelles 2008; Verhagen 2017). Three dimensional reconstructions incorporate D.E.M. which is the 3-D digital representation of topographic surface without vegetation or buildings (Ghilardi and Desruelles 2008:3). Topographical data for the creation of D.E.M. can be obtained from various sources: digitalization of contour lines, LiDAR (Light Detection And Ranging) and SONAR (Sound Navigation and Ranging), SRTM (Shuttle Radar Topography Mission) data and DGPS (Digital Geographical Positioning System) surveys (Ghilardi and Desruelles 2008:3-4). Furthermore, with time as an additional dimension, 4-D reconstruction is possible, modelling the diachronic changes of the landscape (Ghilardi 2021 Landeshi 2018).

In aquatic environments, several technologies are used for mapping bathymetry, such as acoustic systems, aerial optical imagery, or underwater optical imaging (Filisetti et al. 2018). In recent years, LiDAR has started to be employed in surveys of shallow waters (Li 2005; Ghilardi and Desruelles 2008:4).

LiDAR systems can be classified to terrestrial/marine and mobile/stationary (Fig. 21). Benefits of stationary systems are very high resolution of acquired data, performed to sub-centimetre accuracy, and the system is easily portable and operatable and relatively lowcost. Airborne LiDAR is capable of mapping large areas in short time, both terrestrial and underwater in shallow waters. In terrestrial measurements, Airborne LiDAR operates with an infrared laser at 1064nm wavelength which does not propagate through water. Therefore, a green laser,

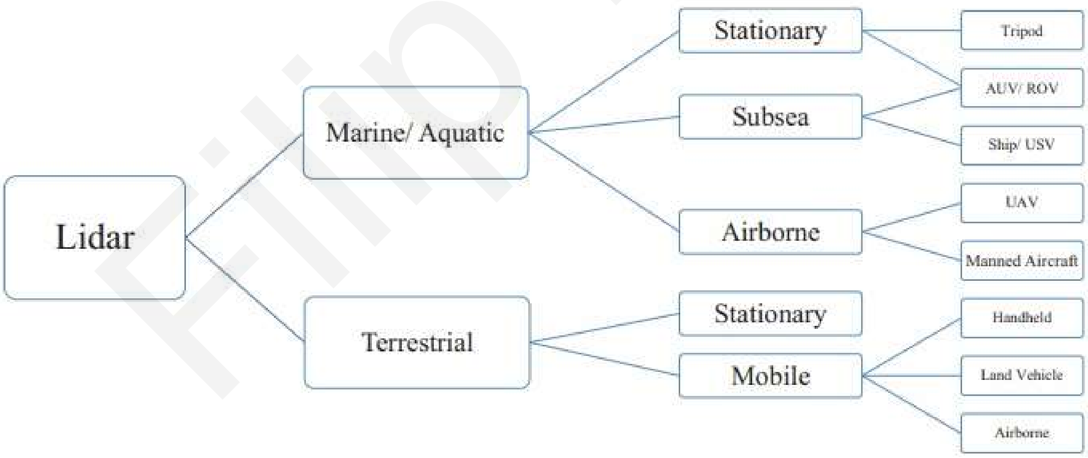


Figure 21: classification of terrestrial and marine LiDAR systems (Filisetti et al. 2018: Fig. 1)

typically with 532 nm wavelength is used as green colour is the least attenuated in water. LiDAR system contains both infrared and green laser beams, and the green laser is switched on when it reaches the water surface, with the infrared beam measuringthe water surface and the green beam measuring the seabed (Sørensen et al. 2016, Filisetti et al. 2018). Subsea LiDAR systems incorporated onto AUV/ROV or ships are in development infancy and few developed systems are currently used commercially, in oil and gas industry (Filisetti et al. 2018).

3.5. Palaeocoastlines: Methodology

The modelling palaeocoastline reconstruction consists of three parts: 1) creation of D.E.M., generated from LiDAR data in ArcGIS; 2) a field survey; 3) visualization of palaeocoastline reconstruction in ArcGIS by generating contours from D.E.M.

Lidar data were provided by the Department of Lands and Surveys (DLS) at 1:10 m resolution. LiDAR data were obtained in txt. file which was imported to GIS and provided the distribution of points with 10 meters spacing. The points were extrapolated with the IDW tool into a raster file with topographic values. As the raster file is generated only in square shape, areas behind the limits of the surveyed area are automatically calculated by the software, but these values do not reflect reality. Therefore, the IDW raster file had to be extracted by a mask in the shape of the scanned area. Subsequently contours were generated, and the mask was combined with orthophotos, available on Geoportal of DLS.

Considering the bathymetry of *Kaminoudhia* Bay and the predominant clockwise sea currents observed at the site, it has been decided to focus on the rocky promontory at the north of the bay. The aims of the survey were to: 1) confirm bathymetry, previously plotted based on LiDAR data, provided by the Department of Lands and Surveys; 2) identify geomorphological markers, such as tidal notches, beachrocks and abrasion platforms; and 3) detect possibly archaeological remains underwater. All located features were measured and photo-documented. Their coordinates were taken with the assistance of a surface diver, using the GPS embedded in camera GoPro 9 Black. The depths were measured with diving computer Suunto Zoop Novo.

The last step was to collect and summarize sea level studies of Cyprus and the eastern Mediterranean. Local vertical movements caused by tectonic activity were documented in different parts of the island, and as the tectonic uplifts and drops had not been studied, it was decided, for the purposes of the thesis, to exclude isostatic changes from the analysis. Georeferenced geomorphological and archaeological features were plotted into ArcGIS and palaeocoastlines were visualized by contours, generated from D.E.M. and subsequently compared with sea level studies.

3.6. The Survey at Kaminoudhia Bay

3.6.1. The Environment

The site of Paralimni *Nissia* is located on the coast of Protaras, Ammochostos district, in southeastern Cyprus. This area is characterized by well-developed red terra rosa soils and by “denticular“ rocky coasts, formed by numerous small headlands and bays (Nir 1993:17; Zomeni 2012:44-45). The southeastern most part is dominated by Cape Greco, consisting of marine terraces of Calabrian and Pliocene age (Zomeni 2012:24-25). The rocky coasts with marine terraces are composed of calcarenites, biocalcarenites, and grainstones, with basal conglomerates at the bottom and aeolinates at the top, which are the main coastal geomorphological feature in Cyprus (Zomeni 2012:24-25; Tsakalos 2016:680). Aeolinates, which are fossilized sand dunes, are semifriable,

Figure 22: Kaminoudhia Bay surrounded by Green Bay/Nissia coves in the south and submerged northern promontory on the north. The toponyms: 1 (Paralimni Nissia), 2 (Vyzakia Beach)(modified Google Earth)


Figure 23: Tidal notches along the coastline of Kaminoudhia Bay corresponding to present sea level (photo by Filip Hájek)

brown in colour, and composed of coarse calcarenitic components, and apart from forming the cliffy morphology of the coast, they are a source of brown coarse sand in certain coastal regions (Nir 1993:7,17).

The climate is characterized by hot and semi-arid summers from mid-May to mid-October, followed by mild and rainy winters from November to mid-March, separated by short spring and autumn. The frequency and the strength of the winds vary through the years, with prevailing westerly and southwesterly winds in the summer, accompanied by easterlies during the winter (Murray 1995:39-40; Zomeni 2012:41; Demesticha 2021:320). The waves are generally higher along the north coast than in southern Cyprus (Rabban 1995:140; Leonard 2005:351). The tidal range is minor, some less than 0.3 m and nowhere exceeding 0.5 m (Zomeni 2012:41; Galili et al. 2016:212). Anti-clockwise direction of the longshore sediment transport is proposed for the coasts of eastern and southern Cyprus (Garzanti et al. 2000; Zomeni 2012:30). The local vegetation is dominated by Sub-Saharan scrub and grasslands, and the area is characterized by fertile soils (MetaKron Consortium 2010).

The coast of Protaras is characterized by low-lying rocky cliffs with occasional sandy beaches in the bays. Kaminoudhia Bay, where the site of Paralimni *Nissia* is situated, is flanked by the *Nissia* coves (or Green Bay) to the south and a submerged rocky promontory to the north. The hillock of the Late Neolithic site to the west dominates the modern beach (*Vyzakia*) (Fig.22) and the area is busy with leisure activities and water sports, such as diving and jet skiing.

Figure 24: fossil shell deposits (in red circle) on the eroded scarp of the hillock with the Neolithic site atop (photographed by Filip Hájek)

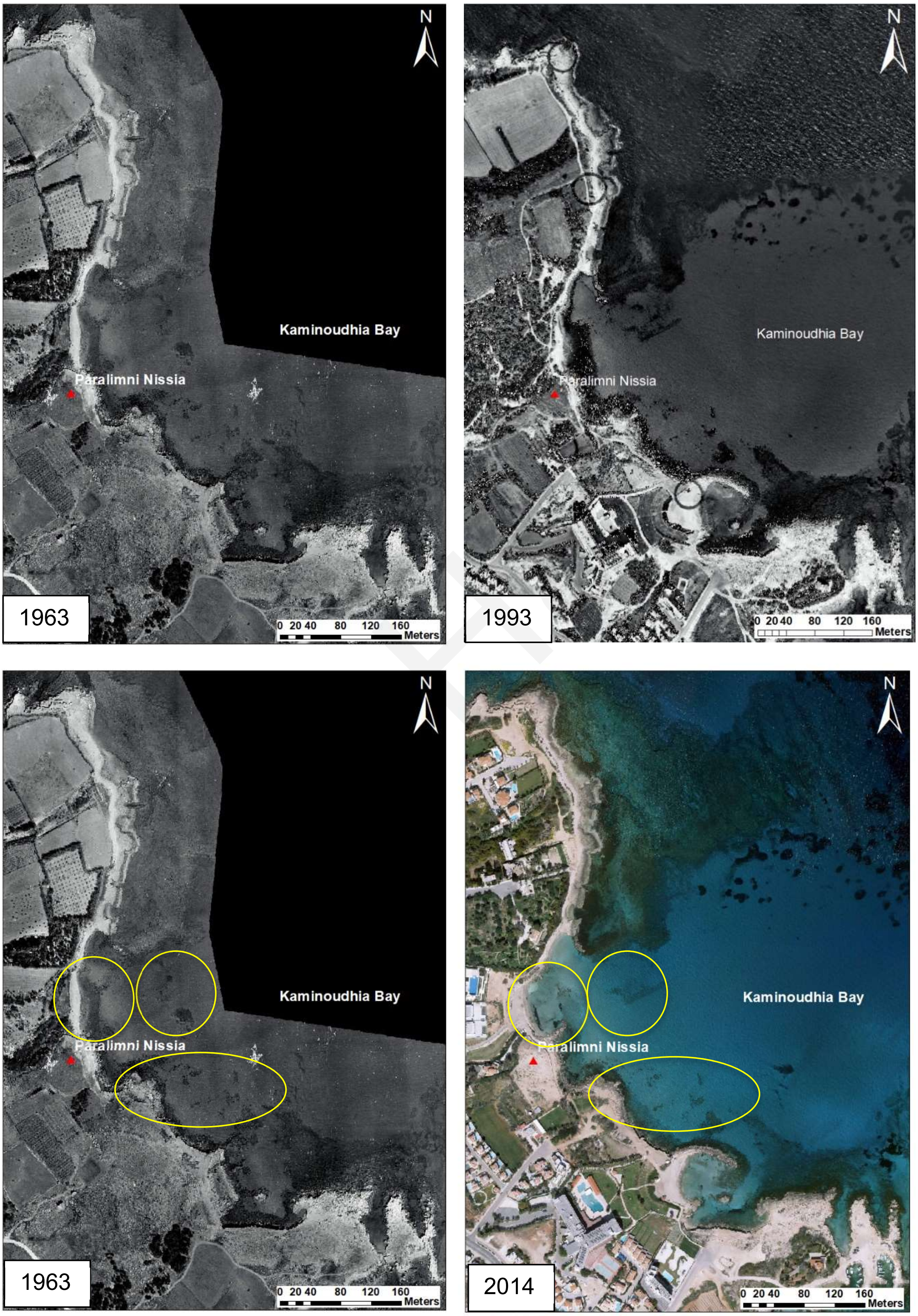


Figure 25: Comparison of aerial orthophotos from 1963 with 1993 and 2014). Yellow circles show areas affected by the beach replenishment with sand.

The height of rocky cliffs on the coast of Kaminoudhia Bay ranged between 0.5-3 m. The gently sloping seabed is sandy with sporadic rocky outcrops. Several tidal notches, mostly visible to the north and in the central scarp, correspond to the current sea level (Fig.23). In front of the rocky hillock of the Neolithic site, towards the sea, the scarp is eroding, exposing geological stratigraphic layers, some of which with broken pieces of shells (Fig.24). The coastal relief forms a small, protected cove at the south/southwest, with the seabed consisting of coarse sediments, such as gravel and pebbles.

Aerial orthophotos from different years (1963, 1993 and 2014), accessed online through the Geo-portal of the Department of Lands and Surveys (DLS), were compared by layering in ArcGIS. There are almost no differences between the coastline of the years 1963 and 1993 (Fig.25) but this is not the case with the coastline of 2014. Between the years 2000 and 2010, the area was affected by anthropogenic interventions, namely the construction of breakwaters and development activities at the Vyzakia beach. As a result, the comparison between orthophotos from 1963 and 2014 shows a decline of the coast by ca. 20 meters (Fig.26), as well as an increase of the amount of sand in the bay, most likely because of repetitive efforts to create a sandy beach for swimmers.

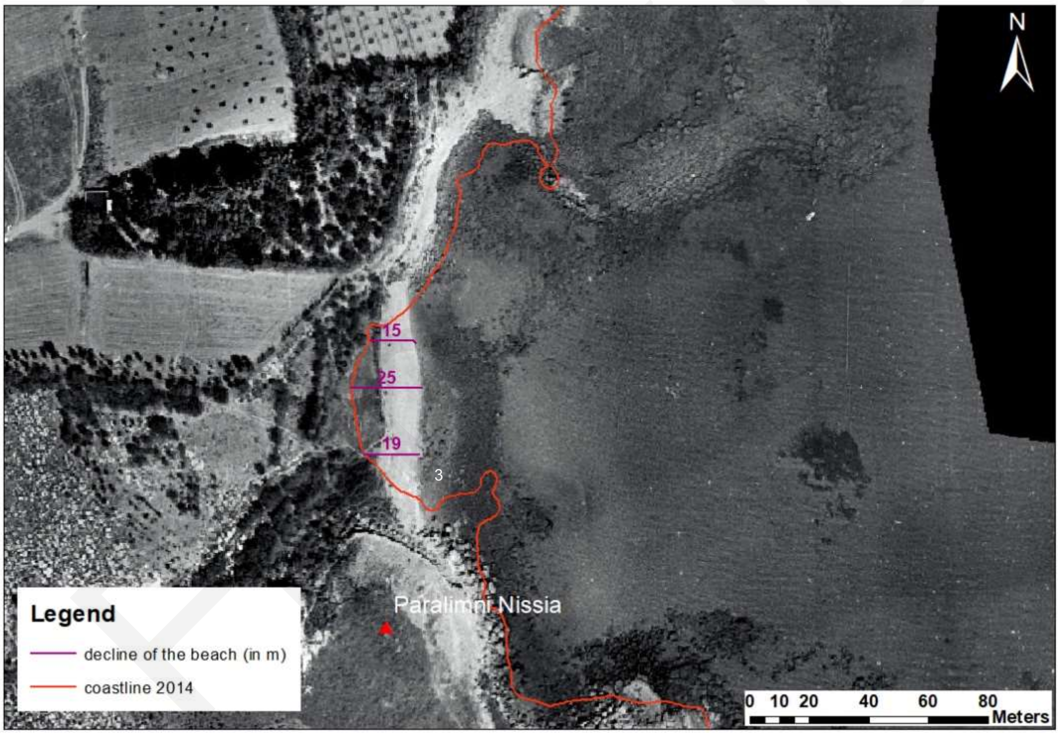


Figure 26: Layering of the aerial orthophotos from 1963 and 2014 showed a decline of the coastline, ranging between 15 and 25 m

3.6.2. The Underwater Survey

The survey was carried out between the 4th and the 7th of July 2022. Considering the bathymetry of *Kaminoudhia* Bay, the predominant clockwise sea currents and the greater probability of locating geomorphological markers on a rocky rather than on a sandy seabed, it has been decided to focus on the rocky promontory at the north of the bay (Fig. 27). A reconnaissance survey with an underwater scooter was first deemed necessary. The flat gently sloping topography of the rocky plateau indicates that the promontory is an abrasion platform, formed by marine abrasion during the low-stand of sea level. It has a trapezoid

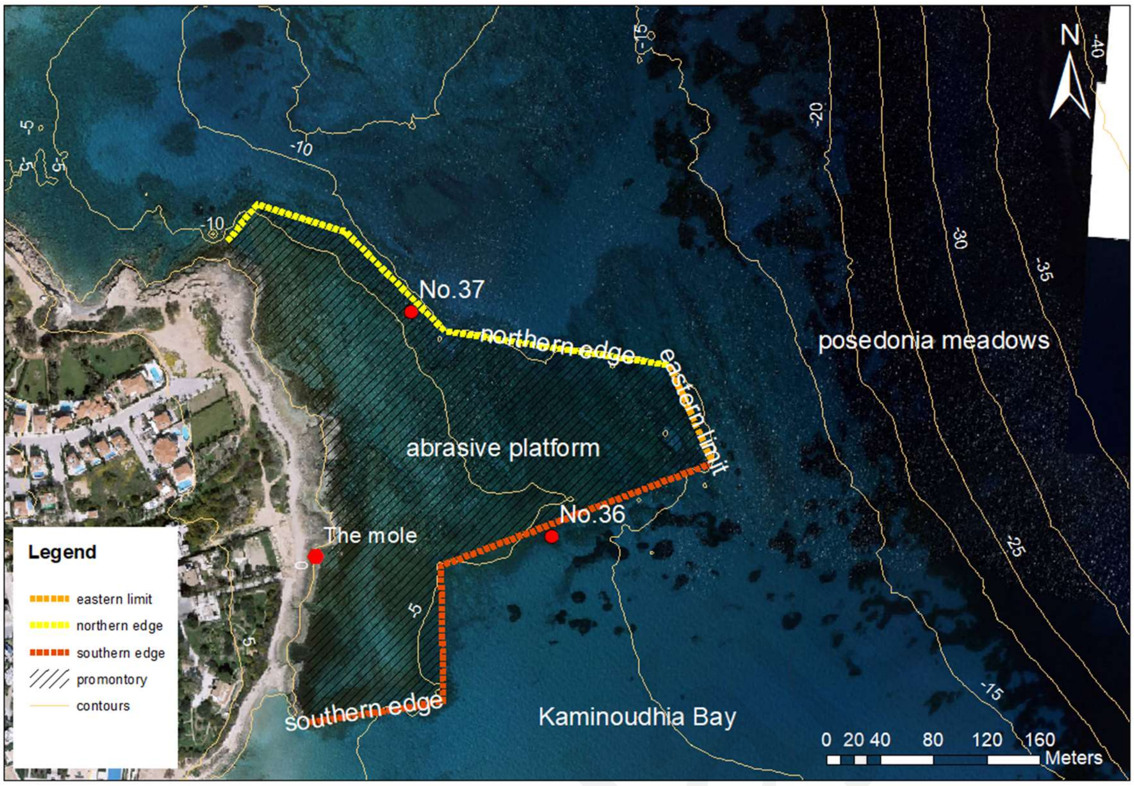


Figure 27: the survey area of the northern promontory

shape, ca. 400 m wide along the coast and with ca. 110 m in its narrowest, easternmost limit, and covers an area approximately of 68 900 m^2, from the coastline up to a depth of ca. -10 m, followed by a flat rocky seabed gently sloping seaward. Posidonia meadows appear at a depth - 17 m. The northern edge of the submerged promontory consists of visible cracks on scarps surrounded by the debris of rockfall (Fig. 28, Table 4, No.37), is considerably eroded. This made the identification of geomorphological markers, such as tidal notches, more difficult.

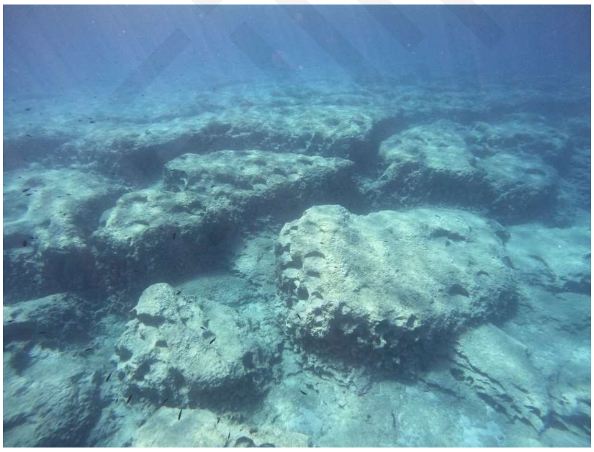


Figure 28: Feature No 37: the cracks and eroded rocks along the northern edge of the platform

On the abrasion platform, at a depth of ca -2 m, a small group of stumps were found close to the southern edge (Fig.29). The notches of the stumps were ca 0.2 m high, situated at the depth of -2.1 m. The southern edge of the platform was eroded, with distinguishable cracks and rockfall debris on the seabed. Some surfaces bore geomorphological features, however, resembling tidal notches (Table 4). Although their characterisation as tidal notches is uncertain due to the level of erosion, they were all situated approximately at the same depth (ca. -5.4 m). More notches were also located at the depth of -6.7 m, but most of them were partially buried in the sand (see below 3.1 Results). Eroded scarp appeared at ca. -8 m depth (Fig. 30**,** Table 4, No.36) and continues seaward, which impeded the identification of other geomorphological features at greater

Figure 29: Left: Stumps with possible tidal notches, located on the abrasion platform. Right: Stump No.21

depths. The deepest limit of the promontory, at ca. -10 m, consists of small coves, eroded potholes, and folds containing conglomerated scattered, non- diagnostic pottery fragments.

As already mentioned, the seabed of the bay is predominantly sandy with the depth of the sandy layer being unknown. In order to better understand the sediment infill in the bay, it was decided to probe the seabed in the front of the site (Vyzakia beach) (Fig.31). The seabed was probed with a 1m-long metal probe. In total, four sondages were executed in a line, 10 m apart (Table 4). Three of the four probes reached the hard substrate, meaning that the thickness of the soft substrate was less than one meter. Taking into account the rocky outcrops exposed within the bay, it has been preliminary concluded that the sandy layer within the bay is relatively shallow, at or around one meter.

Figure 30: Feature No. 36: the eroded slope at the depth ca. -8 m

3.6.3. Recorded features

In total, 16 geomorphological markers were observed and recorded (Table 4, Fig. 32). Taking into consideration their depths, at least five palaeocoastlines can be proposed in various depths: -2.00±0.10 m, -4.30 m, -5.45±0.25 m, -6.70 m and -7.60 m. These geomorphological markers are possible tidal notches, stumps and signs of abrasion. No beachrocks nor other conglomerated aggregates have been identified. The survey also yielded archaeological finds,

Figure 31: probing of the seabed in the front of the Late Neolithic site; right: the map with the probes 1-4

such as pottery fragments and anchors. All features, both geomorphological and archaeological, were photo-documented and geotagged in ArcGIS.

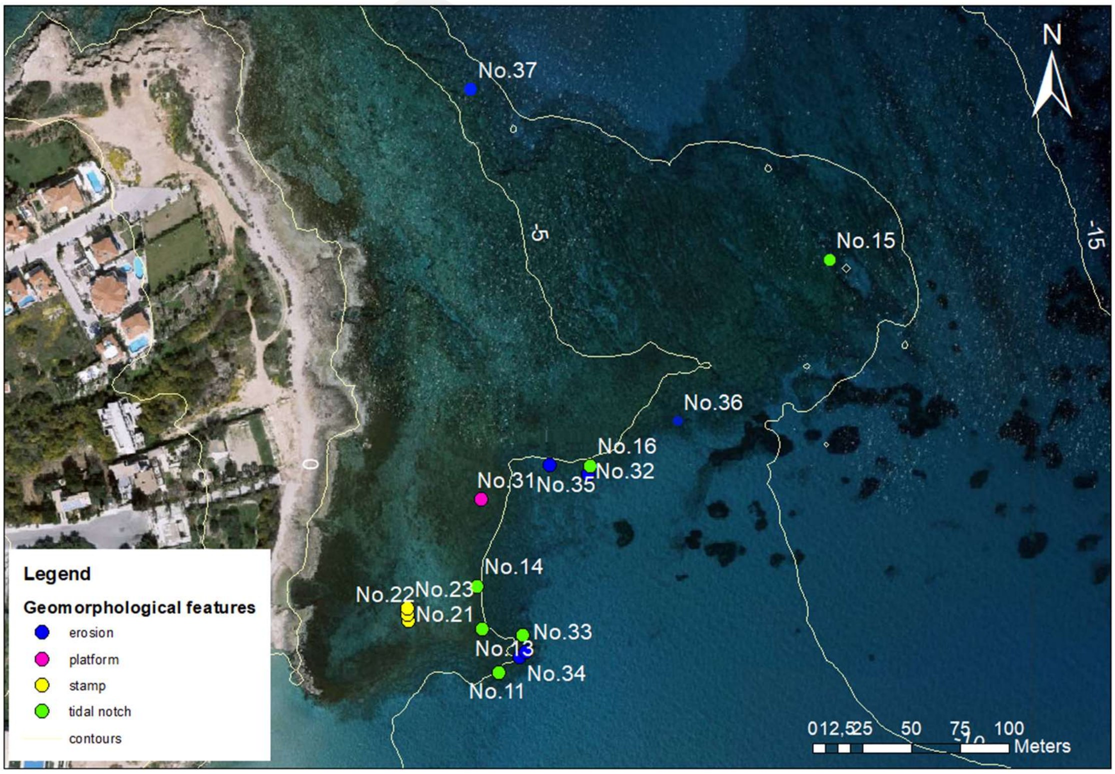


Figure 32: Location of all geomorphological features

Feature Number	Type of Feature	Depth (m)	Date of dive	Date of recording
No.11	Tidal notch	-5.40	05/07/2022	07/07/2022
No.12	Tidal notch	-6.70	05/07/2022	07 /07/2022
No.13	Tidal notch	-5.20	05 /07/2022	07/07/2022
No.14	Tidal notch	-4.30	05 /07/2022	07/07/2022
No.15	Tidal notch	-7.60	07 /07/2022	07/07/2022
No.16	Tidal notch	ca.-5.40	06 /07/2022	Not recorded
No.21	Stump	-1.90	05 /07/2022	06/07/2022
No.22	Stump	-2.10	05 /07/2022	06/07/2022
No.23	Stump	-2.10	05 /07/2022	06/07/2022
No.31	Platform	-2.40	06 /07/2022	06/07/2022
No.32	Eroded rock	-5.70	06 /07/2022	06/07/2022
No.33	Eroded rock	-5.40	06 /07/2022	06/07/2022
No.34	Collapsed reef face	-7.30	05 /07/2022	07/07/2022
No.35	Eroded rock	-5.60	06 /07/2022	06/07/2022
No.36	Eroded slope	-7.50	06 /07/2022	06/07/2022
No.37	Eroded slope	-7.90	04 /07/2022	07/07/2022

Table 3: Possible geomorphological features identified during the survey

Six features have been recognized as possible tidal notches (Nos. 11, 12, 13, 14, 15 and 16), most of which were found along the southern edge of the platform, ca. 100 m from the current coastline. Three of the recorded features (Nos. 21, 22 and 23) represent stumps. A third category of features (Nos. 31, 32, 33, 34 and 35) concerns erosion markers located within the same depths as other tidal notches and features (Nos 36 and 37 are geotagged eroded walls of the promontory).

Probe number	Depth of probing	Thickness of sand layer
Probe 1	-1 m	0.15 m
Probe 2	-1 m	0.75 m
Probe 3	-1.8 m	>1 m
Probe4	-2.3 m	0.55 m

Table 4: Probes with the in which they were probed and measured thickness of soft substrate

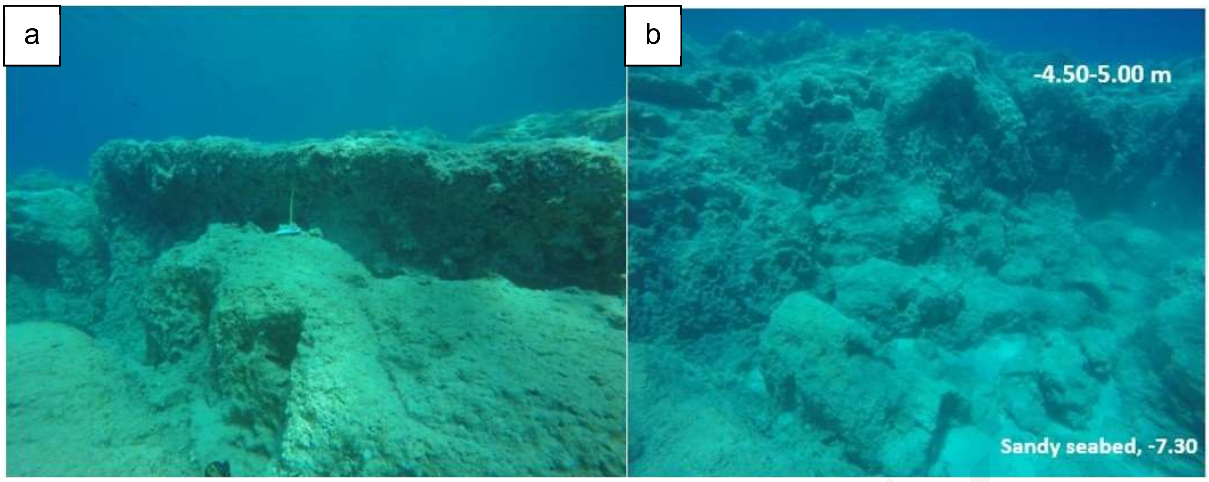


Figure 33: a) A possible tidal notch at the depth -5.40 m (Feature No.11); b) The eroded reef face. The sandy seabed is as the depth ca. -7.30 m while the upper edge of the reef is between the depths of -4.50 and -5.00 m (Feature No.34)

3.6.4. Tidal notches and stumps

Six features have been recognized as possible tidal notches (Nos. 11, 12, 13, 14, 15 and 16). Feature No. 11 is the most westerly situated identified tidal notch along the promontory. It lies on the edge of the reef at the depth of -5.40 m (Fig.33a). The feature is surrounded by cracks and fallen rocks on the seabed (No. 34) (Fig.33b).

Possible abrasion of the promontory at the depth of ca. -6.7 m was recognized several times during the survey. However, the morphology was mostly hardly recognizable as the sandy layer covered, fully or partly, the scarp at this depth. As such, in most cases half buried abrasion and notches couldn't be confirmed as tidal notches (Fig.34a). Feature No. 12, identified as a possible tidal notch was situated right above the sandy layer at the depth -6.7 m (Fig.34b).

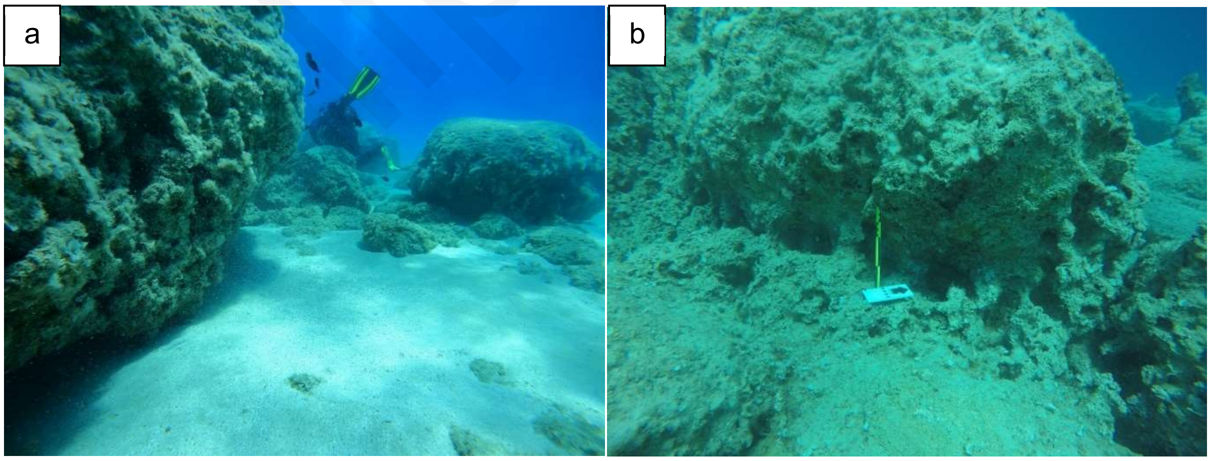


Figure 34: a) Eroded face at the depth -6.70 m, half buried; b) a possible tidal notch at the depth -6.70 m (Feature No.12)

Close to the feature No. 12, the promontory forms a small sheltered area dominated by steep scarp. In this area, signs of abrasion at the depth of -5.20 m were recognized in different parts of the rocky scarp and possibly also on the nearby (probably fallen) rock. This area was recorded as No. 13 (Fig.35a). Right above this area, a possible tidal notch (No.14) was found

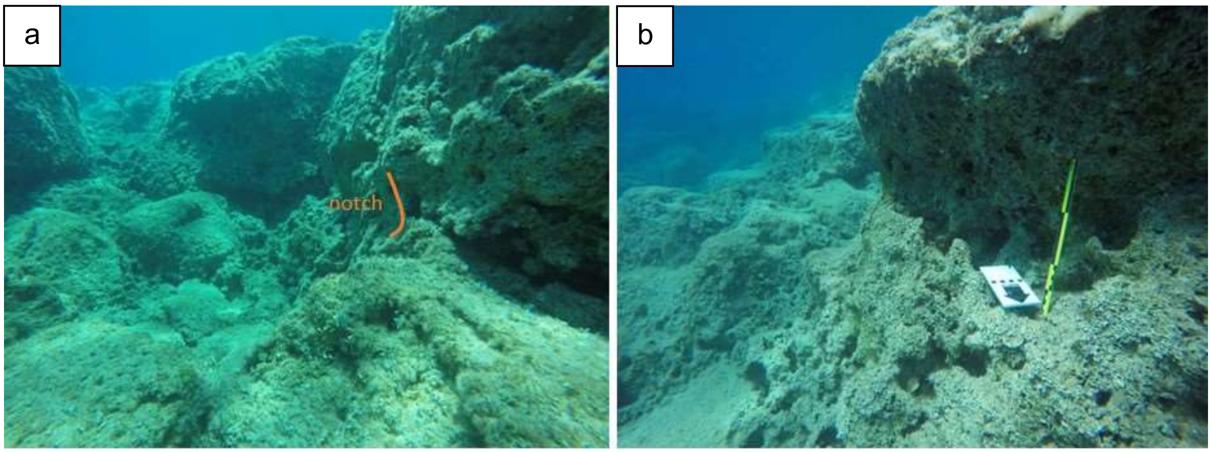


Figure 35: a) A possible tidal notch at the depth of -5.40 m (Feature No.13). Orange curve highlights the notch; b) a possible tidal notch at the depth -4.30 m (Feature No.14)

at the depth of -4.30 m on the flat surface of scarp (Fig.35b). This tidal notch represents the only geomorphological feature identified at this depth.

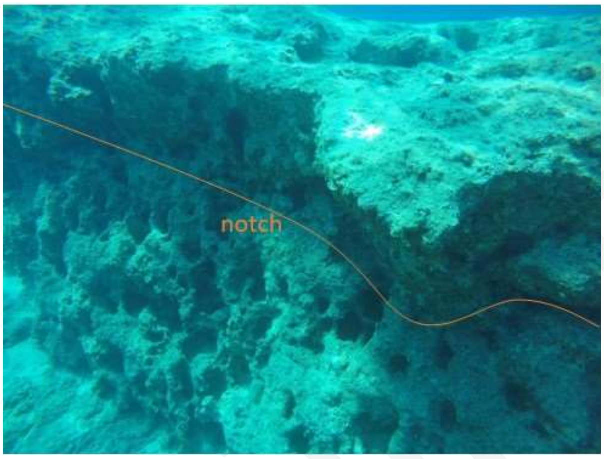


Figure 36: A possible tidal notch at the depth -7.60 m (Feature No.15). The orange curve highlights the notch; right: abraded platform at the depth -2.40 m

Feature No. 15 was discovered during snorkelling on the last day (Fig.36). It is located within the eastern limit of the promontory, on the face of the reef within a small cove opened to the south. It is situated at the depth of -7.60 m; no other markers have been discovered at this elevation.

Lastly, opposite to the abraded rock No. 32, a suspicious notch has been noticed on the edge of the scarp (Fig.37). Notch (No. 16) was recognized after the survey ended and thus was not properly recorded; it is situated slightly higher than the abraded rock No. 32 (-5.70 m) thus the estimated depth is -5.40±0.10 m.

Figure 37: Left: an eroded rock No.35 ; Right: a possible tidal notch (No.16) opposite of No.35

Stumps with notches have been located in the southwestern/southern part of the promontory at the depth of ca. -2 m formed in a small group with N-S direction, parallel to the coast. The depth was measured at the bottom of the notches. From this group, three representative notches were recorded (Nos. 21, 22, 23). Notch of No. 21 was recorded at -1.9 m while notches of Nos. 22 and 23 at -2.1 m (Fig.38). The height of the recorded notches varies

Stump	Depth by computer (m)	Depth by tape (m)	The height of notch	Depth of the top of stumps (m)
No.21	-1.90	-1.95+-0.05	17cm	ca. -1.50
No.22	-2.10	-2.15+-0.05	18cm	ca. -1.90
No.23	-2.10	-2.10+-0.05	20cm	ca. -1.60

Table 5: Depth of the notches of stumps measured by diving computer Suunto Zoop Novo. The depth of the tops of stumps was estimated during the data processing by the scale of the ruler

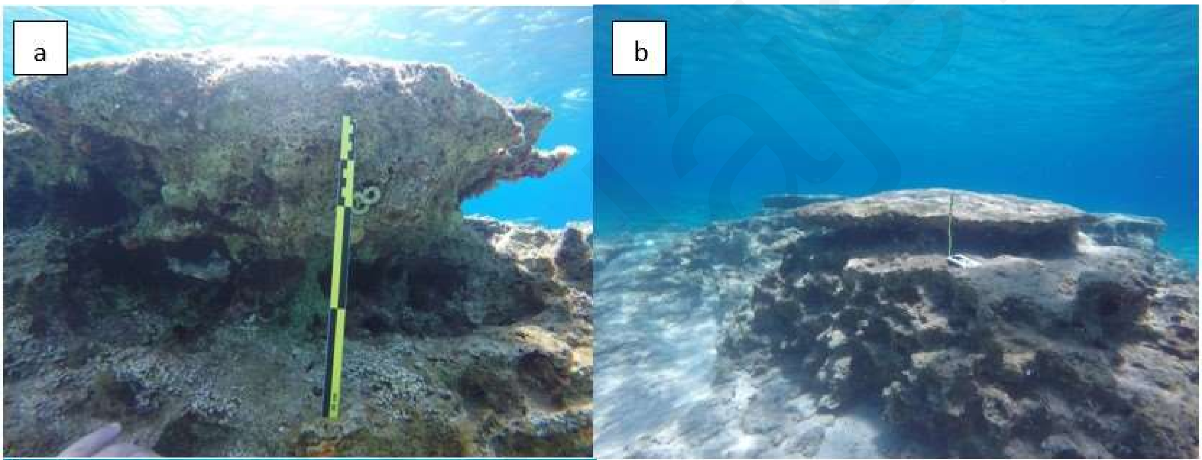


Figure 38: Recorded stumps at the depth -1.90-2.10 m: a) Feature No.21 (-1.90 m); b) Feature No. 22 (-2.10 m); c) Feature No.23 (-2.10 m)

between 0.17-0.20 m. The top of stumps were abraded, usually ca. 0.30-0.50 m above the bottom of the notches. The depth of the top of stumps was estimated during the data processing by the scale of used ruler (Table 5).

3.6.5. Signs of erosion

Eroded rocks and platforms situated at the depths of above-mentioned markers were also recorded as they may relate with sea levels. No. 31 is a platform eroded at the depth of -2.4 m (Fig. 40a). Nos 32, 33 and 35 are located at a similar depth (No.32 in -5.70 m, No.33 in -5.40 m and No.35 in -5.60 m). As mentioned above, No. 32 is accompanied with a possible tidal notch (No.16)(Fig.37). An abraded rock was also located in the vicinity of No.11 and No.34, at -5.40 m (Fig.40b). Particularly interesting is No. 35: the large single rock with deep notch eroded in the lowest part (Fig.39). The height of the notch is 0.20 m. No. 34 is the debris of rockfall close to the possible tidal notch No. 11 (Fig.33b). Fallen rocks lie on the seabed at -7.30 m. No. 36 and 37 represent eroded slopes and debris of rockfall along the scarps.

Figure 39: Eroded rock with abraded notch in the lowest part, at the depth -5.60 m (No.35)

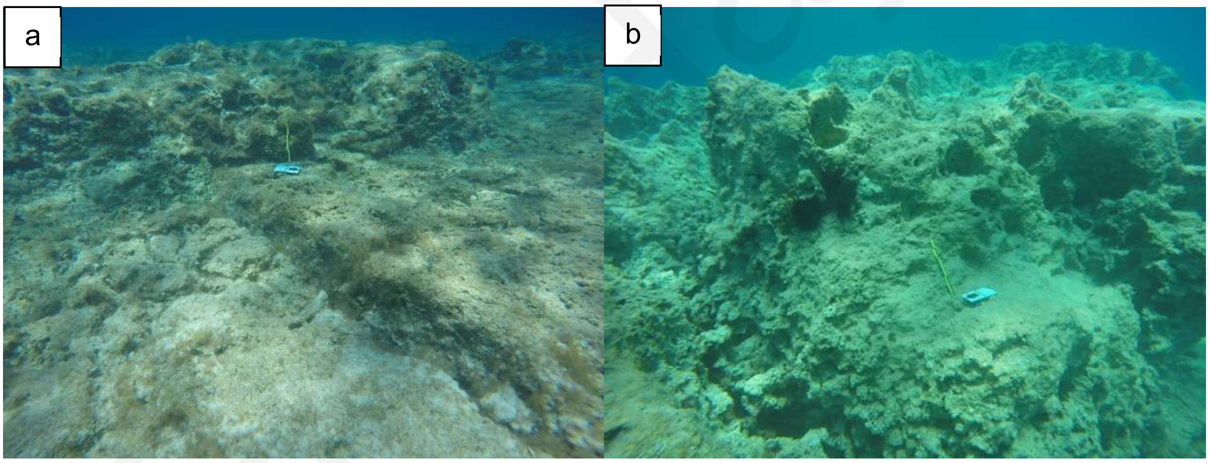


Figure 40: a) abraded platform at the depth -2.40 m; : abraded rock at the depth -5.40 m (No.33)

3.6.6. Pottery and anchors

During the survey, pottery sherds and two anchors were found (Table 6). Scattered pottery sherds were abundant at the upper platform along the coast, predominantly concentrated within a zone, approximately 60 m wide and 220 m long (Fig.41). Beyond this zone, pottery remains were sporadic. Most of them are conglomerated on the rocky seabed. During the reconnaissance survey, one three-holed anchor and one iron anchor were located (Fig.42).

Figure 41: Finds of archaeological significance located during the survey

The three-holed anchor was lying within the eroded folds at the eastern limit of the promontory at -8.0 m. The iron anchor was found at -7.90 m, deposited in a vertical position and conglomerated on the eroded rocks.

Archaeological finds No.	Description	Depth (in m)	Date of discovery	Figure
No.41	Body fragments of a pithos	-3.30	07 July 2022	43d
No.42	Cluster of non-diagnostic conglomerated body sherds	-2.80	07 July 2022	43e
No.43	Clusters of conglomerated non-diagnostic sherds	-2.80	07 July 2022	44
No.44	Pottery sherd	-7.60	05 July 2022	43a
No.45	Amphora neck	-7.90	04 July 2022	43b
No.46	Conglomerated body sherd	-10.30	04 July 2022	43c
No.51	Three-holed stone anchor	-8.0	04 July 2022	42
No.52	Iron anchor, possibly a grapnel, of recent date	-7.90	04 July 2022	42
No.53	Two pierced stones, of uncertain date and function	-1.30	07 July 2022	45

Table 6: Finds of archaeological significance located during the survey (for the finds location see Figure 30)

Figure 42: Left: A three-holed stone anchor at the eastern limit of the promontory; right: conglomerated iron anchor (No.52), depth -7.90 m

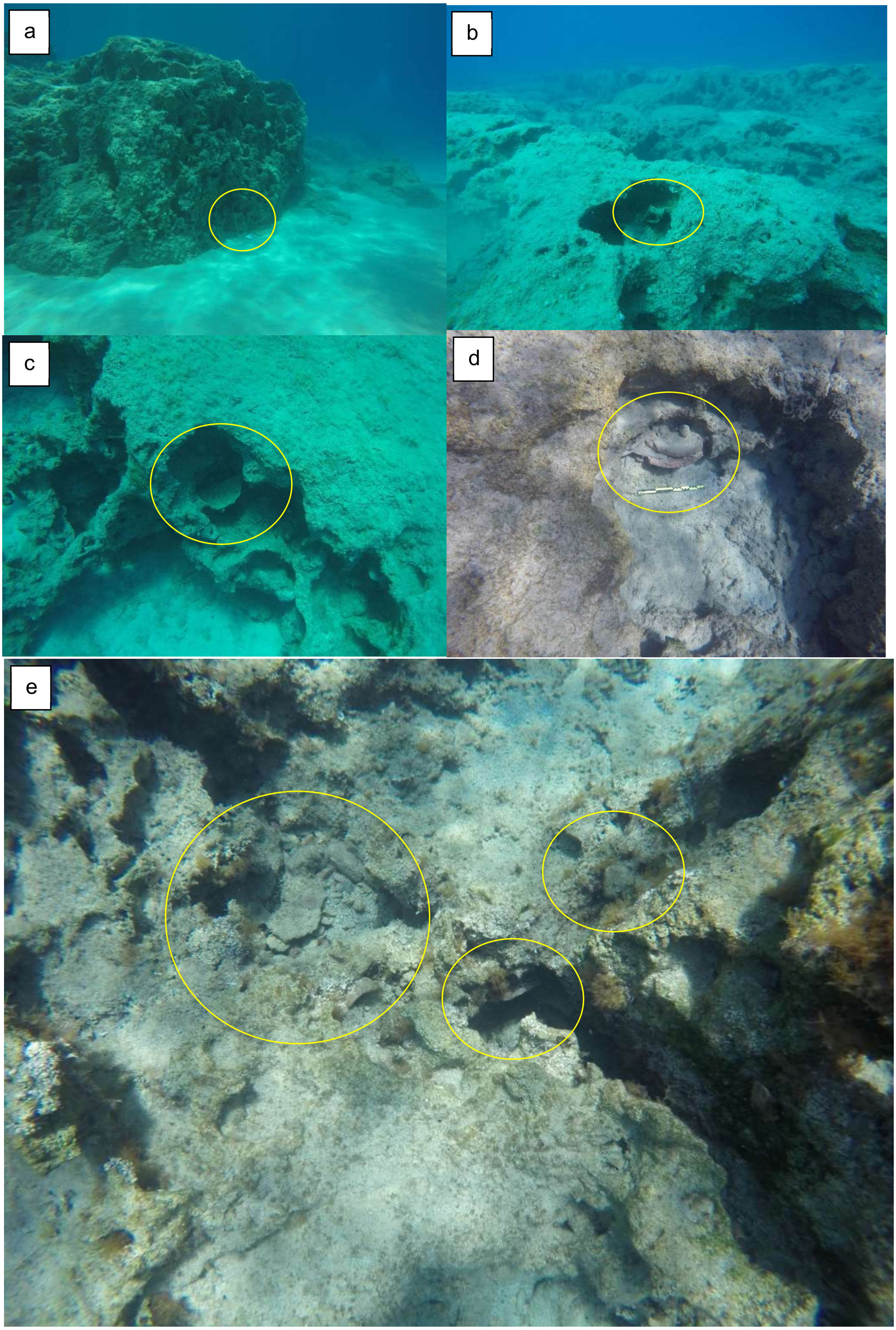


Figure 43: Pottery sherds, marked with yellow circles a) N.44 b) No.45 c) No.46 d) No.41 e) No.42;

Figure 44: Small group of conglomerated non-diagnostic sherds (in yellow circles) spread all over the dense distribution area)(No.43)

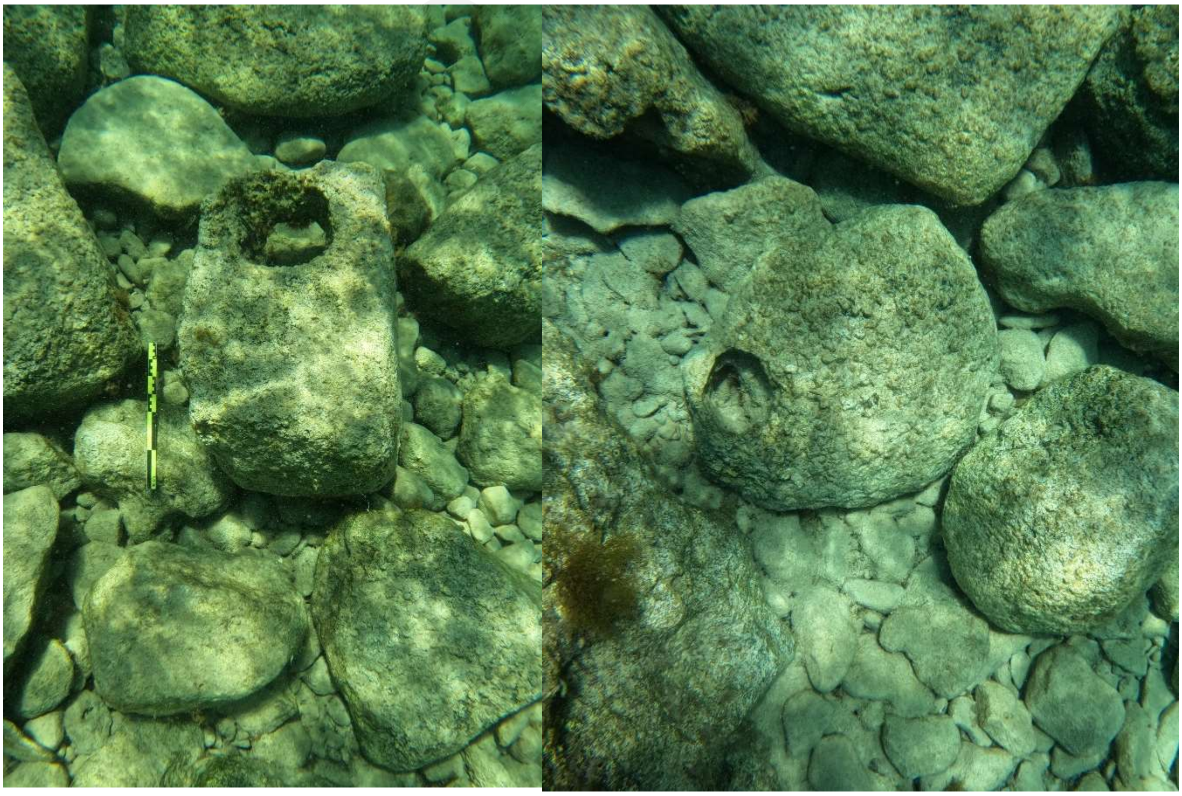


Figure 45: Two pierced stones right next to the coastline, depth -1.80 m (photograph by Stella Demesticha)

Two pierced stones were found in the northern part of the upper platform, right along the coastline (Fig.45), surrounded by rectangular to sub-rectangular stone blocks of size ranging from 0.3-1 m in diameter. Due to the dissimilarity of the stone blocks deposit with the rest of the seabed and its location right next to the coastline, it is likely that the blocks have been deposited during the recent anthropogenic activities and thus the interpretation and date of the two pierced stones is uncertain.

3.7. Discussion

3.7.1. Possible Palaeocoastlines

Based on the depths of observed features, several possible palaeocoastlines could be suggested. The notches of the stumps on the platform indicate a sea level at -2.0 ±0.10 m. A second palaeocoastline was probably situated at the depth of -5.45±0.25 m, based on possible tidal notches and abraded rocks along the eroded scarp. With caution, it can be proposed that more palaeocoastlines could be recognized around the depths of -4.30 m, -6.70 m and -7.60 m.

The following palaeocoastline reconstruction combines sea level data with depths of identified possible geomorphological markers during the survey. Palaeocoastlines have been visualised in ArcGIS by generating contours from D.E.M. based on LiDAR data, provided by the Department of Lands and Surveys at 1:10m resolution. None of the markers could be dated thus the reconstruction is hypothetical, assuming, that the sea level rose gradually, and thus it is based on sea level data of tectonically stable region (Israel) provided by Sivan et al. (2001) and Galili et al. (2005).

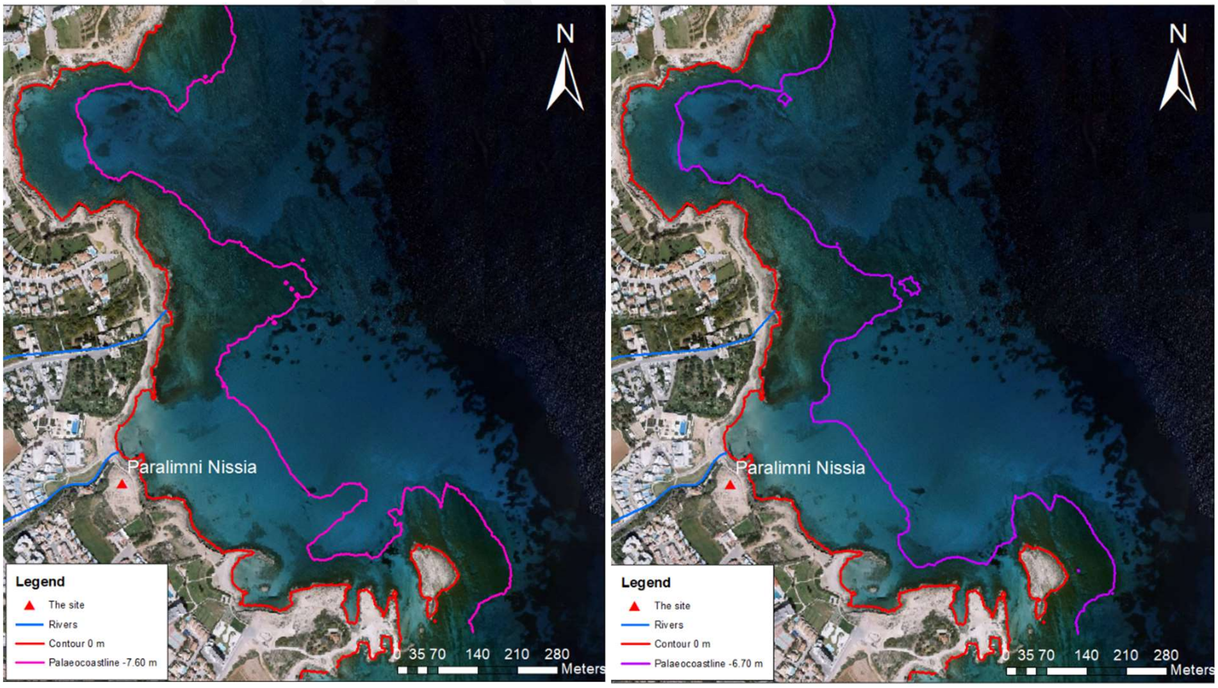


Figure 46: Palaeocoastline reconstruction for -7.60 m (left) and -6.70 m (right)

The deepest possible palaeocoastline was identified at the depth -7.60 m (Fig. 46). Based on mean sea levels, a possible date could be around 5000 BCE, thus prior or at the beginning of the permanent occupation of Paralimni *Nissia*. The shortest distance from the site to the coastline was ca. 210 m. The coast formed a small bay covering area of ca. 93 000 m^2, protected by the rocky promontory at the north and *Nissia* coves at the south. The small river Potamos tou Lombardi flowed into the sea probably along the southern edge of the northern promontory.

Another possible coastline was located at the depth -6.70 m (Fig. 46). Such coastline would be approximately 150 m from the Neolithic site. Following the consideration of Galili et al. (2005) that the average rate of sea level rise between 5000 BCE and 2000 BCE was 2-4 mm per year, from the previous hypothetical coastline, this coastline would be reached in less than 500 years, which implies that this coastline may occurred during the first half of the fifth millennium BCE. At this time, the site of Paralimni *Nissia* may have been already occupied (Flourentzos 2008:96). The area of the bay increased to ca. 106 000 m^2.

Following the average rate of sea level rise proposed by Galili et al. (2005) the coastline 5.45 m lower than today may have existed during the second half of the fifth millennium BCE (Fig. 47). It is at this time when the second floor of House 16 was documented, as indicated by radiocarbon dates (Flourentzos 2008:96). The settlement would be at a distance of ca. 120 m from the nearest point of the coastline. The bay covered an area of ca. 113 000 m^2. The northern promontory became partially submerged. Most identified geomorphological markers have been located at these depths, situated along the southeastern scarp of the promontory.

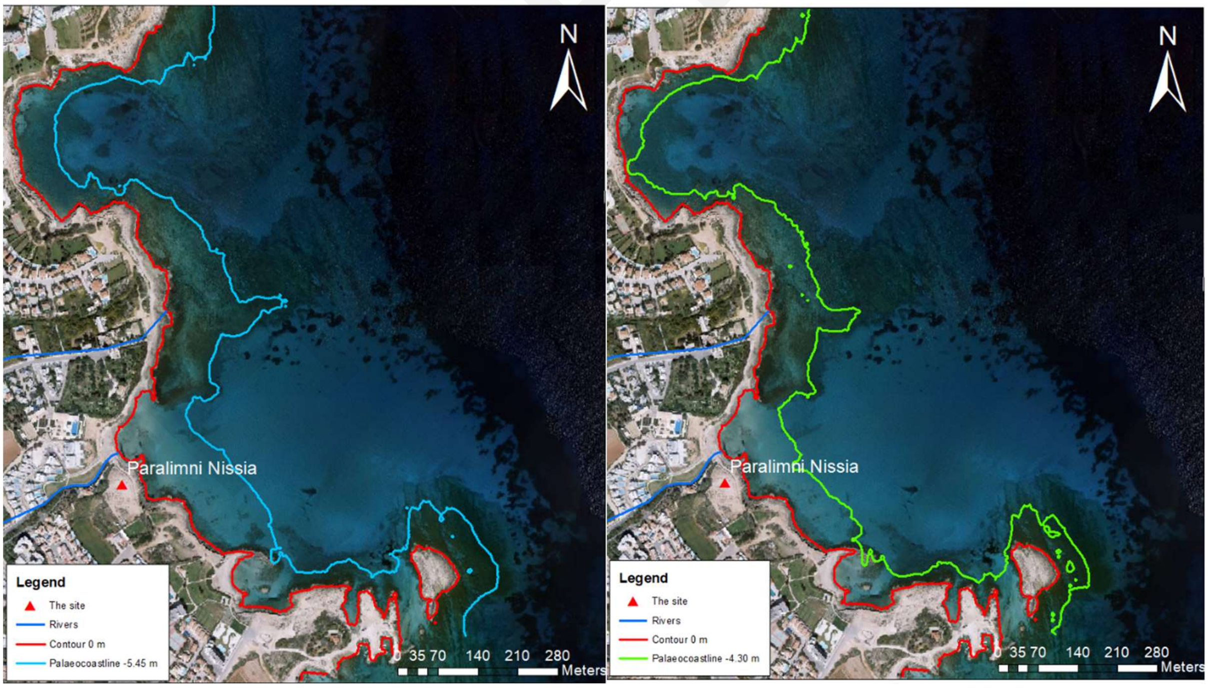


Figure 47: Palaeocoastline reconstruction for -5.45 m (left) and -4.30 m (right)

Following the convention mentioned above, the coastline at - 4.30 m could be placed at the end of the fifth millennium BCE/the beginning of the fourth millennium BCE, (Fig. 47). At that time, the site may have been either at the final phase of the occupation or recently abandoned. The closest distance between the coastline and the site was ca. 80 m. Similarly, a coastline now at -2 m may have appeared at the end of the fourth millennium BCE and/or during the first half of the third millennium BCE (Fig. 48).

According to Galili et al. (2005) present day sea level has been reached approximately 4000 years ago, followed by stable sea level with vertical oscillation not more than 0.5 m. As such, during the Hellenistic-Roman occupation of the site, the coastline may have been similar as today.

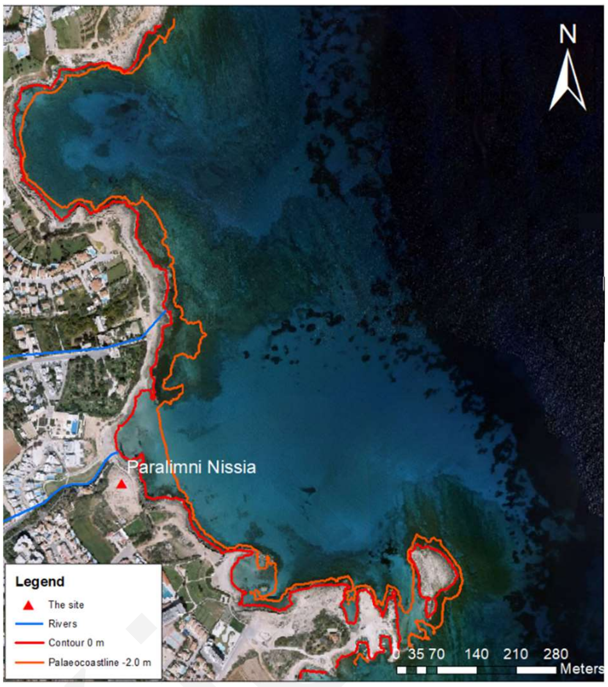


Figure 48: Palaeocoastline reconstruction for -2.0 m

4. The evidence of the molluscs

4.1. Molluscs in archaeology

Molluscs are invertebrates and represent one of the oldest and most numerous genera of the animal kingdom. Molluscs are divided into seven classes: Gastropoda (snails), Bivalvia (bivalves), Scaphopoda (tusk shells), Polyplacophora (chitons) and Cephalopoda (cuttlefish), all of which are further divided into families, genus, and species. Most secrete calcium carbonate and conchiolin in order to produce shells, the outer skeleton which protects and supports their body (Bar-Yosef Mayer 2007:192; Βεροπουλίδου 2011:25). Molluscs represent a valuable food resource, and their shells vary in shapes, sizes, hardness, and decoration and thus have been collected for the producing of various ornaments and tools. Therefore, shells belong among a common repertoire of archaeological assemblages dating from prehistory onwards (Karali 1999:1).

Molluscs are considered as critical environmental indicators as the existence of each species is restricted to specific ecological conditions, such as climate, the ecology and morphology of the seabed, composition of the water, tides, currents, temperature, dissolved oxygen, salinity, depth, and other marine environmental conditions (Karali 1999:1,6-7; Βεροπουλίδου 2011:32; Karali 2013:446; Saliari 2013:37). Based on environmental factors, molluscs can be divided into several groups of aquatic or terrestrial environments; salty, fresh or brackish waters; hard substrates; those that dig and sink to a lesser or greater depth of soft substrates; or those that are nektonic, i.e. have ability to swim (Βεροπουλίδου 2011:32). Taking into consideration the depths, some species live in the intertidal zone and shallow waters while some occupy the sublittoral zone and deep waters. Therefore, quantitative analysis of molluscs combined with the habitat criteria of identified species can reveal information about the predominant composition of the seabed and the coastline by the site, the temperature and salinity of the seawater, together with possible exploitation strategies of past societies and changes in human activities during the timespan of a site occupation (Karali 1999:2,6-8; Βεροπουλίδου 2011:25,35,50; Somerville et al. 2017:).

The potential of shell assemblages for the interpretation and study of past societies and their economies has been recognised already during the second half of the 19th century (Bar-Yosef Mayer 2005a:18). Since 1970's, researchers have become aware of the importance of malacological material, and emphasis was put not only to study cultural and economic aspects, but to reconstruct the season of the occupation and/or micro-palaeoenvironment of the site (Bar-Yosef Mayer 2005a:20; Bar-Yosef Mayer 2008:193). Karali (2013) studied shell assemblages of different occupational phases separately at the EBA site of Dhaskalio on Keros island, in order to distinguish diachronic changes in exploitation strategies and shell use. D. Bar-Yosef Mayer (2008) studied shells from different periods mainly in Israel but also in other countries, such as Turkey (Bar-Yosef Mayer 2017). Shackleton and Van Andel (1986) estimated environmental changes of the coastal zone near Franchthi cave based on molluscs' assemblages ranging between Upper Palaeolithic and Final Neolithic. Ridout-Sharpe studied molluscs at Aceramic Neolithic site of Kissonerga *Mylouthia* (Croft et al. 2017:209-211) or Ceramic Neolithic Ayios Epiktitos *Vrysi* (Ridout 1983:93-95). Reese studied shell remains at numerous sites of different periods, with prehistoric sites of Cape Andreas *Kastros* (Reese 1978), Paralimni *Nissia* (2008:119-154) and Nissi Beach (Ammerman et al. 2017). At Nissi

Beach, he reconstructed the palaecoastline environment based on habitat preferences of identified species. This site yielded shell assemblages dated to both Aceramic and Ceramic Neolithic periods, and he stressed that multiple consumption and discard strategies, together with different distances of the coastline from the site in different periods, may affect the total assemblage and environmental reconstruction. Also, he pointed out that nowadays frequent Mytilus has not been located in archaeological strata of Nissi Beach, which may result from social and/or taste preferences or may indicate that Mytilus sp. was not as abundant millennia ago as today.

4.2. Procurement strategies

All diverse molluscs habitats were accessible to humans, though some easier than others, depending on the procurement strategies (Karali 1999:9). Procurement strategies depend on the knowledge of mollusc's habitats, the technological background, and the amount of material intended to collect (Βεροπουλίδου 2011:56). Another factor affecting the final shell assemblage are choices made by exploiters, depending on the environmental settings of the area on the one hand, and possible cultural preferences on the other. These choices may change through time by various factors, such as environmental changes, changes in technology or better know-how, or due to overexploitation during previous periods (Karali 1999:9-11; Βεροπουλίδου 2011:60, Karali 2013:447,450).

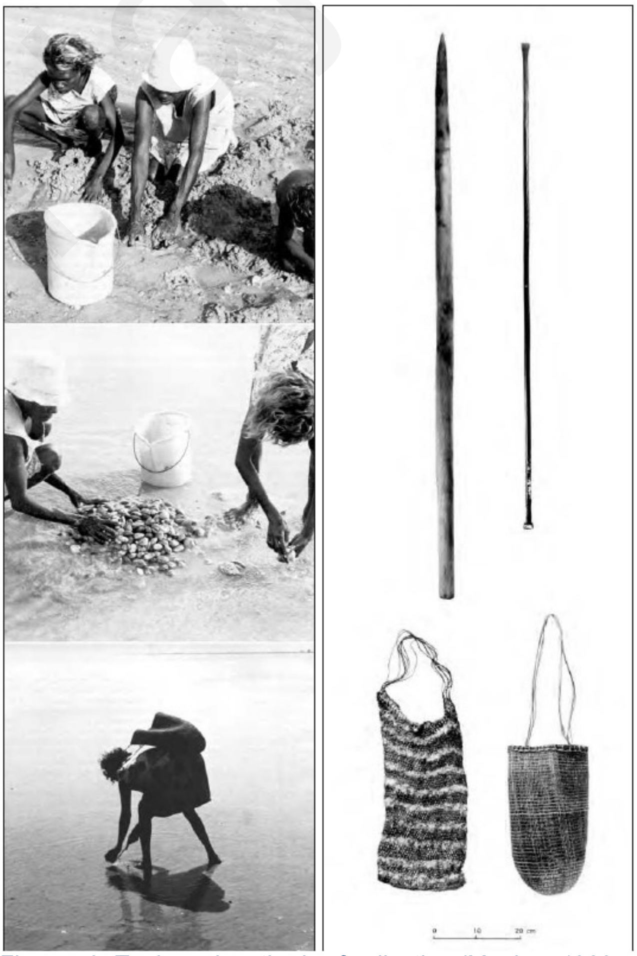


Figure 49: Tools and methods of collection (Meehan 1982: Plate 9, 11, 22 and 8; Βεροπουλίδου 2011:57, Fig.2.9)

The collecting of molluscs from the coastal zone is the most widespread practice, as this activity does not require any technological equipment (Βεροπουλίδου 2011:56). In shallow waters with soft substrates, molluscs can be collected on the top of the seabed. Buried molluscs leave marks in sand, such as lines and holes, and a collector with good knowledge of the mollusc lifestyle can acquire the animal by digging with his hands or with simple tools, such as wooden sticks, knives, chisels, forks or scoops (Fig.49) (Karali 1999:10; Βεροπουλίδου 2011:56; Winder 2017). On rocky substrates, molluscs are collected by detaching from the surface of the rocks either by hand or knife, or by hitting with a stone (Karali 1999:10; Βεροπουλίδου 2011:56). Species living in greater depths were obtained by diving and by using a boat. Further, molluscs were collected with the same techniques as in shallow waters. Another special equipment a diver might need was a weight, probably a stone, to facilitate the submergence and a bag for collecting catches (Karali 1999:10; Βεροπουλίδου 2011:58). Collecting of deep-dwelling molluscs can be a difficult and dangerous task and was often done by specialist collectors (Βεροπουλίδου 2011:58). More sophisticated methods of collecting were baskets or wicker twigs used as traps, attracting the prey with a bait or using a net in order to collect molluscs en masse. However, it is likely that these techniques were not focused strictly on collection of molluscs but rather to exploit more marine resources, such as fish, and subsequent collection of molluscs can be a coincidence (Βεροπουλίδου 2011:58).

Apart from living 'fresh' shells, generally associated with consumption, shells of dead molluscs are collected too. 'Dead' shells can be gathered on a beach after they were washed ashore by the sea. Eroded on a shore or in the water, shells of dead molluscs can bear several traces on the outer and/or inner surface of a shell. The surface can be bored by organisms, which may create a partial perforation of a shell. Wave action combined with soft substrate cause wear of inner and/or outer surfaces, represented by smoothed and rounded edges, disappearance of natural colouring, while pushing against hard substrate by water movement often result in the creation of scraps, disintegration of calcium carbonate, or the creation of irregular holes in the area of the vertebral column of bivalves (Βεροπουλίδου 2011:50). Level of water-wornness depends on the time for which a mollusc is dead, and a shell is exposed to the power of the sea. As such, in an assemblage, a shell can look fresh, although it was collected dead, but shortly after the death of a mollusc so that it was not exposed to wave abrasion for too long. In case of bivalves, although looking fresh, the presence of jointed valves also indicates that the shell was collected dead (Βεροπουλίδου 2011:50). Although not used as a food resource, dead shells still have plentiful options of utilization, such as, for instance, jewellery and tool manufacture, building material, or trade and exchange goods.

4.3. The shell utilization: consumption and shell modifications

Molluscs have been consumed since the early stages of human history. However, not all molluscs are edible. Scaphopods are not edible and served only as ornaments (Bar-Yosef Mayer 2007: 192). The rest, namely gastropods, bivalves, cephalopods, and polyplacophores are considered as edible. The most frequent groups located in archaeological sites are gastropods and bivalves, but the majority of gastropods are not consumed. Among frequently edible species are limpets, whelks, winkles, and ormers. Compared to gastropods, the bivalves's repertoire of edible species is much more extensive, including mussels, oysters, scallops, cockles, and many species of clam (Somerville et al. 2017:440). Although they are not strictly associated with nutrition, most of the eastern Mediterranean species are harmless to a consumer. The exception may be *Conus mediterraneus*, which has a poisonous gland in its chewing apparatus and its consumption can cause nervous paralysis and, more rarely, death (Βεροπουλίδου 2011:41). *Conus mediterraneus* has been recorded at several archaeological sites, meaning that this species should be associated with decorative purposes rather than with consumption.

Molluscs are rich in nutritional values, as they contain high values of nitrous substances, minerals, fats and non-nutritious extractive substances. As such, shells may represent a valuable source of nutrients. However, even in cases of large shell middens, the dominance of shells in human subsistence is improbable, as a large quantity has to be consumed to reach the equivalent nutritional values of meat of bigger animals (Karali 1999:12; Bailey and Flemming 2008:2156-2157; Βεροπουλίδου 2011:6-11, Karali 2013:447). For example, Bailey (1975 in Βεροπουλίδου 2011:8) estimated that a dozen thousands of shells (more specifically: 52,267 oysters (*Ostrea* sp.) or 156,800 oysters (*Cerastoderma edulis, C. glaucum*) need to be consumed to reach same nutritional values of a deer.

Molluscs can be eaten raw or cooked. In case of consumption of raw animals, flesh must be extracted first. The methods of extracting flesh do not require special tools, which were not used for other activities in a settlement (Βεροπουλίδου 2011:64). Gastropods are extracted from the shell by a sharp tool, such as an awl or needle, by the cutting off the apex, or drilling a hole in a shell while closed valves of bivalves are opened by a sharp and flattened tool (e.g a flint blade) which is inserted in the dorsal or ventral area and runs around the entire rim of a bivalve (Βεροπουλίδου 2011:63). According to Sommerlike et al. (2017:446) the upper (right) valves represent the primary waste while the mollusc is consumed from the lower (left) valves. Therefore, different distribution of left and right valves may differentiate between areas of preparation and consumption.

Thermal preparation of molluscs involves several methods, differentiated by the factors, such as the use utensils, the addition of water, the direct or indirect contact with fire or the temperature of the fire (Βεροπουλίδου 2011:66). Cooking methods involve boiling, steaming, roasting, and baking. The cooking of molluscs may further facilitate the extraction of flesh from the shells or valves, as bivalves open in boiling water and are then easily consumed and cooked gastropods can be easily removed from the shell by a pin (Prummel 2005:317). The cooking of molluscs does not require much time, which impede the creation of recognizable traces from the different methods of preparation (Βεροπουλίδου 2011:66,68). The only recognizable method is roasting when the shell is in direct contact with fire or fuel. The shell can be placed in a horizontal position atop of the fuel or with the lip in the soil and the fuel is atop. Shells can also be placed around the perimeter of the open hearth or on hot ashes when the fire has been extinguished (Βεροπουλίδου 2011:66). Spots with direct contact with the fire or fuel are marked by the change in colour of the external side of the shell, from white to grey (Prummel 2005:319; Βεροπουλίδου 2011:67; Karali 2013:447).

As already mentioned, apart from consumption purposes, shells were collected for tool manufacture and jewellery production. In general, shells represent a raw material, which is easily accessible on the beach, with a shape and size suitable for the human body, and often being naturally perforated in a form of ready-to-use beads which make them ideal for decoration (Bar-Yosef Mayer 2005b:176-177). Shells differ in shape, size, and hardness and thus were used as either worked on unworked tools for various purposes. Shells collected

Figure 50: Perforated Columbella rustica shell beads from Çatalhöyük (Bar-Yosef Mayer 2017:2, Fig.2)

both alive and dead can be used for tool and jewellery manufacture and a shell might be gathered as a food resource and subsequently used as raw material (Karali 1999:18; Karali 2013:447). Unworked shells can be used as a tool only once and then dumped and replaced with another piece. Such shells can be used for opening other shells, as scrapers or for imprinting a pattern of mouldable material (Karali 1999:19). Hardness of shells mostly correspond to that of bones; thus the same methods are used in shell manufacture: percussing, abrading, polishing, sawing, and drilling. According to Karali (1999:32) shell ornaments with natural holes are recorded since the Palaeolithic, while working and shaping of shell ornaments emerged in later phases, during the Late Neolithic and Early Bronze Age (Fig.50).

Tool manufacture involves either limited intervention or substantial alterations which often considerably affect their original form. However, it is necessary stress that the same marks can be caused by natural processes which makes the identification of shell tools demanding and the examination of marks should be executed under the microscope (Karali 1999:18-19; Βεροπουλίδου 2011:85). The most common shell tools involve spoons of various shapes, platters, lamps, spatulas, vases, trumpets, weapons, net sinkers, and shells were used to manufacture fishhooks, game-pieces, toys and figurines (Karali 1999:20-25,41-42; Serrand et al. 2005:414; Karali 2013: 450; Saliari 2013:37; Sommerlike et al. 2017:427; Bar-Yosef Mayer 2018:213; Fritz et al. 2021).

4.4. Interpretation of shell assemblages

Quantitative combined with spatial analysis may reveal important information about daily life, such as which molluscs were collected for consumption and which ones were assembled for decorative needs; or which part of a settlement can be associated with shell-manufacturing activities, shellfishing and shell-collecting activities and which was dedicated to dumping of food remains. However, one should keep in mind that the distribution and quantity can be affected by numerous factors of social and natural origin, as well as possible biases during their excavation and investigation (Saliari 2013 p.46). At a site, the distribution of shells can be affected by predators or birds, or by erosion and other site formation processes (Bar-Yosef Mayer 2005a:1; Bar-Yosef Mayer 2007: 192; Saliari 2013:38).

Shell deposits vary in quantity, from small heaps of single discard, homogeneous masses cumulated against walls or in ditches, middens resulting from continuous long-term deposition or single items or minor assemblage of exotic species, which may not be associated with consumption but rather with social practices (Somerville et al. 2017). Concentrations inside buildings may indicate either cooking activities or a workshop (Saliari 2013:42; Somerville et al. 2017).

Quantitative analysis of molluscs' species recovered at a site may indicate the scale of exploitation. Assemblages with a great number of species but with only a few species dominating may point to some level of specialization. On the contrary, assemblages with many species at lower frequencies are usually interpreted as small-scale, occasional and diverse type of exploitation (Βεροπουλίδου 2011:59). However, different shells may have different values for inhabitants of a particular site, ranging from ordinary food resource or raw material for jewellery manufacture, to exotic due to difficulties in obtaining them (distance, or depth), or can be related to ritual and/or burial practice (Bar-Yosef Mayer 2007: 191).

The distribution and the quantity of taxa can be influenced by distance from the sea and the role of species in human daily life. Some edible taxa can be consumed and discarded at the coast right after the collection and only part of the total collection can be transported to a particular site, which creates the disproportion in final assemblages with taxa gathered for manufacture (Ammerman et al. 2017). In addition, the role of shells can change with the passage of time, either in short-term, when shells collected for consumption can be further used for decorative purposes or tool manufacture, or in long-term, resulting economic and/or social changes (Saliari 2013 p.46).

The sizes of the shells may indicate the over-exploitation of marine molluscs' populations, which is evident in the reduction of sizes of the individuals. In regular natural conditions, molluscs vary in size, from the smallest to the large ones. In case of over-exploitation, molluscs have decreased chance to grow into the larger dimensions and in a particular assemblage, the species is represent by individuals with reduced size (Somerville et al. 2017:441-443; Winder 2017:477-479).

4.5. Molluscs: Methodology

One the objectives of this thesis is to understand the palaeoenvironment, based on mollusc habitat and to reveal the maritimity of the site through the methods of procurement and shell utilization, based on quantitative and spatial analysis.

The Shell assemblage of Paralimni *Nissia*, published by Reese (2008:113-154), was used for the quantitative and spatial analysis. At first, the ratio of fresh to worn shells was estimated, as it is necessary to determine how many shells of the total assemblage was probably collected alive and which were most likely collected dead. The quantity of fresh shells and their habitat preferences were used for the palaeoenvironmental reconstruction of the coastal area in the vicinity of Paralimni *Nissia*. The procurement strategies are proposed based on the ratio of fresh to worn shells of each species, with emphasis on ratio of shallow- to deep-dwelling molluscs. Quantitative approach was also chosen to reveal the ratio of worked and unworked shells. For the spatial analysis, the site plans were digitalized in ArcGIS and shell quantities were plotted in every sector. The aim was to visualise the distribution of shells, upper and lower valves of Spondylus, burnt and modified shells.

4.6. Shells in Paralimni Nissia

4.6.1. The mollusc assemblage

Five seasons of excavation at Paralimni *Nissia* yielded a total amount of 913 minimal number of individuals (MNI) (Table 7). The assemblage consists of sixteen species of gastropods, eight species of bivalves and one specimen of cephalopod. Apart from molluscs, the shell assemblage also involves one caphopod, *Sepia officinalis* (cuttlefish).

Gastropods with 798 MNI represent the dominant class of molluscs, followed by 154 MNI of bivalves. The most numerous species, *Patella* sp., represents 53.6% of total assemblage with 491 MNI. In Reese's catalogue, not all shells were identified at species level and the identification was left at genus level. Some species, such those of *Patella* sp., are hardly recognizable in archaeological material, moreover, such identification is rarely necessary for the purposes of archaeological analysis (Sommerlike et al. 2017:434).

Bivalve *Spondylus gaederopus* with 98 MNI is the second most common species, followed by *Charonia* sp. with 58 MNI, *Tonna galea* (58 MNI) and *Monodonta* sp. (57 MNI). Along with fresh marine molluscs, excavation revealed eight land snails, which were interpreted as intrusive, and 74 fossils of marine molluscs. According to Reese (2008:143), none of the fossils have been modified by man and most probably originate from local bedrock, or sea rocks used for construction.

Taxa	MNI	Species	Depth of habitat	Habitat	References
GASTROPODS	798				
Patella sp.	491		Intertidal	Rocky	Popper and Goto 1991:69-71; Ayas 2010:172-173
Monodonta sp.	58	19 MNI M. *turbinata*; 7 MNI M. *articulata*	Intertidal to few meters	Rocky	Poppe and Goto 1991:85-86
Charonia sp.	58	25 MNI of C. *sequenzae*	Shallow to deep	Gravel, rocky (hard substrates)	Poppe and Goto 1991:129-130; Karali 1999:22; 2013:450
T. galea	58		20-80 m	Any type	Poppe and Goto 1991:128
Phalium sp.	20		8-80 m	Any type	Poppe and Goto 1991:128
Bivonia sp.	14		Shallow	Rocky	Poppe and Goto 1991:109-110
M. trunculus	49		1-100 m	Mud	Poppe and Goto 1991:136
L. lurida	10		1-60 m	Sandy	Poppe and Goto 1991:124
C. mediterraneus	5		Shallow to deep	Rocky	Poppe and Goto 1991:131
T. haemastoma	4		Intertidal to deep	Rocky	Poppe and Goto 1991:141
E. cornea	2		Shallow	Rocky	Poppe and Goto 1991: 144
C. vulgatum	3		Shallow	Sandy, muddy	Poppe and Goto 1991:111-112
C. parthenopium	2		10-30 m and even more	Rocky	Poppe and Goto 1991: 176-177
F. lignaria	2		Shallow	Rocky	Poppe and Goto 1991: 150-151
C. rustica	1		Intertidal to shallow	Rocky	Poppe and Goto 1991:158
Fusus sp.	1		20-150 m	Muddy	Poppe and Goto 1991:135,147
BIVALVES	154				
S. gaederopus	97		Deep	Rocky	Βεροπουλίδου 2011:34,38;539
Glycymeris sp.	42	17 MNI G. *pilosus*	Deep	Sandy	Βεροπουλίδου 2011:34,38,537; Karali 2013:450
P. nobilis	4		Intertidal to deep	Sandy	Βεροπουλίδου 2011:34,39,538
A.tuberculatum	2		Intertidal	Sandy	Βεροπουλίδου 2011:38,534
A.noae	3		Intertidal to deep	Rocky	Βεροπουλίδου 2011:34,38,533
C. chione	1		Shallow to deep	Sandy	Coglievina et al. 2014
C. glaucum	3		Intertidal	Sandy, muddy, brackish water	Βεροπουλίδου 2011:39,534; Sommerlike et al. 2017:445
T. aurea	1		Intertidal	Sandy, muddy, brackish water	Βεροπουλίδου 2011:39,538

Table 7: Molluscs discovered at Paralimni Nissia, with their quantities (in MNI) and habitat. (Intertidal 0-0.5m depth, shallow 0,5-10 m depth, deep over 10 m depth)

4.6.2. Quantitative analysis

4.6.2.1. Fresh vs. worn shells

Reese's catalogue is detailed and usually describes whether the shell was fresh or worn, complete or fragmented, whether was burnt or was somehow modified. The only exceptions are *Patella* sp. and *Monodonta* sp., where information on whether they were fresh or worn is predominantly missing (Table 8). Only one *Patella* sp. is described as water-worn. According to Reese (2008:123) *Patella* sp. and *Monodonta* sp. certainly represent food shells at Paralimni *Nissia*. As such, it can be assumed that they were collected fresh. In case of *Charonia* sp., Reese (2008:120) mentioned that only four individuals were certainly collected dead (out of 20 MNI described as worn or water-worn. *S. gaederopus* with 97 MNI consisted of 48 MNI fresh and 47 MNI worn, of which one shell is described as worn but was collected alive. Out of 42 MNI of *Glycymeris* sp., 15 MNI were fresh and 24 MNI water-worn, of which, according to Reese (2008:121), 13 were certainly alive and 17 were clearly collected dead. *T. haemastoma, C. vulgatum, C. parthenopium, C. glaucum, A. tuberculatum, T. aurea, Bivonia, C. rustica, P. nobilis* and *C. chione* lack the information if they were fresh or worn though Reese (2008:121) noted that *Bivonia* may represent a minor food supply or were used as ornaments.

In total, 123 MNI were worn, of which one *S. gaederopus* is referred to as collected alive. Considering that all worn and water-worn shells were dead, 122 out of 912 shells (if we exclude sepia) could have been collected on the beach, meaning, that worn shells represent 13.4% of

Taxa	**MNI**	**Fresh**	**Worn/water-worn**	**Not specified**	**Not specified (without *Patella* and *Monodonta* sp.)**
Patella sp.	491		1	490	
Monodonta sp.	58			58	
Charonia sp.	58	38	20		
M. trunculus	48	23	19	6	6
T. galea	40	34	1	5	5
Phalium sp.	20	7	2	11	11
Bivonia sp.	14			14	14
L. lurida	10		1	9	9
C. mediterraneus	5		4	1	1
T. haemastoma	4	3		1	1
C. vulgatum	3	3			
E. cornea	2		1	1	1
C. parthenopium	2	2			
F. lignaria	2	1	1		
C. rustica	1			1	1
Fusus sp.	1		1		
S. gaederopus	97	48	47	2	2
Glycymeris sp.	42	15	24	3	3
P. nobilis	4			4	4
C. glaucum	3	1			
A.noae	3	1	1	1	1
A.tuberculatum	2	2			
C. chione	1			1	1
T. aurea	1	1			
TOTAL	912	179	123	608	60

Table 8: The quantities of fresh and worn/water-worn shells

the assemblage. Although some had bored exteriors, 180 (including that individual of *S. gaederopus* mentioned above) were specifically identified as fresh 19.7%. Due to the lack of description of *Patella* and *Monodonta* sp. In Reese's catalogue, these species are referred as none specified in Table 9. However, as these species were interpreted as food residues, the settlement yielded 547 MNI of these species, which is 60% of the total assemblage. Therefore, considering *Patella* and *Monodonta* sp. as fresh, these species, together with other fresh shells described in Table 6, represent 79.9% of the total assemblage. The remaining 60 MNI (6.6%) were not specified, presumably meaning that they did not contain any demonstrable marks of wearing and thus were potentially fresh.

It is necessary to keep in mind that these numbers are strictly hypothetical. Not all worn shells were collected dead, as indicated by several cases, for instance *Charonia* sp. and *Glycymeris* sp., and, at the same time, not all fresh shells were not certainly collected alive. Nonetheless, this quantitative analysis indicates that considerably higher number of shells were collected alive.

4.6.2.2. The shell utilization

Over 60 shells bear signs of possible decorative modifications (Table 9). Although there is a possibility that some might be of natural origin, i.e., abraded during the deposition and post-deposition, most of them demonstrate a unity in the placement of percurations and their shape. The features of modifications involve holes, body openings, lacking apex, and cutted lips. Only one shell of S. gaederopus was described as bearing a natural bored hole made from exterior (Reese 2008:132). Holes and body openings are associated with manufacture of pendants and other jewelleries (Karali 1999:27-28). Although apex can be eroded by natural causes, most of the M. trunculus with opened apex bear other possible modification, such as holes and opened body and Fusus sp. shell, which was lacking apex and had a hole, was interpreted by Reese as an ornament (2008:121). In addition, edible taxa lacking apex may indicate the removal of apex in order to extract the meet from the shell (Βεροπουλίδου 2011:63). Nonetheless, more than half of the Monodonta sp. sample are fragments lacking apical part, while 15 shells have the preserved apex. Shells with cutted lips were interpreted by Reese

Taxa	**MNI**	**Hole**	**Open body**	**Open apex**	**Cutted lips**
M. trunculus	27	10	15	12	
C. parthenopium	2	2			
Fusus sp.	1	1		1	
E. cornea	1	1			
L. lurida	5	1	3		1
Phalium sp.	10(+2?)	2	3		6(+2?)
Glycymeris sp.	1	1			
S. gaederopus	1	1			
C. mediterraneus	1		1		
Monodonta sp.	11			11	
T. galea	1			1	
Patella sp.	1		1		
TOTAL	62(+2?)	19	23	25	7(+2?)
	fresh	6	4	19	2
	worn	11	12	5	1
	Not specified	2	7	1	4(+2?)

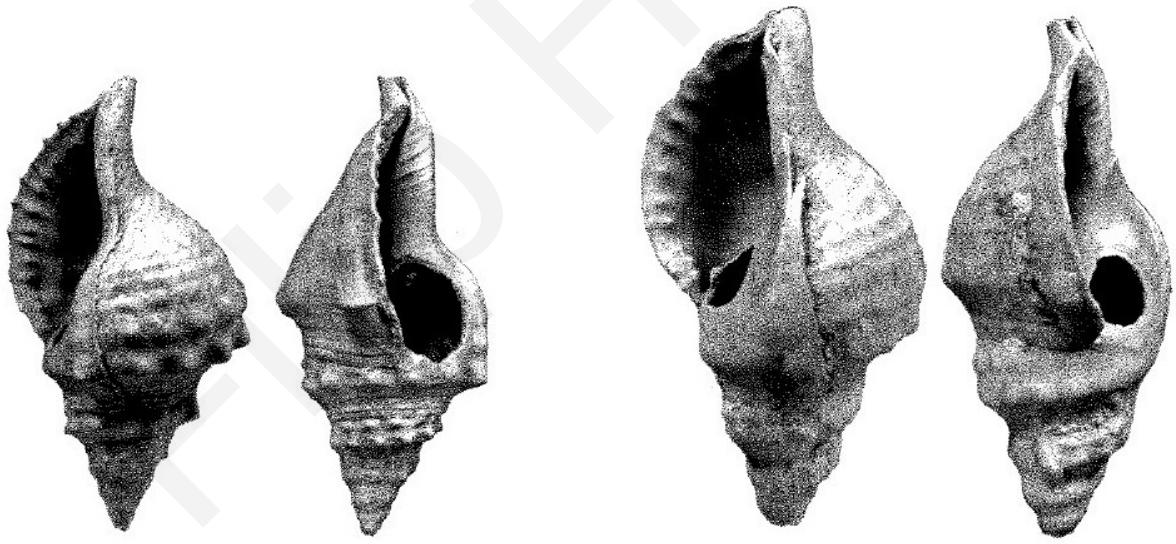
Taxa	**Vessel**	**Spoon**	**Platter**
Charonia sp.	7(+3?)		
T. *galea*	1?		
S. *Gaederopus*		1	2
TOTAL	7(+4?)	1	2

Table 9: Shells with possible anthropogenic modifications

(2008:120). As already mentioned, *Bivonia* located at Paralimni *Nissia* may have served as both food supply and decorative ornaments (Reese 2008:120). Finally, one shell of *Patella* sp. is lacking the central part and the upper part was smoothed down in order to manufacture a ring (Reese 2008:140).

7 *Charonia* sp. with catalogue numbers P.N.44,244,304,497,507,668 and 669, were interpreted as vessels (Fig.51) (Reese 2008:120,123). Three other shells of *Charonia* sp. and one large fragmentary shell of *T. galea* shells may been used as vessels (Reese 2008:123,143), but it cannot be said with certainty due to the level of their preservation. One very water-worn lower valve of *S. gaederopus* is lacking distal and was interpreted as a spoon (P.N.31) (Flourentzos 2008:17) and Reese (2008:127,128) further proposes that two water-worn upper valves, located in Houses 2 and 7, may have been used as platters. Finally, one worn upper valve of an animal, which had been collected dead, was uncovered with slightly chipped sides.

Out of the 912 MNI, at least 62 shells (6.8%.) were recorded as modified or possibly modified (having hole and/or larger opening on the body, cut lips, or used as tool). Holes and openings associated with decorative purposes were on 42 shells, of which 25 were worn or water-worn (59.5%), 9 were fresh (21.4%) and 8 were not specified (19.1%). Adding 9 lip fragments, the rate is less specific, with 51% water-worn, 21.5% fresh, due to the increase of unspecified shells (27.5%). Nonetheless, the prevalence of worn and water-worn shells is apparent. This analysis does not include taxa, such as *Bivonia* sp., which may have been utilized as ornaments as interpreted by Reese (2008:120). Moreover, as *M. Trunculus* may represent a hazard for its consumer, one may consider that this species may have been primarily collected for jewellery manufacture.



669 (1:3) 668 (1:3)

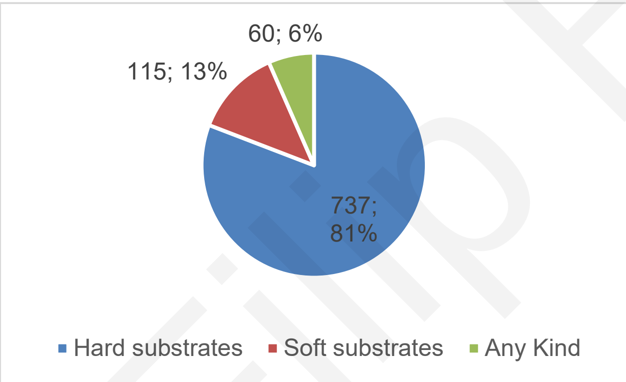
Figure 51: Charonia vessels (P.N.669) and (P.N.668) (Flourentzos 2008: Plate XCV)

4.6.2.3. Palaeoenvironmental reconstruction of Kaminoudhia Bay

In total, 10 of the recorded species live in shallow waters, 5 species occupy deep waters, and 9 species occur in both shallow and deep waters (Table 10, 11). Comparing habitats and MNI of all gastropods and bivalves, out of the total assemblage, 81% are molluscs living on rocky shores while 19% molluscs on soft substrates (Fig.52). Nonetheless, taking into account the preferred depths, species living in shallow to deep or in deep waters exclusively consist of 169

Taxa	Depth of habitat			Habitat			
	Intertidal	Shallow	Deep	Any Kind	Hard substrates	Soft substrates	
						Sandy	Muddy
T. galea			■	■			
Phalium sp.		■	■	■			
Patella sp.	■				■		
Monodonta sp.	■	■			■		
C. rustica	■	■			■		
Bivonia sp.		■			■		
E. cornea		■			■		
F. lignaria		■			■		
Charonia sp.		■	■		■		
C. mediterraneus		■	■		■		
S. gaederopus			■		■		
C. parthenopium			■		■		
T. haemastoma	■	■	■		■		
A.noae	■	■	■		■		
A.tuberculatum	■					■	
L. lurida		■	■			■	
C. chione		■	■			■	
Glycymeris sp.			■			■	
P. nobilis	■	■	■			■	
M. trunculus		■	■				■
Fusus sp.			■				■
C. glaucum	■					■	■
T. aurea	■					■	■
C. vulgatum		■				■	■

Table 10: Marine mollusc taxa recorded at Paralimni Nissia and their habitats



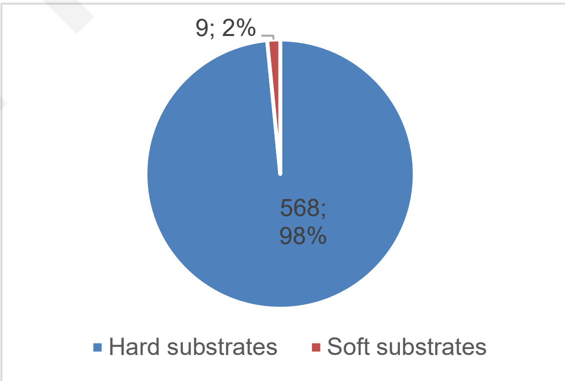


Figure 52: Two pie diagrams showing proportions of shells representative of hard or soft substrates habitats. Left: regardless depths; right: only intertidal/shallow depths

MNI (60%) living on hard substrate and 109 MNI (40%) on soft substrate, while T. galea and Phalium sp. (together 60 MNI) can live on all kinds of sediments. Considering that deep-living molluscs were collected alive, it is necessary to keep in mind that these species could have been collected offshore, which may create offsets in the analysis.

In order to combine palaeoenvironmental reconstruction based on mollusc assemblage with palaeocoastlines proposed in Chapter 2, molluscs living in the intertidal and/or shallow waters exclusively supposes to be considered. As such, shells, living in the intertidal zone and/or in shallow waters, are in total 576 MNI, with 567 MNI (98%) of those living on hard substrates and 9 MNI (2%) of molluscs habituating soft substrates (Fig.52). It is apparent that such contrast is caused by high MNI of *Patella* sp. And one may consider possible overrepresentation of this species. On the other hand, at the same time, hard-bottom-living molluscs have superiority in taxa representations in the total assemblage over those living on soft substrates in ratio 6:4.

Taxa	**MNI**	**Depth of habitat**		**Habitat**		
		Intertidal and/to shallow	Shallow to deep	Any Kind	Hard substrates	Soft substrates
T. galea	40		40	40		
Phalium sp.	20		20	20		
Patella sp.	491	491			491	
Monodonta sp.	58	58			58	
C. rustica	1	1			1	
Bivonia sp.	14	14			14	
E. cornea	2	2			2	
F. lignaria	2				2	
Charonia sp.	58		58		58	
C. mediterraneus	5		5		5	
S. gaederopus	97		97		97	
C. parthenopium	2		2		2	
T. haemastoma	4		4		4	
A.noae	3		3		3	
A.tuberculatum	2	2				2
L. lurida	10		10			10
C. chione	1		1			1
Glycymeris sp.	42		42			42
P. nobilis	4		4			4
M. trunculus	48		48			48
Fusus sp.	1		1			1
C. glaucum	3	3				3
T. aurea	1	1				1
C. vulgatum	3	3				3
TOTAL	912	575	335	60	737	115

Table 11: Marine mollusc taxa recorded at Paralimni Nissia and their habitats based on MNI

4.6.2.4. Spatial distribution

Reese (2008:119-120) already reported that a great concentration of shells had been recorded on the outskirts of the settlement, in squares N3, N3-4, N4 (Fig. 53). In this area, 347 MNI were discovered, which is 37.9% of the total. In this 263 MNI or 53.6% of the entire *Patella* sp. sample and 22 MNI or 38.6% of the entire *Monodonta* sp. Sample are included. Large concentration of shells was recorded also in Pyre Γ where 123 shells were unearthed. The assemblage is again dominated by *Patella* sp. with 101 MNI (20.6% of the entire *Patella* sp. sample).

Six Pyres were discovered within the settlement, however Pyre Γ has the richest shell assemblage. Pyre A yielded two shells, Pyre B three shells and Pyre Δ did not contain any shells (Flourentzos 2008:19). Additionally, Pyres A and Γ were filled with ash and charcoals. Moreover, Pyre Δ was constructed within House 19 and probably after its destruction.

Higher concentrations of shells were documented in Houses 24 (35 MNI), 19 (34 MNI) and 32 (31 MNI). Assemblage of House 24 is dominated by *S. gaederopus* (8 MNI), *Glycymeris* sp. (6 MNI), *T. galea* (6 MNI) and *Patella* sp. (6 MNI). It is worth mentioning that the largest concentration of Glycymeris sp. and T. galea were recorded in this House. The assemblage of House 19 is not dominated by any species. Within the House 32, two *Charonia* sp. vessels (P.N.507, P.N.304) were found in the northern and northeastern part of the house while concentration of 29 shells was documented in the western corner of the house. P.N.507 was found on the floor with a hearth, while P.N.304 was found beneath this floor. The concentration of shells in western corner is multi-level assemblage, not dominated by any specific species and containing six burnt shells (9.5% of all burnt samples). Burnt samples consists of 61 shells

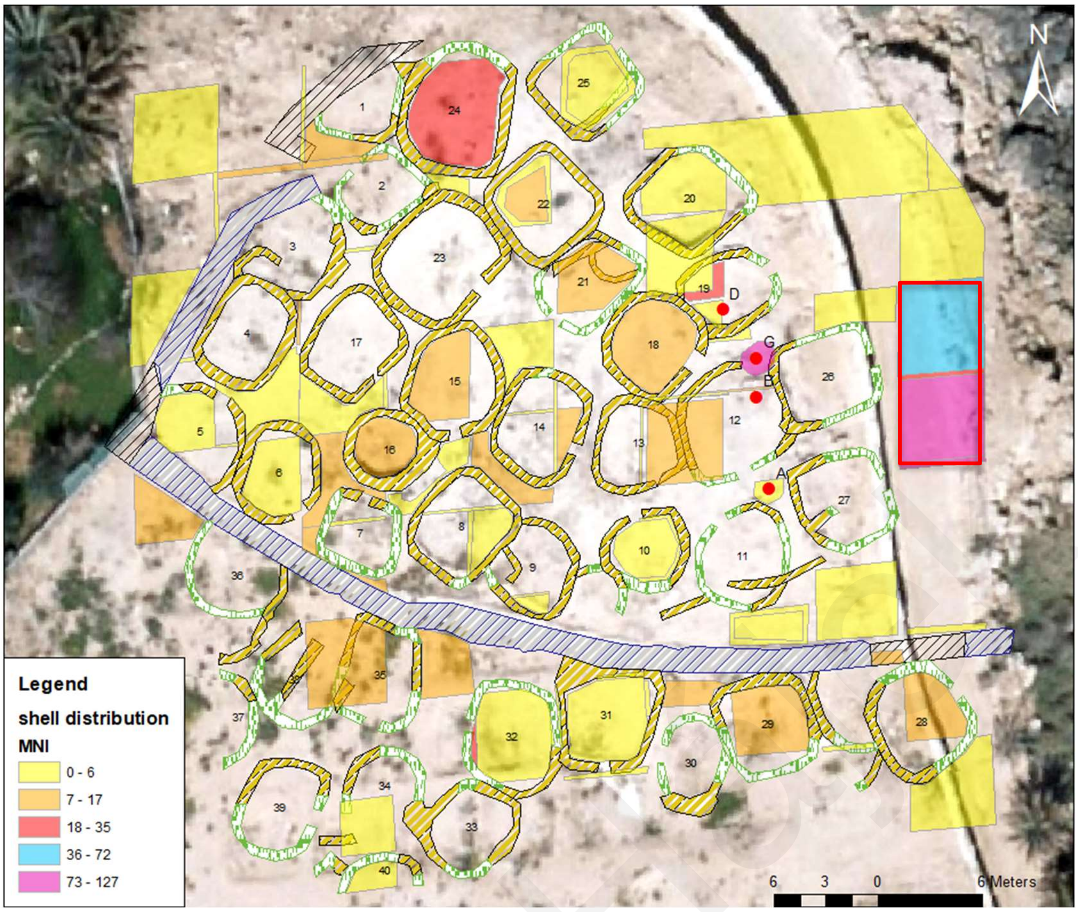


Figure 53: Shell distribution at Paralimni Nissia with Pyres A,B,G(Γ) and D(Δ). The map combines the site plan (Flourentzos 2008: FIGURE B) and catalogue of shells made by Reese (2008). The squares N3, N3-4, N4 are highlighted by red square.

Figure 54: Distribution of burnt shells

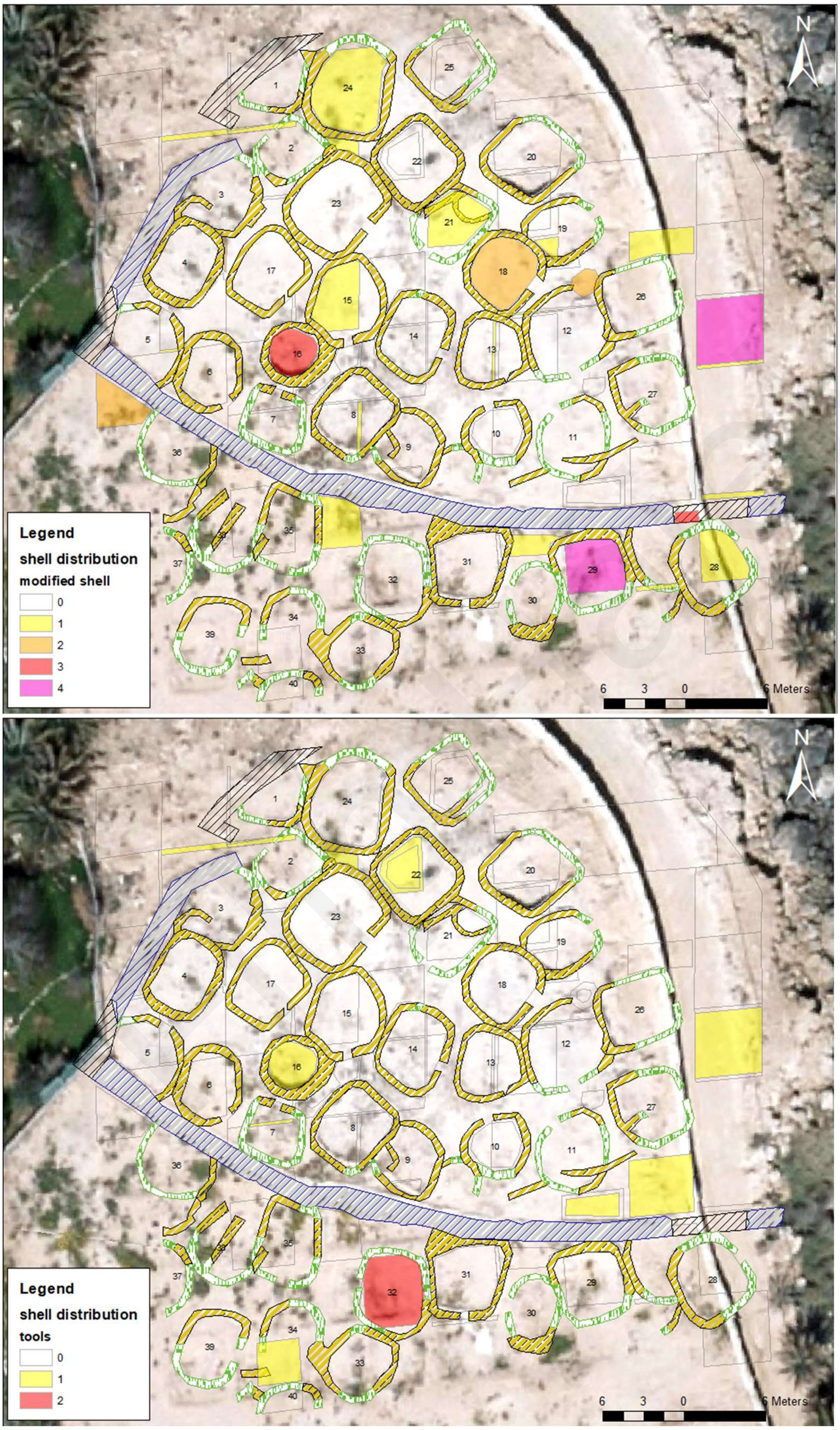


Figure 55: Distribution of possibly modified shells (above) and tools (below)

and two Eriphia cerrucosa (crab) claws (Table 12). Burnt shells were present in the section of House 12 (13MNI), and a single burnt *Phalium* sp. shell was located in House 20 (1 MNI). Besides Houses, concentrations of burnt shells were documented in the northeastern outskirts of the settlement and in Pyre Γ while individuals were also unearthed in open space areas along the surrounding wall (Fig.54).

Location	MNI	Amount
House 20	1	1.5%
between Houses 29 and 31	2	3.2%
section in H12	13+1	22.2%
Northeastern outskirts	24+1	39.7%
west of House 36	1	1.5%
outside the settlement to the northwest	1	1.5%
House 32	6	9.8%
Pyre Γ	13	20.6%
TOTAL	61+2	100%

Table 12: Locations and amount of burnt shells

Shells with possible anthropogenic modifications were spread through all the settlement, predominantly consisting of one or two pieces (Fig. 55). The largest concentration was documented again in the northeastern part of the settlement, in House 29, in House 16 and in the main entrance area. Again, in House 16 the samples originate from different phases of occupation and the same can be assumed for House 29, where shell assemblage comes from the stratigraphic sequence with height of 0.70 m and dwelling was during the timespan of occupation restructured (Flourentzos 2008:21). The assemblage from this house (9 MNI in total) consists of predominately broken shells of *Glycymeris* sp., *Monodonta* sp. and *C. sequenzae*. No other remains of any jewellery production have been reported. The distribution of shell vessels or shells used as tools does not show any concentration (apart from House 32 mentioned above).

Although shells at Paralimni *Nissia* are distributed all over the site, most of the deposits comprise low quantities of shells, counting from isolated finds up to little over ten pieces. These deposits may result from low-scale or single events of discarding, especially in outside areas, or waste from food processing and consumption. Furthermore, most of the assemblages come from layers ranging between 30-80 cm in height and thus may cover longer occupational sequences. Worth noting is House 18 which yielded 11 shells collected from one single floor. The house contained one of the largest assemblages of *Spondylus* and two modified shells.
Comparison with other food residues, such as animal bones, is not possible due to lack of published data. Nonetheless, taking in account fish quantities from wet sieving, the largest quantity corresponds with large quantity of shell in Pyre Γ.

5. Final Discussion

5.1. Shell-collection practice of Neolithic Cyprus

Quantitative analysis of the shell assemblage from Paralimni *Nissia* revealed that shells which were = collected alive represent 60% of the total assemblage. According to Reese (2008:123) *Patella* sp. and *Monodonta* sp, living attached to the rock within the intertidal zone, certainly represent the food resource. These shells can be thus collected by gatherers scouring the rocky coastline. No special tools are required for their collection and gatherers, who needed to know the habitat preferences of the shells, could collect them by their hands, or may have used flint knives or just simple stone to detach them from the substrates. *Patella* sp. and *Monodonta* sp. are also the dominant molluscs in assemblages of other sites, such as contemporary Ayios Epiktitos *Vrysi* in northern Cyprus (Ridout 1983:93). *Patella* sp. were also dominant species in the Ceramic Neolithic strata of Nissi Beach (Ammerman et al. 2017), at coastal Aceramic Neolithic sites of Cape Andreas *Kastros* (Reed 1978), Kissonerga *Mylouthkia* (Ridout-Sharpe 2003), and Upper Paleolithic site of Akrotiri *Aetokremmos* (Reese 1999). In Greece, *Patella* sp. was dominant in numerous Neolithic sites, for instance, Franchthi Cave in Argolid (Shackleton and van Andel 1980:357-359), or in Neolithic caves in Dodecanece, at Koumelo Archaggelou and Ayios Georgios (Karali 2003).

The great amount of *Patella* sp. in the shell assemblage of Paralimni *Nissia* may indicate a specialization in their collection. Each species of *Patella* varies in size and with average length of 31.79 mm, as such it is difficult to estimate whether the species was overexploited. At *Vrysi*, the average limpet length was 26 mm and Ridout (1983:93) proposed that the rather small dimensions of limpets indicates either over-exploitation of the species or that smaller shells were most palatable or easy to collect. However, as *Patella* sp. is the dominant mollusc in shell repertoires of the most Neolithic coastal sites (Karali 1999:16), one would have to further attribute this specialization to entire Neolithic societies. Furthermore, in areas with brackish and fresh water, other species are dominant, such as *Unio* sp. or *C. glaucum* (Karali 1999:14-17; Βεροπουλίδου 2011). As such, rather than specialized collection practice, large quantities of *Patella* sp. most likely simply result from the ease of their collection and the nature of environmental conditions in the vicinity of Neolithic sites.

At Paralimni *Nissia*, soft-bottom-dwelling molluscs living within the intertidal zone or in shallow waters are represented only by nine shells. Moreover, *C. glaucum* and *T. aurea*, which live in estuaries and in areas with brackish water are presented only by four individuals. *C. glaucum* was the dominant species at Neolithic sites of Makrygialos, Paliabela, A. Athanasios or Toumba, located along Thermaikos Gulf in Northern Greece (Βεροπουλίδου 2011) as well as in the Neolithic strata at Franthhi Cave (Shackleton 1988; Βεροπουλίδου 2011:163). Although it is likely that areas with brackish waters existed also in the surroundings of Paralimni *Nissia*, *C. glaucum* remains are sparse. Besides, limited amount of *C. glaucum* was also revealed at other Cypriot Neolithic sites, such as CN sites of Sotira *Teppes* and Ayios Epiktitos *Vrysi* (Reese 2008:122) or at aceramic Parekklisia *Shillourokambos* (Serrand et al. 2005). It is thus possible that *C. glaucum* shells were either deposited elsewhere and is underrepresented in the archaeological record or that these shells were not broadly exploited due to some unknown social preferences. Nonetheless, one may also consider who were the collectors of the shells. Limpets attached to the rocks within the intertidal zone are easily accessible, and thus can be collected by women and children (Meehan 1982:71). On the other hand, *C. glaucum* digs in sand and mud, and their collection may have not been preferred by Neolithic collectors.

Deep-living molluscs represent 36.8% of the total assemblage of Paralimni *Nissia* (336 MNI). Of that, 167 MNI (49.7%) were reported as fresh shells and 47 MNI were not specified. It is thus safe to assume that shells were also collected in deeper waters. This collection practice requires specialized and skilled shellfishermen (Βεροπουλίδου 2011:58). The collection methods involve the same tools as in shallow waters, i.e., bare hands or knives for detaching molluscs from hard substrates or wooden sticks or pools to unearth molluscs buried in soft-substrates. Additionally, collectors may have used bags for storing of gathered shells. Deepsea-shellfishing may have incorporated boats from which the collectors searched for shells from the surface and dived in when the shell had been spotted (Karali 1999:12). Collection methods may have also involved the use of traps with bait or nets (Βεροπουλίδου 2011:58). A considerable quantity of netsinkers was uncovered within the Neolithic settlement (Flourentzos 2008:89). Their (at least partial) use in shell collecting may thus not be excluded.

Out of dominant deep-dwelling species from the total assemblage, only one *T. galea* with opened body was recorded and another one was possibly modified into a vessel. All modified *Charonia* sp. were recorded as fresh. Only one *Glycymeris* shell bore a hole and out of 97MNI of *S. gaederopus*, one fresh shell possibly had a natural hole and three other individuals, two of which were possibly used as platters and one modified into a spoon, were all water-worn pieces. Comparing with other contemporary sites of Cyprus, larger shell assemblages were found at Ayios Epiktitos *Vrysi* and at Nissi Beach, while other sites yielded only few individuals. At *Vrysi*, above-discussed deep-living shells with considerable quantities are only *T. galea* (44 MNI) and *Charonia* sp. (42 MNI), while *Spondylus* sp. (5 MNI), *Glycymeris* sp. (18 MNI) were less frequent. While *T. galea* sample was more fragmentary than at Paralimni *Nissia*, these shells were represented predominantly by fresh shells and similarly as at Paralimni *Nissia*, only sporadically manufactured (only two *Glycymeris* shells bore a hole) and no vessels of *Charonia* sp. were found (Ridout 1983:94; Reese 2008:122). At Nissi Beach, shell assemblage is dominated by *Patella* sp. and *Osilinus* sp. while other molluscs, including *T. galea* and *S. gaederopus* are represented only by few individuals (Ammerman et al. 2017:140).

Reese (2008:123-125) stated that Paralimni *Nissia* yielded the richest assemblage of shell vessels from all known archaeological sites in Cyprus. Shell containers are known from the Aceramic Neolithic sites of Khirokhitia *Vounoi* (Dikaios 1953:439), Cape Andreas *Kastros* (Reese 1978:43), Petra tou Limniti (Reese 2008:125) or from numerous Neolithic sites in Greece, for instance, Knossos in Crete (Shackleton 1968b:264-266), Kitsos Cave in Attica (Karali 1999:23) or Ftelia on Mykonos (Karali 2002:207). In Greece, *Charonia* sp. and *Spondylus* sp. were used as spoons during the Neolithic and several examples are known from Franchthi Cave (Karali 1999:23) and Saliagos in Cyclades (Shackleton 1968a:122-138; Karali 1999:24), while one *Spondylus* shell at Franchthi Cave was manufactured into a chisel (Karali 1999:24). *Glycymeris* and *Spondylus* sp. were abundantly used in jewelry manufacture in Greece during the Neolithic (Karali 1999:40).

It is questionable why shell-collectors from Paralimni *Nissia* would run the risk of fishing shells in deep waters. As only few individuals were modified or presumably used as utensils, it seems that deep-dwelling molluscs were not collected for manufacture. Instead, it is likely that were collected for consumption needs. One may speculate whether their elaborate gathering increased their status in food consumption or even the social status of their collectors/keepers/consumers. Ethnographic records from Trobriand Islands of Melanesia documented the collection *Spondylus sp.*, where this deep-dwelling species was collected in context of great ritual celebrations, including the use of sacred tool and spells performed on the sea to make it clean, in order the facilitating the collection (Malinowski 1922:366-375; Βεροπουλίδου 2011:58). Special symbolic meaning is proposed by Karali (2013:450) for the worked objects found in Dhaskalio in Cyclades, where shell artifacts are made of *Charonia*. Therefore, the possible incorporation of the collection of deep-dwelling molluscs into symbolism and/or ritualism (at least) at certain sites cannot be excluded.

5.2. Paralimni *Nissia* as Mediterranean Fishing Village

As already mentioned in Chapter 2, apart from subsistence strategy combining exploitation of terrestrial and marine resources, Galili et al. (2002:171) proposed conditions for the recognition of prehistoric sites as MFV, involving wide variety of fish remains, from different biological niches without signs of selectivity, the presence of fishing gear and tools associated with fish procuring activities and incorporation of fish and fishing activities into symbolism. Nonetheless, their assessment is mainly oriented towards fishing, due to the large quantities of fish remains uncovered at Atlit-Yam and other Neolithic submerged sites along Carmel coast. Fish remains at Paralimni *Nissia*, however, are scarce, represented only by 20 fragments of larger fish (Croft 2008:105). Reese (2008:148) mentioned only nine fish bones in his catalogue, of which two were shark/ray vertebra holed in the centre (Fig.56). Additionally, the site yielded two crab claws and two turtle bones. Croft (2008:101-102) stated that fish remains, and other marine fauna recovered at Paralimni *Nissia,* are seriously under-represented. The reason may have been that very little wet sieving was done and only four wet sieved samples were taken, of which three yielded small fragments of fish bones (Table 13, Fig.57). Similarly, Ayios Epiktitos *Vrysi* yielded a mediocre quantity of fish and marine fauna remains. Interestingly, while both Paralimni *Nissia* and Ayios Epiktitos *Vrysi* yielded large quantities of molluscs, no shells were recorded from Israeli Neolithic submerged sites (Galili et al. 2004b:25). As marine shells occur in assemblages of inland Neolithic sites (Reese 1991, Bar-Yosef Mayer 2007), Galili et al. (2004:25) argued that the absence of marine shells in coastal Neolithic sites may result from the preference of other sources in food consumption, considering shells as trade good rather than food resource or the raw material, or from taboo customs that precluded the consumption of molluscs. As such, it is possible that different consumption habits and/or social preferences occurred in Cyprus and southern Levant.

203 (1:1)

Figure 56: Shark/ray vertebra holed in the centre, 13.75 mm in diameter (Reese 2008:150)(P.N.203) (Flourentzos 2008: PLATE XLIX)

Considering the shell consumption at Paralimni Nissia, the low number of burnt shells suggest that the preparation of molluscs involved methods that do not expose shells to open fire, such as steaming, boiling, or that they were consumed fresh. However, burnt samples indicate that

Sample	Area	Amount of fish fragments
Sample 1	Shallow pit outside of House 16	3
Sample 2	Pyre A	over 100
Sample 3	House 2	0
Sample 4	Pyre Γ	ca. 24

Table 13: Wet sieving samples and quantities of fish remains (after Croft 2008:105-106)

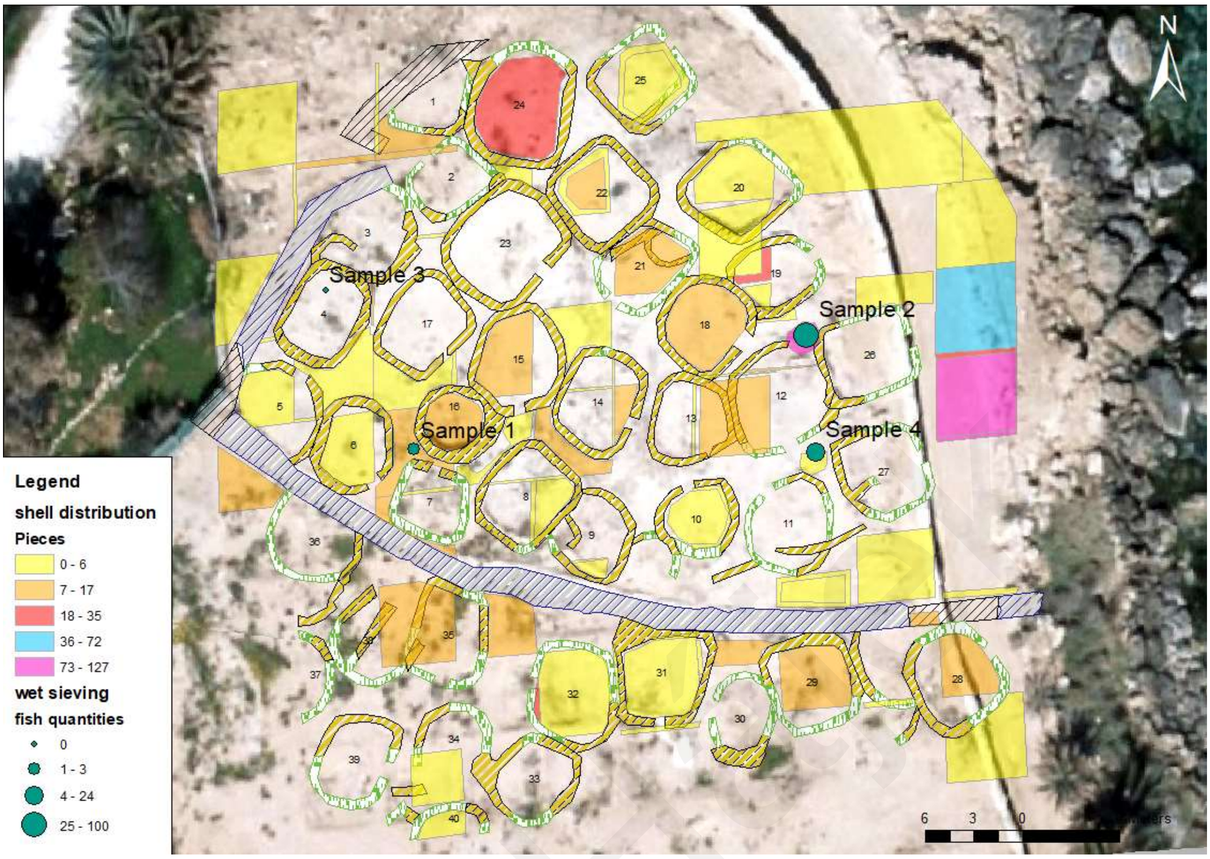


Figure 57: distribution of shells and location of wet sieving samples with quantities of fish bones

these shells were in direct contact with fuel, which left traces of burning in grey colour. Therefore, baking shells in ovens, on ashes. or on the periphery of hearths cannot be excluded. Burnt shells were concentrated in dumping areas, including Pyre Γ and northeastern outskirts of the settlement, which may point to discard of destroyed shells after culinary accidents. The only in-house concentration of burnt shells was documented at House 32, which is most likely a multi-level deposit, cumulated during the timespan of the dwelling.

Besides quantities of marine fauna, Paralimni *Nissia* meets another condition for the recognition as MFV, i.e., occurrence of marine-related finds, such as fishing gear and figurines of marine fauna. Distribution of marine-related artifacts revealed apparent concentration in eastern part of the settlement, notably at Houses 20 and 12. Worth noting is the concentration of two marine fauna figurines accompanied with considerable quantity of shells that was documented at House 32. However, no interpretation is possible due to lack of any other evidence. Association of axe and blade concentration with maritime activities is disputable but ,nonetheless, cannot be excluded. Lastly, regarding the incorporation of marine aspects into symbolism and ritualism, based on the quantity of fresh shells of deep-dwelling molluscs and the occurrence of figurines and the amulets possibly associated with marine fauna and exploitation, one may consider that not only daily life, in terms of consumption and decoration, but also beliefs had been influenced and shaped by the connection to the sea.

Finally, assuming that the sea level rise was linear in time, without any vertical changes and considering that palaeocoastline(s) proposed in Chapter 3 reflect the reality, the minimum distance between the sea and the settlement was app. 80-210 m, which is in contrary with the assumption of Galili et al (2002:171). They proposed that the close distance to the sea may impede farming activities due to increased salinity of the soil caused by ocean spray.

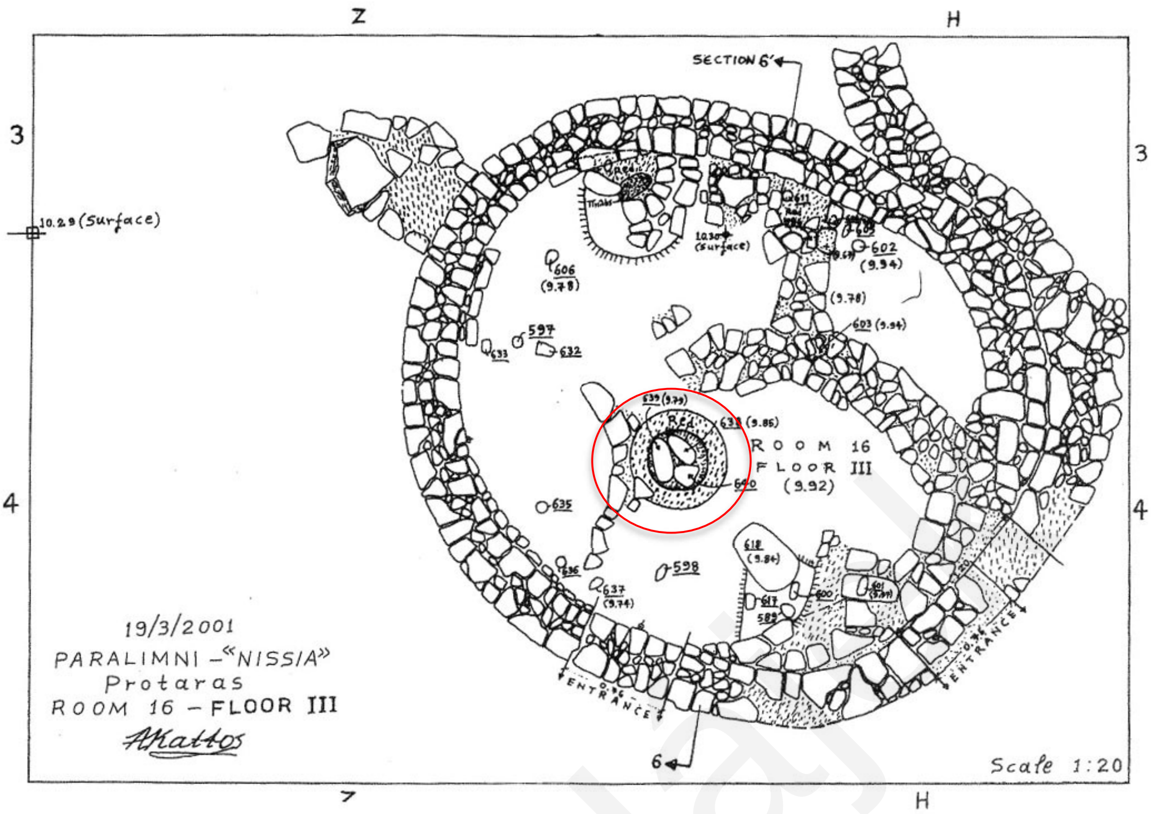


Figure 58: The plan of Floor III of House 16. The construction of hearth (in red circle) on this floor involved the mixing of havara, red soil and sand, and the inclusion of three pieces of oblong querns (P.N.638,639,640) (Flourentzos 2008: FIGURE H)

Nonetheless, Paralimni *Nissia* yielded large quantities of tools associated with farming and crop processing, such as grinders, mortars, pestles, and pounders. Moreover, Floor III of House 16 yielded a hearth with the inclusion of three oblong mortars, which, according to excavators (Flourentzos 2008:12) suggest the ritual meaning and possible association with cult of agriculture related with the preparation of bread was proposed (Fig.58). Therefore, there are no doubts that agricultural activities were important aspect of the economy at *Nissia* and farming, together with hunting and marine resource exploitation, was practiced in the vicinity of the site. It is thus less likely that Paralimni *Nissia* was the satellite village of some unknown greater settlement.

5.3. Environmental reconstruction

The modern coastline of Kaminoudhia Bay is predominantly rocky with small cliffs and one sandy beach, while the seabed is covered by a layer of sand, presumably 1 m thick, as indicated by probing executed in the bay during the field survey. Such an environment represents a sufficient habitat for molluscs living both on rocky shores (*Patella*, *Monodonta* sp.) as well as sandy seabed (*C. vulgatum*, *C. glaucum*, *A. tuberculatum* and *T. aurea*) within intertidal zone and shallow depths. Shell assemblage of Paralimni *Nissia* indicates that the coastline was also predominantly rocky during the Ceramic Neolithic period. However, bathymetry combined with geomorphological markers suggests that during the Ceramic Neolithic Kaminoudhia Bay was more protected by exposed northern promontory to the north and by *Nissia* coves to the south, and thus cumulation of soft sediments within the bay cannot be excluded. As mentioned above, the small river of Potamos tou Lombardi was flowing around the hillock with the Ceramic Neolithic settlement atop, with the estuary situated along the palaeocoast. Another small river was situated to the north from the site, with the river

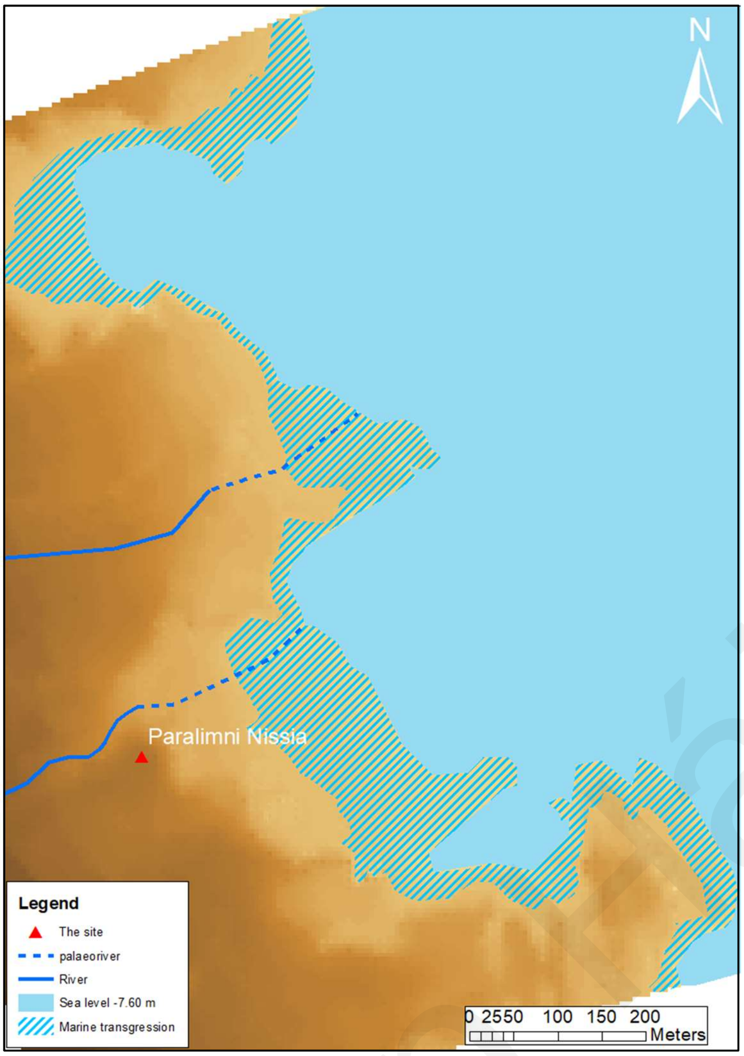


Figure 59: Coastal landscape during the occupation of Paralimni Nissia. The reconstruction demonstrates the marine transgression, based on palaeocoastlines (between -7.60 to -4.30 m) proposed in Chapter 2. Palaeoriver channels are generated from contour lines

mouth somewhere in the area of the submerged rocky promontory, as bathymetry suggests (Fig.59). Considering that the coastline was predominantly rocky, as indicated by the dominance of hard-bottom-dwelling molluscs living in intertidal and/or shallow waters, one may suggest that if *C. glaucum* and *T. aurea* were collected in the immediate vicinity of the site, they could originate from the brackish environment around the mouths of these rivers.

The predominance of molluscs living on hard substrates can be caused by overrepresentation of species living in these habitats, as mentioned above. The similar pattern was documented by Shackleton and Van Andel (1986:141) at Franchthi Cave in Greece, where they pointed out that hard-bottom-dwelling molluscs were more abundant than molluscs habituating soft substrates, despite the greater distance to such environmental zones. Therefore, one needs to stay cautious and keep in mind that shell assemblages reflect both the coastal micro-environment of the site as well as social preferences.

If Flourentzos' (2008:96) assumption is correct and the settlement was occupied since the beginning of fifth millennium BCE till the edge of the fifth and the fourth millennium BCE, it is likely that Neolithic villagers experienced the considerable rise in sea levels. Assuming that the sea level rise was linear, comparison of the reconstructed coastlines attributed to the beginning and the end of the fifth millennium BCE indicates that within the nearly 1000 years, the sea level rose from -7.60 m to -4.30 m, when the area of the bay increased by 40%, from ca. 93 000 m^2 to 131 000 m^2 and the coast approached the site from ca. 210 m to ca. 80 m at the nearest point (Fig.59).

Vertical changes caused by tectonic activity are beyond the scope of this thesis. Nonetheless, it is worth noting that hypothetical palaeocoastline reconstructions proposed in Chapter 4 are based predominantly on tidal notches. As described above, tidal notches are formed during the stable sea levels and their vertical displacement result from sudden change in sea level (Bird 2008:47,52). Therefore, the existence of tidal notches in many different elevations underwater may point to vertical movements of the coast. The subsidence of harbour of Salamis, located ca. 25 km to the north of Paralimni Nissia as the crow flies, was addressed to 345 CE earthquake (Flemming 1978). However, in the same area, Galili et al. (2016:204)

Figure 60: Marine Isotope Stage 5e tidal notch at Cape Greco at an elevation of 30 m (Zomeni 2012:107,Fig.2-29)

reported a beachrock located at the present sea level along the coast of Famagusta Bay, which contained possibly Roman sherds and thus they suggested that the tectonic changes were minor during the last 2500 years. Furthermore, based on positions of Pleistocene marine terraces, Zomeni (2012:120) proposed the coastal uplift rate of 0.19 mm/y for the area of Protaras-Ayia Napa. It means that since the site was abandoned, some 6000 years ago, the coastline has uplifted for 1.12 m. Moreover, one needs to ask to which geological time tidal notches belonged. During the Pleistocene the sea level changes varied from -130 m up to +6 m and possibly +13 to + 15 m during the interglacial periods (Rohling et al. 1998; Benjamin et al. 2017), emerged coastlines have been recorded in Cape Greco (Fig.60). Therefore, due to lack of dating it is not possible to exclude that any of the proposed palaeocoastline corresponds to former sea level, prior to the Holocene. As such, without further research, it is not possible to reveal the influence of tectonic activity on the Kaminoudhia Bay.

6. General conclusions

The coastal landscape of the Ceramic Neolithic site of Paralimni *Nissia* was examined through geomorphological observations of the area, sea level studies and bathymetry, and mollusc assemblages recovered within the settlement. Geomorphological markers, consisting of possible tidal notches, stumps, and signs of abrasion, were located during the field survey and indicate five distinct palaeocoastlines. Although quantitative analysis of shells points to predominantly rocky coastline, one needs to take into consideration the overrepresentation of several species caused by preferences in procurement strategies and/or social needs and beliefs.

Large quantities of molluscs, together with other marine fauna remains and marine-related artifacts points to the importance of marine resource exploitation at the settlement. This, alongside strong evidence of agricultural and hunting activities, means it is safe to conclude that Paralimni *Nissia* meets all conditions proposed by Galili et al. (2002) to be recognized as MFV.

As such, one may conclude that the environmental approach towards the maritimity of the Neolithic settlement provides information not only about the possible appearance of the littoral zone in the vicinity of the site and the positions of palaeocoastlines and specific environmental zones, but also how Neolithic people may have exploited, utilized, and understood the coastal environments. Leaving hypothetical reconstructions aside, future steps could involve incorporation of remote sensing techniques, in order to reveal the composition of the seabed, while geological coring and dating of samples could show the changes in environmental zones and the location of palaeocoastline(s).

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