[Based on corrections to: Fourth_Report_RDAC_4.doc
16 March 2011; the last section was revised and updated in March of 2012]

Fourth Report: Excavations at Nissi Beach

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1. INTRODUCTION

The purpose of this report is to present some of the findings from our recent excavations at Nissi Beach, the open-air site located just to the west of the town of Agia Napa on the south coast of Cyprus. Previously, three articles have appeared in the *RDAC* on our investigations at early sites of Cyprus. The first report dealt with the reconnaissance work that led to the discovery of Nissi Beach and Aspros in the Akamas in 2004 (Ammerman *et al.* 2006). Each of the sites is situated on the coastline today, and both of them occur on formations of aeolianite -- the name given to old sand dunes that have become lithified over the course of geological time. At first glance, the aeolianite appears to be a rather barren and inhospitable place. Accordingly, those who conducted archaeological surveys on Cyprus over the years took little interest in examining this part of the landscape. It was only in 2004 that this began to change. As we now know, there are early archaeological sites all around the island on the formations of aeolianite. The aeolianite represents a good place for a small group of coastal foragers to make a short-term campsite since there is little in the way of vegetation to clear and the thin soils there are soon dry even after a heavy rainstorm. Moreover, in some place, the aeolianite offers what amounts to built-in, stone-age furniture (Ammerman *et al.* 2008, fig. 7; see section 3 below). In the second report (Ammerman *et al.* 2007), the emphasis shifted to placing the two new early sites in environmental context. In addition, there was the chance to report on Alimma, a small satellite site that is located 200 m. to the north of Aspros. We also introduced the hypothesis that the origins of seafaring in the eastern Mediterranean (on a regular basis and not just accidental voyages or rare cases of rafting) go back to the time of the Younger Dryas, the cold snap at the end of the last ice age (Ammerman *et al.* 2006, 18). Working independently on a review article in the same year, Broodbank (2006) came up with the same idea -- the connection between the Younger Dryas (ca. 10,800-9,600 cal B.C.) and the birth of Mediterranean seafaring. Previously, the evidence for pre-Neolithic sites on the offshore islands of Cyprus and Crete in the eastern Mediterranean was so thin that no one was in a position to advance this hypothesis (Ammerman *et al.* 2007, 15-20; Ammerman 2010). The third article included a report on the results of the underwater survey carried out in front of Aspros in July of 2007 (Ammerman *et al.* 2008, 4-11; see now Ammerman *et al.* 2011). It also reported on the trial excavations that were initiated at Aspros and Nissi Beach in the same year. Given the thin soils that occur on the aeolianite, the challenge was a considerable one: that of identifying good places at the respective sites where chipped stone tools could be recovered in the context of well-developed paleosols. The focus of the fourth report will be on the excavations that were conducted in the swale area at Nissi Beach in 2008 and 2009. The fieldwork was again done in collaboration with Pavlos Flourentzos, who was the Director of the Department of Antiquities at the time. The work now led to a new and unexpected finding: coastal foraging did not come to an end once the aceramic Neolithic made its appearance on the island. Instead it persisted much longer than anyone had thought. As we shall see, there was the persistence of coastal foraging as a way of life well into Neolithic times.

It is worth saying a few words at this point about the organization of the article. The aim of the first section is to provide background information on the site and the approach that we took to its excavation. The second section presents the multiple lines of evidence that now confirm that the site has an inverted stratigraphic sequence, which is due to the action of one or more tsunamis over the centuries. Shown in Fig. 1 is the excavation in progress at Nissi Beach and also one of the tsunamis blocks resting on top of the nearby coastal cliff (at an elevation of about 8 m. above sea level today). In effect, the oldest chipped stone artefacts at Nissi Beach are found on the surface of the site. One of the major gains of the 2008 season, as mentioned in our third report (Ammerman *et al.* 2008, 12), was a better understanding of the many fragments of beach rock on the site's surface. This arose from our collaboration with Ioannis Panayides of the Cyprus Geological Service. Along the coast in a position just above sea level, beach rock forms in the exposed aeolianite (see Fig. 3). The rich biological life of the tidal zone gives the beach rock its distinctive dark colour. Previously, we had interpreted the many small dark fragments of rock on the site's surface as burnt pieces of aeolianite (Ammerman *et al.* 2007, 12). Panayides now took a closer look at them and realized that most of them were, in fact, pieces of beach rock. The inference to draw was that a major natural event, such as a tsunami, had dislodged pieces of beach rock from the cliff face and tossed them up on the site. An event of this kind would also have swept up pieces of chipped stone resting on the seabed (that is, archaeological material at one or more early sites that once stood on land but over the course of time found themselves in a submerged position due to sea-level rise) and redeposited them on top of Nissi Beach. Accordingly, we now made plans to undertake a more quantitative study of the beach rock fragments at the site in 2009. Studies of the soils in the upper part of the site, based on grain-size analysis, would be conducted as well.

The third section of the article turns to the archaeological features that came to light in 2008 and 2009. All of them were recovered in the context of the reddish-brown paleosol in the swale. This section also considers some of the wider implications of the features for our understanding of the use of space at the site. It was far from clear at the start of the excavation in 2007 whether any features would be found at all. On Cyprus, no one had tried to excavate an early site on the aeolianite before. The main point to make here, by way of introduction, is that the swale at Nissi Beach turns out to be quite rich in this regard. The fourth section deals with the marine shells recovered at Nissi Beach. It is written by Ken Thomas who recently completed the study of the marine shells from the 2008 and 2009 excavations. Thomas first summarizes the wide range of species that occur in the shell assemblages and then goes on to consider the shells in the context of the local coastal ecology. The article closes with a discussion in section 5. It comments on the role of "big events" – such as tsunamis and the Younger Dryas -- in the early prehistory of Cyprus and on the persistence of the coastal foraging at Nissi Beach well into Neolithic times.

Here a few words need to be added on the swale at Nissi Beach. By definition, a swale is a low-lying place on the landscape. In our case, the term is used for the low area in the aeolianite formation that occurs on the east side of the site. On the Quick Bird image map of Nissi Beach (Ammerman *et al.* 2006, fig. 5), the swale is seen as a dark patch on the ground located just above Transect II. Its darker colour comes from the vegetation cover there, which is connected with the greater depth of the soil in the swale. Elsewhere the aeolianite at Nissi Beach has very sparse vegetation. The swale has more or less a rectangular shape (with a southwest to northeast orientation) and it measures about 40 m. in length and 20 m. in width. At a distance of ca 15 m. to the south of the swale, there is the low crest of an aeolianite ridge (reaching an elevation of ca. 9.5 m.) which runs more or less parallel to the coast and which has always protected the swale area from winds blowing from the sea. At the same time, the crest would have offered a good place to look out over what was once the low coastal plain on the south side of the site (in the time before 6,000 years ago when sea level was lower) as well as the interior on its north side. In short, for those who led a coastal way of life, the swale together with the nearby crest would have formed a special place on the landscape. As shown by the surface collections at Nissi Beach, the swale represents the richest part of the site (Ammerman *et al.* 2007, fig. 4). The surface there has on average 3.3 pieces of chipped stone per square metre. Given the size of the swale, one can estimate that there are some 2,500 pieces of chipped stone on its surface alone (Ammerman *et al.* 2007, 11). Thus, if one is thinking of making an excavation at Nissi Beach, the swale is the natural place to turn.

The question that now came up was where to put the trial trench in the swale area. Here the choice was far from obvious. In the end, we chose to place the trench on the southwest side of the swale where the bedrock comes up to the surface. Specifically, the centre of large circle **H** was used as the southwest corner of the trial trench (for an overhead photograph showing the position of the 1 x 2 m. sounding, see Ammerman *et al.* 2007, fig. 5). In retrospect, this turned out to be a good choice, since the slightly elevated bedrock along the south and west sides of the swale once formed a well-defined space where those living at the site were able to sit (Ammerman *et al*. 2008, 12; for the location of the two metre squares excavated in 2007, see Fig. 2). More will be said in section 3 about the "basin" feature that came to light along the south side the swale in 2008 (see Figs. 8 and 9). It is perhaps worth adding here that in 2007 our recent experience at Aspros (where we had dug four small trial trenches in the weeks before we began the excavation at Nissi Beach) had drawn our attention to the possibility that the aeolianite bedrock could function as built-in, stone-age furniture. This was one of the insights that we brought with us when we moved to Nissi Beach. The approach that we took to the first excavation season was to work on a small scale and to dig cautiously. The decision was made to work in February when the soils at the site are in a moist condition. On Cyprus, there is usually some rainfall in the winter months (December, January and February). On the other hand, the soils on the aeolianite are quite dry and hard during the rest of the year. Moreover, on the practical side, there are few tourists at Nissi Beach in the winter months. It will be recalled that the site is located in the heart of a major tourist area. Every year, from April through October, there are several hundred tourists within a short distance of the site. The decision was made to record in three dimensions all of the pieces of chipped stone recovered by hand during excavation. This was also done for the other classes of material, including the larger pieces of marine shell. All of the excavated soil was dry sieved, and soil samples were taken for flotation. Flotation and the water separation of materials were implemented at Nissi Beach in 2009, when the samples taken for this purpose in previous years were processed as well.

Figure 2 shows the position of the metre squares that were excavated over the course of three years (2007-2009). In the first year, two squares (**1** and **2**) were dug on the south side of the swale, as mentioned before. Since they both produced positive results, we decided not to open a second trial trench in 2007. Fortunately, we had chosen a place where the soil reached a depth of 25 cm. and where pieces of chipped stone and ground stone were recovered at this depth in the ground. Just below a thin upper soil with a light colour, there is a well-developed paleosol that goes down to the top of the bedrock. This paleosol has a colour that varies from reddish brown to dark reddish brown (in a moist condition, the soil colours fall between the pages called Hue 5 YR and Hue 7.5 YR of the *Munsell Soil Color Charts*), and it has a much finer texture than the horizons of the upper soil (see Fig. 5). It will be recalled that the soils that form on the formations of aeoliante are not good for the purpose of agricultural (Ammerman *et al.* 2007, 23). There is little or no indication that the paleosol in the swale has been disturbed by cultivation over the centuries. In all, the trial trench produced 16 pieces of chipped stone, 5 fragments of ground stone and a number of marine shells. The chipped stone was produced by means of a pebble-and-flake based reduction technology (much like the one previously reported for the surface collections at the site; see Ammerman *et al*. 2006, 11-17; Ammerman *et al.* 2008, 12). In addition, there were two whole *Patella* shells that made it possible to obtain radiocarbon dates, which were run at Oxford and Groningen. When the determinations are calibrated and corrected for the reservoir effect, they both date to the eighth millennium cal B.C. (Ammerman *et al.* 2008, fig. 6; see Fig. 11 below). All in all, the results of the trial excavation were quite promising.

In 2008, ten more squares (**3**-**12**) were excavated in the swale. Here only a few of highlights of the second season will be mentioned – with an emphasis on those things that are not covered in other sections of this report. By the end of the second season, one could begin to make out the basic configuration of the aeolianite.

As shown in Fig. 6, the bedrock stands in a slightly higher position on the south and west sides. The surface of the bedrock also has a more rounded and weathered appearance there than it does in the squares on the north side (**7-9)** and the east side (**11** and **12**). In the latter case, the paleosol resting on the bedrock consistently has a thickness of 20 to 25 cm. In square **5**, a small hearth with a circular shape was recovered near the base of the paleosol. In addition, there was evidence at ten different points in the 2008 excavation for small burnt patches of soil with reddish and black colours. Finally, on the east side of square **12**, we could see that the bedrock (on the basis of its more reddish colour and friable character) had been exposed to a high temperature. In other words, there was good reason to think that activities involving the use of fire had once been done in the swale. The most interesting feature found in 2008 was the "basin" in the aeolianite in square **3**. As mentioned in the third report (Ammerman *et al.* 2008, 15 and fig. 7) and presented in more detail in section 3, this feature began its life as a natural depression in the bedrock, and it was then purposefully modified to create an enclosed storage space. At the same time, the new squares continued to produce pieces of chipped stone (10 pieces on average from the paleosol in a given square), fragments of ground stone (2 to 3 pieces per square) and a few whole marine shells (in each square; see section 4).

In February of 2009, there was the chance to add 15 more squares. The project had now reached the stage where it was time to bring out more specialists to Cyprus. Their names and their fields of study are given in the acknowledgements at the start of this article. In short, things were moving forward on a range of different fronts. Only a few words will be said about some of the main developments here. One of them, as mentioned before, was the implementation of a flotation operation and the water separation of archaeological materials. This was done under the supervision of Maria Ntinou, whose field of specialization is the recovery of charcoal samples and their analysis. A new flotation machine was built for this purpose, and it now gave us the chance to process the soil samples collected in previous years as well as the new ones taken in 2009. One of the goals of the field season was to open up an area large enough so that we could map the configuration of the aeolianite. As we had learned in 2008, drawing plans that properly capture the complex and amorphous shapes of the aeolianite constitutes a demanding task. The challenge, of course, was that of finding the right person to do the job. This turned out to be Emanuela Brunacci, an architect who lives in Rome and who has many years of experience doing work of this kind at archaeological sites in Italy. As we shall see in section 3, the high-quality drawings that she now produced made a major contribution to the project. The work on several deposits of marine shells, discarded as food refuse, was another development of major interest. The shell deposits are located on the north side of the excavation where several small hearths occur as well. There was the good fortune that Ken Thomas, a marine shell specialist, had just come out from London at the time when the shell deposits came to light. As we shall see in section 4, Thomas finds clear patterns of difference between the few whole shells used for purposes of decoration (recovered on the south side of the excavation from contexts that are coeval with the aceramic

Neolithic on the island) and the more abundant and fragmentary remains of shells discarded as food refuse (recovered on the north side and coeval with the late Neolithic; see Fig. 11).

2. BEACH ROCK AND THE SOILS ON TOP OF THE SITE

One of the lines of investigation that we planned to develop in 2009 was a more quantitative study of the many fragments of beach rock that occur on the site's surface. Here the work was the logical extension of the observations that Ioannis Panayides had made at Nissi Beach in 2008 (Ammerman *et al.* 2008, 12). As mentioned above, they led to a new way of seeing the site. The oldest pieces of chipped stone turn out to rest on top of the site. And they were placed there by the action of the sea: that is, by one or more tsunamis that swept up pieces of chipped stone at submerged early sites in front of Nissi Beach and redeposited them on the coastal formation of aeolianite. In our third report (Ammerman *et al.* 2008, 29), we cited briefly some of the recent literature on the geological and historical evidence for tsunamis on Cyprus (e.g., Whelan and Kelletat 2002; Noller *et al.* 2005; Guidoboni and Comastri 2005). For example, one finds good evidence in the historical sources for a major earthquake that took place in nearby Syria on 20 May 1202 and that wrought havoc along the coasts of this part of the Mediterranean. Another tsunami that may have contributed to the inverted stratigraphy at Nissi Beach is the one that devastated Pafos in 1222 (e.g., Salamon *et al.* 2007). In addition, at the Roman port of Caesarea Maritima (located between Haifa and Tel-Aviv at a distance of ca. 300 km. from Nissi Beach), there are archaeological deposits that have been linked with the textually attested tsunamis of A.D. 115 and 551 (Dey and Goodman-Tchernov 2010). So, as possible candidates, one has to keep these two dates in mind as well. Without going into a lengthy digression on still other possible candidates, the main point to make here is that it is entirely possible that we are dealing with more than one tsunami at Nissi Beach. A further point to make is that it is only in the last decade or so that the field geologist on Cyprus has begun to take a more active interest in the impact on the coast of major events such as tsunamis. In the case of early archaeological sites on the island, the literature that takes into account the possible role of tsunamis in site formation processes is even slimmer.

The work itself was done in two steps. At the start of the 2009 season, we opened eight new squares (**13**-**20** in Fig. 2). To begin with, an overhead photograph was taken of the surface of each square, and a detailed video record was made of the pieces of beach rock visible on its surface. In most cases, 10 or more pieces of beach rock (each with a length of ≥2 cm.) were observed on the surface of a given square. Beach rock, as mentioned before, forms in the cliffs of aeolianite along the coast; it takes its dark colour from the rich biological life in the tidal zone (Fig. 3). The main difference between a burnt piece of aeolianite and a piece of beach rock is that the former has a dark colour on only one or two of its faces while the latter has the same dark grey colour on all of its faces. In addition, a piece of beach rock commonly has a more rounded shape (due to the pounding it has taken from the sea). From the excavation in 2008, we knew that there is a well-defined soil boundary at a depth of 4 cm. in the ground (that is, between the upper soil with a lighter colour and coarser texture and the well-developed paleosol below with a reddish-brown colour and a finer texture). The idea that we now wanted to test further was whether the thin upper soil was the handiwork of major natural events of the kind that Panayides had proposed. The plan then was to recover systematically the many pieces of beach rock in the uppermost soils at the site and count them.

For purposes of recording, the surface of a given square was called SU-1. The top 1 cm. of the upper soil (that is, the soil from 0 to 1 cm. depth in the ground) was the first excavated soil unit. This thin spit was called SU-2. The next unit, SU-3, was the lower part of the upper soil (that is, the excavated soil from 1 to 4 cm. depth in the ground and the top of the soil boundary mentioned before). The third excavated unit, SU-4, was the top 3 cm. of the paleosol (that is, the soil from 4 to 7 cm. depth in the ground). Fragments of beach rock are not recovered from soil horizons below this depth in the ground. For a given square, all of the excavated soil was kept separately for each the three units (SU-2, SU-3 and SU-4). Next all of the soil from a give unit was dry sieved (using a 4 mm. mesh), and the material recovered in this way was washed and sorted. Finally, counts were made of the pieces of beach rock measuring 2 cm. or more in length. In the case of SU-2 (the top soil unit), five squares yielded 20 or more fragments of beach rock, and the other three squares had counts of 18, 14 and 12 respectively. In other words, the top 1 cm. of the upper soil is rich in beach rock fragments. On the other hand, in SU-3 (the lowest 3 cm. of the upper soil), the counts fell off consistently in all eight squares. For example, square 13 produced only 9 pieces of beach rock -- even though the volume of the excavated soil was three times larger than in the case of SU-2. Turning to SU-4 (the top 3 cm. of the paleosol), the numbers were even lower. Several of the squares produced no piece of beach rock, while the other squares had only a few pieces. It is likely that they had moved down locally into the upper part of the paleosol due to processes of soil formation. Thus, the counts of the beach rock fragments now provide added support for the new interpretation put forward in 2008.

As a check on these results, the same procedure was repeated when we opened four more square (**21**-**24**) in the second half of the 2009 season. Now the main focus was on the recovery of fragments of beach rock in SU-3 and SU-4. In addition, we wanted to make sure that what we were counting were actually pieces of beach rock. So we had Panayides sort and count the fragments this time. For SU-3 (the lowest 3 cm. of the upper soil), he identified a number of beach rock fragments in each square. In the case of SU-4, on the other hand, he found only one or two pieces of beach rock in a given square. In short, the four new squares gave the same basic result as the first eight squares.

There are four lines of evidence that one can use to explore and evaluate the tsunami hypothesis at Nissi Beach. They are: (1) the tsunami blocks resting on top of the coastal cliff, (2) the fragments of beach rock (presented above), (3) the "wear and tear" on the surface of the chipped stone artefacts found on the site's surface and in its thin upper soil and (4) the nature of the soils themselves. The main task of this section, as its heading indicates, is to focus on the second and fourth lines of evidence. Here it is perhaps worth saying a few words about the other two lines in order to fill out the picture. A tsunami results from the massive displacement of water -- due to a geological event such as an earthquake, a volcanic eruption or offshore slumping. The seismic sea wave produced by the event moves at a high velocity over the sea and builds into a "wall" of water as it approaches the coastline. In contrast, storm waves are gravity and wind driven; they have cyclical patterns and move more slowly over the sea. In addition, tsunamis have longer wavelengths than storm waves, and they commonly have a more devastating impact on the coast. Figure 1 shows one of the tsunami blocks standing on top of the coastal cliff at Nissi Beach. All along the coast to the east of the site for a distance of 400 m., one sees large, irregular-shaped "blocks" of this kind jumbled up on top of the coastal cliffs. There they stand at elevations as high as 8 or 9 m. above sea level today. In order to move them into this position, a tsunami has to do some heavy lifting. The wall of advancing water, as it slams into the coast and breaks loose large masses in the cliff face (facilitated by the undercut notches made just above sea level by waves breaking against the soft aeolianite), has to reach a height of around 9 m. in order to throw a tsunami block on top of the cliff. Even the strongest storm surges in the Mediterranean are unlikely to have enough force to accomplish this. Thus, these large blocks provide the best evidence for the occurrence of one or more tsunamis. It is worth adding here that Jay Noller had recognized the tsunami blocks at the time the site was discovered in January of 2004 (Ammerman *et al.* 2007, 8). However, we did not appreciate their full implications for the lithics occurring on the site's surface for some time. In the past when sea levels were lower, the wall of water produced by a given tsunami would have had to be even taller than 9 m. for the seismic sea wave to flow over the top of the aeolianite ridge at Nissi Beach. For this reason, the tsunami events that we wish to learn more about are, in effect, the ones that took place during the last 4,000 years.

The third line of study concerns the damage that is observed on the surface of a piece of chipped stone that is collected from the site's surface. The "wear and tear" on the artefact can take a range of different forms (Fig. 4): breakage of the piece, the removal of chips, battering of the surface, edge damage, different degrees of patination (on the same piece), severe weathering of the surface and local encrustations on its surface. By the end of the 2008 excavation season, it had become clear to us that such "wear and tear" was more pronounced on those pieces found on the site's surface than it was on the pieces recovered from the paleosol. A study of this kind is a new and very demanding undertaking, and we have asked Janusz Kozlowski, one of the leading lithic specialists in Europe, to work on the question. One of the main aims here will be to learn how to recognize the "signature" of pieces of chipped stone that have experienced a doubly difficult life: that is, they have spent part of their lifetime on the seabed (during the time when an early site was submerged by rising sea level) and they were then kicked around by a tsunami. Once the results of this line of investigation are available, they can be used in the examination of the surface collections made at the other early sites on the Cypriot coastline.

This brings us to the fourth line of study, the analysis of the soil samples. The aim here was to examine the grain-size distribution of the soils found in the upper part of the site. If the soils there derived from one or more high-energy natural events, they should show a fairly high proportion of coarse grains. The samples were analyzed at Colgate University, and they came from the same sequence of soil units that were used in the study of the beach rock fragments. As a first step, each sample was dried, weighed and passed through a 1mm. diametre sieve. The fraction having a size larger than 1 mm. (recovered in the sieve) was then weighed to determine the percentage of coarse sand in the sample. In addition, part of this fraction was mounted in an epoxy plug and polished so that the properties of individual grains could be studied. Bruce Selleck then carried out the examination of the grains using a scanning electron microscope (JEOL 6360 LV) linked with equipment giving the chemical signature of a given grain (a PGT Spirit Energy Dispersive X-ray Analyzer). The analysis of the smaller fractions (that is, all of the grains measuring less than 1 mm. in size) was performed by using a Malvern Mastersizer (specifically, a 2000 laser diffraction grain-size analyzer; for the methodology, see McCave *et al.* 1986). The data from the Malvern were combined with the sieve data using Excel software to prepare frequency distributions (see Fig. 5). As a means of control, triplicate analyses of a given sample were performed in most cases.

In general, the samples analyzed for grain size are comprised of sand and silt in varying proportions. As shown in the top row of Fig. 5 (A and B), the two near-surface samples (those from SU-2 in squares **19** and **21** respectively**)** typically contain a significant coarse fraction (coarse sand and some fine gravel) mixed with finer sand. Both of the near-surface samples contain relatively little silt and clay. The two samples in the middle row of Fig. 5 (C and D; from squares **13** and **27** respectively) are from SU-3, the lower part of the upper soil. Both of them are somewhat finer than the two samples from SU-2. They have proportionately fewer grains that belong to the coarsest fraction (the left side) and also more silt (the "bumps" on the right side of the curves). We also analyzed a number of soil samples from different depths in the reddish-brown paleosol (the lower soil with the *in situ* archaeological features). All of them contain relatively greater proportions of silt, and they generally lack the coarse sand/fine gravel fraction. Two examples of these samples (taken from SU-5 and SU-6 in the upper part of the paleosol; both from square **13**) are shown in the third row of Fig. 5 (E and F).

The relatively greater abundance of coarser fragments in the upper samples (that is, those from SU-2 and SU-3) suggests transport of the materials by high-energy storm waves or tsunamis to the site. The relatively greater abundance of silt fraction sediment in the deeper samples (from the well-developed reddish-brown paleosol) is interpreted to result from downward translocation of silt by normal soil-forming processes. Silt fraction grains are likely derived from mechanical and chemical weathering of coarser beach rock clasts in combination with long-distance transport of aeolian silt (dust from the deserts of North Africa). As shown in Fig. 6, A, the coarse grains in samples from SU-2 typically consist of calcarenite clasts derived locally from cemented aeolianite, which forms surface outcrops in the immediate vicinity of the site. The coarse fraction of SU-2 also contains calcareous sandstone clasts with marine fossils (Fig. 6, B), which eroded from beach rock found seaward of the site. Exotic volcanic clasts consisting of fine-grained potassium feldspar, quartz and magnetite with melt textures (Fig. 6, C-D) indicate transport of the material over some distance by energetic storm or tsunami waves, since these material are not currently found in outcrops near the site. The results of the soil study are in good agreement with what was learned from the study of the beach rock fragments.

3. CONFIGURATION OF THE BEDROCK AND FEATURES

The nature of the aeolianite is the key to understanding the configuration of the bedrock at the site. Aeolianite, as mentioned before, is the name given to a rock that began its life as a sand dune. Over the course of geological time, the sand dune gradually became lithified: that is, cemented and consolidated. The sea cliff on the south of the site shows what the distinctive bedding of the aeolianite looks like in cross section (Ammerman *et al.* 2007, fig. 2). It consists of cross-stratified beds of wind-blown sand that occur within larger sets of beds having variable orientation. In more technical terms, the hallmark of aeolianite is its high angle alpha sets. In general, the degree of lithification increases with the passage of time, and it is more advanced in the upper part of the formation (the top 3 m. in our case). For this reason, the lower part of the formation is less resistant to erosion, and it is easily undercut by the waves of the sea (hence creating the overhanging rock that can be snapped off by a tsunami and tossed up on top of the coastal cliff). The formations of aeolianite that occur along the coasts of Cyprus are fairly easy to recognize, even at a distance, since they often have the rounded forms of "fossilized" sand dunes on the landscape.

Figure 7 shows the natural relief of the part of the swale area that has been excavated so far. Outcrops of aeolianite occur on the south, west and north sides, and there is a low open space in the middle. In the time before the site was occupied, the bedrock in the low central area was covered by a thin natural soil. This is the lowest soil horizon of the reddish-brown paleosol mentioned in the previous section. The bedrock immediately beneath this soil horizon has rested in a buried position for thousands of years. For this reason, it has a different appearance than the same rock in the adjacent outcrops, where it is much harder since it has been directly exposed to the elements for a long period of time. In the middle, the relief of the aeolianite has some local irregularities but it tends to be relatively flat. There the buried surface of the rock is lumpy in character and has a whitish colour. In some places, the rock there can be quite soft . In contrast, the outcrops of aeolianite along the sides are all very hard; one cannot drive a nail into them. And the surface of the rock takes on shapes and forms that are more animated. There are places with a pronounced change in height over a short distance: for example, a high point on the outcrop can be juxtaposed with a depression or even a deep pocket in the bedrock. One of the challenges that we had to face, as mentioned before, was to find a person with the skills and experience to draw such dynamic and complex surfaces. Fortunately, Emanuela Brunacci, an architect who works on archaeological projects in Italy, was able to come out to Cyprus and do the job. In the case of the outcrops, the aeolianite has a smooth surface with colours that range from off-white to light gray. Due to long exposure to the wind and the rain, the tops of the outcrops have in some places what looks like a polished appearance.

On the south side, the highest points on the outcrop have elevations in the range of 1 to 4 cm. below the local datum, which has a value of 8.83 m. above sea level based on differential GPS measurements. Along the west side, the elevations on the high points of exposed bedrock tend to decrease gradually as one moves from south to north. But the overall change in height over a distance of 7 m. is a modest one: only about 15 cm. If a comparison is made of the elevations on the south and north sides of the open area, one observes much the same slope: that is, a drop of around 10 cm. over a distance of about 5 m. At the same time, the relief of the open area slopes down gradually to the east as well. On the north side and in the northeast corner in particular, the high points on the aeolianite are clearly lower in elevation than they are elsewhere. There the exposed bedrock stands in a position just above the natural soil. In squares **22** and **26**, the difference in elevation between the two is only some 10 to 13 cm. In other places, the difference between local high points on the aeolianite and the top of the nearby natural soil is usually greater; the values fall in the range of 20 to 30 cm. This happens to be, by the way, the height of a low bench or chair. What this part of the swale had to offer then was not just an open space enclosed by outcrops of aeolianite on three sides but a habitat where the outcrops could serve as places to sit and recline around the open space in the middle. A further point to make is that this open space turns out to have a fair size – one that is slightly larger than a room measuring 3 x 4 m. on a side – making it a good place for everyday activities and for social life. In short, what one has then is a rather special place where the local configuration of the bedrock encouraged people to gather and do things together.

This line of interpretation -- the idea that the aeolianite served as built-in furniture -- is strengthened by the discovery of the “basin” feature in square **3**. This is the large irregular depression in the bedrock that was purposefully modified in order to create a place to store things (see Figs. 8-9). The feature first came to light at the end of the 2008 field season. In our third report, there is a photograph showing the slab of rock that was inserted on its north side to close a gap in the bedrock (Ammerman *et al.* 2008, fig. 7). In 2009, there was the chance to complete its excavation, and the drawings of the feature were made by Brunacci at that time. In fact, she now identified two more pieces of rock – both of some size – that were used to close a gap on the feature’s west side. Thus, there are three pieces of rock (highlighted in yellow in Fig. 8) that were carefully selected and inserted to complete the feature -- one that is at once organic in form and opportunistic in nature. The piece on the north side is a well-shaped slab of aeolianite that measures 35 cm. in length, 28 cm in width and 7 cm in thickness. It has just the right size to fill in the gap there. Several small pieces of rock were placed under the slab's northern end to make sure that it rested at the right angle. In terms of its dimensions, the feature has a length of 120 cm., and its width at the widest point is about 36 cm. It reaches its lowest point in the ground at an elevation of 50 cm. below the local site datum (a depth well below the top of the natural soil on the south side, as shown in Fig. 7). In other words, its lower part comprises a pocket or fissure in the bedrock. The soil filling the feature is the same reddish-brown paleosol that is found in association with the other features in the swale. Its lowest part also contains many small fragments of rock, which fell into it as a consequence of the weathering of the aeolianite bedrock immediately above and around it.

While the finds recovered from the fill of the feature are limited in number, they are of interest due to their special character. Among the lithics, there are three pieces of chipped stone, including a whole blade that is made of high-quality Lefkara chert (not a local material) measuring 6 cm in length. Only two other blades of comparable length were recovered from the excavations at the site in 2007 and 2008. In addition, there are three fragments of ground stone (all three of them derive from cobbles of microgabbro) as well as a soft piece of local stone with a concave shape. The latter was found near the base of the feature, and it may represent a fragment of a stone bowl. This brings us to the most interesting finds, the four marine shells. They are respectively: (1) a whole shell of a Cowry (*Erosaria spurca* L.; found at 26 cm. below the datum), (2) a valve of *Spondylus gaederopus* L. (at 38.5 cm. below the datum), (3) a large fragment of a *Chlamys* (a shell belong to the scallop family; again at 38.5 cm. below the datum) and (4) a whole shell of Mediterranean Cowry (*Luria lurida L.;* at 41.5 cm. below the datum). What is of particular interest here is that three of them – the Cowry, Mediterranean Cowry and Spondylus – were used as ornamental objects in ancient times (e.g., Tornaitis 1987). What is involved here is not food refuse (that is, fragments of *Patella* and *Osilinus* of the kind found in association with the hearths in the northeast corner, as we shall see in the next section) but whole shells that have symbolic values. Of the shells that were once stored in the feature, only a few of them have prbably come down to us in the archaeological record. In terms of dating of the feature, there is now an AMS determination on the Cowry (OxA-19330, 8199 ± 36 B.P.); it dates to the beginning of the seventh millennium cal B.C. (see Fig. 11; for the methods used in its calibration and reservoir correction, see the Appendix by Higham in Ammerman *et al.* 2008, 30).

Before turning to the hearth features that came to light on the north side in 2009, it is worth saying a few words about what was found in three other depressions or basins in the bedrock. Briefly, the main point to make here, without going into the details of the three other cases, is that the feature found in squares **3** is not unique; it has parallels elsewhere in the swale area. For instance, there is a fairly large and deep depression – again with an irregular shape – in squares **1** and **2** (see Fig. 7). It was excavated in 2007, and the reddish-brown soil there produced 7 pieces of chipped stone (all in a pebble-and-flake tradition), 3 fragments of ground stone (in hard rocks such as diabase and microgabbro) and several pieces of marine shell. As mentioned above, two whole shells (both identified as *Patella caerulea* L.) were carbon-dated at Oxford and Groningen and gave ages in the eighth millennium cal B.C. (see Fig. 11). In another case, the soil filling a small local depression in square **18** produced 1 piece of chipped stone, 5 pieces of ground stone and a few small pieces of shell. In the third case, the depression occurs in the bottom of square **24**. Found there were the remains of a fired clay surface (stratigraphic unit 112), resting just above the bedrock. Its numerous pieces all have a thin white lens on their upper face. A study by Georgia Tsartsidou, currently in progress, shows that the white lens is rich in phytoliths. In short, this baked clay surface was clearly used for cooking things but there is no evidence that domesticated cereals such as wheat or barley were involved. It is worth adding here that this feature was found in a stratigraphic position beneath two hearth features, and all three of the features have some sherds of painted late Neolithic pottery associated with them. More will be said about the phytolithis and the pottery in our next report.

It is time to say a few words about the features at Nissi Beach that take the form of a small, roughly circular concentrations of rock fragments -- what is often called a "hearth" in the archaeological literature. Some ten features of this kind have been recognized in the swale area so far. Most of them were excavated in 2009; they occur on the north side of the excavation within the space of five squares (**15**, 1**6**, **23**, **24** and **25**). As we shall see in section 4, this is also the place where deposits of shells representing food refuse were recovered. In this preliminary report, there is space to illustrate only one of these features. As shown in Fig. 10, it is the one identified as SU-108 in squares **24** and **25** (it is the uppermost of the three features found in stratigraphic sequence in square **25**). Here the cluster of rocks has basically an oval shape with a major axis that measures ca. 90 cm. and a minor one some 60 cm. long. It is worth noting that the feature occurs in a partially disarticulated state due of trampling of the site's surface in the time after the feature's last use. Given the low rate of sedimentation in the swale (the soil in the open central space builds up, on average, only few millimetres per century), processes of site formation are not conducive to the rapid burial of such a feature. On the positive side, the accumulations of the marine shells as food refuse in the northeast corner tend to speed up, at least for a time, the inflation of the land surface there -- thus offering somewhat better conditions for the survival of the feature. In short, what we have the chance to see in the archaeological record, when it comes to the study of a feature of this kind in the swale at Nissi Beach, is only the end produce of multiple bouts of use and reuse and then the ensuing phase of a hearth's disarticulation, which is more active at its edges. The density of the rocks in its core gives that part of the feature a better chance to keep its integrity over the course of time. In any event, there are more than 50 pieces of rock (almost all of them fragments of aeolianite) in the case of unit 108. Most of them have angular or sub-angular shapes, and very few of them exceed 10 cm. in their longest dimension. A closer examination of the rocks indicates that 16 of them present signs of breakage, abrasion or patches of dark colour. The soil found in association with this feature is again the reddish brown paleosol. The top of the soil stands at ca. 41 cm. below the local datum and its base at ca. 46 cm. Figure 10 also shows the positions of two sherds of late Neolithic pottery and 13 pieces of marine shell (8 are of them are *Patella* and the rest are *Osilinus*). Finally, just below the upper feature (SU-108)**,** there is a feature that consists of two adjacent rings of rock fragments (each with a diametre of about 50 cm.); associated with it is an *Osilinus* shell that dates to the middle of the fifth millennium cal B.C. (OxA-22271; see Fig. 11).

At this point, it is useful to step back and consider the larger picture that is beginning to emerge in the swale. At the start of the excavation in 2007, it was an open question whether or not the work would produce any features at all. It was entirely possible that what awaited us was disappointment. By the end of the third excavation season, things were looking up. The features and the finds that have come to light are more interesting than we had expected. No one, for instance, would have imagined that, given the thin soils on the aeolianite, there would be the chance to recover three features nested one on top of another in stratigraphic sequence in square **24**. And much the same holds for the rich shell deposits. The shellfish assemblages, as we shall see in section 4, turn out to show clear patterns of variation in time and space at the site. It is perhaps worth making a few brief comments on the use of space in the swale at this point. As mentioned above, what we find is closely linked with the configuration of the aeolianite itself. The outcrops of bedrock on three sides define a low open space where people could meet and do things. They could also find places to sit or recline along the sides. And there were even places such as the basin feature in square **3** where things of value could be stored. On the other hand, one does not encounter much in the way of finds in the open area in the middle. There in a given metre square, one recovers only a few pieces belonging to each of three main classes of material culture (chipped stone, ground stone and marine shells; no Neolithic pottery was recovered in squares **1-13, 17-19** and **21**). In short, there are no concentrations of archaeological materials -- of any kind -- in this part of the swale. The suggestion is that the open area in the middle was intentionally kept clean. In contrast, the space in the northeast corner of the excavation was actively used for hearths, cooking and the discard of marine shells and other food refuse (a few fallow deer bones) in the late Neolithic period. Thus, we have to remember that what we are dealing with is not just a mosaic in space but a palimpsest in time as well. There is a span of some 3,000 years, as shown by the AMS dates in Fig. 11, between the oldest material found on the southern side of the excavation (in squares **1-3**) and the material recovered in the northeast corner (squares **16** and **24-27**). These are, of course, initial impressions. More will be learned about spatial patterns at the site when the studies of the other lines of material culture are completed.

4. THE SHELLFISH ASSEMBLAGES

The remains of invertebrate animals (principally shells of molluscs along with a few remains of crustaceans) were recovered at Nissi Beach by hand during excavation, by sieving of excavated deposits and also in the residues from flotation; this report deals with the marine taxa recovered from the 2008 and 2009 seasons of excavation. The principal aim of the study was to establish the range of species present, their abundance and state of preservation. These data would indicate the range of shore types that were being exploited by the inhabitants of the site and, perhaps, the foraging strategies and decisions that were employed to acquire the molluscs and other taxa, either for their flesh or for their shells. Another aim was to determine if the shells of some species were selected because they were valued as ornaments or as symbols. These investigations would then permit a comparison between the two known phases of occupation of the site: one concentrated in the southern area of the excavation (contemporary with aceramic Neolithic sites on Cyprus) and the other mainly concentrated in the north eastern area of the excavation (contemporary with late Neolithic sites on the island).

The marine taxa. Identifications were made to species level as far as possible but sometimes the condition of the shells did not permit this. In other cases, identification was taken only to genus level because there was no time or opportunity to compare the specimens with a reference collection. The taxa identified in the 2008 and 2009 assemblages are listed in Table 1.

Counting fragments and specimens. The condition of the material ranged from fully intact specimens to very small fragments that could not be identified beyond "nacreous fragment of shell of a marine bivalve." All fragments that could be identified to specific or generic level were included in the analysis, along with other fragments such as the columellae of murex-type shells (recorded as "Indeterminate muricids"), fragments of claws (chelae) of indeterminate "small crabs" and individual plates of barnacles. The number of identifiable specimens (NISP) was recorded for each animal category in each stratigraphic unit within each excavation square. The NISP counts for each stratigraphic unit in each excavation square were used to calculate the minimum number of individuals (MNI) present. In 2008 a total of 27 identifiable specimens were recovered, amounting to a minimum number individuals of 23 which are distributed among 15 taxa (details are given in Table 2). In 2009, the total NISP was 691, yielding a total MNI of 231 distributed across 21 taxonomic categories (Table 2). Note that where specimens are identified to genus or to species within that genus (e.g. *Osilinus turbinatus*, *Osilinus articulatus* and *Osilinus* sp.; prior to the last decade, the term *Mondodonta* was commonly used in the literature), the number of taxa is given by the number of identified species within that genus (in this case, two). In cases where specimens are identified only to a supra-specific category, such as a genus (e.g. *Alvania* sp.) or a higher taxon (e.g. Cirripedia), each one counts as a unit in the total number of identified taxa.

Details of the numbers of different categories of fragments (intact shells or valves; apical and spire fragments; apertures and other identifiable fragments) for each taxon are given in Table 3. In the 2008 material, 63% of the identifiable specimens are intact shells or valves (in the case of bivalves); it falls to 9% in the 2009 material. This cannot be attributed to either differential damage during excavation between the two seasons or to different recovery methods, and seems to be associated with the larger numbers of taxa found in 2009 that probably constitute food refuse, as discussed below.

Spatial distribution of the marine taxa. The exact location of each specimen recovered during hand excavation was recorded in three dimensions, but here the shells are discussed in relation to the metre squares and stratigraphic units in which they occurred. Tables 4 and 5 show the distribution, by MNI, of the various taxa recovered from the squares excavated in 2008 and 2009. It is clear that the distribution of specimens across the site is uneven, with the majority of specimens being found in the more northerly squares (**16**, **23** to **27**). Within these squares, there is a concentration of specimens in certain stratigraphic units, varyingly between units 105 to 110. For example, 353 specimens (NISP) were recovered from stratigraphic units 105 to 108 of square **25**, amounting to 49% of the total NISP from the 2008 and 2009 excavations combined; for MNI this falls to 29% of the total MNI for the site, and for number of taxa to 22% (Table 6). The very high NISP counts relative to MNI and taxon diversity counts in square **25** and also in squares **16**, **23**, **24**, **26** and **27** stem from the samples being dominated by food species (principally the various species of *Osilinus* and *Patella*, along with the muricids), the shells of which are highly fragmented, probably as a result of processing activities to extract the flesh.

Environmental aspects of the marine invertebrate assemblages. A little over 75% of the taxa are characteristic of the intertidal zone of hard substratum (rocky) shores, while the rest are found on, or in, unconsolidated sandy or muddy substrata, usually in the sub-tidal zone. For example, *Tonna galea* is usually found on muddy or sandy substrata at depths below 30 m. Overall, the various taxa that occur in the archaeo-malacological assemblage can either be found living on rocky shores near the site today or else their empty shells occur in strand-line death assemblages on sandy beaches near to the site. In the aceramic Neolithic, when the site was initially occupied, relative sea levels would have been lower and the coast was probably more than a kilometer away from the site. In the late Neolithic, the coast would have been closer to the site. In both periods, the shells and other remains would have been collected some distance from the site and subsequently transported to it, although the distance (and therefore 'costs') of transportation would have been less in the late Neolithic. As shown in Figure 12, there is a difference between the 2008 and 2009 shell assemblages in terms of the frequency of soft-substratum (mainly sandy) shore species, which comprise 17% of the 2008 assemblage and only 4% of the 2009 one. This probably reflects the differential selection, transportation, use and discard of various species in different parts of the site, as discussed below.

Acquisition and uses of the shellfish. Most of the taxa associated with rocky shores could easily have been collected alive by those frequenting the site, but it is unlikely that many (if any) of the taxa associated with sub-tidal soft-substratum shore habitats were acquired alive. Probably their shells were collected empty from the shore line and some of the shells in the archaeological assemblage show signs of wear consistent with this. A broad classification of the material in the assemblages into potentially "edible" taxa and taxa that were probably not consumed shows a significant difference between the 2008 and 2009 collections (Fig. 13).

Some 39% of the 2008 assemblage is comprised of shells that could represent food discard, this rising to 95% in the 2009 assemblage. A high proportion of the 2008 assemblage, derived from the southern part of the site and contemporary with the aceramic Neolithic, is of shells that were probably collected empty from beach deposits. The fact that they were transported back to the site, some distance from the then existing coast, indicates their importance to the site's occupants, possibly as objects of symbolic significance (such as the cowries *Erosaria spurca* and *Luria lurida*), for decorative purposes such as beads or pendants (e.g. *Columbella rustica* and *Conus*), or because they were unusual and fascinating in other ways (e.g. *Serpulorbis* and the very large specimen of *Arca noae*, although if collected alive this rocky shore species could also have been consumed). The 2009 assemblage is mainly from the northern part of the site and is overwhelmingly dominated by potentially edible taxa (various species of top shells, limpets, muricids, crabs and so forth). It is likely that the northern, especially north-eastern, part of the site was principally the locus of late Neolithic activities primarily associated with the preparation and consumption of shellfish food and the subsequent discard of shells, which were often in a fragmented state (see Table 3). The 2009 assemblage is, of course, very much larger than that of 2008 and also includes a number of taxa of probably non-dietary significance, such as *Serpulorbis, Erosaria spurca, Luria lurida, Tonna galea, Phalium saburon, Mitrella scripta, Conus ventricosus, Chlamys* sp., and *Antalis* ('dentalium').

*Discussion***.** The assemblages of marine invertebrates represent taxa that were collected for food or other purposes and transported back to the site. Both hard substratum (rocky) and soft substratum (mainly sandy) shore types are represented and all the taxa present can be found near the site today -- either living on rocky shores or as empty shells in the strand line on sandy beaches adjacent to rocky shores. There are many taxa that occur in the vicinity of Nissi Beach today which are not present in the archaeological assemblages from the site. Some of these species are Lessepsian migrants of Indo-Pacific (Red Sea) origin (Öztürk *et al.* 2004), which arrived in the eastern Mediterranean as a consequence of a range of human activities (such as the opening of the Suez Canal and transportation on the hulls of shipping); these species need not concern us further. There are, however, many "native" species, which are not present in the archaeological assemblages. They include *Mytilus galloprovincialis* (Mediterranean Mussel), which occurs in large numbers on rocks in the modern lower intertidal zone close to the site as well as numerous taxa associated with sandy shores, such as the gastropods *Natica* (Necklace Shells) and *Nassarius* (Dog Whelks), and the bivalves *Glycymeris* (Dog Cockles), Cardiidae (Cockles), *Venus, Venerupis* and *Tapes* (Venus Shells and Carpet Shells), *Mactra* and *Donax* (Trough Shells and Wedge Shells). Many of these species are edible, being widely consumed in various parts of the Mediterranean today, while others (such as *Natica*) have highly decorative shells.

It is probable that most or all of these taxa existed in the coastal zone at the time the site was occupied, so why are they not present in the excavated material? With a total NISP of only 718 and MNI of 254, small sample size could be a factor. If the shells and shell fragments that probably represent food refuse are discounted, the NISP falls to 34 and the MNI to 30, distributed among 16 taxa that can be broadly categorized as "non-food". The small sample of shells recovered at the aceramic Neolithic site of Shillourokambos (Serrand *et al.* 2005), which is much further from the coast than Nissi Beach, had a NISP of 267 distributed among 33 different species of marine invertebrates. Most of the shells transported to Shillourokambos appear to have been collected dead, with only 11 specimens (of *Osilinus*, *Patella* and a marine crab) apparently having been collected alive, possibly for human consumption (Serrand *et al.* 2005, 125). If these are removed from the counts for this site, the NISP of the 30 species that were probably not consumed by humans becomes 256. The Shillourokambos assemblage includes *Natica*, *Nassarius*, *Glycymeris* and various species of Cardiidae. The shell assemblages from the early occupation phase at Nissi Beach and from Shillourokambos (Serrand *et al.* 2005, 125) suggest the principal interest in marine molluscs was in the decorative or symbolic value of their shells rather than as food.

It is improbable that the people associated with the earlier occupation at Nissi Beach, contemporary with the aceramic Neolithic, were not interested in shellfish as sources of food. Lower sea levels at the time of the site's occupation would have caused the contemporary shoreline to be more than a kilometre distant from that of the present day. It is probable that shellfish were processed and consumed at camps close to the shores from which they had been gathered. Ethnoarchaeological research supports this possibility. Meehan's (1982) classic studies of shellfish exploitation by Gidjingali-speaking Anbarra people in Arnhem Land, northern Australia, revealed that considerable quantities of shellfish, especially bivalves, which could be cooked in large numbers in a 'clam bake', were consumed at locations away from occupation sites and therefore were significantly under-represented in the dietary record at such sites. A study by Bird and Bliege Bird (1997) of shellfish gathering strategies by the Meriam people of Torres Strait shows, on the other hand, that the shells of species with high processing costs tend to be relatively over-represented at home bases compared with species with low processing costs, which were either processed or consumed in the field (with the shells being discarded near the place of collection).

The shellfish assemblage from the northern area excavated at Nissi Beach, contemporary with the late Neolithic, would have been deposited when the contemporary shoreline was close to that of the present day. It is overwhelmingly dominated by specimens probably representing food refuse; only 7 taxa (with a combined NISP of 13) were probably not eaten. These data are comparable with those from the painted pottery Neolithic site of Paralimni, which is also located on the coast today. The substantial assemblage of shells from Paralimni includes large numbers of food items and some specimens that were apparently collected dead and therefore used for other purposes (Reese 2008). Most of the food items are gastropods of the genera *Patella* and *Osilinus*, their combined MNI of 548 being 72% of the total gastropod MNI of 759. Other edible taxa include cuttlefish (*Sepia*) and crabs (*Eriphia*), with a combined MNI of 3, plus 3 cockles (Cardiidae) and 13 *Glycymeris*, of which a further 17 had been "clearly collected dead on the beach" (Reese 2008, 121). It appears that in the late Neolithic at Paralimni, as at conteporary Nissi Beach, the larger edible rocky shore gastropods were transported to the site for consumption, but edible bivalves such as rocky shore *Mytilus* and various other species associated with unconsolidated soft-substratum shores were not. Possibly people at this time were not able to access living edible sub-tidal sandy bottom bivalves, only their empty shells cast up onto the beach. Alternatively, such species could have been consumed, and their shells discarded, elsewhere, possibly close to the place of collection. The shells of bivalves open once the animal is cooked (possibly in the hot ashes or embers of a fire) and their contents can be consumed immediately. Taxa less easily removed from their shells (such as *Osilinus* species and the muricids) could have been taken back for on-site processing, although this model fails to explain why large numbers of easily extracted limpets also occur in the on-site assemblage. Perhaps these rocky shore taxa were all collected together and transported back to the site for bulk processing, although this hypothesis fails to explain why *Mytilus* was not also included. It is notable that *Mytilus* did not occur at either Shillourokambos or Paralimni, so perhaps it was less abundant on hard substratum shores in the past than at the present day.

In general, the Nissi Beach shellfish assemblages are in accord with similar assemblages from aceramic Neolithic and late Neolithic sites on Cyprus. Looking further afield in the eastern Mediterranean, comparisons can be made with sites in the Levant, as recently reviewed by Bar-Yosef Mayer and Zohar (2010), and in southern Greece, specifically the well-studied shellfish assemblages from Franchthi Cave (Shackleton 1988). At Natufian sites in the Levant, close to the Mediterranean coastal plain, marine shell assemblages are overwhelmingly dominated by scaphopods ("dentalium") with smaller numbers of *Nassarius*, *Columbella*, *Glycymeris* and *Cerastoderma* (Bar-Yosef Mayer and Zohar 2010). Most of the shells at these sites appear to have been collected as dead empty ones. Shells of taxa that might have been consumed are very rare, or absent, at most sites. Mollusc shells in the Natufian were prized as ornaments and were traded between coastal and inland settlements (Bar-Yosef Mayer and Zohar 2010, 40). Bar-Yosef (1991) demonstrated that while scaphopods dominate Natufian assemblages, they decline somewhat in the PPNA, when there is an increase in *Glycymeris* and *Cerastoderma*. This trend continued into the PPNB with fewer scaphopods and many more *Glycymeris* and *Cerastoderma*, along with (at some sites) more cowries and *Nerita* species, some from the Red Sea (Bar-Yosef 1991, 632; Reese 1991, 623). There is little evidence that these shells represent food remains -- most apparently being used as ornaments and being highly worked. This need not imply that shellfish were not part of the diets of Natufian or Pre-Pottery Neolithic people. The various species identified among the fish remains from various Natufian sites (Bar-Yosef Mayer and Zohar 2010) show that littoral zones were being exploited, and it is possible that any shellfish gathered for food were processed and consumed near the location of collection (that is, at places occurring in submerged positions today due to rising sea levels), with only highly-ranked food items, the various species of inshore fish, being transported back to settlement sites (Bar-Yosef Mayer and Zohar 2010, 41). The earlier shell assemblage from Nissi Beach could indicate that it was a near-coastal site at which shells were processed before being transported (exchanged or traded) further inland. Shillourokambos is an example of such an inland site, and Serrand *et al.* (2002) have drawn comparisons between the shell assemblage from Shillourokambos, dominated by ornamental elements, and assemblages from middle and late PPNB sites in the Near East and the southern Levant.

Looking westwards and to the Franchthi Cave in particular, we find a markedly different picture with marine shells including the gastropods *Patella*, *Osilinus*, *Murex* and *Cerithium*, occurring abundantly in pre-Neolithic deposits dating to the eleventh and tenth millennia cal B.C. (when the coast was more than 3 kilometres from the site). Bivalve molluscs are absent from these early deposits, which Shackleton and van Andel (1986) attribute to ecological factors, such as shore substratum types, governing their availability. This could have been the case, although the accuracy of reconstructions of changing shore types relating to the Franchthi sequence has been questioned by Thomas (1987), who also suggested that human choices could have played a significant role in determining what was transported to the site. Thus, as in the ethnoarchaeological studies noted above, easily processed bivalves could have been cooked and eaten near to where they were acquired, while gastropods were transported back to the cave for extraction of flesh and consumption.

In conclusion, the site of Nissi Beach has yielded two distinct assemblages of marine shellfish remains, one contemporary with the aceramic Neolithic and the other with the late Neolithic on Cyprus. The earlier assemblage is dominated by shells that were selected for ornamental or other non-dietary uses. By contrast, the more recent assemblage is dominated by shells that represent food debris, although ornamental elements are also present. It might be tempting to interpret these differences in terms of changing cultural attitudes to shells as materials, and shellfish as food, but the environmental contexts of the phases of occupation need to be taken into consideration. At the time of the earlier occupation, contemporary with the aceramic Neolithic, the coast would have been more than a kilometre. from Nissi Beach, and it is possible that shellfish gathered for food were processed, consumed and their shells discarded at locations nearer the coast. Only shells with perceived ornamental or symbolic value would have been transported back to the site, possibly for further working before being transported to sites in the interior. By late Neolithic times, the shoreline would have been much closer to where it stands today -- with only a short distance to transport shellfish gathered in the littoral zone for processing and consumption at the site, along with other shells collected for ornamental purposes. While the total assemblage of marine shells and crustaceans from Nissi Beach is still comparatively small, it derives from an excavated area of just 27 square metres. Compared with the marine shell assemblages from the large-scale excavations at Paralimini (more than 2,000 square metres) and Shillourokambos (several times larger than Paralimni), the shell density at Nissi Beach is very high, suggesting an intensive focus on the exploitation of marine resources at the site.

5. DISCUSSION

Only a few comments of a broader nature will be made here. The article is already quite long. If we look back on the fieldwork that was carried out at the sites of Nissi Beach and Aspros between 2004 and 2009, it is of interest to note how many new things first came to light on Cyprus in such a short span of time: (1) discovering the early sites on the formations of aeolianite, (2) tracing the site of Aspros out into the water (Ammerman *et al.* 2008, 4-9; Ammerman *et al.* 2011), (3) learning that the oldest lithics at Nissi Beach occur in an inverted stratographic position on the top of the site (as a consequence of one or more tsunami events), (4) linking the start of seafaring in the Mediterranean with the rollercoaster ride of climate change known as the Younger Dryas (Broodbank 2006, 208-11; Ammerman *et al.* 2006, 18; Ammerman *et al.* 2007, 18-20; Ammerman 2010, 87-88), and (5) finding evidence at Nissi Beach for the persistence of coastal foraging into the Neolithic period (as seen in the excavation of the paleosol). We have previously written about the first two topics at some length. The discussion here will focus on the last three.

When the archaeologist considers the processes involved in site formation, it is common to think that that they happened at a rather slow pace. Big events do not normally enter the picture. Indeed, if anything, this angle of vision is frowned upon. Gradualism is part of the intellectual heritage that prehistory inherited from geology in the nineteenth century. However, while the earth scientist today is prepared to explain various aspects of the geological record in terms of big events, most archaeologists are still not at home in doing so. Due caution is, of course, understandable in this regard. Journalists, for example, know full well that they can attract a large audience when they write about an earthquake or a volcanic eruption in the remote past. The problem here is that what the journalist has to say is often less than reliable. At times, it can be downright reckless. Thus, when those who study prehistory encounter a big event in the literature, they tend to feel that their comfort level is being challenged. This may be doubly so in the present case where we are now talking about big events of two different kinds: one or more tsunami events and also an event involving abrupt climate change, the Younger Dryas. In other words, the pendulum is swinging away from gradualism. As we have seen in section 2, there is now good evidence for one or more tsunamis at Nissi Beach. There is, of course, much that still needs to be done on this line of investigation. In addition to conducting further studies on the upper soils and completing the study of the "wear and tear" on the chipped stone, it will be of interest to establish the dates of the tsunami events, to learn more about their magnitudes and to model their dynamics in the context of the coast at Agia Napa. At the same time, it is important to realize that research of this kind is not just of archaeological and geological interest; it has wider implications for public policy on Cyprus.

Viewing the Younger Dryas as a big event is a comparatively recent development for the earth scientist and, if anything, even more so for the archaeologist. In the 1990s, the Younger Dryas was still a question of minor interest for most archaeologists working in the Mediterranean. There were, of course, a few notable exceptions (for the names of the scholars and their publications, see Bar-Yosef and Belfer-Cohen 2002; Grosman and Belfer-Cohen 2002). In the opening years of the present century, attention focused, for the most part, on the changing patterns of vegetation in the Near East and on the forms of intensification that led to the origins of food production. It was only in 2006, as mentioned before, that the connection between the Younger Dryas and the origins of seafaring in the Mediterranean was first proposed (Broodbank 2006, 208-211; Ammerman *et al.* 2006, 18).

The turning point in the study of the Younger Dryas was the joint American and European project to drill two deep ice cores in the Greenland ice sheet (e.g., Alley 2000). The project ran from the summer of 1989 through the summer of 1993. And it would then take several more years to complete the analysis of each of the annual layers of ice over a span of 17,000 years. It called for a vast amount of work to reconstruct in detail the patterns of climate change over this span of time (recall that the basic trends for temperature and the accumulation of snowfall, a proxy for precipitation, are illustrated in Ammerman *et al.* 2007, fig. 1; in a more recent study, the transition from the Younger Dryas to the warmer climatic conditions of the Holocene is now placed at 11,703 years before A.D. 2000; Rasmussen *et al.* 2006). Based on the ice cores, there was now good evidence for abrupt climate change at the end of the Pleistocene – the rapid dive into and then out of the cold snap known as the Younger Dryas. In short, new ideas about climate change began to circulate more widely in the literature of the earth sciences in the second half of the 1990s. At that time, most archaeologists were still not fully cognizant of the advances that were being made in the field of climate change. As best they could, some of the archaeologists interested in the pathways leading to the domestication of plants and animals in the Near East now began to pick up on the new ideas about climate change. Of course, the patterns of environmental change in the Near East have to be seen as more attenuated ones than those on the Greenland ice sheet itself. What was missing from the literature even as late as 2006 was a comprehensive account of the multiple lines of environmental evidence in the Near East, which was accessible to those who were not specialists in environmental archaeology. It was only at this point in time that an important book, *Civilizing Climate*, made its appearance (Rosen 2007). And to bring the story rapidly up to date, it can now be seen in more recent archaeo-botanical studies (e.g., Willcox *et al.* 2009; Rosen 2010; Rosen 2011) that farming as such came fully into its own only around 8,500 cal B.C. Thus, it was only when climate change had settled down that early farming really took off. In brief, during the course of the Younger Dryas, climate change acted both positively as a catalyst setting in motion multiple pathways that would lead in time to agriculture and negatively as an ever-changing bottleneck holding back the full-fledged expression of agriculture.

Today there is also a better appreciation of the role that the Younger Dryas played in the extinction of animal species around the world. On Cyprus, there is the well-known case of the pygmy hippopotamus. At the site of Aetokremnos on the Akrotiri Peninsula, Simmons (1999) used the overkill hypothesis, borrowed from North America, to explain the extinction of *Phanourios minutus* on the island. There is, by the way, no mention of the Younger Dryas in *Faunal Extinction in an Island Society*. For more than a decade, Aetokremnos has been the subject of debate in the literature. This is, of course, not the place to go into a digression on the questions that have been raised (e.g., Binford 2000; Grayson 2000; Ammerman and Noller 2005). Suffice it to say here that the overkill hypothesis has fallen out of favour in North America. Indeed, Grayson and Meltzer (2003; see also Waters *et al.* 2011) have written "a requiem for North American overkill." They see the Younger Dryas as a more promising line of explanation, pointing out the lack of evidence for the hunting of 33 of the 35 animal species that became extinct in North America at the end of the Pleistocene. On Cyprus, the recent excavation of the palaeontological site called Agia Napa (Theodorou *et al.* 2004) suggests that the extinction of *Phanourios minutus* may have less to do with human hunting and more to do with a major climatic event at the end of the last ice age. The rock shelter, which is named after the nearby town, presents a rich bed of hippo bones much like the one in stratum 4 at Aetokremnos. The two rock shelters have more or less the same elevations, orientations and distances to the sea. While an area of some size has been excavated at Agia Napa and all of the excavated soil has been water sieved, not a single piece of chipped stone has been recovered so far. In short, Agia Napa is strictly a palaeontological site. It documents the kind of place where pygmy hippos went to die a natural death, and the best way to explain the rich bone bed there is by looking towards the Younger Dyras. In any event, the main point that we wish to make here is another one. It concerns seeing the Younger Dryas as a major event in our planet's climate history – an event that will play an increasingly important role in our understanding of the opening chapter of the island's prehistory over the next twenty years. This big event enters the picture in three ways: (1) it set in motion the pathway to a new way of life based on agriculture in the Near East; (2) it sparked voyaging on a regular basis in the eastern Mediterranean; and (3) it contributed to the farewell of pygmy hippos on Cyprus.

When we began the excavation at Nissi Beach in 2007, there was no expectation that coastal foraging would persist into the time when the PPNB had become well established on the island. One assumed was that coastal foraging soon faded out once agro-pastoralism made its appearance on the island. At sites such as Shillourokambos and Mylouthkia, which both go back to the last quarter of the ninth millennium cal B.C., the excavators initially thought they were dealing with sites with the full Neolithic package (a subsistence economy based on both domesticated plants and animals) as well as a material culture closely related to the PPNB on the mainland (Guilaine and Le Brun 2003; Pelternburg and Wasse 2004; see also Knapp 2010). More recent studies of the faunal remains at Shillourokambos have brought to light a rather different picture (Guilaine *et al.* 2011; Vigne *et al.* 2011). In the years before 8,000 cal B.C., the remains of domesticated animals are not found at the site. Wild pigs and wild goats were exploited. The subsistence economy was thus a combination of cultivation on the plant side and hunting on the animal side. Both the pigs and the goats became fully domesticated during the first half of the eighth millennium cal B.C. And around 8,000 cal B.C. a new wild species, fallow deer, made its appearance in the faunal record. It then continued to be hunted for the rest of the eighth millennium cal B.C. In short, once the PPNB arrived on the island, the exploitation of "wild" mammals did not simply come to an end. And much the same now would seem to hold at Nissi Beach where coastal foraging continued for many years. Indeed, over a long span of time that is coeval with what is traditionally called the Neolithic period (see Fig. 11), all of the evidence for subsistence at Nissi Beach turns out to be on the "wild" side. This includes the marine shells, the few animal bones recovered from the paleosol (fallow deer) and the evidence from phytoliths. Only the evidence for sickle gloss on chipped stone artefacts (recovered from the paleosol) points toward the cultivation of plants. More will be said about this last line of study in our fifth report.

At the same time, the chipped stone artefacts recovered from the paleosol in the swale are, for the most part, quite different from those found on the site's surface, where one finds tools of small size made from local pebbles using a flake-based technology (Ammerman *et al.* 2008). In contrast, the reduction technology observed in contexts coeval with the PPNB has affinities with the blade-oriented traditions now well documented at the PPNB settlement of Shillourokambos (Briois 2011; Guilaine *et al.* 2011). On the other hand, the lithics from the paleosol at Nissi Beach that date to the eighth millennium cal B.C. do not appear to be simply a sample of one of the PPNB assemblages at Shillourokabos. In fact, comparatively few blades of any length have actually come to light at Nissi Beach. And the study of the reduction technology at Nissi Beach shows that blades were not produced at the site. This raises the question of how the blades found their way to Nissi Beach. There are two main possibilities to consider: either those who frequented the site on a seasonal basis and continued to be coastal foragers and voyagers but who now added some plant harvesting to their subsistence strategy obtained the blades by means of exchange with farmers living at PPNB settlements in the interior or else the PPNB farmers themselves made short visits to Nissi Beach (to collect resources such as sea salt and marine shells there) and left some of their tools at the site. It is premature at this stage of the investigation to decide between these two models. In our fifth report to the *RDAC*, Malgorzata Kaczanowska and Janusz Kozlowski will present what they have learned from their study of the chipped stone at Nissi Beach.

In retrospect, the persistence of coastal foraging at Nissi Beach and the on-going contribution of hunting to the subsistence at a PPNB settlement such as

Shillourokambos should perhaps not come as a surprise to us. In the first place, Cyprus, in light of the lack of predators on the island, would have been a paradise for anyone with an interest in hunting once wild pigs were introduced from the mainland around 10,000 cal B.C. and then fallow deer about 8,000 cal B.C. (Vigne *et al.* 2011). In short, Cyprus soon became an island-wide game preserve as it were. Given this favourable situation, a site such as Shillourokambos enjoyed walking through the transition to the Neolithic at its own leisurely pace. Secondly, recognizing the persistence of coastal foraging represents a step toward correcting for a longstanding bias in Neolithic studies on the island. Whenever the archaeologist had the chance to dig a Neolithic site on Cyprus, the excavation was invariably done at a large and rich site in the interior and not a lean one on the coast. Thirdly, the long term development of the Neolithic on the island posts various signs along the way showing that hunting and coastal foraging have deep roots there. To mention just two them, there is the marine component of the subsistence economy at Cap Andreas, a site located on the tip of Karpasia, which has three C-14 dates in the sixth millennium cal B.C. (Le Brun 1973-1974). And there is the important role played by the hunting of fallow deer played at late Neolithic sites on the island (e.g., Clarke 2007). At Paralimni, for example, one stills finds the exploitation of both fallow deer and marine resources in the fifth millennium cal. B.C. (Flourentzos 2008; Croft 2008; Reese 2008).

Fourthly, if one looks at the situation from a wider geographic perspective, there is another reason for thinking that first farming and foraging may have coexisted as two complementary ways of life for some time. This brings us to the paradox of early voyaging in the Mediterranean and the slowness of the spread of early farming between Cyprus and Italy (Ammerman 2011). The paradox emerges if one asks the following question: why in a world where pre-Neolithic seafaring is already well established, does it take agro-pastoralism so long to get from Cyprus to Crete, next from Crete to the Greek mainland and then from there to the heal of southern Italy? On the basis of the radiocarbon dates that are currently available, the spread of first farming from Cyprus (ca. 8,300 cal B.C.) to southern Italy (ca. 6,200 cal B.C.) took just over 2,000 years, and the distance involved, as the crow flies over the seascape, was around 1500 km. This means an average rate of 0.75 km per year, which corresponds to a distance of only 19 km. per human generation. This is far too slow in the context of boat people who could easily make voyages at the time in the range of 60 to 100 km., as shown by the early Neolithic circulation of obsidian (Ammerman 2010, 83-86). One way to explain why these two lines of evidence are not in sync with one another is to realize that those who had the boats and the skills to cross the sea were not the first farmers living at settlements in the interior but instead those who lived on the coast and who still looked toward the sea for part of their livelihood. Indeed, it is entirely possible that, in terms of their interests, the first farmers in the interior and the foragers on the coast were not always on the same page. Accordingly, delays arose, and this may have been one of the reasons for the remarkable slowness of the spread of early farming between Cyprus and Italy.

Acknowledgements

The authors would like to thank the Institute for Aegean Prehistory for a grant in support of the excavation at Nissi Beach in 2009. For their encouragement and assistance in various ways during the field season, we extend our appreciation to the following officials in Agia Napa: Antonis P. Tsokkos (Mayor of the Municipality), Maria Tofini-Tsantila (Cultural Officer of the Municipality) and Fotos Kikillos (Curator of the Thalassa Museum). The following specialists participated in the 2009 field season at Nissi Beach: Manuela Brunacci (architect), Carole McCartney (chipped stone), Maria Ntinou (flotation and charcoal), Ioannis Panayides (geology), Ken Thomas (marine shells) and Christina Tsoraki (ground stone). In addition, we are grateful to the following specialists for their contributions to the investigation: Thomas Higham (radiocarbon dating) and Bruce Selleck (soils and sedimentology). For their participation in the excavation, we wish to thank: Kerstin Mannergren Ågren, Ingmar E. Anderson, Magnus Billing, Amalia Filippidi, Christos Hadjisavvas, Dimitris Kloukinas, Silas Michalakas, Dora Moutsiou and Ioannis Voskos.

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Figure Captions

Figure 1. Photograph of the fieldwork in progress at Nissi Beach in 2009: in the foreground the excavation of a deposit of marine shell in square **25** and behind one of the tsunami blocks resting on top of the coastal cliff.

Figure 2. Plan showing the position of the excavated metre squares (**1**-**27**) excavated at Nissi Beach (2007 – 2009).

Figure 3. Beach rock in the process of forming on the coast cliff just to the east of Nissi Beach.

Figure 4. Examples of the "ware and tear" on the surface of pieces of chipped stone: all of the pieces illustrated here come from the surface collection made in large circle **Q** at Nissi Beach.

Figure 5. Graphs of the grain-size distribution of the soils in the upper part of Nissi Beach (see the text for further information on the samples analyzed). The results of grain-size analyses are presented as frequency curves. The vertical axis is percent by volume; the horizontal axis is grain size measured in phi ( ) units, where = -log2 (diameter in mm.). Grain size decreases to the right in these plots. Note the prominent coarse fraction peak in the two near-surface samples in the top row (NB-19-2 and NB-21-2). **[Note to the editors: insert the capital Greek letter for phi between the parentheses and also just before the equal sign.]**

Figure 6. Scanning electron microscope (SEM) images of individual grains in the coarse fraction of the uppermost soil, SU-2, at Nissi Beach: (A) porous calcarenite (aeolianite), (B) feldspathic aarenite beach rock, (C) rounded volcanic clast and (D) close up of the volcanic clast (illustrating finely crystalline quartz, feldspar and magnetite).

Figure 7. Plan showing the configuration of the bedrock in the excavated area of the swale at Nissi Beach: note the outcrops of aeolianite along the north, west and south sides of the excavation. There is a low open area in the middle. The numbers give the elevation of the natural land surface (below the local datum; see the text for its height relative to sea level today).

Figure 8. Plan of the "basin" feature on the south side of the swale (see Fig. 7 for its location on the plan of the excavation). As explained in the text, it was purposely modified -- by inserting the three piece of rock highlighted in yellow to fill in gaps in the bedrock -- to create a storage space.

Figure 9. Three details of the "basin" feature (shown in Fig. 8): (upper left) cross section of the pair of inserted rocks on the west side, (upper right) cross section of the rock slab inserted on the north side and (below) perspective drawing of the feature from the east side. **[Note to the editors: there is a good photograph of the work in progress on drawing the "basin" feature; it could be used as an option here instead of the three "details" shown here; see the caption for the optional Figure 9 below. Or one could even use both, if there is space for them.]**

Figure 10. Plan of the cluster of rocks (SU-108) in squares **24** and **25** (seen from the north side). It is interpreted as the remains of a disarticulated hearth feature. The three letters indicate respectively the locations of pieces of Patella shell (P), Osilinus shell (O) and ceramics (C). The elevations are given below the local site datum (see Fig. 7).

Figure 11. Diagram giving the calibrated ages of six AMS dates run on samples of marine shell from the excavations at Nissi Beach. On the methods used in the calibration and the correction for the reservoir effect, see the Appendix written by Thomas Higham at the end of Ammerman *et al.* 2008, 30).

Figure 12. . Pie diagrams summarizing the results of the study of the marine invertiebrates recovered from the excavations at Nissi Beach in 2008 and 2009: proportions (of total taxa and MNI) of the shells representative of either rocky shore habitats or soft-substratum (principally sandy) shore habitats.

Figure 13. Pie diagrams summarizing the results of the study of the marine shells recovered from the excavations at Nissi Beach in 2008 and 2009: proportions (by MNI) of the marine shell taxa that were probably food items ("edible") and those that were probably collected for other purposes ("non-edible").

[Optional Figure 9. Photograph of the "basin" feature on the south side of the swale. Manuela Brunacci is shown drawing the two rocks that were inserted on the west side of the feature (they are highlighted in yellow on the right side of Fig. 8). Not used.] **DO NOT PRINT**.

Table Captions

Table 1. List of marine taxa, along with commonly used English names (where applicable), recovered from the excavations at Nissi Beach in 2008 and 2009.

Table 2. Nissi Beach 2008 and 2009. Quantification by minimum numbers of individuals (MNI) of the taxonomic groups of marine invertebrates recovered in the excavations. See the text for further explanation.

Table 3. Nissi Beach 2008 and 2009. Fragment counts for the various marine invertebrate taxa.

Table 4. Nissi Beach 2008. Distribution of marine mollusc taxa by minimum numbers of individuals (MNI) in each metre square.

Table 5: Nissi Beach 2009. Distribution of marine invertebrate taxa by minimum numbers of individuals (MNI) in excavation squares **13**-**27**.

Table 6: Nissi Beach 2009. Quantification of the marine invertebrates recovered from stratigraphic units 105 to 108 in square **25**.