

THE ARCHAEOLOGY AND PALEOENVIRONMENT OF THE SUBMERGED POTTERY NEOLITHIC SETTLEMENT OF Kfar SAMIR (ISRAEL)

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Abstract. *This article focuses on a recently excavated stone and wood-built water well (Well no. 13) from the submerged Pottery Neolithic site (Wadi Rabah culture) of Kfar Samir on the Carmel coast, Israel. This feature is considered within the context of previous research on the site and other submerged sites in the same area, incorporating new data on botanical remains and radiometric dates from Kfar Samir. Taken together, the new and previous investigations of the site shed light on the lifestyle of Pottery Neolithic coastal populations in the Southern Levant, especially those relating to management of water resources, olive oil production and the evolution of Mediterranean food ways. This research further informs us on the palaeoenvironment of the Carmel coast and sea level changes.*

Résumé. *Le présent article porte sur un puits construit en pierre et en bois (puits n° 13) récemment fouillé sur le site subaquatique du Néolithique céramique (culture de Wadi Rabah) de Kfar Samir situé près de la côte du Carmel en Israël. Cette structure est considérée dans le contexte des recherches précédemment réalisées sur le site tout comme sur d'autres sites submergés dans la même région, tout en intégrant de nouvelles données sur les restes archéobotaniques et les datations radiométriques obtenues à Kfar Samir. Dans l'ensemble, les nouvelles et les précédentes enquêtes menées sur le site apportent un éclairage sur le mode de vie des populations côtières du Néolithique céramique dans le Levant Sud, en particulier en ce qui concerne la gestion des ressources aquatiques, la production d'huile d'olive et l'évolution du régime alimentaire méditerranéen. Ces recherches nous renseignent également sur le paléo-environnement de la côte du Carmel et les changements du niveau de la mer.*

Keywords. *sea-level rise, Wadi Rabah culture, water wells, olive oil production, underwater archaeology*

Mots-clés. *élévation du niveau de la mer, culture Wadi Rabah, puits, production d'huile d'olive, archéologie subaquatique*

Underwater archaeologists have long recognised the intrinsic potential of submerged prehistoric sites and their remains (e.g., Bailey and Flemming 2008; Gusick and Faught 2011; Flemming 2014; Evans *et al.* 2014; Galili 2016 and references therein; Benjamin *et al.* 2017). Along the Mediterranean coast of Israel, the first discoveries of such sites took place during the 1960s (Ronen 1965; Wreschner 1977; Raban 1983). Since the 1980s eleven Neolithic sites that were inundated by the post-glacial sea-level rise have been found on the seabed off the Carmel coast (fig. 1B). Their exposure is caused by changes in the patterns of seabed sedimentation and erosion rates in recent centuries due to modern human activity and

natural processes, most notably winter storms. These factors have resulted in the removal of mobile sediments (mainly sands), thereby exposing the underlying, *in situ* and relatively compact, palaeosol deposits containing the prehistoric remains (Galili and Weinstein-Evron 1985).

Researchers have developed multi-disciplinary methods for identifying, excavating and documenting these sites (Galili *et al.* 1993, 2015; Galili and Rosen 2011a, 2011b). Ongoing studies have shown that the deeper and more westerly a submerged site is located, the older it is. Thus, the oldest site, Atlit-Yam dating to the Pre-Pottery Neolithic C period (PPNC), ca. 9200-8500 cal. BP, lies 200-400 m offshore at 8-12 m

below present sea level. Ten more recent late Pottery Neolithic (PN) sites, *ca.* 8000-6500 years cal. BP, lie in shallower water, at depths of 0-6 m, and only 1-200 m offshore (Galili *et al.* 1988; Galili and Shick 1990; Galili and Sharvit 1994-1995; Galili *et al.* 2007, 2017a, 2017b).

Inspired by a renewed interest in continental shelf archaeology (*e.g.*, Bailey and Flemming 2008; Benjamin *et al.* 2011), and international cooperation with the SPLASHCOS network (Bailey *et al.* 2012), a short program to train early career researchers on practical aspects in submerged prehistoric archaeology was held in Israel in 2011. This was followed by the 2014 excavation at Kfar Samir, funded by the Honor Frost foundation (Galili 2013; Galili *et al.* 2017a, 2017b).

This article presents new archaeological, archaeobotanical and radiometric data resulting from the 2014 field campaign and summarises the previous finds from this site. The findings are discussed within the context of their overall contribution to our understanding of the lifestyle of Late Neolithic populations on the Levantine coast, with special reference to the development of water wells, the emergence of olive-oil production in the region and the emergence of the Mediterranean diet. Implications for the paleoenvironment of the region, especially changes in sea-level, are also discussed.

THE KFAR SAMIR SITE

The PN site of Kfar Samir is located in the area between the modern shore and some 200 m seaward, at depths ranging from the current shore down to 6 m below present sea level (fig. 1C; Galili *et al.* 1989; Galili and Schick 1990; Galili and Sharvit 1994-1995; Galili *et al.* 2007). In its hinterland lies Mount Carmel, noted for its Middle and Late Pleistocene cave sites as well as open air Holocene (Neolithic and Chalcolithic) settlements (Olami 1984; Weinstein-Evron 2015). The prehistoric remains of Kfar Samir are scattered along a 1200 m strip on the seabed, parallel to the coastline. Previous investigations at the site revealed sections of paved stone surfaces and installations dug into the clay, including water wells, but no stone-built dwellings. Typical PN flint artefacts have been recovered (axes, burins, chopping tools and other flake tools), as well as several reused and patinated Middle Palaeolithic implements in secondary contexts. Large (up to 80 cm) stone artefacts include oval and round basins made of Kurkar (a local calcareous cemented sand stone of aeolian origin), and several basalt chalices, all characteristic of the PN, as described by A. Gopher and R. Gophna (1993). Faunal remains are scarce and comprise

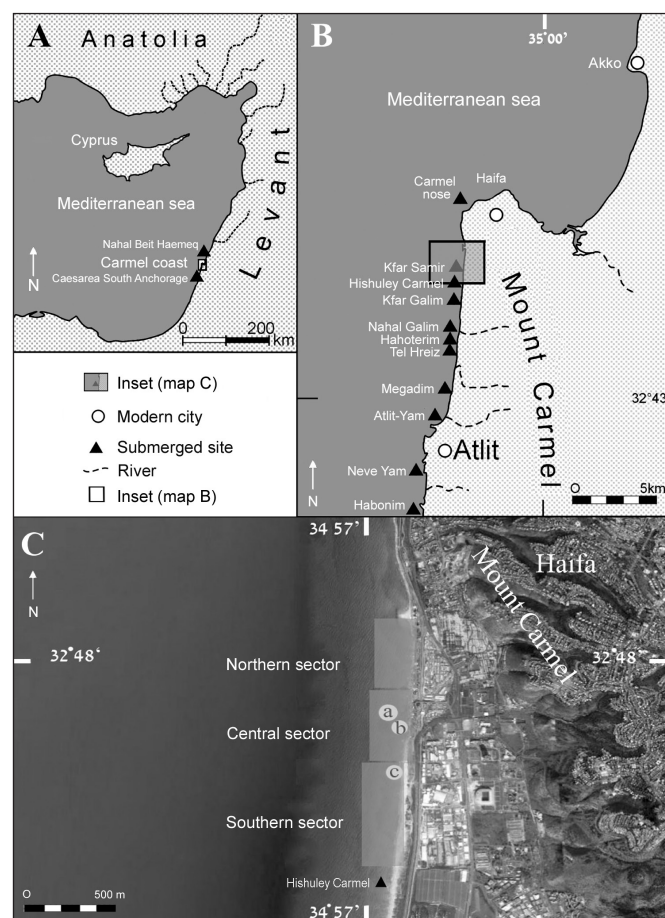


Fig. 1 – Location map: **A.** Eastern Mediterranean and Levant coast; **B.** Submerged settlements off the Northern Carmel coast; **C.** Kfar Samir site (maps: E. Galili).

seven bones of mallard duck (*Anas platyrhynchos*) and an unidentified mammalian bone fragment (Galili and Weinstein-Evron 1985: 40; Horwitz *et al.* 2002). Unique features of the site are the preserved wooden and woven objects, as well as non-charred macro-botanical remains, items that are generally absent in terrestrial Neolithic sites in the region.

Given the large extent of Kfar Samir, it was divided into three sub-areas to manage the site and its excavations: northern, central and southern (fig. 1C), although the finds recovered from the different areas resemble each other.

The central sector: this part of the site (*ca.* 400 m long and 200 m wide), was the focus of the 2014 field season. It lies at 34° 57' 8.65" E, 32° 47' 6.72" N (fig. 1C), 0-200 m from the water line and at a depth of 0-5.9 m. Previously documented architectural remains include floors paved with unworked local stones (8-10 cm in diameter) that were partially embedded

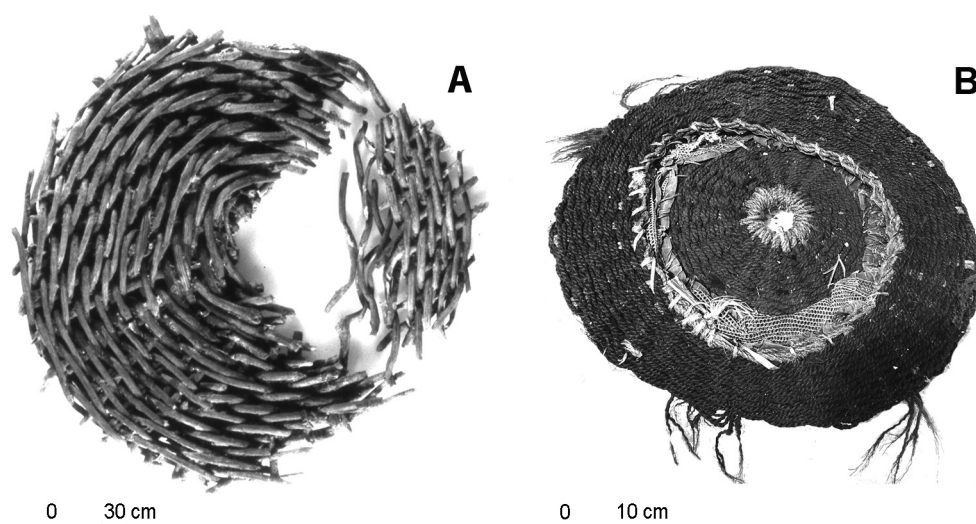


Fig. 2 – A. Container, maybe for pressing olives, made of braided twigs (courtesy of the Israel Antiquities Authority); B. Modern example of a container used for pressing olives (photo: E. Galili).

in the clay seabed, floors constructed of flat stone slabs, hearths (*ca.* 0.5 m in diameter), pits dug into the clayey seabed and three stone and wood-built water wells (fig. 1C: a). One pit was paved with stones at its bottom and contained thousands of crushed olive stones and traces of pulp, interpreted as olive oil extraction waste (fig. 1C: b; Galili *et al.* 1997). A second pit (diameter 0.9 m, depth 0.55 m) was exposed at a depth of 2.3 m and contained braided pieces of thin branches (diameters 3-5 mm) from a basket (fig. 2). It may have served as a container for pressing olives for their oil (locally termed *aqal*). At a depth of 1.5 m, in an unlined pit dug into the upper clay level, a fragment of a mat, 70 × 160 mm in dimension, was found and was dated by ¹⁴C to 7568-7027 cal. BP (RT 855, table 1). It was made of bundles of unidentified material, perhaps rushes or straw. From a technological point of view, it was assigned to the “coiled basketry with intricate stitch” type (Galili and Schick 1990). At a depth of 0.5 m and 15 m from the shoreline, a fragment of a wooden bowl with a vertically placed, elongated and pierced handle was found on a stone paving (Galili *et al.* 2007).

The southern sector is located at 34° 57' 8.6" E, 32° 47' 6.72" N (fig. 1C). In the central part of this sector, a large (1.5 × 2 m) and dense concentration of olive pits and pulp was exposed. A notable find was a complete, wooden bowl discovered in a pit *ca.* 300 m south of Kfar Samir central sector (fig. 1C: c). It is made of *Ceratonia siliqua* (carob tree or St John's bread) and dated to 8115-7949 cal. BP (RT 1360,

table 1; Galili and Schick 1990). Fragmented straw, perhaps remains of a mat or a basket and a two-pointed fork made of wood (0.6 m long) were found next to it.

The northern sector is located at 34° 57' 17.99" E, 32° 47' 35.59" N (fig. 1C). Four upright stone slabs (1.3 × 0.9 × 0.5 m) and some tilted ones were found at a depth of 1.5-2.5 m, some 30-60 m offshore. The lower part of the slabs was partly inserted into the clayey bottom. They do not appear to represent the walls of a dwelling, but may have served as ritual features or a marker for burials or other locations of importance.

WATER WELLS AND THE NEWLY EXCAVATED WELL NO. 13

In the central sector of Kfar Samir three water wells, constructed of alternating layers of wooden branches and stones, were previously investigated (Galili and Weinstein-Evron 1985; Galili *et al.* 1997). The installations were arranged in a line parallel to the coastline, some 180 m off shore at a depth of 5.9 m below present sea level. The distances between them are *ca.* 20 m. Excavation of the southern well (no. 3) begun during the 1980s but only to a depth of 2 m, and the bottom was not reached. It had a rectangular opening (1 × 0.8 m), which widens with depth to become more circular in plan. In its upper section (from the sea

Table 1 – ^{14}C datings from Kfar Samir site. **RT**: Weitzman Institute, Israel (Segal and Carmi 1996; E. Boaretto pers. com. unpublished report 2005); **PITT**: Pittsburgh, USA; **PTA**: Pretoria (South Africa), **Beta**: Beta Analytic Inc. (Miami, Florida). Calibration according to OxCal v 4.3.2 (Stuiver and Reimer 1993; Ramsey 2009 and 2017; Reimer et al. 2013). Provenance refers to the sector of the site shown on the site plan and the archaeological feature number.

Lab Reference	^{14}C Age BP	Calibrated Age 2 σ Range (95.4%) cal. BP	Material	Provenance
Beta 82851	5860 $\pm$ 140	7146-6323	Wood	Central, Well 13
RT 682B	6470 $\pm$ 130	7613-7030	Wood	Central, Well 5
RT 682A	6670 $\pm$ 160	7786-7320	Wood	Central, Well 3
PTA 3820	6830 $\pm$ 80	7844-7520	Wood	Central, Well 5
PTA 3821	6830 $\pm$ 160	7964-7431	Wood	Central, Well 3
Beta 82850	6940 $\pm$ 60	7930-7667	Wood	Central, Pit 10
Beta 82845	6080 $\pm$ 70	7162-6783	Olive pit	Central, 6
Beta 82846	6210 $\pm$ 150	7424-6751	Olive pit	Central, 6
Beta 82847	6210 $\pm$ 80	7288-6897	Olive pit	Central, 6
Beta 82848	6230 $\pm$ 80	7310-6930	Olive pit	Central, 6
Beta 82715	6500 $\pm$ 70	7560-7273	Olive pit	Central, 6
RT 1898	5790 $\pm$ 55	6729-6466	Olive pit	Central, 6
RT 1930	5870 $\pm$ 70	6877-6497	Olive pit	Central, 6
Beta 82843	6100 $\pm$ 60	7162-6793	Olive pit	Central, 7
Beta 82844	6290 $\pm$ 60	7413-7128	Olive pit	Central, 7
RT 1929A	5630 $\pm$ 55	6531-6299	Olive pit	Central, 7
RT 1929	5870 $\pm$ 70	6877-6497	Olive pit	Central, 7
Beta 82849	6350 $\pm$ 90	7434-7019	Wood	Central, 8
RT 855	6420 $\pm$ 120	7568-7027	Mat fragment	Central, 8
RT 1360	7230 $\pm$ 80	8275-7872	Wooden bowl	South
Beta 433765	6890 $\pm$ 30	7791-7667	Wood	Central, Well 13

bottom to a depth of 1 m) it is constructed of alternating layers of wooden branches and stone pebbles. In its lower section (from 1 m below the sea bottom to 2 m), a single layer of stones was laid between two layers of wooden branches. The well fill consisted of soft clay, small stones, few pot sherds (one with an incised design), flint flakes, bird bones (noted above), olive pits and probable straw remains.

Well no. 13, the central of the three above-mentioned wells (fig. 1C: a), was excavated in October 2014 by the University of Haifa and the Flinders University, as part of an international collaboration. A total of 68 dives were carried out at the site involving 25 participants. The well is located at a depth of 5.9 m below present sea level. It had been exposed and identified during previous winter storms, however by the time of the 2014 excavation, approximately two meters of sand had settled on top of the *in-situ* deposits. This required the removal of approximately 50 cubic meters of sand to expose the top of the well. The 1.5 $\times$ 1.5 m surface of the

exposed well was recorded (fig. 3A) using drawing and photography for photogrammetry, allowing the creation of three-dimensional model and plan of the feature (fig. 3B, and see McCarthy and Benjamin 2014).

Excavation revealed that the rectangular structure was constructed of alternating layers of branches and stones, similarly to the previously excavated Well no. 3. The uppermost rectangular well frame was built of wooden branches (5-15 cm in diameter) and lying stones. The exposed north-eastern section of the well fill (0.5 $\times$ 0.5 $\times$ 0.1 m) was excavated manually and the excavated deposit (25 litres) was removed for sieving. The material contained soft clay, lying stones (3-8 cm) and broken wooden branches. These were probably the remains of the top of the well and upper lining, that had collapsed. Core samples were taken from the undisturbed fill inside the well and from the compacted deposits outside the structure, for palynological and other sedimentological analyses (fig. 4).

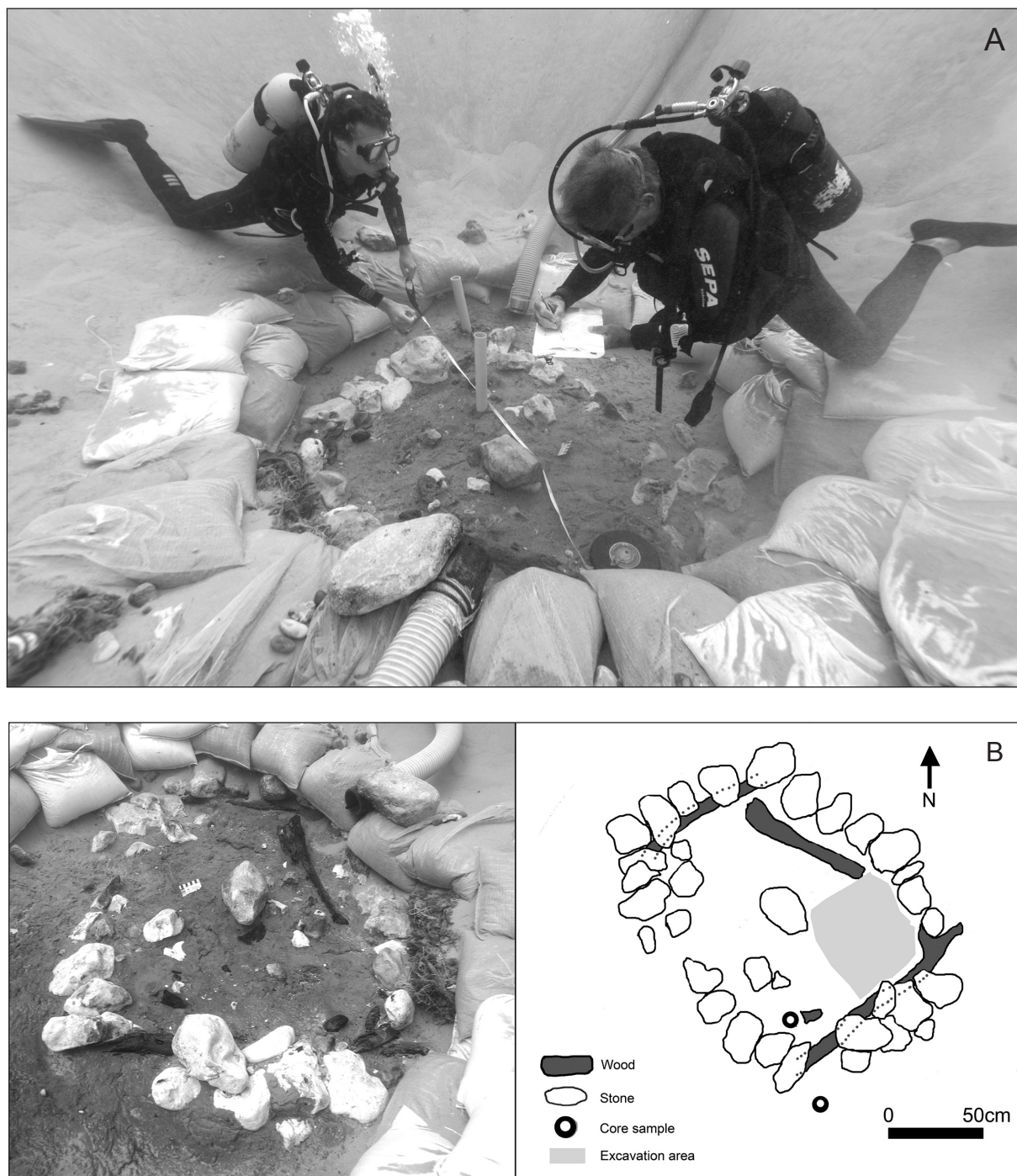


Fig. 3 – A. Divers drawing and measuring Well no. 13, central sector of Kfar Samir (photo: I. Grinberg); B. The excavated Well no. 13: right: plan and location of core samples and test excavation (E. Galili), left: general view, scale is 9 cm (photo: J. McCarthy).



Fig. 4 – Kfar Samir: Core sampling of sediments for pollen analysis in Well no 13 and outside it (photo: J. Benjamin).

RADIOCARBON DATING

Wood samples from Well no. 3 were previously ^{14}C dated and the ages range from 8115 to 6317 cal. BP (RT 1360, 1929, table 1; Galili *et al.* 2017b). Following the 2014 excavation, an additional wood sample from Well no. 13, identified as ever-green oak (*Quercus calliprinos*), was dated using AMS radiocarbon dating at the BETA Analytic Laboratory (table 1, BETA-433765) and yielded an age of 7791-7667 years BP. These dates place the excavated well with certainty within the PN Wadi Rabah phase and establishes the Kfar Samir water wells as some of the oldest, wooden-built structures in the world.

BOTANICAL REMAINS

The fill of Well no. 13 contained large pieces of waterlogged wood (fig. 5), as well as micro-botanical remains retrieved by sieving the fill, using a 0.5 mm mesh. This yielded several types

of botanical remains including small pieces of waterlogged wood, herbaceous remains (which were not previously recorded at the site), and a single olive pit (*Olea europaea*; fig. 6).

HAND-COLLECTED WOOD REMAINS

Four large (up to *ca.* 15 cm long and 5 cm thick) and 26 smaller pieces of wood were found in the well (fig. 5). Though the wood was preserved by the marine environment, its anatomical structures had deteriorated becoming soft and distorted because of water-logging. This made specific identification difficult, though much of this was overcome through careful analysis aided by a Scanning Electron Microscope (SEM; TM3030plus) in addition to a stereo-microscope (Carl Zeiss SteREO Discovery V20 microscope with magnifications of up to $\times 360$ under oblique angled top-lighting). Identification was based on the three-dimensional structure of wood (transverse, radial and tangential sections) when the state of preservation was satisfactory. The anatomical structures of the wood (*e.g.*, the presence/absence of annual growth rings, abundance,



Fig. 5 – Kfar Samir: The wood remains assemblage from Well no. 13 (photos: M. Cavanagh).

arrangement, and size of vessels, tracheids, rays and fibres), along with a number of other diagnostic characteristics, were noted and compared to local wood and charcoal reference collections held in the Steinhardt Museum of Natural History, Tel Aviv University. Regional wood anatomy atlases were also used (Fahn *et al.* 1986; Wheeler *et al.* 1989; Schweingruber 1990; Richter *et al.* 2004; Akkemik and Yaman 2012; Crivellaro and Schweingruber 2013).

All the identified species belong to the Mediterranean forest/maquis: five wood samples represent species of *Quercus* (four *Q. calliprinos* [evergreen oak] and one *Quercus* sp.),

17 of *Styrax officinalis* (officinal styrax), three of *Arbutus andrachne* (Greek strawberry tree), and one of *Pinus halepensis* (Aleppo pine). In the case of *Styrax* and *Arbutus*, which share very similar anatomical structures with other species within their genera, the species identifications are assumed on the basis of their natural disperse range, as they are the only respective members of their genera among the native Israeli flora (Zohary 1962). The remaining four samples could not be confidently identified to family or species. It is possible, if not likely, that multiple samples derive from the same tree or branch, having been broken either by the constructors of the

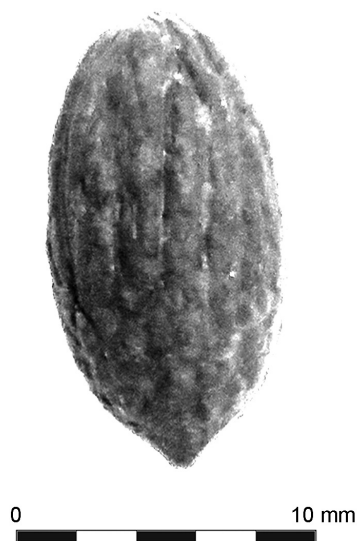


Fig. 6 – A stone of olive fruit from Well no. 13 (photo: M. Cavanagh).

well themselves or through post-depositional processes that caused deterioration of larger segments. Therefore, as the number of samples studied is likely higher than that of the number of individual plants used in well construction, the presence of the recorded taxa is more significant than the number of samples per taxa. Details of the plants that were positively identified follow below.

Quercus calliprinos (fig. 7A): An evergreen tree or shrub growing in areas with a minimum of 300–350 mm annual rainfall to heights of 15 m with a trunk that can reach a diameter of 2 m, and an age of several centuries. Today it is a major constituent of the Mediterranean climate zone's *Quercus calliprinos*–*Pistacia palaestina* associations that characterise the Upper Galilee, Mount Carmel and Judean Mountains (Zohary 1973). Wood remains of *Q. calliprinos* have also been recovered from other PPN and PN sites in Israel, including the submerged site of Atlit-Yam (Liphschitz 1986; 2007, Table 2.7) and terrestrial Neolithic sites such as Yiftahel (Liphschitz 2007, Table 2.4), Nahal Oren (Liphschitz 1986, Table 1) and Nahal Zehora, Neve Yaraq (Liphschitz 2012), Kabri (Liphschitz 2002), and Nahal Qanah Cave (Liphschitz 1996). *Q. calliprinos* was quite abundant in the anthracological assemblages (Lev-Yadun and Weinstein-Evron 1994; Caracuta *et al.* 2016) and the palynological spectra (Weinstein-Evron *et al.* 2007) from late Pleistocene (Natufian) el-Wad Cave, Mount Carmel. The occurrence of *Q. calliprinos* pollen type in an Early Holocene palynological

spectra from the Carmel coast suggests that during the Neolithic it grew in the vicinity of Kfar Samir (Galili and Weinstein-Evron 1985; Galili *et al.* 1993; Kadosh *et al.* 2004).

Styrax officinalis (fig. 7B): A small deciduous tree or shrub growing to heights of 6 m. It is common in the Mediterranean forest/maquis and is a major component of the present-day *Quercus ithaburensis* (and/or *Q. calliprinos*)—*Styrax officinalis* association (Zohary 1973). The *S. officinalis* wood sample identified in this study is the earliest sample of wood of this species identified in an archaeological context in Israel, though fruits of *S. officinalis* have been identified at the Middle Pleistocene site of Gesher Benot Ya'akov (Alpersen-Afil *et al.* 2009: table S3) and seeds of this taxon have been identified at the submerged site of Atlit-Yam where it may have been used as a poison for fishing (Galili *et al.* 1993: 152; 2004: 24).

Arbutus andrachne (fig. 7C): An evergreen tree of the Mediterranean forest/maquis which is commonly found in the Galilee, Mount Carmel, Samaria, the Judea Mountains, the Shephelah and the Trans-Jordan (Zohary 1962). It grows to heights of 5–6 m on average and is noted for its red-brown bark and red fruits (Zohary 1973; Danin 1992). It is uncommon in archaeological contexts in Israel but has been identified in the Neolithic site of Nahal Bezet in the Galilee (Liphschitz 1993, 1997).

Pinus halepensis (fig. 7D): A coniferous softwood tree, rarely growing larger than 16 m in height in mountainous environments (Zohary 1973) and is the only naturally occurring pine species in the Southern Levant (Weinstein-Evron and Lev-Yadun 2000). The wood quality is poorer than many other pine species, though its timber is still valued in shipbuilding and construction projects (including roof beams and furniture) since it produces straight logs for construction purposes. According to Theophrastus (*Enquiry into Plants*, 5.7) and Pliny the Elder (*The Natural History*, 16.81), pine was used for underground water-pipes. The wood and bark also produce a resin that is used as a natural preservative and may be processed into pitch (*e.g.*, Gale and Cutler 2000: 391–393). In a previous analysis from the Kfar Samir site, one wood sample was identified as *P. halepensis* (Liphschitz 1986). The two Kfar Samir samples are the earliest recorded evidence of *P. halepensis* wood in the region though its pollen is known from Late Pleistocene Natufian (Weinstein-Evron 1994; Weinstein-Evron *et al.* 2007) and other Pleistocene and Early Holocene localities on the Carmel coast (Galili and Weinstein-Evron 1985; Galili *et al.* 1993; Kadosh *et al.* 2004).

Olea europaea (fig. 6): The wild olive is an evergreen tree able to attain heights of up to 10 m and has always been a

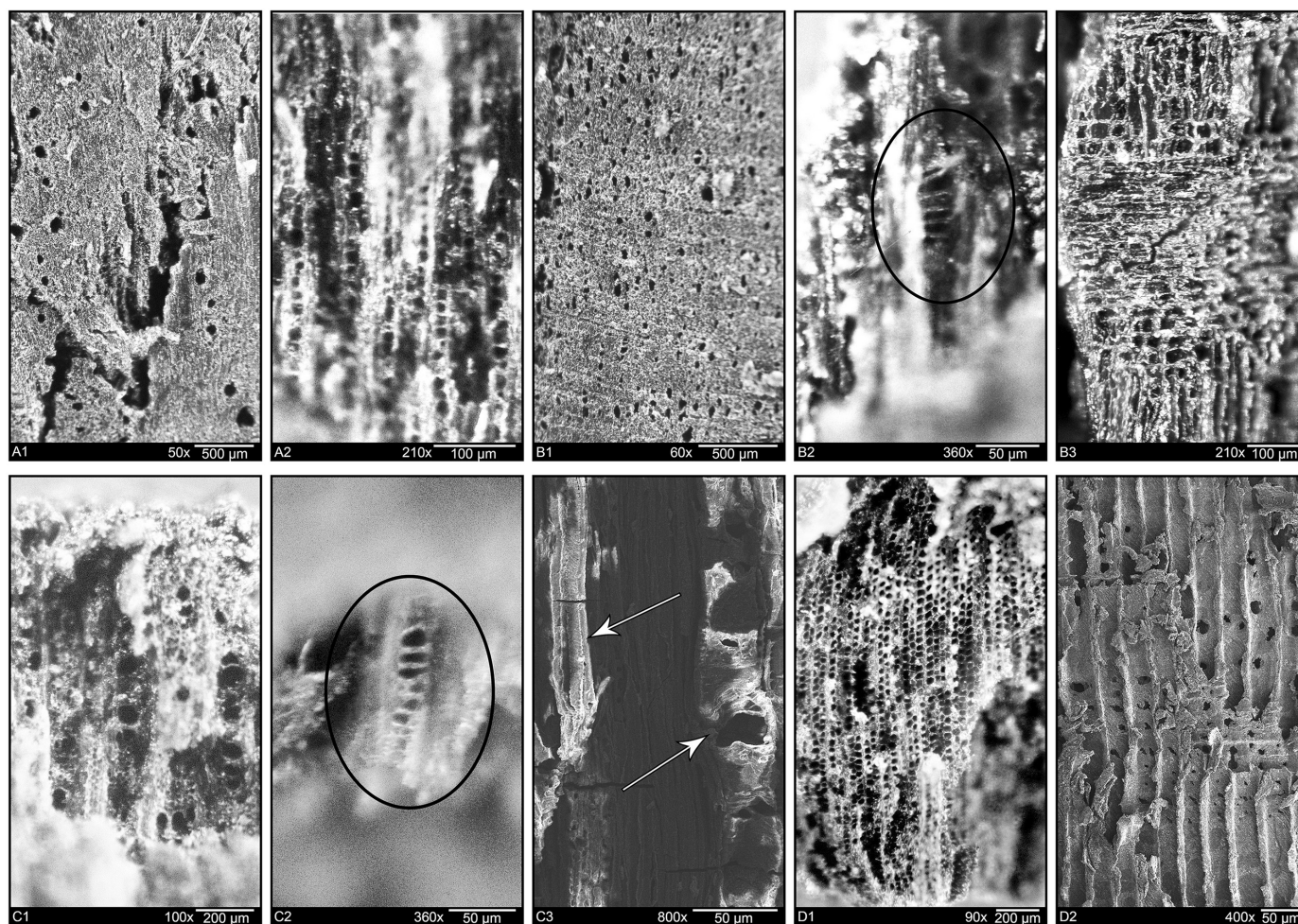


Fig. 7 – Thin sections presenting the microscopic structures of the identified ligneous taxa: **A.** *Quercus calliprinos*; **B.** *Styrax officinalis*; **C.** *Arbutus andrachne*; **D.** *Pinus halepensis* (photos D. Langgut).

Quercus calliprinos could be identified by the solitary, diffuse porous vessels radially arranged (A1) and the uniseriate rays (A2).

Styrax officinalis is identifiable by its slightly semi-ring-porous vessels arranged in radial rows (B1), widely spaced and ubiquitous scalariform perforation plates (B2), and mostly 2-4 rows of square or upright ray cells flanking procumbent central cells (B3).

Arbutus andrachne is characterised by diffuse porous to weakly semi-ring-porous vessels arranged mostly in radial rows (C1), predominant simple perforation plates with the less common occurrence of scalariform or reticulate perforation plates generally in the smaller vessels (C2) and distinct spiral thickenings (C3). Note as well in (C3) the simple perforation plates, contra the scalariform/reticulate type seen in (C2).

Pinus halepensis is readily identified as a gymnosperm (softwood), one of the few such species growing in the region, due to the lack of vessel structures that are present in most angiosperms (hardwoods) and is further distinguished from among the other gymnosperms by the presence of resin canals seen throughout each growth ring (D1). It is distinguished from among the other species of *Pinus* by the 1-3(4) fairly large (up to 10 µm in diameter) pinoid cross-field pits present in each ray cell (D2). It should be noted that the bad preservation of the samples made both observation and imaging of the samples and their identifying features difficult.

component in the natural Levantine environment as reflected in Pleistocene pollen diagrams (Horowitz 1979; Weinstein-Evron 1983; Langgut *et al.* 2011). It is documented in pollen spectra from Late Pleistocene Natufian (Weinstein-Evron 1994; Weinstein-Evron *et al.* 2007) and Early Holocene (Galili and Weinstein-Evron 1985; Galili *et al.* 1993; Weinstein-Evron 1994; Weinstein-Evron *et al.* 2007) localities in Mount Carmel. A single complete olive pit was recovered in the material analysed from Well no. 13 (fig. 6).

SIEVED HERBACEOUS MICRO-REMAINS

The herbaceous remains were in a poor state of preservation (fig. 8). They were sieved with a 0.5 mm mesh and examined visually and with a $\times 40$ binocular microscope. Most of the remains were identified as stems of grasses (family *Poaceae*), most similar to plants of the tribe *Triticeae* (wheat and barley) due to the thickness of the node and the base of the spike. Since a variety of sizes and nodal morphologies were observed in these stems, it probably indicates a wide diversity of grass species within the herbaceous assemblage. This may indicate that the plant materials were collected among wild plants and not in a homogeneous agricultural field (Hartman-Shenkman *et al.* 2015). In addition, despite the careful screening of the herbaceous plant materials, no reproductive organs (*i.e.*, flowers, inflorescences or fruits) were found except for one base of a spike, broken irregularly. This suggests that the herbaceous plants were probably collected at the end of the dry season (September/October in the Mediterranean climate in the region), when all seeds had already been dispersed. The stems could have undergone physical breaks due to animal activities or post depositional processes.

POLLEN ANALYSIS

Three pollen samples were collected from Well no. 13 at depths of 0-7, 7-11 and 11-20 cm. Twenty grams of sediment were processed for each sample using standard palynological techniques (Faegri and Iversen 1989) and identified using the comparative reference collection of the Laboratory of Palynology at the Zinman Institute of Archaeology, University of Haifa, and relevant atlases and reports (*e.g.*, Reille 1999). The composition of the pollen assemblages is presented in Table 2. Following common practice, the various pollen types are arranged in two groups—Arboreal Pollen (AP) and Non-

Arboreal Pollen (NAP)—followed by the number of the total pollen counted and by the hydrophilous pollen count.

The main arboreal taxa represented are both evergreen (*Quercus calliprinos* type) and deciduous (*Quercus ithaburensis* type) oaks, pine (*Pinus halepensis*) mainly in the deepest sample, some olive (*Olea europaea*), and occasional pistachio (*Pistacia*) and Rosaceae (rose family). Amongst the Non-Arboreal Pollen (NAP), Poaceae (grasses), Chenopodiaceae (goosefoot family) and Apiaceae (parsley family; mainly of the *Bunium* type) are clearly dominant. Other common taxa include Asteraceae Asteroidae (Aster subfamily; mainly of the *Inula* type) and Dipsacaceae (teasel family), alongside Fabaceae (legume family), Liliaceae (lilly family) and Lamiaceae (mints), and occasional *Centaurea*, Malvaceae and Boraginaceae. The scarce hydrophilous pollen is dominated by Cyperaceae (sedges), with occasional *Sparganium* (reeds), *Myriophyllum*, and *Potamogeton* (pondweed) in the uppermost sample only.

Similar to the anthracological picture, the arboreal taxa represent the typical Mediterranean vegetation found today in the Mount Carmel area. The relatively high pine values in the bottom sample may be a factor of the over-representation of pine pollen in the Israeli coastal spectra due to their long-distance transport from the east by seasonal, easterly winds (Weinstein 1979). Pines were always present within the natural vegetation of Mount Carmel, but probably not dominant (Weinstein-Evron and Lev-Yadun 2000). Given their typical over-representation in the pollen spectra, if the pines were more widespread, they would have been much more common in our samples as well.

Other AP levels are usually low, as expected from the coastal location of the retrieved samples and are clearly within the range of other spectra originating from submerged Neolithic sites off the Carmel coast (Galili and Weinstein-Evron 1985; Galili *et al.* 1993).

Grasses were found within the analysed botanical materials and are dominant in the pollen spectra. Cerealia pollen was not found. Cerealia pollen is typically under-represented in the pollen spectra (partly because many of them are self-pollinating; *e.g.*, Zohary 2001). In our case, the lack of Cerealia pollen may also reflect the fact that no reproductive organs were found among the cereal macro remains at the site, indicating their possible collection season (see above).

The NAP group contains more taxa than the wood assemblage, many of them probably growing in the coastal environment near the site. Among them, Chenopodiaceae are indicative of a rather saline environment. Some of them (*e.g.*, *Atriplex* or saltbush) are edible and may have been collected by the Neolithic inhabitants of the site. The apparent interplay



Fig. 8 – Kfar Samir: Herbaceous remains including stem fragments and fibers (photo: M. Cavanagh).

between Chenopodiaceae and Apiaceae is worth noting. Even though the precise Apiaceae species could not be determined, it was established before (Galili and Weinstein-Evron 1985) that Apiaceae thrive in relatively saline environments. Hence, both the Chenopodiaceae and Apiaceae can be taken to reliably represent the coastal environment of the site. Worth noting is that there are some edible coastal Apiaceae as well (e.g., *Crithmum maritimum*, that was found in the Ma'agan Mikhael ship, for example; Weinstein-Evron and Chaim 1999), but the *Crithmum* pollen type is different than the *Bunium* type found

at the site. Based on comparisons with former palynological studies of fossil and recent water bodies (from saline through brackish to freshwater; Galili and Weinstein-Evron 1985), Apiaceae pollen (mainly *Bunium* type) become more abundant as salinity increases (Weinstein-Evron 1994).

The occasionally high values of insect-pollinated taxa (Fabaceae, Lamiaceae and Liliaceae) may indicate some human collection. While burrowing insects can be sometimes considered as a contributing factor, various case-studies suggest that pollen assemblages resulting from burrowing

Table 2 – *The pollen spectra (M. Weinstein-Evron and S. Chaim).*

POLLEN TYPE	DEPTH (cm)		
	0-7	7-11	11-20
AP (%)			
<i>Quercus callip.</i> type	2.3	0.8	1.8
<i>Quercus ithab.</i> type	2.3	1.2	
<i>Pistacia</i> sp.	0.5		
<i>Pinus halepensis</i>	1.4	0.8	12.5
<i>Olea europaea</i>	0.9		1.8
Rosaceae	0.5		
Total AP (%)	7.9	2.9	16.1
NAP (%)			
Poaceae	14.4	4.1	28.6
<i>Artemisia</i>	2.3	0.4	
Chenopodiaceae	40.5	8.7	16.1
Apiaceae	8.8	64.0	8.9
Asteraceae Asteroidae	1.9	5.8	3.6
<i>Inula</i> type	4.2	3.3	3.6
<i>Centaurea</i>		0.4	
Fabaceae	0.5	5.0	5.4
Liliaceae	6.5		1.8
Lamiaceae	3.7		1.8
Dipsacaceae	8.8	5.4	12.5
Malvaceae			1.8
Boraginaceae	0.5		
Total pollen counted (no.)	215	242	56
Hydrophilous (%)			
Cyperaceae	13	12	8
<i>Sparganium</i>	1		
<i>Myriophyllum</i>	1		
<i>Potamogeton</i>	3		
Total Hydrophilous (no.)	18	12	8
<i>Lycopodium</i>	40	21	10

insects, burrowing mole rats, as well as seasonal cracks in the soil tend to exhibit dominance of Asteraceae pollen (Bottema 1975; Weinstein-Evron 1983), which is not the case in Kfar Samir. The high proportion of Dipsacaceae, especially in the lowest sample, probably represents ruderal plants. Some of the Asteraceae pollen could also thrive in such human-induced environments (*e.g.*, Weinstein-Evron 1994).

The constant appearance of Cyperaceae indicates that, despite the coastal environment, fresh-water biotopes were also present, indicating the presence of a nearby stream or high ground water levels, as also attested by the water wells. The presence of nearby streams may also be indicated by the occurrence of concentrations of pebbles embedded in the clay matrix of the site. These may represent the presently submerged channels of the small wadies draining the western slopes of Mount Carmel adjacent to the site (Nahal Siah and Nahal Ezov in the northern sector and Nahal Ahuza in the southern sector). Similar submerged river channels were reported off Kfar Samir and in the Atlit-Yam site (Galili *et al.* 2005).

DISCUSSION

The archaeological evidence from the 2014 field campaign, when added to the information from previous excavations at Kfar Samir and other contemporaneous submerged sites, has contributed further to our understanding of PN settlement life-style and environments on the Carmel coastal plain, especially, the nature of vegetation cover of the region and paleoenvironment, modes of subsistence and the early management of fresh-water resources by the local inhabitants.

RECONSTRUCTION OF THE PN VEGETATION COVER

The botanical evidence (wood, herbaceous plants and pollen) recovered from the Kfar Samir water wells, indicates that three ecological niches existed near the site: Mediterranean maquis/forest, saline soils and possibly fresh-water bodies. The vegetation was characterized by the same Mediterranean arboreal and herbaceous species that grow today along the coastal plain and on the nearby Mount Carmel. Three out of the four arboreal species identified within the wood assemblage (*Quercus calliprinos*, *Pinus halepensis* and *Arbutus andrachne*), as well as *Olea europaea* (olive), were also recognised in previous palynological studies from the Carmel coast, dated to the Neolithic period (Galili and Weinstein-Evron 1985; Galili *et al.* 1993; Kadosh *et al.* 2004). *Styrax officinalis*, although not identified among previous regional palynological or anthracological assemblages, was already known to the Neolithic inhabitants of the Carmel coast at Atlit-Yam (Galili *et al.* 1993: 152; Galili *et al.* 2004: 24). The proximity to trees would have facilitated the collection of wood for construction purposes, as evident in the water wells.

The carob wooden bowl found in the southern section of the site is worthy of further discussion. Together with *Pistacia lentiscus*, *Ceratonia siliqua* is indeed common in the lower vegetation belt of Mount Carmel (up to ca. 300 m; Zohary 1962). Its pollen is very rarely found in fossil pollen samples (Weinstein 1981; Weinstein-Evron 1994), so nothing much can be gathered from its absence at Kfar Samir. The carob wooden bowl is the only indication of its occurrence. As no major climatic change can be gathered from the available archaeobotanical data, and the local environments during the PN seems not to have differed much from those of today, it is reasonable to assume that the wood was gathered from a nearby *Ceratonia siliqua* – *Pistacia lentiscus* association.

EARLY EXTRACTION OF OLIVE OIL

Olive oil is a major component of traditional Mediterranean subsistence and diet (e.g., Zohary *et al.* 2012: 116). The olive fruit is rich in oil, containing up to 20% oil and sometimes more (Patumi *et al.* 2002). The Kfar Samir site provides valuable information on the beginning of olive oil exploitation. Evidence for extraction of olive oil was found in previous excavations at Kfar Samir (Galili *et al.* 1997). These included evidence for several stages of production: (1) crushing basins made of stone; (2) a pit filled with waste of olive oil extraction (crushed olive pits and pulp, representing olive oil cake); and (3) containers made of twigs. Possibly the olive oil waste can represent a further step when the container was emptied after pressing. To date, this is considered the oldest known evidence for olive oil extraction, while organic residue in pottery vessels from the Wadi Rabah phase at Ein Zippori (Galilee) is considered the oldest evidence for storing olive fruit or oil in a ceramic container (Namdar *et al.* 2015). In a fully agricultural community such as the Kfar Samir, waste from olive oil extraction may have been used to feed livestock or as a substitute for fire wood (Galili *et al.* 1997). M. Hadjipanayiotou (1999) noted that olive oil cakes are used for feeding livestock such as cattle, goats, pigs and rabbits. In the older PPNC site of Atlit-Yam, on the other hand, even though the presence of olive trees is evident (in the form of charcoal and pollen grains), no olive stones were recovered. These data strongly suggest that olive oil was first extracted and became a component of the Mediterranean diet during the Wadi Rabah phase of the PN (Galili *et al.* 1989; Galili and Sharvit 1994-1995).

It is not yet clear whether the olives used for oil extraction in Kfar Samir were derived from domesticated or wild trees

(Galili *et al.* 1997). Attempts were made to distinguish the endocarp (fruit stones) of domesticated and wild olives by using statistics of pit characteristics (Kislev 1995; Terral *et al.* 2004). Kislev suggested that the morphological heterogeneity of the stones from Kfar Samir was too great to attribute them to domesticated forms and suggested that olive oil extraction pre-dated the domestication process (Kislev 1995). Terral *et al.* 2004, using different morphological characteristics, have proposed that wild olive stones may be distinguished from cultivated forms by shape, but not by size. DNA study of the olive stones from Kfar Samir (Elbaum *et al.* 2006) provided short sequences but no conclusive evidence regarding domestication. Further studies of the olive stones from Kfar Samir using morphometric and molecular markers, both nuclear and cytoplasmic (e.g., Breton *et al.* 2009) may clarify whether they were picked from domesticated or wild (oleaster) trees. Archaeobotanical data from the site of Teleilat el-Ghassul, Jordan (Meadows 2001; Lovell 2002) together with analysis of Southern Levantine palynological diagrams, may provide indirect evidence of a Middle Chalcolithic date for the domestication of the olive, based on a dramatic rise in *Olea europaea* pollen (Zohary *et al.* 2012: 119-120; Langgut *et al.* 2016 and references therein). However, palynologically, wild and domesticated olive pollen grains are indistinguishable (Baruch 1986; Langgut *et al.* 2014).

TRADITIONAL MEDITERRANEAN ECONOMY

Coastal environments are highly productive (Phillipson 1966: 46, fig 5-2). They provide diverse ecological niches (fig. 9) and enable the exploitation of both terrestrial and marine resources (e.g., Bailey and Parkington 1988). In their quest for a productive and resource-rich environment, Neolithic populations in the Southern Levant settled on the Mediterranean coast, primarily from the PPNC onwards (Gopher 1993; Galili *et al.* 2002, 2004; Garfinkel and Dag 2001). The combination of terrestrial, saline and fresh-water coastal environments, as well as Mediterranean forest—as indicated by the faunal and botanical finds from the submerged PN sites, demonstrates the diversity of habitats that were available (Galili and Weinstein-Evron 1985; Horwitz *et al.* 2002, 2006; Kislev *et al.* 2004; Hartman-Shenkman *et al.* 2015). Inhabitants of the PPNC and the PN coastal Neolithic villages pursued mixed modes of subsistence, comprising fishing-farming-hunting and animal husbandry which together constituted the earliest form of the traditional Mediterranean diet.

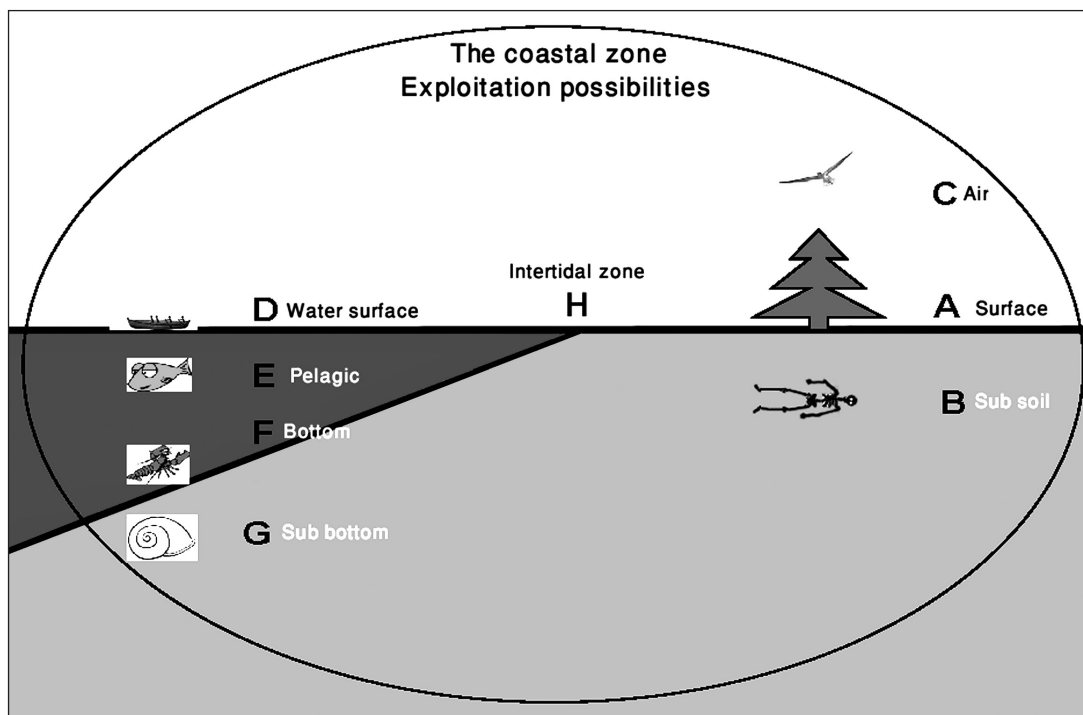


Fig. 9 – Diverse possibilities of exploitation of terrestrial and marine environments in the coastal zone (E. Galili after Galili et al. 2017a, fig. 7.23).

SEASONALITY OF OCCUPATION

It has been proposed (Galili *et al.* 2002) that subsistence activities in the permanent PPNC settlement of Atlit-Yam were staggered and seasonal, with fishing mainly in the spring and autumn, peak animal husbandry between April and June, and cultivation activities focused in the winter and summer months.

Data from PN Kfar Samir suggest that a seasonal mode of exploitation may have also been practiced at this site. A study of oil content and fruit size indicates that olives in Israel can be harvested for oil from October to January (Dag *et al.* 2011). However, traditional local harvesting of olives today is usually done after the first significant rain, during October-November. Given the evidence for olive oil extraction at the site, it is reasonable to assume that oil extraction took place during the autumn-early winter, when olives mature. This is supported by the absence of remains of reproductive organs (*i.e.*, stems and carpels) within the herbaceous assemblage, which implies that they were probably collected during autumn (see above). The mallard duck, whose remains were identified in Well no. 3, is a migratory waterbird, traditionally wintering in Israel (Griffin 1964; Paz 1987). Thus, its presence supports the suggestion

that the site occupation took place in late autumn-winter, though the data do not negate a year-round or summer use of the site. The absence of stone-built dwellings in Kfar Samir site, as opposed to PPNC Atlit-Yam or other submerged PN sites in the region, such as Neve Yam and Tel Hreiz, also raises the possibility that site occupation at Kfar Samir was seasonal (Galili *et al.* 2017b). However, the presence of several water wells, installations requiring an investment to build, may point to the possibility that a more permanent related settlement was located somewhere inland. According to the radiometric dates, habitation in both sites (Atlit-Yam a permanent occupation and Kfar Samir perhaps a seasonal occupation), lasted only a few hundred years (table 1).

MANAGEMENT OF FRESH-WATER RESOURCES

A sustainable, independent fresh-water supply is a precondition for a permanent settlement. Supplying drinking water is usually a limiting factor in the Southern Levantine coast, where the streams are mostly dry in the summer. In an area rich in economic resources, but lacking fresh drinking

water, excavating wells is a solution. It can be highly rewarding as it creates an artificial, permanent source of water that facilitates the occupation of new territories, and significantly increases the viability and carrying capacity of a region. The appearance of water wells in the Southern Levantine coast may be associated with attempts by Late Pre-Pottery Neolithic communities to occupy new areas and habitats, possibly to cope with shrinking resources and a growing demand for agricultural land (Rollefson and Köhler-Rollefson 1989; Rollefson *et al.* 1992; Galili *et al.* 2002). The Israeli coastal plain overlies a high aquifer that is exploitable all year round using the proper technology, such that the construction of water wells, enabling the occupation of this previously uninhabited area. The earliest example of a water well in this location was found at PPNC Atlit-Yam (Galili and Nir 1993; Galili and Rosen 2011a). The presence of these early wells shows that the Neolithic settlers of the Carmel coast had, early on developed the ability to access and control underground fresh-water and create an artificial, long lasting source of water. The technology used to build the Kfar Samir wells is unique due to the integration of wood and stones (fig. 3), demonstrating the sophistication of this structure. The earliest known wells (from Cyprus) were simple shafts cut into the local sediments (*e.g.*, Peltenburg *et al.* 2001), while in the Southern Levant, later wells comprise shafts walled by stones (Galili and Nir 1993; Garfinkel *et al.* 2006, 2007; Galili and Rosen 2011a and references therein). Today the coastal aquifer provides seasonal fresh-water springs that are visible on the coastline and on the sea bottom in the northern Carmel coast.

SEA-LEVEL RISE

A global sea-level rise of *ca.* 17 cm during the 20th century resulted in coastal erosion, the flooding of beaches and the destruction of coastal facilities and ancient coastal cities worldwide (Church and White 2011; Fagan 2013). It is expected that sea level will continue to rise during the 21st century (*e.g.*, Vermeer and Rahmstorf 2009) and a rise of one meter or more in the coming years will have a significant influence on coastal populations, low-lying countries, marshlands and coastal defences around the globe (Van de Noort 2013: 70; Rohling *et al.* 2013; Dutton *et al.* 2015; DeConto and Pollard 2016). The submerged Neolithic settlements off the Carmel coast facilitate a reconstruction of Holocene sea-level changes in the region (fig. 10) and demonstrate the inevitable evacuation of Neolithic coastal settlements due to post-glacial sea-level rise (Galili *et al.*

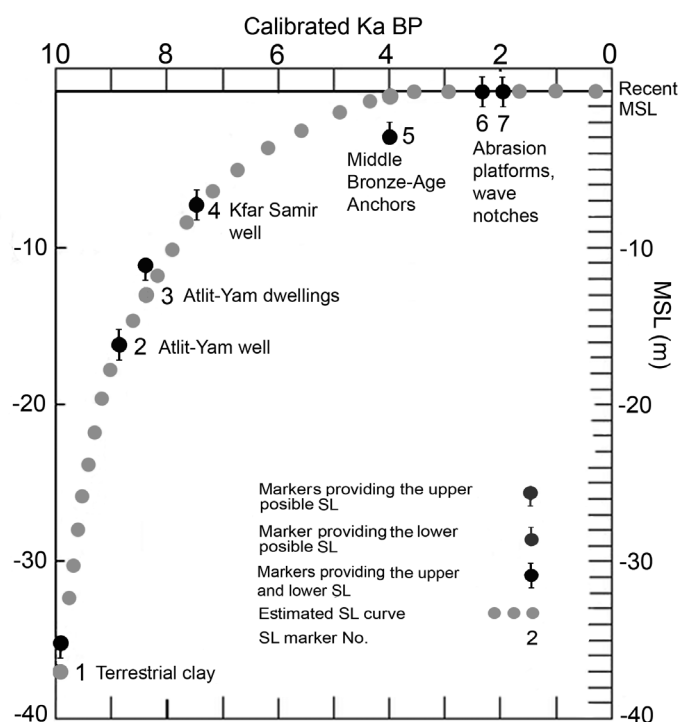


Fig. 10 – Sea-level changes in the Carmel coast region based on archaeological features which are used as sea-level markers. Ka = thousands of years (E. Galili).

1988; Galili *et al.* 2017a, 2017b). Notably, coastal water wells provide valuable information on sea-level changes, as sea-level rise results in ground-water table rise and water well salinization. The bottom of Well no. 11 in Atlit-Yam is about 15.5 m below present sea level; this would have been the fresh-water table at the time. Hence sea-level was about 16 m below the present level during the initial use of the well. As attested by the Kfar Samir wells, during the subsequent PN period, sea-level was *ca.* 8-9 m below present sea level. Indeed, all the submerged PN sites are located 0-200 m offshore at depths of 0 m to 6 m. Atlit-Yam PPNC site is located 200 m to 400 m off the present shoreline at a depth of 8 to 12 m. Thus, between 9200 and 7500 BP sea-level rose some 8 m (from -16 m to -8 m), at a mean annual rate of *ca.* 5 mm/year. From 7500 to 4000 BP, sea-level rose an additional 8 m (from -8 m to the present level), at a mean annual rate of *ca.* 2.3 mm/year. Since *ca.* 4000 BP, sea-level has been relatively stable, with possible minor changes of less than the local tidal range (± 0.30 m; fig. 10). Thus, there is a direct correlation between the sea-level rise and the abandonment of coastal settlements and their translocation eastward (Galili *et al.* 1988, 2005).

CONCLUSIONS

The finds from the new excavations at Kfar Samir show that during the Early Holocene the region was characterised by Mediterranean vegetation cover, with saline and fresh-water bodies probably present along the Carmel coast (Galili *et al.* 2005).

The study also sheds light on the management of fresh-water resources through the digging and use of water wells, and the introduction of olive oil, an essential component of traditional Mediterranean subsistence and diet.

The botanical and faunal remains suggest that the activities at the site took place mainly at the end of the dry season, when olives were harvested and processed. Given the above, and the lack of stone-built dwellings, it is suggested that the settlement may have been seasonal in nature, perhaps specializing in olive oil extraction. Still, the presence of several water wells may indicate the presence of a more permanent settlement in the hinterland.

As R. Van de Noort has written on the subject of resilience and reactive adaptations of past societies who lacked the climate prediction methods available today: “It is about finding examples of adaptation to the consequences of environmental and climate changes in the past that, in a small way, can help build the socio-ecological resilience of communities in the present and future” (Van de Noort 2013: 41). The submerged settlements off the Carmel coast may contribute to this issue, as their inhabitants experienced sea-level rise and inundation leading to settlement abandonment. Such a scenario may be relevant for some coastal communities today.

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