An offprint from

ISLAND ARCHAEOLOGY AND THE ORIGINS OF SEAFARING IN THE EASTERN MEDITERRANEAN

Proceedings of the Wenner Gren Workshop held at Reggio Calabria on October 19-21, 2012

In memory of John D. Evans

Eurasian Prehistory Guest Editors:

Albert J. Ammerman and Thomas Davis

PART ONE

(*Eurasian Prehistory* 10/2013)

Introduction

Placing island archaeology and early voyaging in context

Case studies

A. Cyprus

PART TWO

(*Eurasian Prehistory* 11/2014)

Eurasian Prehistory, 10 (1–2): 83–98

MARINE RESOURCES IN THE EARLY NEOLITHIC OF THE LEVANT: THEIR RELEVANCE TO EARLY SEAFARING

Daniella E. Bar-Yosef Mayer

Steinhardt Museum of Natural History, Tel Aviv University, Tel Aviv 69978, Israel; baryosef@post.tau.ac.il.

Abstract

Aquatic resources and especially molluscs and fish are encountered from the Lower Palaeolithic. In the Levant, shellfishing and the fishing of marine species began in the Early Natufian (ca. 15ka BP). Fish and mollusc exploitation before and during the Neolithic period, as proxies for interaction between humans and the marine environment, enhance our understanding of how and why Southwest Asian populations migrated to Cyprus. A survey of the fish exploited in the Eastern Mediterranean during the Epipalaeolithic and Neolithic periods reveals that they are mostly shallow-water, lagoonal, and brackish-water fish. Although larger fish and fish from deeper waters are not found in the Levant at these early times, they are recovered at later Neolithic sites in the Aegean Islands and on Cyprus. During the PPNB in the Levant, there is little or no evidence for Mediterranean fishing. Instead, fish were obtained from the Nile River and the Red Sea. Thus, fish were a desired food, and this may hint at yet another motivation for exploring the seas. At the submerged Neolithic site of Atlit Yam, triggerfish may have been caught for a utilitarian purpose in addition to food consumption. Shellfishing in the Levant is not well attested, and if shell middens once existed, they are now submerged. But in other parts of the Mediterranean there is evidence for the collection of *Patella* and *Osilinus*, rocky shore species. They are present at coastal sites of Neolithic age on Cyprus and served as interim food after landfall and before terrestrial fauna and flora could be consumed. The familiarity of people living at coastal sites, which had marine environments close at hand offering sources of both food and raw materials, motivated and enabled early seafaring in that it assured the provision of food during voyages and immediately after landfall.

Key words: mollusc shells, fish remains, marine resources, Neolithic, Levant, Cyprus, Mediterranean

INTRODUCTION

The early evidence for the colonization of Cyprus, in the sense of the permanent occupation of a site on the island and not just a seasonal or short-term campsite on the coastline there, now goes back to around 10,750 cal. BP on the basis of the evidence from Klimonas and Asprokremnos, where hunter-cultivators lived in the interior at two settlements of late PPNA age (see Briois and Guilaine in this issue and Manning in the next issue). In order to cross over from the mainland to Cyprus, those making a voyage had to have the ability to sail, to survive the journey, to land on the island, and to survive there once they reached it (Knapp, 2010). Le Brun (2001:116) emphasizes "the possession of a maritime culture and knowledge of the sea" over the long term. The ability to obtain food from the sea is probably one of the main conditions for initiating a voyage that involved setting out on the open sea as well as for basic livelihood during the first weeks and months after landfall. Here I shall review the evidence for marine resources exploited by pre-Neolithic and early Neolithic societies of the Levant, which commonly held to give rise to the two oldest Neolithic cultures on Cyprus: namely, the periods there now called Cypro PPNA and Cypro PPNB (see Davis in this issue). By comparing the faunal assemblages at sites on the Mediterranean coast of the Levant (part of Southwest Asia in broader geographical terms), as well as coeval sites located on coasts in

other parts of the Mediterranean such as Greece, with their counterparts on the island of Cyprus, we can gain a better sense of the connections between populations, societies and cultures – in the sense of showing continuity or else discontinuity with respect to certain traditions – and thus complement what is known on the basis of other lines of archaeological study.

WHAT ARE MARINE RESOURCES?

Marine resources, in the early periods discussed here, are primarily vertebrate and invertebrate fauna. Vertebrates include fish, marine mammals, marine birds, and sea turtles. Invertebrates include molluscs (including gastropods, bivalves, scaphopods, cephalopods and polyplacophorans), crustaceans, and other invertebrates such as echinoderms (e.g., sea urchins). Of these, fish and molluscs are the best known archaeologically. Other resources such as sponges, marine flora (sea weeds), and salt could also have been collected. Evidence for sea weeds or grasses is rare in the archaeological record, but they were found in California, where they were used to make rope and other things (Vellanoweth *et al.*, 2003). Evidence for salt extraction is scarce (but see Ammerman, 2010:88; Ammerman *et al.,* 2008:fig. 10). Thus, mostly fish and mollusc remains are found in the archaeological record of the periods under consideration here, and they will be the main focus of discussion, centered on the Natufian and Neolithic cultures of the Levant.

CULTURAL AND CHRONOLOGICAL BACKGROUND

The Natufian (14.5-11.5 cal. BP) was the principal culture the end of the Epipalaeolithic, and it is considered to be the precursor to the "Neolithic Revolution" in this part of the world (e.g., Bar-Yosef, 2011). It is distinguished, among other characteristics, by increased sedentism, which is accompanied by an increase in the long-distance exchange of marine shells among other things. The Natufian culture is divided into the Early Natufian, 15,000-13,000 cal. BP and the Late to Final Natufian, 13-11,500 cal. BP). Its subsistence economy is based on the exploitation of a wide spectrum of fauna and flora. Most of the Natufian sites are located either on the coastal plain (the western part of its spatial distribution) or else in the Jordan River basin with its associated lakes (in the east). Both offer habitats that were ideal for exploitation of aquatic resources such as mollusks and fish. Surprisingly, while the broad spectrum of the Natufian economy has been widely discussed in the literature for years (e.g. Edwards, 1989; Stiner, 2001; Munro, 2004), it is only quite recently that the contribution of aquatic resources has begun to be studied more systematically (Bar-Yosef Mayer and Zohar, 2010).

The Neolithic period is divided into various cultures and phases (see Fig. 1 in Davis in this issue, called Chronological Framework, where three parallel time lines are shown for the Levant, southeast Turkey and Cyprus). In the case of the Levant, the main units include: the Pre-Pottery Neolithic A (PPNA; ca. 11,600-10,500 cal. BP), Pre-Pottery Neolithic B (PPNB; ca. 10,500-8,200 cal. BP), the Pre-Pottery Neolithic C (PPNC; ca. 8,200-7,500 cal. BP), and the Pottery Neolithic (ca. 7,500-7,000 cal. BP). The distributions of Natufian and Neolithic sites, as known to us today, pose a challenge for the study of marine resources. Because of sea-level rise at the end of the Pleistocene and during the Holocene, if there were any coastal sites during those periods, they are now submerged (Bailey *et al.,* 2008; see also Bailey in this issue). Accordingly, only a few Neolithic sites are known from the coast, one of which, in a submerged context, was extensively excavated (Galili *et al.*, 2004), and no submerged Natufian sites on the coastline at the time, which requires working on the seabed at depths of more than 30 m below sea level today) have yet been found. On the other hand, the Natufian sites of the Mount Carmel range and western Galilee, which are located a few kilometers to the east of the coastline today, have produced the remains of marine resources (fish bones and molluscs) as well as fishing gear.

The use of fish as a food source and mollusks, as both food and raw material for ornaments and other artifacts, is known from Palaeolithic times onwards throughout the Old World. But the intensification of their use in the periods of interest in this paper is significant. While the use

of fish and shell for consumption and for artifacts complement one another, they will be presented separately here, which is done only for purposes of convenience.

FISH AND FISHING

Evidence from the Levant

The collection and consumption of freshwater fish in the diet makes its appearance as early as the Lower Palaeolithic (e.g., Erlandson, 2001 and references therein). Palaeolithic sites in the Levant with freshwater fish include Gesher Benot Yaakov dated to about 800,000 years ago and Amud Cave (Zohar and Biton, 2011). There has been the occasional recovery of marine fish bones at other Palaeolithic sites (e.g., at Douara Cave; van Neer *et al.,* 2005). But they are considered to be fossils, and their role in subsistence is doubtful. Fishing was undoubtedly part of the economy at the end of the Upper Palaeolithic, as documented at the submerged site of Ohalo II, found on the bottom of Lake Kinneret (Sea of Galilee), which dates to ca. 23,000 BP (Nadel, 2002). However, the onset of marine fishing is less clear. It is assumed that those living in Epipalaeolithic times exploited fish, although the evidence is scant. Extensive research on fauna of the Natufian culture (Garrod and Bate, 1937; Tchernov, 1991; Stiner, 2001; Munro, 2004; Bridault *et al.,* 2008; and see Bar-Yosef and Valla, 1991; Bar-Yosef and Valla, 2013) shows that there was the reliance on the hunting of gazelles as well as a wide range of smaller animals, and there was also intensive use of plant foods (Rosen, 2010) – all part of what is commonly called "broad spectrum subsistence" (Stiner, 2001). The small animals include fish both from inland waters and from the sea. It is perhaps worth mentioning here that, in the Western Mediterranean, Cueva de Nerja has also produced fish remains, which date to the Late Upper Palaeolithic (Morales-Muñiz and Roselló-Izquierdo, in press).

Fishing in the Natufian

Van Neer and colleagues have argued that, in the Levant, marine fishing is clearly documented only from the Epipalaeolithic onwards (van Neer *et al.*, 2005; see also Bar-Yosef Mayer and Zohar, 2010). Marine fish remains have been discovered at the Kebara Cave (Turville-Petre, 1932); el-Wad terrace (Desse in Valla *et al.*, 1986); and Hatoula (Lernau and Lernau, 1994). At Hayonim Cave, bones of marine and freshwater fish are both present (Bar-Yosef Mayer and Zohar, 2010). The bones are those of marine fish with littoral and estuarine environments (*Serranidae, Sparidae, Sciaenidae* and *Mugilidae*). Such marine fish from the littoral zone are easy to catch without the need for sophisticated equipment: that is, they could be caught by hand or with the aid of simple nets and traps. The presence of bone harpoons at the caves of Kebara and Raqefet (Campana, 1989; Nadel *et al.*, 2008) and at Antelias Cave in Lebanon (Copeland, 1991:30, 34-5) as well as bone hooks at Kebara (Campana, 1989) provides evidence on the fishing methods that were used. It is worth adding here that harpoons could be used for catching octopus and squid (of which there are, of course, no material remains in the archaeological record so far).

Fishing in the PPNA

One of the most important sites for understanding the value attributed to fish is that of Hatoula, which is located about 30 km inland from coastline today. Hatoula had three phases of occupation: Natufian, Khiamian and Sultanian. The continuation of fishing there from Late Natufian into the PPNA (Khiamian and Sultanian), and the increase in the diversity of fish over time are important for our understanding of the main trends in fish exploitation. Furthermore, fish that were brought to the site from the Mediterranean may have been processed by drying, smoking, or salting prior to transportation in order to avoid spoiling along the way (Lernau and Lernau, 1994).

Fishing in the PPNB, PPNC and Pottery Neolithic

Currently there is in Israel no published information on fishing in the Mediterranean Sea during the PPNB. However, this lacuna is surely a temporary one. The little that is known consists of one fish bone discovered at Yiftah'el

(Lernau, 2008; van Neer *et al.,* 2005). The PPNB site of Ujrat el Mehed in southern Sinai produced unidentified marine fish bones, which may come from the Red Sea (Dayan *et al.*, 1986), while the PPNB site of Wadi Tbeik in southern Sinai yielded bones of a Nile Perch, which were brought from Egypt (Lernau, 2008; van Neer *et al.*, 2005). The PPNB site of Ain Jammam in southern Jordan contains bones of the Parrotfish *Scarus* sp., from the Red Sea, at a distance of 150 km from the site (Dean 2013; Makarewicz, 2009). The evidence from the sites mentioned here is of significance since all of the PPNB sites are located at some distance from the place where the fishing took place. The southern sites obtained fish from southern sources (the Red Sea or the Nile River); this suggests that fish consumption during the PPNB may have already become a special food or even a desired one and not just a necessity driven by the "broad spectrum diet," which represents a widely held view of the subsistence strategy during the Natufian (Stiner *et al.*, 2000).

Mediterranean fishing then picks up during the PPNC with the establishment of fishing settlements along the coast (Galili *et al.*, 2004). The best evidence comes from the submerged site of Atlit Yam where large concentrations of triggerfish bones (*Balistes capriscus* Gmelin, 1789, previously known as *B. carolinensis*) were recovered from specific structures covered with clayey sediments of terrestrial origins. Importantly, other species are also present at the site – mostly littoral species. Additional evidence comes from other PPNC and Pottery Neolithic sites: Ashkelon, Ziqim, Neve Yam, and Kabri. Typically, the fish assemblage contains medium-sized fish that measure up to 70 cm in length) and that were caught in shallow waters. Such is the case of the groupers (*Epinephelus* spp.), which can be easily fished under rocks in shallow waters with baited line or else a harpoon. At most of these sites, there appears to be the dominance of a given species: groupers at some sites and triggerfish at others, whereas in later sites from the Bronze Age there is less selection and consequently a much larger species richness (Lernau, 2008, see also Morales-Muñiz and Roselló-Izquierdo, in press). The observed dominance may be due either to availability or else to preference, yet the presence of a Nile Perch bone at Ashkelon in a PPNC context suggests that other sources of fish were sought as well, and that drying, smoking or salting of fish was being practiced. In contrast with the situation in Israel, very little information is available on fishing in other parts of the Levant during these time periods. During the late Epipalaeolithic and early Neolithic in Turkey and Syria, fish are mostly from freshwaters and the relatively few assemblages with taxa determinations indicate Cyprinids (carp) and catfish (van Neer *et al*., 2005).

Evidence for fishing on Cyprus

Few reports on fish remains have been made for Neolithic sites of Cyprus, and only the remains from Shillourokambos, Cap Andreas Kastros, and Khirokitia have been thoroughly studied and published, and those of Paralimni-Nissia were briefly mentioned. In the case of the PPNB settlement called Shillourokambos, whose occupation goes back to ca. 10,300 cal. BP, the fish bones consist mostly of Serranidae (groupers comprising 90 percent of the assemblage): within this taxon, the measurements made by the authors indicate large individuals in the range of 63 to110 cm in length and weighing from 4 to 17 kg each. A few sting bones of rays were recovered as well (Desse and Desse-Berset, 2011).

At the site of Cap Andreas Kastros, which is carbon dated to the 8th millennium cal. BP, some 6,000 fish bones were recovered. The ichthyofauna is composed of 22 percent of fish from the littoral zone (the *Sparidae* family); groupers, also from the littoral, comprise 28 percent of the assemblage, while the largest class (36 percent) belongs to pelagic fish such as tuna and mackerels. The relatively large proportion of triggerfish (about 8 percent) is surprising; based on an ethnographic analogy, the researchers propose that the rough skin of this fish was collected and used for polishing materials such as wood and ivory (Desse and Desse-Berset, 1994). The authors conclude that fishing was done on a year round basis at Cap Andreas Kastros.

At Khirokitia, the occupation of the site dates to the period of the Aceramic Neolithic just after the PPNB on Cyprus with its oldest C-14 dates going back to about 8,800 cal. BP. Despite its location next to a small seasonal stream and at a

distance of 6 km from the sea today, only marine fish from the littoral zone have been recovered at the site. Given the size of the excavation, the assemblage is quite small: with specimens mostly of groupers and sparids, which were brought to the site in the form of whole fish (all skeletal parts were represented); in terms of size, the fish measure over 30 cm in length and weigh more than 2 kg in some cases. A few mullets and sea bass were recovered as well (Desse, 1984; Desse and Desse-Berset, 1989).

At the site of Nissia, also called Paralimni, a late Neolithic settlement with painted pottery located on the east coast of Cyprus, there are only some 20 fragments of larger fish bones recovered by hand during the course of the excavation. The flotation of soil samples yielded samples of small fish bones, attesting to the potential of finding fish remains in that site (Croft, 2008:105-106).

A total of 25 fish bones, as yet unidentified, were found at the settlement of Kalavasos-Tenta (Reese, 2008a), but the age of these finds is unclear. At the PPNB settlement of Akanthou-Arkosyko (Tatlısu Çiflikdüzü in Turkish), located on the north coast of the island, fish bones of both littoral and deep-sea species are mentioned in a preliminary report as well as fishhooks made of fish bones and sea turtle shell (Şevketoğlu, 2006).

Evidence for fishing in other areas of the Mediterranean

Little information is available on fishing from other sites located elsewhere in the Eastern and Central Mediterranean during late Epipalaeolithic and Neolithic periods. The information comes mainly from the Franchthi Cave in Southern Greece and the Cyclops Cave on the island of Youra in the Northern Aegean.

The fish assemblage at the Franchthi Cave was first described by Rose (1995), and more recently another study of a different part of the stratigraphic sequence was carried out by Stiner and Munro (2011).

After reading both publications, it would appear that marine fishes first appeared around 11,000 cal. BP, and they became prominent during the Mesolithic (9,100-8,000 cal. BP, as seen in the FAS trench) when the coastline was about 2 km away (Rose, 1995). Fishing during the Mesolithic is attested at first by the remains of inshore fish such as breams, later by barracuda (*Sphyraena* sp.) and other open water taxa, and finally by large quantities of tuna fish (Rose, 1995). Another study by Powell (2003) claims that, in the Upper Mesolithic levels at Franchthi, the bones of large (50 plus kg) tuna are accompanied by those of sea bream, mullet, grouper, barracuda, and eel, which accounted for up to 50 percent of the bone assemblage. Clupeiforms (sardines) are also found in small numbers, according to Rose (1995:24) and also Stiner and Munro (2011:627).

According to Powell (2003), a similar picture emerges at the Cyclops Cave on the island of Youra, which was visited (possibly from Skyros) in the months of June and September for the purpose of fishing. Stiner and Munro (2011), who identified the same taxa in the assemblages at the Franchthi Cave, attribute some importance to the degree of burning observed on fish bones and note that it declined as evidence for fishing intensity increased (first 15-16 percent prior to and then 8-13 percent during the Mesolithic), but all other indications are that human beings brought the fish into the cave, including tuna. Stiner and co-workers (2012:37) note that "Marine resources came into importance in the second half of the Franchthi Cave sequence with sparids or sea breams (mostly gilthead, *Sparus aurata*) and are especially common in the fish assemblages (rarely mullets, Mugilidae, and sea bass, *Dicentrarchus labrax*), later replaced to some extent by barracuda (*Sphyraena sphyraena*) and conger eel (*Conger conger*) and eventually bluefin tuna or **"**tunny**"** (*Thunnus thynnus*) (Rose, 1995)". It is not known whether the tunny were caught from the shore or from boats at sea. According to Morales-Muñiz and Roselló-Izquierdo (in press), some large migrant fishes such as scombrids, eels, needlefishes (*Belone* sp.) and barracudas (Sphyraenidae) and also pelagic sharks and jacks are offshore species, which approach the coast at certain times and even to such an extent that they become readily accessible from the shore itself.

While the general picture that one obtains from the Franchthi Cave and the Cyclops Cave resembles in some ways what is seen at Cap Andreas Kastros, the lack of detailed zooarchaeological reports for the two Greek sites

means it is not possible to make a more complete evaluation. To this, it is of interest to add some information from the Tyrrhenian and the Adriatic Seas. The marine fauna from Grotta della Serratura on the Tyrrhenian coast of Italy was studied by Wilkens (1993). Fish remains were discovered in the Palaeolithic, Mesolithic, and Neolithic levels. In the Palaeolithic most of the fish remains (about 62 percent) were eel (*Anguilla*) from estuaries; fish bones of mugilid (mullet) represent about 23 percent, while 10 percent are those of needlefish (*Belone*), a brackish water species. During the Mesolithic, the majority of fish were needlefish (92 percent), whereas one observes in the Neolithic a clear shift to shallow water marine species – with sparids and groupers now dominating the assemblage. In all levels of the cave, there is also a variety of other species (represented by a few bones each) with a total of about 20 different fish taxa at the site (Wilkens, 1993). On the island of Vis in the Adriatic, the bones of tuna, dolphin, and sea bream make their first appearance in the Early Neolithic assemblage, and they go on to be found in later deposits as well (Čečuk, 1989:46, as cited in Bass, 1998).

MOLLUSCS AS FOOD

Evidence from the Levant

Marine mollusks, which were consumed as food, are known from Paleolithic sites of both *Homo sapiens* and Neanderthals (Erlandson, 2001 and references therein; Cortés-Sánchez *et al.*, 2011). In the Levant, molluscs are relatively rare as a food source, and no shell mound has ever been discovered. However, during the Late Natufian, there are large numbers of freshwater *Unio* shells at Eynan, which may have served as food. A few *Patella* shells at the El Wad Cave and El Wad Terrace may indicate that this species was consumed during the late Epipalaeolithc and that a shell midden, if one existed closer to the shoreline at the time, would now be submerged. Another possible use for *Patella* shellfish is as bait in fishing (Claassen, 2013). The presence of several unperforated valves of *Acanthocardia tuberculata* and *Cerastoderma glaucum* at Hayonim Cave (currently at 13 km from the Mediterranean shore; Kurzawska, 2013) further supports this suggestion.

At the PPNC site of Ashkelon, a very large concentration of oysters may testify to their consumption (Bar-Yosef Mayer, 2008), and the Pottery Neolithic site of Ziqim, which contained numerous *Cerastoderma glaucum*, a species from brackish water commonly found in estuaries, could have also been collected as food in the nearby estuary of Nahal Shiqma (Lernau, 2008). Large numbers of *Cerastoderma glaucum*, which were found at Yiftah'el and Kefar Ha-Horesh as well, could have served either as ornament or food.

Evidence from Cyprus

Most pre-Neolithic and Neolithic sites on Cyprus contain some shells: either as food, as ornaments and other artifacts, or both. However, in many cases, detailed reports have yet to be published, and some of the information is secondary. Ornamental shells should be discussed as part of the material culture along with lithic artifacts, because they were often collected as heavily abraded specimens (that is, more likely as limestone). What follows is a concise review of the available evidence on edible molluscs, which is developed more or less in chronological order.

At Aetokremnos, *Patella caerulea* and *Osilinus turbinatus*[1] (previously called *Monodonta*; *Osilinus* is the preferred name used in this paper) are two gastropods that live on rocks in the tidal zone. These species were the main ones exploited by those frequenting the site at the end of the Pleistocene (the 12th millennium cal. BP), and they were represented by more than 20,000 MNI (Reese, 1999). Of the two edible species, almost 70 percent were recovered from stratum 2 and its sub-phases. In addition, about 21 percent of the *Osilinus* shells and 40 percent of the *Patella* shells were found to be in a burnt condition, according to Reese (2006). The *Osilinus* shells were often smashed with 80 percent of them being burnt and 30% of the *Patella* shells were burnt as well. Other marine food resources fournd at

[1] *Osilinus turbinatus* is now called *Phorcus turbinatus* (Donald et al. 2012).

Aetokremnos include: 3 pieces of crab, 1 sea urchin (*Paracentrotus lividus*), and 1 cuttlefish (*Sepia* sp.) (Reese, 1999). Only about 10 percent of the shellfish come from stratum 4, the lowest level in the excavation, which produced a rich bone bed with the remains of more than 350 pygmy hippos (based on MNI), but only about 10 percent of the lithic finds at the site (Simmons, 1999:table 6-1). This indicates far less in the way of occupation for stratum 4, which stirred much controversy, than for stratum 2 (for the excavator's latest ideas about the site, see Simmons in this issue).

At the late PPNA settlement of Klimonas, which is located in the interior but from which the sea is visible, marine resources are rare, and according to a preliminary report on the recent excavations at the site, shellfish were not consumed as food (Vigne *et al.*, 2012:8447, S8). At the site called Asproskremnos located near Ayia Varvara in the interior of the island, the settlement has the same late PPNA age as Klimonas (see Manning in this issue), and it has produced no remains of fish or shellfish as one might expect given the site's considerable distance from the coast (Manning *et al.*, 2010).

The PPNB settlement of Shillourokambos is also located at some distance from Limassol on the south coast of Cyprus. It has produced only 12 shells of the edible *Osilinus* and *Patella*; most of the other shells (a total of 372) were used for purposes of decoration or else for other kinds of artifacts (Serrand and Vigne, 2011).

At the open-air site of Nissi Beach located on the coastline near Agia Napa, the excavation of the paleosol in the swale area has produced a PPNB related chipped stone assemblage, which goes back to the 8th millennium cal. BC (see Ammerman in this issue). The marine shells recovered at the site included 27 taxa with 254 MNI shells: of those, 219 (86%) are edible species of the genera *Osilinus*, *Patella*, *Haliotis* and Muricids (see the report on the marine shells by Ken Thomas in Ammerman *et al.*, 2013). Many of the shells derive from shell deposits in the northern squares of the site, which date to the Late Neolithic, and not to the part of the site coeval with the PPNB, which produced a number whole shells of a wide range of different species used for ornaments as well as *Osilinus* and *Patella* for food. Thomas notes that they are rocky shore species, and that edible species, especially bivalves, living on sandy or muddy bottoms were not present.

The PPNB settlement of Kalavassos Tenta, which is located some 4 km from the south coast, has produced a range of edible species: mostly *Osilinus, Patella* and *Cerastoderma* as well as very small numbers of *Gibbula, Euthria, Cerithium, Venus, Spondylus,* and *Arca*. To these, one should add some remains of crabs, apparently both of marine (*Eriphia*) and freshwater origin (*Potamon*) (Reese, 2008a). It seems that most of the material originated from the late Neolithic levels at the site or later.

At Khirokitia, which dates to the time just after the PPNB, several dozen *Osilinus* are present, but *Patella* is absent (Demetropoulos, 1984). According to Reese (1999), most of the shells come from graves at the site, and therefore were probably not a food source (except perhaps in a symbolic sense). It is possible that some shellfish were consumed, but they were not a major source of food at the site.

The molluscs recovered at Cap Andreas Kastros, a site dating to the very end of the Aceramic Neolithic on Cyprus, were first studied by Reese (1978). He reported that *Osilinus* is represented by 85 complete shells and more than 6,800 fragments, while *Patella* has a total of 710 complete shells and almost 600 fragments. They are, of course, the most common edible species. Cataliotti-Valdina (1994) re-studied the shells from the 1973 excavation season and presented a more detailed study relating to spatial and stratigraphic information, and addressed climatological, ecological, and ethno-archaeological information, as well as published photos of selected specimens. Cataliotti-Valdina (1994:appendix 8) was able to identify 66 taxa at the site, and also concluded that *Patella* and *Osilinus* together form the largest group comprising 75 percent of the shells at the site along with *Columbella,* which was the most prominent ornamental shell. The edible species of *Osilinus* and *Patella* complement each other throughout the main strata of site (strata II-VI): whenever there was a shortage of one of the genera it was complemented by the other (Cataliotti-Valdina, 1994:fig. 2). Although she regards *Hexaplex* as an edible species, the photos of the shell themselves do not support this notion, since most of them appear to be heavily abraded and

were probably collected as dead specimens on the beach (Cataliotti-Valdina, 1994:plates XLIII, XLIV XLVII).

The Late Neolithic site of Paralimni-Nissia also yielded various shells, comprising 759 MNI of gastropods and 153 MNI of bivalves. Among the gastropods, the MNI count of 491 *Patella* are most likely food remains (Reese, 2008b).

The general and preliminary impression that one gets from these assemblages is that coastal sites on Cyprus exploited shellfish as food, mostly from the rocky littoral zone, while sites in the interior showed little interest in edible shellfish. If the latter used shells from the sea, it was for purposes of artifacts and not food.

Evidence from other Mediterranean regions

Molluscs used as food are known from a number of Palaeolithic sites around the Mediterranean. Most notably, one should mention Gibraltar and Grotta Moscerini (Ferguson *et al.*, 2011; Stiner, 1994). Since many of the Italian Palaeolithic sites are located on steep coastal areas with limestone bedrock, those frequenting the caves exploited rocky shore molluscs (*Osilinus* and *Patella*) rather than soft bottom dwellers (Colonese *et al.*, 2011). Shellfish had been exploited in the Iberian Peninsula and on the Italian mainland at least as far back as the Mousterian (Stiner, 1994; Cortés-Sánchez *et al.*, 2011), while a marked increase in exploitation in the latter case occurred in the Final Epigravettian, as recorded at Grotta della Serratura (Colonese and Wilkens, 2005), at Grotta della Madonna (Durante and Settepassi, 1972) and at other sites (Mannino and Thomas, 2007:28).

This trend was observed in most Mediterranean shell bearing midden sites. Sites closer to lagoons were generally represented by *Cerastoderma glaucum* (Colonese and Wilkens, 2005). The changes in the molluscan assemblages were probably caused by modifications in local coastal environments likely related to sea- level rise (Wilkens, 1993). Recently Mannino and Thomas have studied shells from Upper Palaeolithic (Late Epigravettian) sites in northwestern Siciliy. Assemblages dating to 14,000 –12,000 cal. BP were composed of rocky shore species, with three species of *Patella* and two species of *Osilinus*. Their research indicates the absence of humans in Sicily before the Final Epigravettian (ca. 15,000 cal. BC) (Mannino and Thomas, 2007; see Mannino in the next issue).

Oxygen isotope analyses on the marine molluscs from late Upper Palaeolithic sites in Sicily (Mannino *et al.*, 2008) show that intertidal mollusc collection usually occurred between the end of autumn and the beginning of spring when sea surface temperatures are lower. Intertidal molluscs were, therefore, a markedly seasonal resource, and the temporal pattern of their exploitation was probably a consequence of the fact that humans moved away from the seashore (possibly to higher elevations) during the summer months. At the sites in Italy, the increase in marine molluscs is paralleled by an increase in fish and bird bones, which is in keeping with the idea of the exploitation of a wide range of coastal fauna (Durante and Settepassi, 1972).

Riparo Blanc, a Mesolithic rock-shelter along the Tyrrhenian coast of Central Italy, which dates to around 9,500 cal. BP, yielded a large assemblage of marine molluscs. They were collected from the intertidal rocky shore (*O. turbinatus* and *Patella* spp.) and lagoonal and soft bottom intertidal and environments (*Ruditapes decussatus* and *C. glaucum*). In addition, there were the remains of crustaceans, echinoderms, and a few fish bones, but the excavation recovered only a few bones of terrestrial mammals. At coastal Neolithic sites on Corsica, some shellfish (*Osilinus* and *Patella*) were consumed as well (Vigne, 1995).

The most detailed and long-term record of exploitation in the Central Mediterranean for the late Upper Palaeolithic is that of the Franchthi Cave. Marine mollusc exploitation at this site is observed at about 12,000-10,000 cal. BP (Stiner and Munro, 2011; Rose, 1995; Shackleton, 1988). As at other Mediterranean sites, marine mollusc exploitation increased in the final Upper Palaeolithic and Mesolithic and became focused principally on rocky shore intertidal species, represented by *O. turbinatus*, *Gibbula divaricata*, *Gibbula rarilineata*, but also sporadically on taxa from lagoons or muddy shores, such as *Cerithium vulgatum* and *Hexaplex trunculus* (Shackleton, 1988). Shackleton and van Andel (1986) have explained this increase as being a direct

consequence of the changes produced by Late Glacial sea-level rise on the coastal ecosystems of the Argolid.

Perlès (2010) sees the consumption of mollsucs (both marine and terrestrial) at Franchthi as a response to dwindling resources during the Younger Dryas, although feasting may have also been one of the reasons for collecting them (Perlès, 2010:124). Stiner and Munro (2011) also see significant increase in dietary breadth, including other marine resources at this time. The later occupants at Franchthi turned increasingly to the sea, beginning with shellfish collecting and shoreline fishing in the late Palaeolithic and expanding then to include fishing in the Mesolithic. During the Mesolithic, the intertidal rocky shore taxa (*O. turbinatus* and *Patella* spp.), which were formerly abundant in the Upper Palaeolithic, decrease dramatically, and they were replaced by coastal lagoon and brackish water taxa (Shackleton, 1988). The Mesolithic mollusc assemblage from Franchthi Cave is dominated by *Cyclope* spp., which was not collected for dietary purposes, and *C. vulgatum*, which was the most important edible mollusc.

In the late stages of the Mesolithic (ca. 9,200 cal. BP) and the Early Neolithic, there is a marked decrease in fishing and an increase in the collection of *C. vulgatum*, which now accounts for 60-80 percent of the marine molluscs. Shackleton and van Andel (1986) state that *C. vulgatum* would not have offered great food value and recognized that although other marine molluscs would have been present in the catchment of the Franchthi Cave, the fact that other species were practically ignored at that time is puzzling. Thomas (1987) has pointed out that a careful taphonomic study should have been undertaken to prove or disprove whether these marine molluscs were actually collected for food. Species could have been used as fishing bait or they could have adhered to fishing nets that were pulled to shore. In any event, at the end of the Mesolithic, when there was a marked decline in the size of the lithic assemblage at the site, marine molluscs constituted a minor item in the diet of the last hunter-gatherers at the Franchthi Cave.

Data on coastal Epipaleolithic sites in Turkey are still few, but exploitation of rocky shore species is indicated by the Epipaleolithic fauna dating to around 20,000 years ago at the Üçağızlı I Cave in Southern Turkey (Stiner *et al.*, 2000; Kuhn *et al.*, 2009). A similar situation is observed at the Öküzini Cave as well as level B at the Karain Cave in Southern Turkey (Albrecht *et al*., 1992). Unlike Üçagızlı, which is a coastal site, the latter are some distance inland, resembling what one finds in the Levant in their relationship to the coast.

DISCUSSION AND CONCLUSION

Marine resources, especially the remains of molluscs and fish, are known from many prehistoric sites around the world and some are from very early periods. In this chapter, I have tried to explore the connection between reliance on marine resources and seafaring – specifically with regard to voyaging between the Southwest Asian mainland and the island of Cyprus. The marine resources exploited in the Mediterranean, and the ones that are most widely recognized in the archaeological record, are mostly species of molluscs and fish, which live in the littoral zone. As we have seen, most common are the gastropods *Osilinus* and *Patella*, which are rock dwellers, and various fish, especially the families Sparidae (sea bream), Serranidae (groupers), Mugilidae (mullets) and *Dicentrarchus labrax* (sea bass). Both local ecological conditions and human choices seem to have played a role in their presence or absence at the various archaeological sites.

The onset of agriculture in southwest Asia as a main economic strategy probably played a central role in the migration of people to Cyprus (Bar-Yosef, 2001; Le Brun, 2001; Knapp, 2010) and also represented the first step in the westward spread of early farming in Europe (Özdoğan, 2010). Population growth fostered the need to control food resources and subsequently fresh water resources as well (Garfinkel *et al.,* 2006). The apparently conflict-ridden mainland (Clare and Gebel, 2010), coupled with the capability to rely on marine resources enabled the attempts at voyaging. In addition, the important domesticated plants and animals that they took with them on their voyages supports this notion (Vigne and Cucci, 2005; see Vigne in this issue). A good understanding of wind regimes together with the skills in the construction of seaworthy boats were

obviously called for in order to make crossings on a regular basis from the mainland to Cyprus, where new fishing grounds and new land for early farming were both available.

The evidence presented in this paper indicates that marine fishing started in the Mediterranean apparently at some time between 18,000 and 12,000 years ago, and the practice probably varied regionally. Groupers were the preferred fishes at various Mediterranean sites, especially near rocky shores (Morales-Muñiz and Roselló-Izquierdo, in press). This is a pattern that was first recognized by Desse and Desse-Berset (1999). The gilthead, *Sparus auratus*, is more typical of coastal lagoons and estuaries along with sea bass, grey mullets and eels. In the case of PPNC sites in the Levant, the preference for groupers is also noted by Lernau (2008); on Cyprus, it is seen at Shillourokambos as well (Desse and Desse-Berset, 2011).

According to Morales-Muñiz and Roselló-Izquierdo (in press), the transportation of fish to a settlement at a distance of more than 2 km from the shoreline signals a critical threshold above which the visibility of local fishing would be considerably reduced and thus unlikely to leave ample traces in the archaeological record. On the other hand, the transportation of fish, admittedly on a modest scale, is documented at the site of Hatoula as well as at several PPNB sites in the Southern Levant, where we are dealing with fish from the Nile and the Red Sea and not the Mediterranean, as mentioned before. I would like to suggest that fishing on the Mediterranean coast was not practiced in the Levant during the PPNB and therefore fish were brought in from elsewhere: the Nile and the Red Sea. The consumption of fish in the PPNB may have already become a special or desired food by this time when early farming (with a diet based primarily on the consumption of domesticated cereals, legumes and animals) was now well established and had a wide spatial distribution in the Levant, southeastern Turkey and Cyprus. One possible factor, which may have held back Mediterranean fishing during the PPNB (if this is indeed the case), is the development of marshes along the coastal plain of Israel at that time (Cohen-Sefer *et al*., 2005; Sivan *et al.*, 2011). The marshes were not only difficult to cross, but they probably had mosquitoes as well: for instance, the *Anopheles*, which is the carrier of malaria and other parasites. The drying out of the marshes on the coast during the subsequent PPNC may well have made it possible to live on the coast again, as seen at the sites of Kabri, Atlit Yam, Ashkelon, and Ziqim. At all of them, fishing was practiced (Lernau 2008; Galili *et al.*, 2004). In the context of the movement of people from the mainland to Cyprus, we should take into consideration the factor of the inaccessibility of the Mediterranean coastline in the case of the southern Levant during the PPNB, which may have been yet another impetus for people to relocate to Cyprus – a large island that offered new land for farming and also new and more accessible places to fish.

The advantage of shellfishing and the role of shellfish in the human diet have been discussed by many scholars (e.g., Meehan, 1982; Bicho and Haws, 2008; Erlandson, 2010). Most notably, aquatic resources can serve as a source of food providing "brain-specific nutrients" (Erlandson, 2010:128). Shellfish are excellent sources of protein, their fat contents are similar to terrestrial resources, and they also contain some carbohydrates, absent in terrestrial animal resources. They are easily harvested and thus represent a low-risk resource, especially for women and children (Meehan, 1982). They entail a minimum risk, while maximizing energy intake (Bicho and Haws, 2008:2169).

Marine molluscs were usually not a major resource during the Palaeolithic and Mesolithic in absolute terms, but they did constitute important seasonal resources, as well as useful supplementary items due to their nutritional value in a diet dominated by terrestrial foods and mammalian protein (Colonese *et al.*, 2011).

The large size of the mollusc assemblage at Aetokremnos caused Simmons (1999) to hypothesize that the site was in part justified by its proximity to the coast, which provided people with access to marine molluscs. Ammerman (2010:86) correctly points out the similarity between the shells at Aetokremnos, Franchti (lithic phase VI), and Aspros. All the other evidence for edible molluscs from later sites in Cyprus, as well as other parts of the Mediterranean, shows that there too, *Patella* and *Osilinus* were the preferred species. On Cyprus, these two species are commonly present at sites on or close to the

coastline but they are not recovered at sites in the interior probably because shellfish, like fish, have to be consumed soon after collection to avoid spoiling. Fish were probably easier to process and transport due to their large size, but even they did not reach inland PPNA settlements such as Klimonas and Asprokremnos. At Franchthi, probably occupied mostly during the fall season, consumption of molluscs is seen as a response to the decline or dwindling down of other resources during the Younger Dryas (Perlès, 2010).

The exploitation of fish and shellfish for purposes of human subsistence played a role of some importance in the voyages that were made between the southwest Asia and Cyprus, since it offered an expedient fallback resource – one that was always there – for the voyagers, who had to be good foragers as well. It was crucial for them to know that if they somehow happened to become stranded due to a sudden shift in the wind, there was always something out there – in one form or another – for them to eat. At times, the voyagers might even have had to turn to open-sea fishing, which was probably not the preferred way of fishing, based on the evidence at the earliest sites. What was paramount was the knowledge that sources of food were available on the coast once the voyagers reached the other side. While it is clear that domesticated plants and animals were carried in the vessels crossing from the mainland to Cyprus (Vigne and Cucci, 2005), they were meant to contribute to breeding various faunal and floral populations on the island, and they would not be ready for consumption at least for several months after landfall or perhaps even longer in some cases – hence marine resources were the heart of the matter over the short run, if the voyagers were to endure when they landed on the island.

Finally, a broader perspective on ancient seafaring and exploration led me to look at a similar process that occurred towards the end of the Pleistocene in America. In North America, Erlandson and others proposed the theory of the "kelp highway" for the expansion of humans from Northeast Asia to the Americas (Erlandson *et al.*, 2007). While the circumstances were different and agriculture played no role there, the reliance on the flora and fauna surrounding the dense kelp forests of the Northern Pacific, according to these authors, is what made possible the seafaring along the coasts of the continents. In the Eastern Mediterranean, there are no kelp forests, which are typical of temperate regions. However, the reliance on readily available marine resources most likely ensured that those courageous individuals who did set out on a voyage would be able to find food along the way.

The study of fish and molluscs at the time of the Pleistocene/Holocene transition in the Eastern Mediterranean is relevant to our understanding of the role that seafaring played in the colonization of an island such as Cyprus. The overall patterns in the exploitation of marine resources in the Levant, on Cyprus and elsewhere in the Mediterranean share some similarities. The exploitation of marine molluscs and fish as a food source would have been a fallback resource when arriving in a new place both for the foragers-voyagers in the time before agriculture (see Ammerman in this issue) and for those voyagers who took an active role in the spread of early farming in the Mediterranean world (see various papers in this and next issues). Even in the case of early farmers, fishing probably continued to be done by many coastal inhabitants and shell fishing could have served seasonally as resource of food that enhanced or rounded out one's diet.

Acknowledgements

I would like to thank Albert Ammerman for inviting me to participate in the Wenner Gren Workshop on "Island Archaeology and the Origins of Seafaring in the Eastern Mediterranean" and to contribute this chapter. To Arturo Morales-Muñiz for sharing as yet unpublished information on fish remains in the Mediterranean and for his thoughtful comments on a previous draft, I extend my appreciation.

REFERENCES

ALBRECHT G., ALBRECHT B., BERKE H., BURGER D., MOSER J., RÄHLE W., SCHOCH W., STORCH G., UERPMANN H.P., URBAN B. 1992. Late Pleistocene and Early Holocene Finds From Öküzini: A Contribution to the Settlement History of the Bay of Antalya, Turkey. *Paléorient* 18 (2), 123–141.

AMMERMAN A.J. 2010. The first Argonauts: Towards the study of the earliest seafaring in the Mediterranean. In: A. Anderson, J. Barrett, K. Boyle (eds.) *Global Origins (and Development) of Seafaring*. McDonald Institute for Archaeological Research, Cambridge, 81–92.

AMMERMAN A.J., FLOURENTZOS P., GABRIELLI R., HIGHAM T., MCCARTNEY C., TURNBULL T. 2008. Third report on early sites on Cyprus. *Report of the Department of Antiquities, Cyprus 2008* 1–32.

AMMERMAN A. J., FLOURENTZOS P., PANAYIDES I., B. SELLECK B., K. THOMAS K. 2013. Fourth report on early sites on Cyprus. *Report of the Department of* Anti*quities, Cyprus.*

BAILEY G.N., CARRION J.S., FA D.A., FINLAYSON C., FINLAYSON G., RODRIGUEZ-VIDAL J. 2008. The coastal shelf of the Mediterranean and beyond: Corridor refugium for human population in the Pleistocene. *Quaternary Science Reviews* 27(23-24), 2095–2099.

BAR-YOSEF O. 2001. The world around Cyprus: From Epi-Paleolithic foragers to the collapse of the PPNB civilization. In: S. Swiny (ed.) *The earliest prehistory of Cyprus: From colonization to exploitation*. American Schools of Oriental Research, Boston, 129–151.

BAR-YOSEF O. 2011. Climatic fluctuations and early farming in West and East Asia. *Current Anthropology* 52(S4), S175–S193.

BAR-YOSEF O., VALLA F. R. (eds.). 1991. *The Natufian Culture in the Levant*. International Monographs in Prehistory, Ann Arbor, Michigan.

BAR-YOSEF O., VALLA F. R. (eds.). 2013. *Natufian Foragers in the Levant: Terminal Pleistocene Social Changes in Weestern Asia*. International Monographs in Prehistory, Ann Arbor, Michigan.

BAR-YOSEF MAYER D.E. 2008. Mollusc shells and barnacles. In: Y. Garfinkel, D. Dag (eds.) *Neolithic Ashkelon*. Institute of Archaeology, Hebrew University of Jerusalem, Jerusalem, 269–270.

BAR-YOSEF MAYER D.E., ZOHAR I. 2010. The role of Aquatic Resources in the Natufian Culture. *Eurasian Prehistory* 7(1), 29–43.

BASS B. 1998. Early Neolithic Offshore Accounts: Remote islands, maritime exploitations, and the trans-Adriatic cultural network. *Journal of Mediterranean Archaeology* 11(2), 165–190.

BICHO N., HAWS J. 2008. At the land's end: Marine resources and the importance of fluctuations in the coastline in the prehistoric hunter-gatherer economy of Portugal. *Quaternary Science Reviews* 27, 2166–2175.

BRIDAULT A., RABINOVICH R., SIMMONS T. 2008. Activities, site location and taphonomic process: A relevant combination for understanding the fauna of Eynan (Ain Mallaha), Level Ib (Final Natufian, Israel). In: E. Vila, L. Gourichon, A. M. Choyke, H. Buitenhuis (eds.) *Archaeozoology of the Near East VIII*. Maison de l'Orient et de la Méditerranée, Lyon, 99–117.

CAMPANA D.V. 1989. *Natufian and Protoneolithic Bone Tools : The Manufacture and Use of Bone Implements in the Zagros and the Levant*. BAR International Series 494, Oxford.

CATALIOTTI-VALDINA J. 1994. La malacofaune marine de Cap Andreas-Kastros. In: A. Le Brun (ed.) *Fouilles récentes à Khirokitia (Chypre) 1988-1991*. Éditions Recherche sur les Civilisations, Paris, 361–392.

ČEČUK B. 1989. Vela špilja na korčuli: Višeslojno nalazište (multistrata site). *Arheološki Pregled Ljubljana* 28, 44–46.

CLAASSEN C. 2013. Invertebrates on San Salvador Island, Bahamas: The use of shellfish as bait. In: G.N. Bailey, K. Hardy, A. Camara (eds.) *Shell energy: Mollusc Shells as Coastal Resources*. Oxbow, Oxford, 35–42.

CLARE L., GEBEL H.G.K. 2010. Introduction: Conflict and warfare in the Near Eastern Neolithic. *Neo-Lithics* 10/1, 3–5.

COHEN-SEFFER R., GREENBAUM N., SIVAN D., JULL T., BARMEIR E., CROITORU S., INBAR M. 2005. Late Pleistocene-Holocene marsh episodes along the Carmel Coast, Israel. *Quaternary International* 140-141, 103–120.

COLONESE A.C., MANNINO M.A., BAR-YOSEF MAYER D., FA D.A., FINLAYSON J.C., LUBELL D., STINER M.C. 2011. Marine mollusc exploitation in Mediterranean prehistory: An overview. *Quaternary International* 239, 83–103.

COLONESE A.C., WILKENS B. 2005. The malacofauna of he Upper Paleolithic levels at Grotta della Serratura (Salerno, Southern Italy). Preliminary data. In: D.E. Bar-Yosef Mayer (ed.) *Archaeomalacology: Molluscs in Former Environments of Human Behaviour*. Oxbow, Oxford, 63–70.

COPELAND L. 1991. Natufian sites in Lebanon. In: O. Bar-Yosef, F.R. Valla (eds.) *The Natufian*

Culture in the Levant. International Monographs in Prehistory, Ann Arbor, Michigan, 27-42.

CORTÉS-SANCHEZ M., MORALES-MUÑIZ A., SIMON-VALLEJOM.D.,LOZANO-FRANCISCO M.C., VERA-PELAEZ J.L., FINLAYSON C., RODRIGUEZ-VIDAL J., DELGADO-HUERTAS A., JIMENEZ-ESPEJO F.J., MARTINEZ-RUIZ F., MARTINEZ-AGUIRRE M.A., PASCUAL-GRANGED A.J., BERGADA-ZAPATA M.M., GIBAJA-BAO J.F., RIQUELME-CANTAL J.A., LOPEZ-SAEZ J.A., RODRIGO-GAMIZ M., SAKAI S., SUGISAKI S., FINLAYSON G., FA D.A., FERREIRA BICHO N. 2011. Earliest known use of marine ressources by Neanderthals. *PlosONE* 6 (9), 24026.

CROFT P. 2008. Appendix A: Animal remains from Paralimni-*Nissia*. In: Flaurentzos, P. (ed.) *The Neolithic Settlement of Paralimni*. Lefkosia, 101–118.

DAYAN T., TCHERNOV E., BAR-YOSEF O., YOM-TOV Y. 1986. Animal exploitation in Ujrat El Mehed, a Neolithic site in southern Sinai. *Paléorient* 12(2), 105–116.

DEMETROPOULOS A. 1984. Marine molluscs, land snails, etc. In: A. Le Brun (ed.) *Fouilles récentes à Khirokitia (Chypre) 1977-1981*. Éditions Recherche sur les Civilisations, Paris, 169–182.

DESSE J. 1984. L'ichthyofaune du site néolithique de Khirokitia (Chypre). In: A. Le Brun (ed.) *Fouilles récentes à Khirokitia (Chypre) 1977-1981*. Éditions Recherche sur les Civilisations, Paris, 167–168.

DESSE J., DESSE-BERSET N. 1989. Les poissons de Khirokitia (campagnes 1983, 1984 et 1986). In: A. Le Brun (ed.) *Fouilles récentes à Khirokitia (Chypre) 1983-1986*. Éditions Recherche sur les Civilisations, Paris, 223–234.

DESSE J., DESSE-BERSET N. 1994. Stratégies de pêche au 8e millénaire: Les poissons de Cap Andreas-Kastros. In: A. Le Brun (ed.) *Fouilles récentes à Khirokitia (Chypre) 1988-1991*. Éditions Recherche sur les Civilisations, Paris, 335–360.

DESSE J., DESSE-BERSET N. 1999. Préhistoire du mérou. *Marine Life* 9 (1), 19–30.

DESSE J., DESSE-BERSET N. 2011. Les poissons. In: J. Guilaine, F. Briois, J.D. Vigne (eds.) *Shillourokambos: Un etablissement neolithique pre-ceramique a chypre. les fouilles du secteur 1*. Errance, Ecole Francaise d'Athenes, Paris, 835–846.

DONALD K.M., PRESTON J., WILLIAMS S.T., REID D.R., WINTER D., ALVAREZ R., BUGE B., HAWKINS S.J., TEMPLADO J. & SPENCER H.G. 2012. Phylogenetic relationships elucidate colonization patterns in the intertidal grazers *Osilinus* Philippi, 1847 and *Phorcus* Risso, 1826 (Gastropoda: Trochidae) in the northeastern Atlantic Ocean and Mediterranean Sea. *Molecular Phylogenetics and Evolution*, 62(1), 35–45.

DURANTE S., SETTEPASSI F. 1972. I molluschi del giacimento quaternario della Grotta della Madonna Praia a Mare (Calabria). *Quaternaria* 16, 255–269.

EDWARDS P.C. 1989. Revising the broad spectrum revolution: And its role in the origins of Southwest Asian food production. *Antiquity* 63, 225–246.

ERLANDSON J.M. 2001. The archaeology of aquatic adaptations: Paradigms for a new millennium. *Journal of Archaeological Research* 9(4), 287–350.

ERLANDSON J.M. 2010. Food for thought: The role of coastlines and aquatic resources in human evolution. In: S.C. Cunnane, K.M. Stewart (eds.) *Human brain evolution*. John Wiley Sons, New York, 125–139.

ERLANDSON J.M., GRAHAM M.H., BOURQUE B.J., CORBETT D., ESTES J.A., STENECK R.S. 2007. The kelp highway hypothesis: Marine ecology, the coastal migration theory, and the peopling of the Americas. *Journal of Island Coastal Archaeology* 2, 161–174.

FERGUSON J.E., HENDERSON G.M., FA D.A., FINLAYSON C., CHARNLEY N.R. 2011. Increased seasonality in the Western Mediterranean during the last glacial from limpet shell geochemistry. *Earth and Planetary Science Letters* 308, 325–333.

GALILI E., LERNAU O., ZOHAR I. 2004. Fishing and coastal adaptations at Atlit-Yam. A submerged PPNC fishing village off the Carmel coast, Israel. *Atiqot* 48, 1–34.

GARFINKEL Y., VERED A., BAR-YOSEF O. 2006. The domestication of water: The Neolithic well at Sha'ar Hagolan, Jordan Valley, Israel. *Antiquity* 80, 686–696.

GARROD D.A.E., BATE D.M.A. 1937. *The stone age of Mount Carmel*. Clarendon Press, Oxford.

KNAPP A.B. 2010. Cyprus's earliest prehistory: Seafarers, foragers and settlers. *Journal of World Prehistory* 23, 79–120.

KUHN S.L., STINER M.C., GÜLEÇ E., ÖZER I., YILMAZ H., BAYKARA I., AÇIKKOL A., GOLDBERG P., MARTÍNEZ-MOLINA K., ÜNAY E., SUATA-ALPASLAN F. 2009. The Early Upper Paleolithic occupations at Üçagızlı Cave

(Hatay, Turkey). *Journal of Human Evolution* 56, 87–113.

KURZAWSKA A. 2013. *Social and economic significance of* Dentalium *shells for hunter-gatherers in the Southern Levant*. Unpublished Ph.D. thesis. Adam Mickiewicz University, Poznań.

Le BRUN A. 2001. At the other end of the sequence: The Cypriot Aceramic Neolithic as seen from Khirokitia. In: S. Swiny (ed.) *The earliest prehistory of Cyprus: From colonization to exploitation*. Cyprus American Archaeological Research Institute, Monograph 2, Boston, 109–118.

LERNAU H., LERNAU O. 1994. The fish remains. In: M. Lechevallier, A. Ronen (eds.) *Le gisement de Hatoula en Judée occidentale, Israël*. Association Paléorient, Jerusalem-Paris, 111–121.

LERNAU O. 2008. The fish bones. In: Y. Garfinkel, D. Dag (eds.) *Neolithic Ashkelon*. Institute of Archaeology, Hebrew University of Jerusalem, Jerusalem, 263–267.

MAKAREWICZ C.A. 2009. Complex caprine harvesting practices and diversified hunting strategies: Integrated animal exploitation systems at late Pre-Pottery Neolithic B ʻAin Jamman. *Anthropozoologica* 44(1), 79–101.

MANNING S.W., MCCARTNEY C., KROMER B., STEWART S.T. 2010. The earlier Neolithic in Cyprus: Recognition and dating of Pre-Pottery Neolithic A period occupation on Cyprus. *Antiquity* 84, 693–706.

MANNINO M.A., THOMAS K.D. 2007. New radiocarbon dates for hunter-gatherers and early farmers in Sicily. *Accordia Research Papers* 10, 13–34.

MANNINO M.A., THOMAS K.D., LENG M.J., SLOANE H.A. 2008. Shell growth and oxygen isotopes in the topshell *Osilinus turbinatus*: Resolving past inshore sea surface temperatures. *Geo-Mar Letters* 28, 309–325.

MEEHAN B. 1982. *Shell bed to shell midden*. Australian Institute of Aboriginal Studies, Canberra.

MORALES-MUÑIZ A., ROSELLÓ-IZQUIERDO E. 2008. 20,000 years of fishing in the Strait: Archaeological fish and shellfish assemblages from Southern Iberia. In: J. Erlandson, R. Torrey (eds.) *Human impacts on ancient marine environments.* University of California Press, Berkeley, 243–278.

MORALES-MUÑIZ A., ROSELLÓ-IZQUIERDO E. (in press). Fishing in Mediterranean prehistory: An archaeo-ichthyological overview. In: T. Bekker-Nielsen, R. Gertwagen (eds.) *The Ancient Mediterranean*.

MUNRO N.D. 2004. Zooarchaeological measures of hunting pressure and occupation intensity in the Natufian. *Current Anthropology* 45(S4), S5–S33.

NADEL D. (ed.). 2002. *Ohalo II: A 23,000-year-old fisher-hunter-gatherers' camp on the shore of the Sea of Galilee*. Reuben and Edith Hechth Museum, University of Haifa, Haifa.

NADEL D., LENGYEL G., BOCQUENTIN F., TSATSKIN A., BAR-OZ G., ROSENBERG D., YESHURUN R., HERSHKOVITZ I., BEERI R., CONYERS L., BAR-YOSEF MEYER D. 2008. The late Natufian at Raqefet cave: The 2006 excavation season. *Journal of the Israel Prehistoric Society* 38, 59–131.

ÖZDOĞAN M. 2010. Westward expansion of the Neolithic way of life: Sorting the Neolithic package into distinct packages. In: P. Matthiae, F. Pinnock, L. Nigro, N. Marchetti (eds) *Proceedings of the 6th International Congress on the Archaeology of the Ancient Near East*. Harrassowitz Verlag, Wiesbaden, 883–897.

PERLÈS C. 2010. Is the Dryas the culprit? Socio-Economic changes during the final Pleistocene and early Holocene at Franchthi Cave (Greece). *Journal of the Israel Prehistoric Society* 40, 113–129.

POWELL J. 2003. Fishing in the Mesolithic and Neolithic – the Cave of Cyclops, Youra. *British School at Athens Studies* 9, 75–84.

REESE D. 1978. Molluscs from archaeological sites in cyprus: Kastros, Cape St. Andreas, Cyprus and other pre-Bronze Age Mediterranean sites. *Fisheries Bulletin, Cyprus* 5, 3–112.

REESE D. 1999. The faunal assemblages: Marine invertebrates. In: A.H. Simmons (ed) *Faunal extinction in an island society*. Kluwer Academic, New York, 188–191.

REESE D.S. 2006. Marine invertebrate exploitation at Akrotiri-Aetokremnos. *Report of the Department of Antiquities, Cyprus* 23–37.

REESE D.S. 2008a. Recent marine invertebrates, fresh-water shells, fossils, and fish from Kalavasos-Tenta. *Report of the Department of Antiquities, Cyprus* 33–66.

REESE D.S. 2008b. Appendix B: Recent and Fossil Shells from Paralimni-*Nissia*. In: P. Flaurentzos (ed.) *The Neolithic Settlement of Paralimni*. Lefkosia, 119–153.

ROSE M. 1995. Fishing at Franchthi Cave, Greece: Changing environments and patterns of exploitation. *Old World Archaeology Newsletter* 18, 21–26.

ROSEN A.M. 2010. Natufian plant exploitation: Managing risk and stability in an environment of change. *Eurasian Prehistory* 7, 117–131.

SERRAND N., VIGNE J.D. 2011. La malacofaune et les crustacés: Subsistence et matières premières. In: J. Guilaine, F. Briois, J.D. Vigne (eds.) *Shillourokambos: Un etablissement néolithique pré-céramique à Chypre*. Errance, Paris, 807–833.

ŞEVKETOĞLU M. 2006. Cypro-Anatolian relations in the 9th millenium BC: Akanthou/Tatlisu rescue excavation. *Anatolia* 30, 119–136.

SHACKLETON J. C. 1988. *Marine molluscan remains from Franchthi Cave*. Indiana University Press, Bloomington.

SHACKLETON J.C., van ANDEL T.H. 1986. Prehistoric shore environments, shellfish availability, and shellfish gathering at Franchthi, Greece. *Geoarchaeology* 1, 127–143.

SIMMONS A. 1999. *Faunal extinctions in an island society: Pygmy hippopotamus hunters of Cyprus*. Kluwer Academic, New York.

SIVAN D., GREENBAUM N., COHEN-SEFFER R., SISMA-VENTURA G., ALMOGI-LABIN A. 2011. The origin and disappearance of the late Pleistocene–early Holocene short-lived coastal wetlands along the Carmel coast, Israel. *Quaternary Research* 76, 83–92.

STINER M.C. 1994. *Honor among thieves: A zooarchaeological study of Neandertal ecology*. Princeton University Press, Princeton.

STINER M.C. 2001. Thirty years on the "broad spectrum revolution" and Paleolithic demography. *Proceedings of the National Academy of Sciences of the U.S.A.* 98, 6993–6996.

STINER M.C., MUNRO N.D. 2011. On the evolution of diet and landscape during the Upper Paleolithic through Mesolithic at Franchthi Cave (Peloponnese, Greece). *Journal of Human Evolution* 60, 618–636.

STINER M.C., MUNRO N.D., SUROVELL T.A. 2000. The tortoise and the hare: Small game use, the broad spectrum revolution, and Paleolithic demography. *Current Anthropology* 41, 39–73.

TCHERNOV E. 1991. Biological evidence for human sedentism in southwest Asia during the Natufian. In: O. Bar-Yosef, F.R. Valla (eds.) *The Natufian culture in the Levant*. International Monographs in Prehistory, Ann Arbor, 315–340.

THOMAS K.D. 1987. Prehistoric coastal ecologies: A view from outside Franchthi Cave, Greece. *Geoarchaeology* 2(3), 231–240.

TURVILLE-PETRE F. 1932. Excavations in the Mugharet el Kebarah. *Journal of the Royal Anthropological Institute* 60, 270–276.

VALLA F.R., BAR-YOSEF O., SMITH P., TCHERNOV E., DESSE J. 1986. Un nouveau sondage sur la terrasse d'el Ouad, Israël. *Paléorient* 12(1), 21–38.

van NEER W., ZOHAR I., LERNAU O. 2005. The emergence of fishing communities in the Eastern Mediterranean region: A survey of evidence from pre- and protohistoric periods. *Paléorient* 31(1), 131–157.

VELLANOWETH R.L., LAMBRIGHT M.R., ERLANDSON J.M., RICK T.C. 2003. Early new world maritime technologies: Sea grass cordage, shell beads, and a bone tool from Cave of the Chimneys, San Miguel Island, California. *Journal of Archaeological Science* 30, 1161–1173.

VIGNE J.D. 1995. Préhistoire du Cap Corse: Les abris de Torre d'Aquila, Petracorbara (hatue-corse) - la faune. *Bulletin de la Société Préhistorique Française* 92(3), 381–389.

VIGNE J.D., CUCCI T. 2005. Premieres navigations au proche-orient: Les informations indirectes de Chypre. *Paleorient,* 31(1), 186–194.

VIGNE J.D., BRIOIS F., ZAZZO A., WILLCOX G., CUCCHI T., THIÉBAULT S., CARRÈRE I., FRANEL Y., TOUQUET R., MARTIN C., MOREAU C., COMBY C., GUILAINE J. 2012. First wave of cultivators spread to Cyprus at least 10,600 years ago. *Proceeding of the National Academy of Sciences* 109(22), 8445–8449.

WILKENS B. 1993. Lo sfruttamento delle risorse marine. In: F. Martini (ed.) *Grotta della Serratura a Marina di Camerota. Culture e ambienti dei complessi olocenci*. Garlatti e Razzai, Florence, 89–98.

ZOHAR I., BITON R. 2011. Land, lake, and fish: Investigation of fish remains from Gesher Benot Ya'aqov (paleo-lake Hula). *Journal of Human Evolution* 60, 343–356.