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Atlit-Yam: A Prehistoric Site on the Sea Floor off the Israeli Coast

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Atlit-Yam, a settlement 400 m off the Israeli shore, is the largest (60,000 sq m) and most deeply submerged (8–12 m bsl) prehistoric settlement ever uncovered along the Mediterranean coast. The architecture of the dwellings, the lithic tool assemblages, and radiocarbon dating indicate habitation during the late Pre-Pottery Neolithic (PPN) period, ca. 8100–7500 B.P. Floral and faunal remains suggest that the village economy was complex, based on several different food resources acquired through hunting, incipient herding, fishing, and farming. These probably permitted year-round occupation. More importantly, however, Atlit-Yam is among the earliest communities to reveal evidence of maritime activity. From this site, new insights into maritime pursuits and the domestication of animals and plants, as well as early evidence for exploitation of water tables, the construction of wells in prehistoric times, and sea level changes will be forthcoming. Further study of Atlit-Yam may also contribute to our understanding of the process of colonization of the Mediterranean islands.

Introduction

In the last 20 years, remains of many prehistoric cultures have been found on the sea floor throughout the world, although rarely in situ (Flemming 1983b: 135). The first submerged Neolithic site to be discovered with concentrated remains of a settlement was at Aghios Petros in Greece. The remains were so well preserved that for the first time survey and excavation in the context of an entire site, rather than the collecting of individual artifacts scattered over hundreds of meters on the sea floor, could be carried out (Flemming 1983a: 234–236).

Recently, Atlit-Yam (FIG. 1), a submerged settlement off the Israeli coast, dating to the very end of the 7th and the beginning of the 6th millennia B.C., was discovered. The site is unsurpassed among submerged sites in its degree of building preservation, remains of material culture, animal bones, botanical material, and human burials. This is not only the largest and best preserved prehistoric settlement ever found on the sea floor, it is the only one known to contain in situ burials.

About 20,000 years ago, the last glacial reached its peak and soon afterwards the melting ice caused a rise in sea level, resulting in a significant reduction of coastal plains throughout the world. By the beginning of the Holocene, however, ca. 10,000 years ago, the Mediterranean remained about 30 m lower than at present (van Andel and

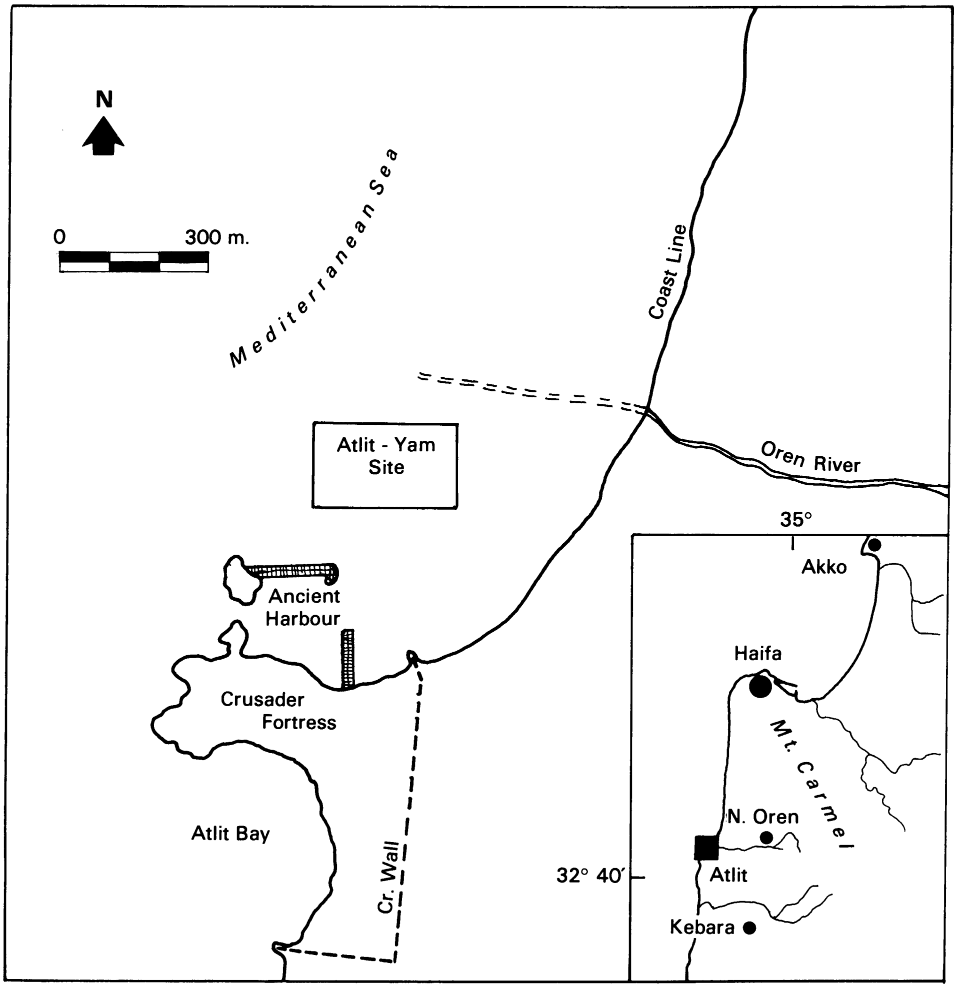


Figure 1. Location of the Atlit-Yam site.

Lianos 1983). In Israel, a number of sandstone (aeollianite, kurkar) ridges running parallel to the present coastline inhibited natural drainage; consequently much of the Israeli coastal plain was covered by swamps. In the beginning of the Holocene, tectonic tilting (Neev et al. 1973) and/or climatic changes caused some of the swamps to dry up in a relatively short period of time. Conditions then became more favorable for coastal settlement and maritime exploitation. During the next 2000 years (10,000–8000 B.P.), the sea continued to rise and cover greater areas of the coast. The early sites were eventually inundated, and new settlements were established along the retreating shoreline (Wreschner 1977; Galili and Weinstein-Evron 1985; Galili, Kaufman, and Weinstein-Evron 1988).

In addition to the Atlit-Yam PPN (Pre-Pottery Neolithic) site, other submerged settlements belonging to a later phase (the Pottery Neolithic period), have been identified along the northern Carmel coast at shallower depths (Galili and Weinstein-Evron 1985). All the sites are embedded in the upper segment of marshy clay deposits, covered with sand most of the year but exposed from time to time, particularly following storms. When first exposed, the remains are remarkably well preserved, but are soon damaged by wave action.

The recent proliferation of finds is due, in part, to more intensified research, but mainly to changes in the pattern of coastal sedimentation as a result of human intervention in the last few decades. Sand quarrying along the coast and shoreline constructions (such as breakwaters) interrupted the flow of replacement sand, and erosion is exposing the sites. Construction of the Aswan High Dam, by impounding a large part of the Nile's sediment, also may have contributed to this process.

Methods

Excavation methods for underwater archaeology were developed basically for shipwrecks, in which all cargo and artifacts tend to be concentrated in a restricted area. When excavating a submerged prehistoric village, however, the marine archaeologist must deal with the same problems involved in land excavations (e.g., stratigraphy, duration of site occupation, function of features), but with the additional complications presented by the sea and limitations of diving. The Atlit-Yam site lies in an area frequented by storms. Currents reduce underwater visibility during most of the year, and constantly shift sand from one area of the site to another. The thickness of the sand cover varies from season to season, and accumulated concentrations of decayed algae cover parts of the site and hamper excavation.

Excavations are carried out each year in September, when weather conditions are optimal, storms are rare, and the water is still relatively warm. Since submerged remains are particularly vulnerable immediately after exposure, occasional survey dives during the winter serve to document and preserve any exposed finds.

The size of the village and the spatial distribution of its structures dictated the following mapping and excavating system.

Each identified structure in the site was marked with a long iron rod bearing an identifying plastic tag. The rod protruded at least 1 m above the structure to enable relocating after possible silting. At the top of each rod, a buoy was floated, also bearing the number of the structure. From two fixed coordinates on the shore, distances were measured by distomate (range finder) to the buoy on each structure. A rope (the "baseline") marked off in 2 m segments was then laid in a straight line on the sea floor. This was anchored at each end by stakes from which additional buoys rise and could be mapped by the range-finder. The position of each structure on the sea floor was also measured by the divers and given a coordinate relative to the baseline. The site plan was prepared by coordinating buoy measurements with those obtained by divers.

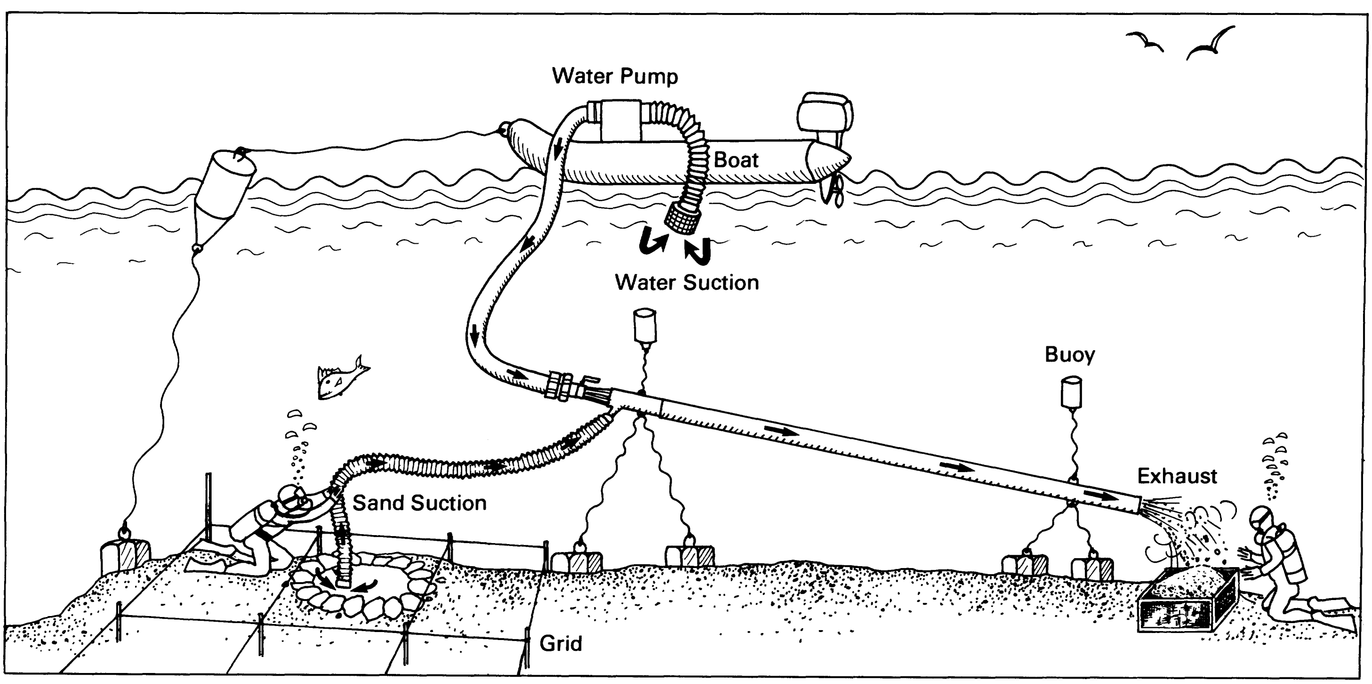
Mapping and excavation of individual structures were carried out by positioning a synthetic fiber or metal grid over the area. One corner of the grid was usually fixed on the iron rod marking the structure. At a later stage, the individual grids of each structure were adapted to the grid of the entire site.

The first step in the excavation was to dredge loose sediment until the surface of hard clay was reached. Since the site is about 300–400 m offshore, the water pump of the dredging system was operated from a boat. All of the tubing used for dredging was anchored to the sea floor (FIG. 2).

The excavation team included two divers, one working in the "suction" area, holding the plastic hose and removing any obstructive debris drawn into the hose, and the other situated at the "exhaust" end of the dredging system.

After the excavation area was cleaned of loose sand, it was photographed and sketched. Excavation in 10 cm spits was then begun in chosen loci, using the dredger suction. All the sand and other material freed by the dredger was

Figure 2. Marine excavation assisted by dredging system.



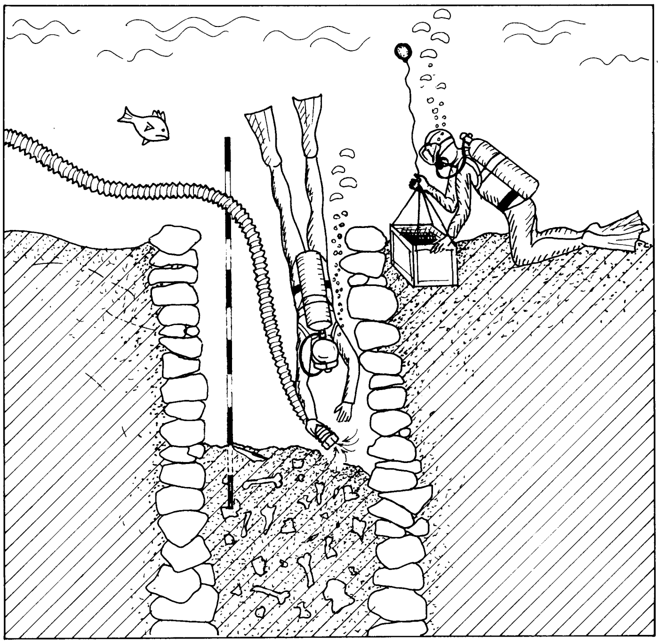
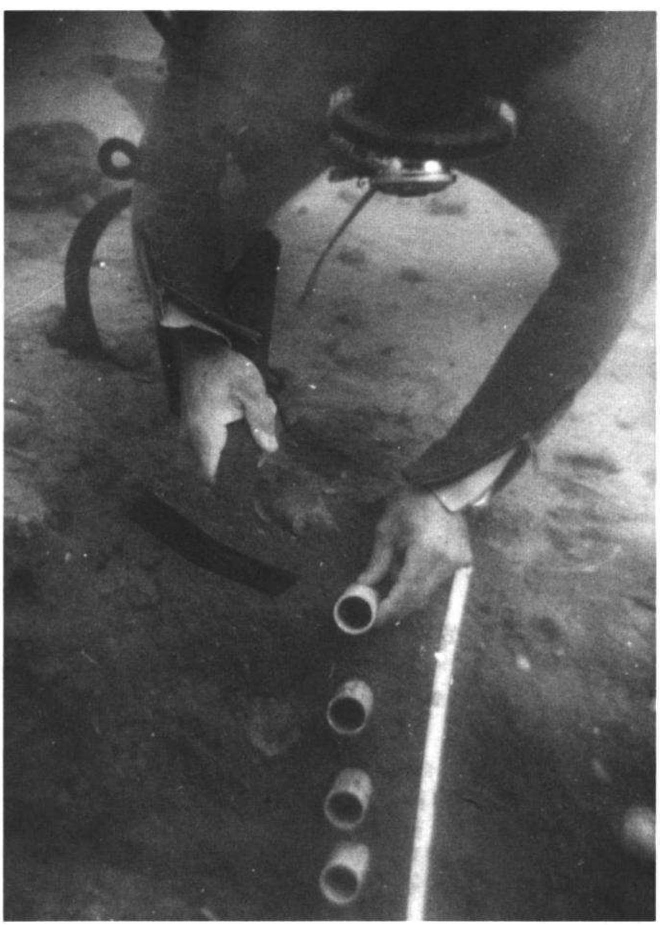


Figure 3. Excavation technique used for pits.

Figure 4. Core sampling for sediment and pollen analysis.



collected in a box at the exhaust, marked by square and layer, and emptied into tagged plastic bags, which were transported to the shore for sieving.

In order to excavate pits that penetrated deep into the clay, special techniques were used (FIG. 3). The clay within the pit, including most of the finds, and the murky water were both dredged. Potential obstructions and large finds were removed to a plastic box; small or fragile artifacts were collected in plastic jars. Boxes at the exhaust were replaced at every 10 cm interval, and core samples of in situ clay were taken for pollen and sediment analysis (FIG. 4). In the 1990 season additional precautions were taken to shore up well walls by inserting metal rings at 70 cm intervals to prevent collapse.

The Site

The Atlit-Yam site is located 10 km south of Haifa, 400 m north of the Crusader castle at Atlit (FIG. 1), and is 300–400 m offshore (34°56′E, 32°42.5′N), at a depth of 8–12 m (FIG. 5) on the sea floor in the northern bay of Atlit. The site is bordered by a peninsula on the south and a submerged kurkar ridge on the west. The archaeological material is embedded in the upper layer of the clay, which fills the trough between the eastern edges of the submerged ridge and the coastline (FIG. 6).

Foundations of several rectangular structures (for example, FIG. 7: structure 6) have been discovered throughout the site. In some of them, only small parts of the foundation walls remained, and the specific plan of the structures could not be determined. In the open areas between some of the structures, paved surfaces and circular features were found. Many artifacts were scattered around outside the built-up area (shown in FIG. 5), and as more parts of the site are uncovered it may prove to be larger than the present estimate of ca. 60,000 sq m.

The foundations of the structures range from 50 to 100 cm in width and are generally made of two rows of boulders with smaller stones, and sometimes even animal bones or baked clay, between them. Some of the walls are built of stones vertically set in the clay, but in most cases the stones are laid horizontally. In some structures, a few courses remained above the clayey surface, but generally only one course of stones, partially embedded in the clay, is visible, the rest being buried under the surface.

Among the structures, No. 15 is exceptional. It consists of a wall (of baked clay bricks) 20 m long, 1–2 m thick, and preserved to a height of 80 cm. Its position, parallel to and near the ancient bed of the Oren River (FIG. 6) may indicate that the wall was built to protect the village from river floods during the winter months, a function

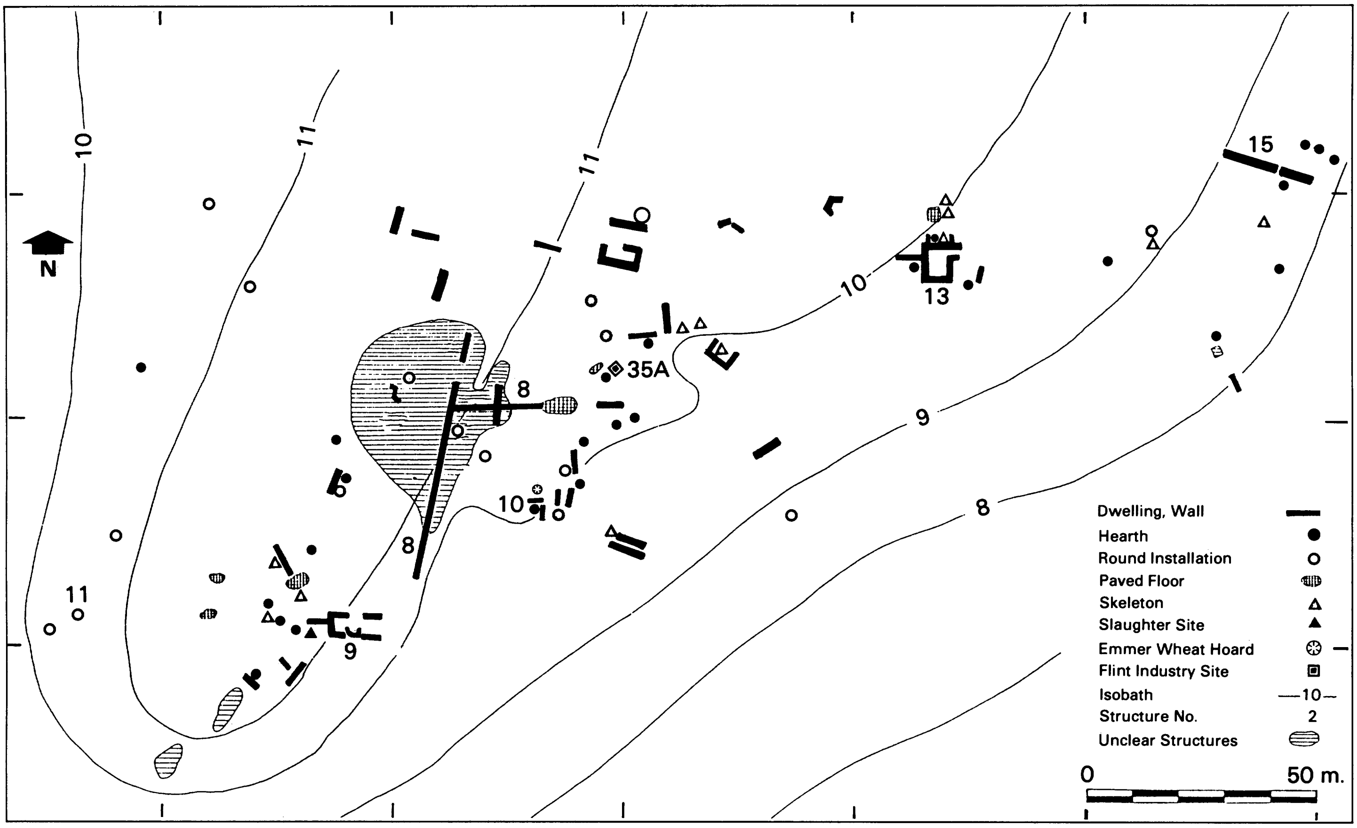


Figure 5. General plan of the Atlit-Yam settlement.

suggested by Bar-Yosef (1986) for the walls at Jericho.

A number of circular pits, 1–2 m in diameter and built of large (15–30 cm) stones, was discovered at the site. These may have been used as storage pits or water holes. Smaller circular features are characterized by the smaller stones (5–10 cm) that were used for their construction. One of these (FIG. 8) has flat, standing stones marking its edges. Another type of circular feature was found a few meters SE of structure 10. It is a 2–5 sq m platform made of semiconvex, baked clay bricks that covers a dense layer of unidentified, ancient plant fiber, and was probably used for processing the latter. The function of the other structures is not clear. Ethnoarchaeological data suggest two possibilities: a) that they served as raised platforms for storing firewood; or b) that they were cooking (steaming or smoking) pits (cf. Stewart 1977: 130–132).

Many hearths, 50–140 cm in diameter, were discovered around or inside the structures (see FIG. 5). They are generally built of small stones laid in a circular pattern, and contain bones, charcoal, baked clay bricks, and, sometimes, a brittle white plaster. A large concentration of wheat grains and fish bones was found near structure 10. This is discussed below. Many linear walls are scattered throughout the site (e.g., structure 8, FIG. 5); some are foundation remains, and others are of uncertain function.

The Structures

In view of the limitations imposed by an underwater site, liable to short exposures and disintegration of finds caused by sand movement during storms, the primary efforts were directed toward recording and rescue work. In addition, a number of specific test excavations were carried out. Some 1 m × 1 m test pits were excavated in rectangular structures 9 and 13; a flint concentration (feature 35A) was fully excavated; and a well (No. 11) was excavated to a depth of 5.5 m.

Structure 9

One sq m was excavated inside the structure (by the western wall) to a depth of 60 cm. One course of stones was exposed within the clay, and below it a concentration of small (5–10 cm) stones. Two rows of stones, forming a curved feature, are inconsistent with the main rectangular structure, and may indicate a later phase of construction.

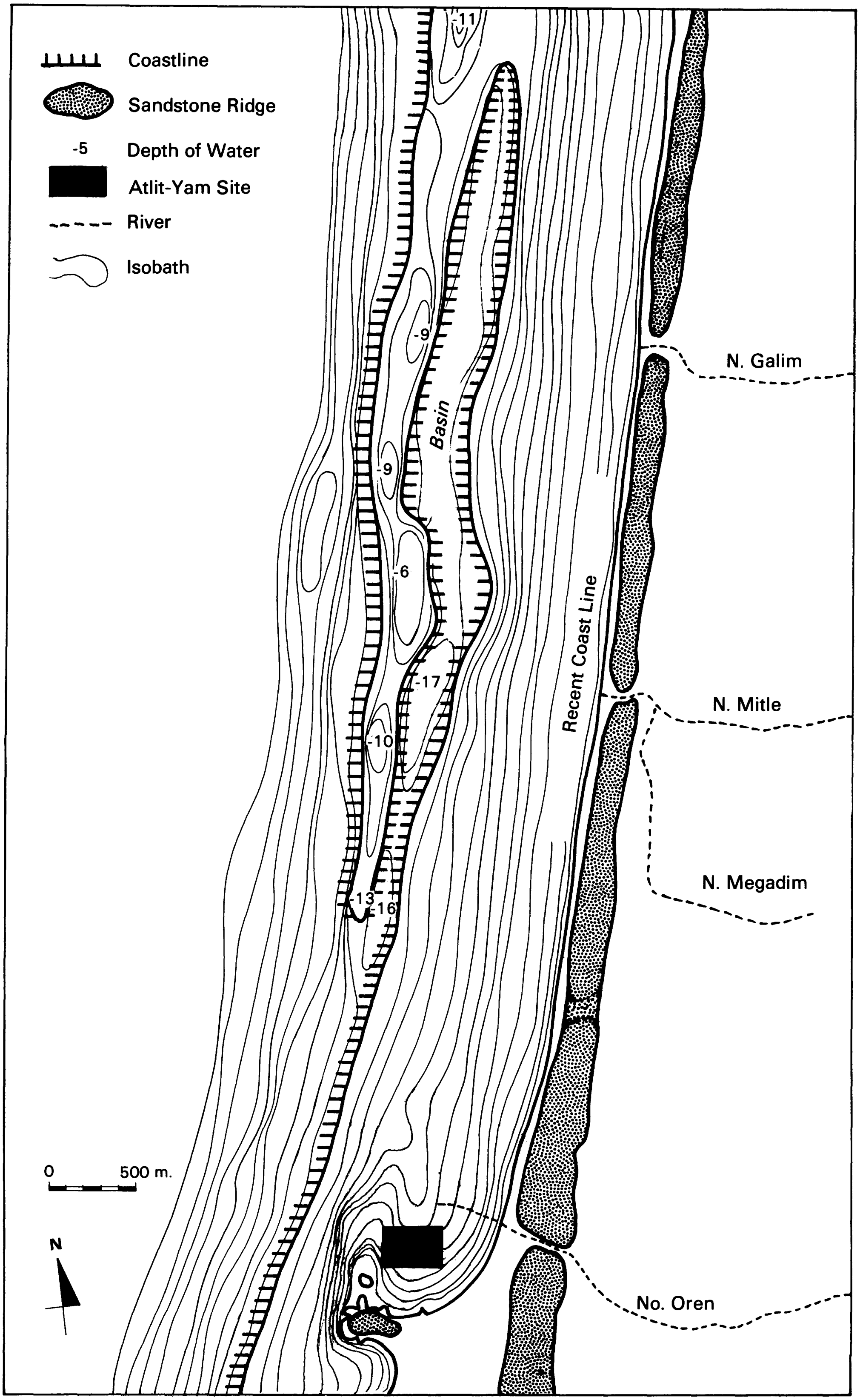


Figure 6. Bathymetric map of the Atlit-Yam region. Note the basin between the shoreline and the submerged kurkar ridge.

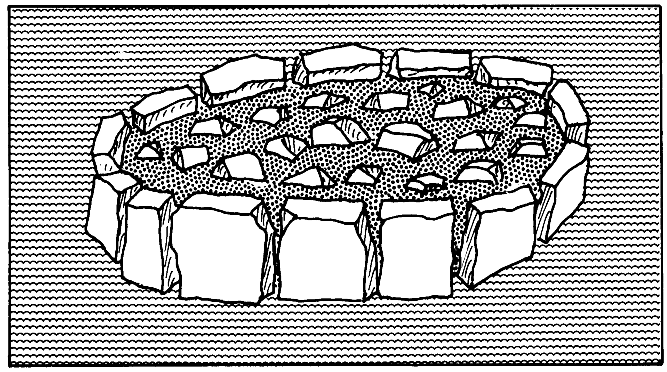
Figure 7. Dwelling walls built by the double-wall method, represented by structure 6.

Structure 13

Two 1-m squares were excavated inside the structure (by the northern wall) to a depth of 60 cm. Three courses of stones were exposed within the clay in addition to the two courses above the clay surface.

The Workshop: Feature 35A

Three especially dense concentrations of flint were noted on the surface some 80 cm apart. Eight 1-m squares were excavated in this area in 10 cm spits. A large quantity of flint artifacts was collected, and as the excavation proceeded it became clear that the "three outcrops" were in fact one concentration some 30 cm thick and 2.5 sq m in area.



0 30 cm

Figure 8. A round feature (schematic).

The Well: Structure 11

On the surface, above the well, a tumulus-like construction protruded from the clay to a height of 70 cm (Galili, Kaufman, and Weinstein-Evron 1988). It is a cylindrical feature some 1.5 m in diameter with walls built of undressed stones (FIGS. 9, 10). Four courses have survived above the clay surface, and others descend for several meters into the clay. Excavation of the structure during the 1988–1990 seasons revealed that the part above the clay surface contained small pebbles and seashells, mainly *Glycimerus* sp. Immediately beneath the surface the sediment inside the structure consisted of soft clay mixed with organic material and contained hundreds of thermally-fractured limestone pebbles, animal bones, stone and bone tools, waterlogged and carbonized plant remains, and a few fragments of human bone. Excavation has extended to a depth of 5.5 m below the sea floor; the lowermost 1.5 m are set into the kurkar (sandstone) bedrock (FIG. 10).

Five ^{14}C dates were obtained for the site, taken from a number of locations around structures 10 and 13 (TABLE 1). All samples were from the top 10 cm of the hard clay.

Stratigraphy

It appears that all of the above features lie in the uppermost part of the ancient marshy clay with only a few courses embedded in the clay itself. Excavations in structures 9 and 13 indicate that the deeper levels have a

Table 1. Radiocarbon determinations from Atlit-Yam.

Date	*Laboratory*	*Sample*	*Provenience*
8000 ± 90 b.p.	(Pta 3950)	charcoal (branch)	(near structure 13)
8140 ± 120 b.p.	(RT 707)	charcoal (branch)	(near structure 13)
7670 ± 85 b.p.	(RT 944A)	charcoal (wheat)	(near structure 10)
7610 ± 90 b.p.	(RT 944C)	charcoal (branches)	(near structure 10)
7550 ± 80 b.p.	(P.I.T.T. 0622)	charcoal (wheat)	(near structure 10)

significantly lower artifact density, and in neither case was a living floor discerned below the clay surface.

Excavation in structure 11 revealed four main phases of fill within the well (from bottom to top, FIG. 10).

1. From a depth of 575 to 565 cm: pure sand with a few flint and stone artifacts.
2. From a depth of 565 to 250 cm: clay rich in sand, many small (5–15 cm diameter) and some medium-sized stones (15–35 cm in diameter), and a few animal bones.
3. Between 250 and 70 cm: clay with a little sand, many small and some medium-sized stones, many animal bones, and a few botanical remains. Some of the animal bones were articulated.
4. From 70 to 0 cm, clay: small stones, shells, and some bones.

Radiocarbon determinations and further study of archaeological content will enable estimation of the time range represented by the pit-fill and the time lapse between its original use and its final infilling.

The vertical stratigraphy was exposed only in the fill of the well, although ^{14}C dates range over some 400 years. It thus seems that the different phases of the settlement occupation are laterally dispersed and that different areas were used at different times. When more structures are excavated, it may be possible to identify settlement phases by the contextual evidence.

The Artifact Assemblages

The Atlit-Yam assemblage includes components of different kinds: a) surface collections made during survey work and in the area of the site during excavation (tools only); b) excavated material from structures and other features (including the well, tools only); c) a dense concentration of flint, excavated systematically in the summer of 1989 (feature 35A, waste and tools). Several kinds of flint were used for knapping, all originating in the nearby Mount Carmel region, ca. 4 km to the east. A few double-patinated artifacts, some of Middle Paleolithic origin, were found.

The sample from the 35A assemblage was randomly chosen and consists of 8755 artifacts, dominated by flakes (blade to flake ratio = 2.15). Approximately half of the 25 cores are bipolar and the rest are uniplatform or broken ones. The ratio of cores to core trimming elements (CTE) is almost 1:4. Core preparation debitage (i.e., ridge-blades) dominates the latter while core rejuvenation elements (i.e., core-tablets) are scarce (ridge-blade to core-tablet ratio is ca. 3:1).

Altogether, 155 tools were studied (TABLE 2; FIGS. 11–13), of which over half were collected on the surface of the site (including structures). Overall, there is a conspicuous dominance of arrowheads (43), sickle blades (31), and bifaces (21). Spearheads (4), notched pieces and denticulates appear in low quantities; and scrapers and burins are almost absent, but there are some bifacially flaked knives and strangled (double-concave) blades.

Figure 9. Structure 11 (the well) in the process of excavation.

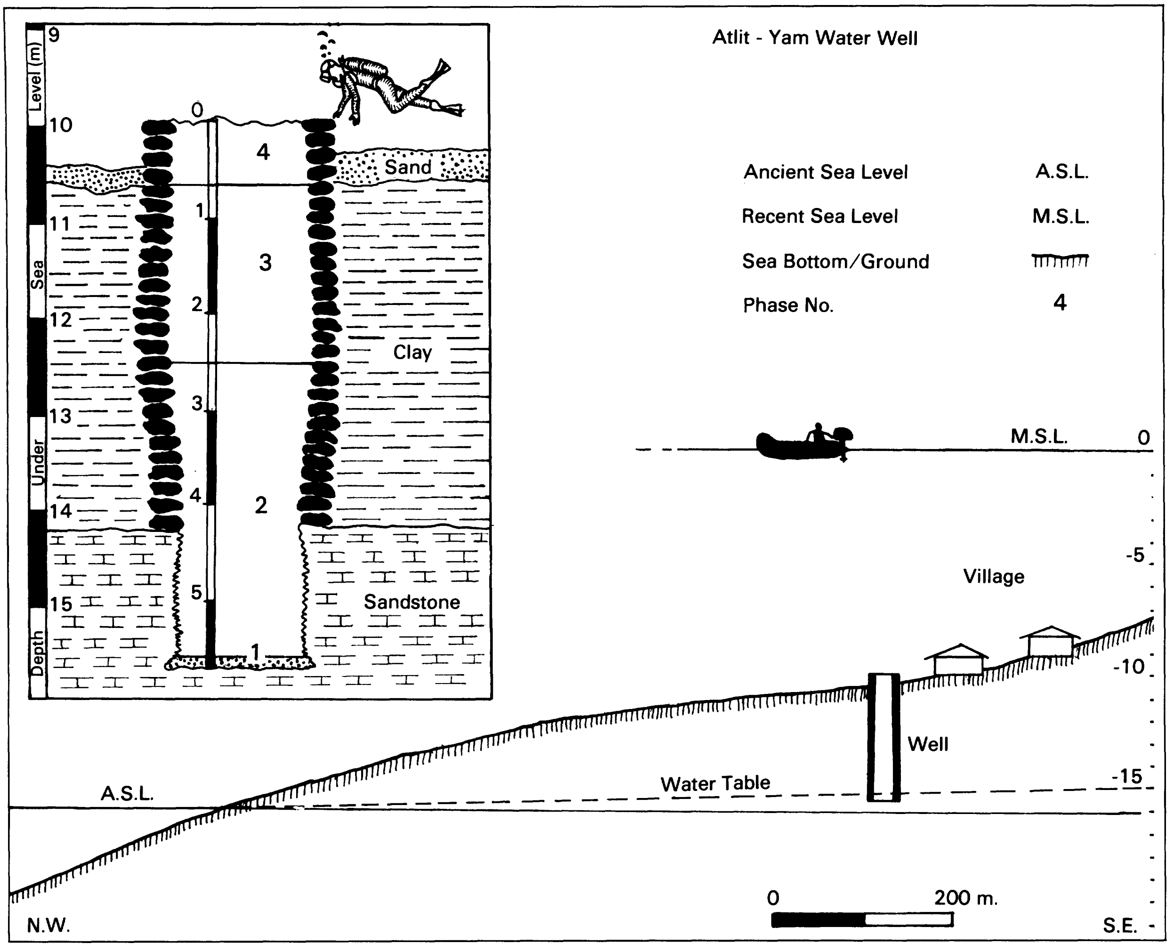


Figure 10. Cross section of the well (scale in meters).

Table 2. Distribution of flint artifacts.

Types	*Surface*	*Structure 11*	*Structure 35A*	*Total*
Spearheads in prep.	—	3	—	3
Spearhead	1	—	—	1
Arrowheads in prep.	3	1	9	13
Arrowheads	15	7	8	30
Sickle blades	12	10	9	31
Bifacial knives	4	1	—	5
Bifaces	17	3	1	21
Denticulates	2	2	—	4
Notched pieces	1	—	4	5
Strangled blades	3	—	—	3
Burins	—	1	2	3
Scraper	—	1	—	1
Retouched blades	7	4	5	16
Retouched flakes	2	—	1	3
Bifacial hammerstones	6	—	—	6
Other	7	3	—	10
Total	80	36	39	155

Byblos and Amuq-type points are dominant among the arrowheads and include subtypes characteristic of post-PPNB assemblages (Gopher 1985: 58–59) (FIG. 11). Absent are typical early PPNB types such as Helwan and Jericho points. The small arrowheads—Haparsa, Nizzanim, and Herzlia types—are present only as single specimens (FIG. 11: 9). This assemblage of projectile points is very thoroughly worked, with almost all the artifacts intensively pressure flaked.

Sickle blades are much alike and include no typical PPNB, finely-denticulated sickles. Most of the blades are deeply denticulated and exhibit flat bifacial retouch; some are truncated (FIG. 12: 1–5). Morphologically and technologically, they are similar to the Yarmukian sickle blade inventory (e.g., Stekelis 1972: 18–19). No "geometric" backed and truncated specimens typical of the 5th-millennium b.c. Wadi Raba assemblages are present (see Gopher 1989a: 122–124).

Bifaces are mostly trapezoidal, with wide working edges shaped by either flaking or polishing (FIG. 12: 7; FIG. 13). There are three almond-shaped axes, one having a transversal blow on the working edge.

Other tool types appear in small quantities; one comprises a few bifacially pressure-flaked knives, very similar in shape and workmanship to specimens described from Jericho Pottery Neolithic A (Crowfoot Payne 1983: 710–711) and Munhata 2B (Gopher 1989a: 122–124).

An early 6th millennium B.C. date for this assemblage is assumed based on the following characteristics: arrowheads are dominated by Amuq points and some Byblos points appear as well; late subtypes of both are present (FIG. 11). The low percentage of small arrowheads agrees with the suggested date. This assemblage, in fact, represents a stage previously lacking in the sequence as recorded at Shaar Hagolan, Munhata, and Byblos (Gopher 1989a: 122–124). The sickle blade morphology also fits the proposed date, and bifacial knives likewise confirm a post-PPNB horizon, further reinforcing an early 6th millennium B.C. date, as does the continued appearance of a relatively high percentage of bipolar cores.

Since no Yarmukian or other pottery is present at Atlit-Yam, a PPN designation is appropriate. It should be mentioned that in a series of later 6th–5th millennia submerged sites in the same area, pottery has been found in abundance (Galili and Weinstein-Evron 1985; Galili, Weinstein-Evron, and Ronen 1988). A Pre-Yarmukian date was suggested, considering the lithics, and reinforced by a series of five radiocarbon dates on charcoal and seeds: four falling between 6050–5600 b.c. (uncalibrated) and one a little earlier (6140 b.c.) (TABLE 1).

Since we have very few radiocarbon dates for early pottery assemblages (e.g., Dunand 1973; Moore 1978, 1982), and the latest aceramic dates such as those from Tel Ramad are very late in the 7th and early 6th millennia (Contenson 1971), we feel confident about assigning an early 6th millennium B.C. date to our assemblage. Note should be taken, too, of the recently-excavated Ain Ghazal layer designated PPNC, which also presents a post-7th millennium aceramic assemblage (Rollefson 1986; Rollefson and Kohler-Rollefson 1989). Atlit-Yam may well represent an additional PPNC site.

Bone tools found at the site include spatula fragments (FIG. 14: 1), blade handles (FIG. 14: 2), fragmented points (FIG. 14: 3), a needle with a drilled eye (FIG. 14: 4) and awls (FIG. 14: 5). Stone utensils include bowls of various shapes (FIG. 15: 1). Some are complete, others merely fragments; among them are deep and flat bowls made of carefully-worked, hard limestone, and large, crudely worked bowls made of sandstone. Exceptional is a flat basalt bowl with a pedestal base that was found on the surface near structure 11. In addition there were a few grinding stones, a pebble with a groove (FIG. 15: 2) and stones with biconical holes (FIG. 15: 3). The latter may have served as sinkers for fishing nets.

Ornamental objects found at the site include two decorated bones with the engraved heads of unidentified animals (FIG. 14: 6); a small, flat, trapezoid-shaped stone plate adorned with four sets of parallel grooves (FIG. 16); a conical anvil stone with parallel grooves (FIGS. 17, 18: 7); broken stone figurines (FIG. 18: 1, 2); stone pebbles with incised grids of scratches; a figurine or a pendant (FIG 18: 3); a limestone phallus (FIG. 18: 4); a pebble with a possible vulva on it (FIG. 18: 5); broken stone bracelets (FIG. 18: 6); and a bone decorated with a set of incised parallel lines (FIG. 14: 7).

Human Remains

Fifteen human skeletons have been discovered at the site, providing insight into some aspects of life in a Neolithic coastal village. The burials are located close to or within dwellings; the latter type of burial was common regionally during the PPN period (Hershkovitz and Gopher 1988, 1990) and suggests a ritual related to ancestor worship (Arensburg and Hershkovitz 1988; Yakar and Hershkovitz 1988). Most of the skeletons were found in single graves with the skulls intact. In one case, however, a burial of an adult and child was situated near the dwellings. Some of the skeletons were in primary burials, always in a flexed position (FIG. 19); others comprised concentrations of disarticulated bones, probably representing secondary burials (in this category we also include isolated skulls). Also found were abraded bones that must have

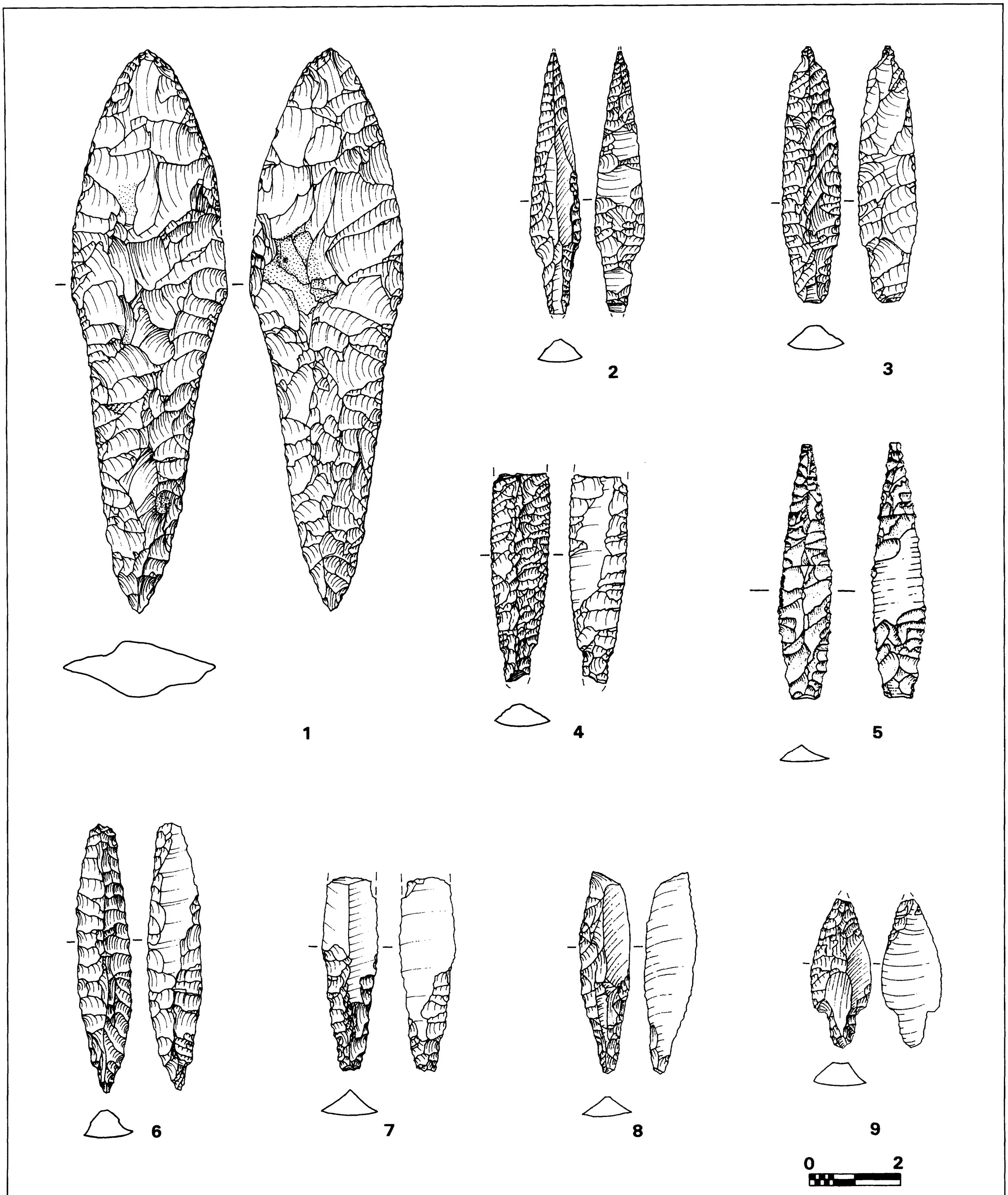


Figure 11. Flint tools: 1) spearhead; 2–9) arrowheads (scale in cm).

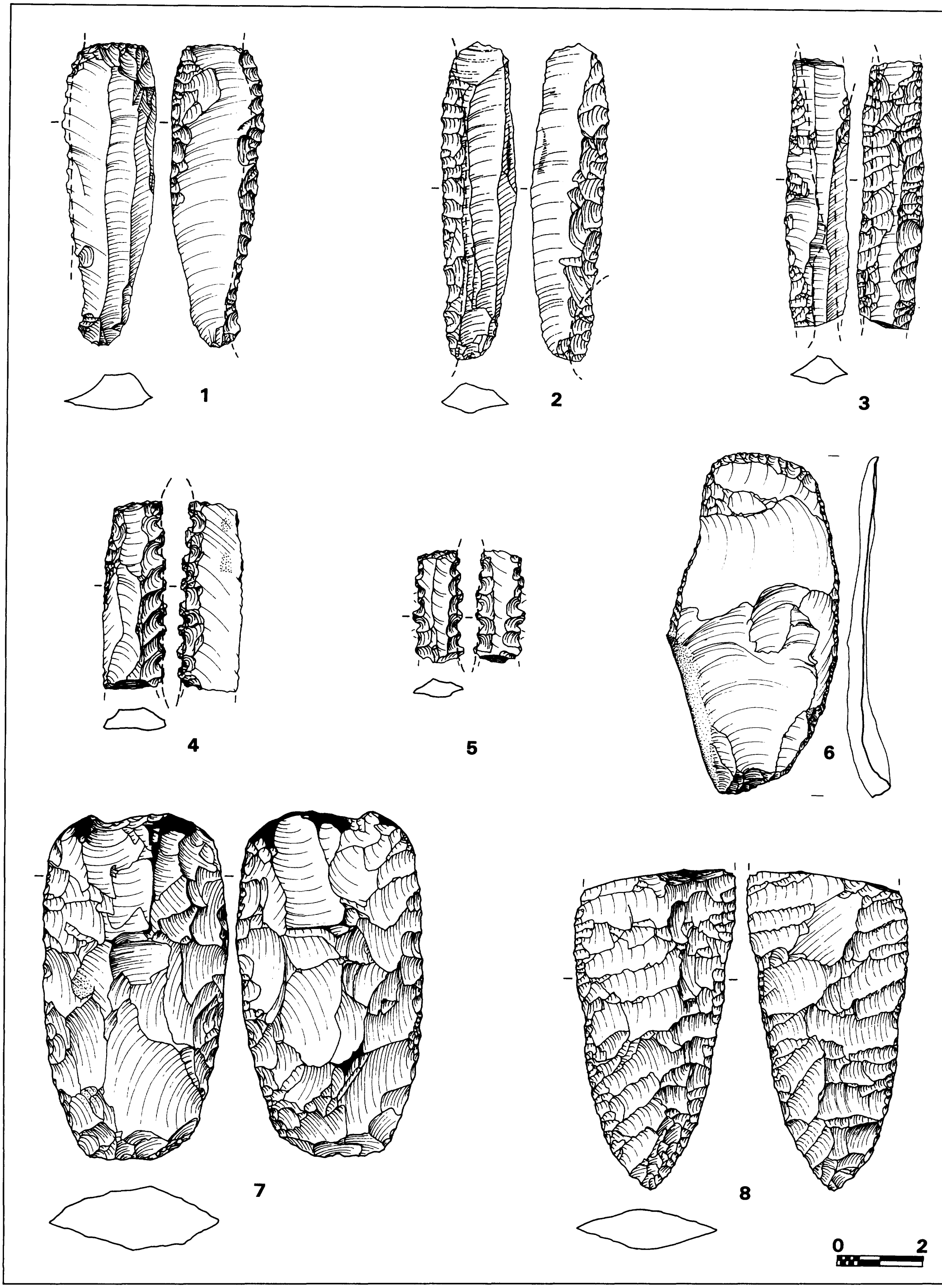


Figure 12. Flint tools: 1–5) sickle blades; 6) end scraper; 7) axe; 8) bifacial knife (scale in cm). (No. 7 is polished.)

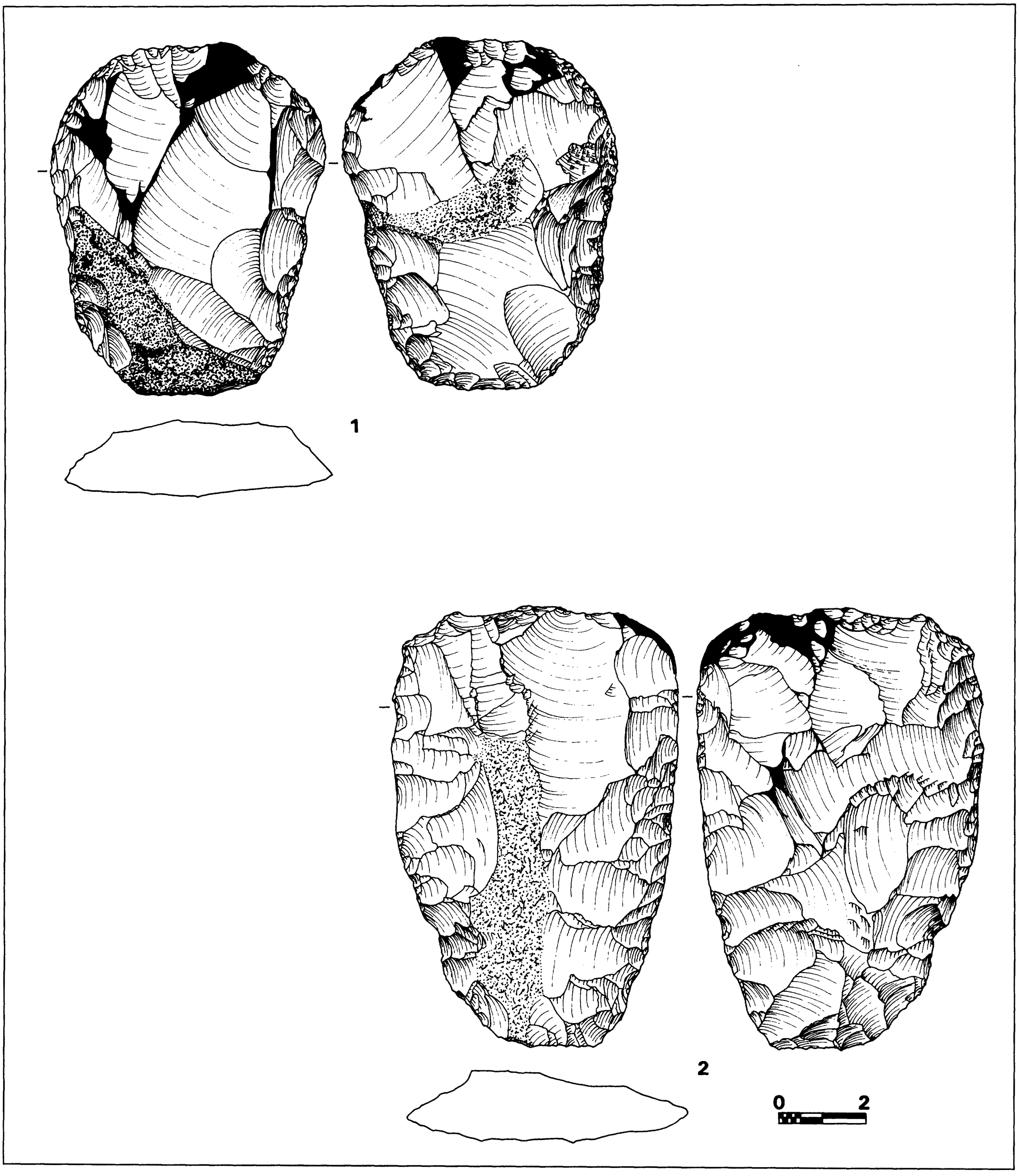


Figure 13. Flint tools: bifaces (scale in cm). (Nos. 1, 2 are polished.)

been removed from their original burial place by sea storms. The skeletons were in varying states of preservation from almost complete and intact to only a few bone fragments (Hershkovitz and Galili 1990: 321).

The sample consisted of two children under the age of 15 years, a youth in the 14 to 20-year age group, four individuals between 20 and 30 years of age, and four of indeterminate age. This age-at-death distribution, how-

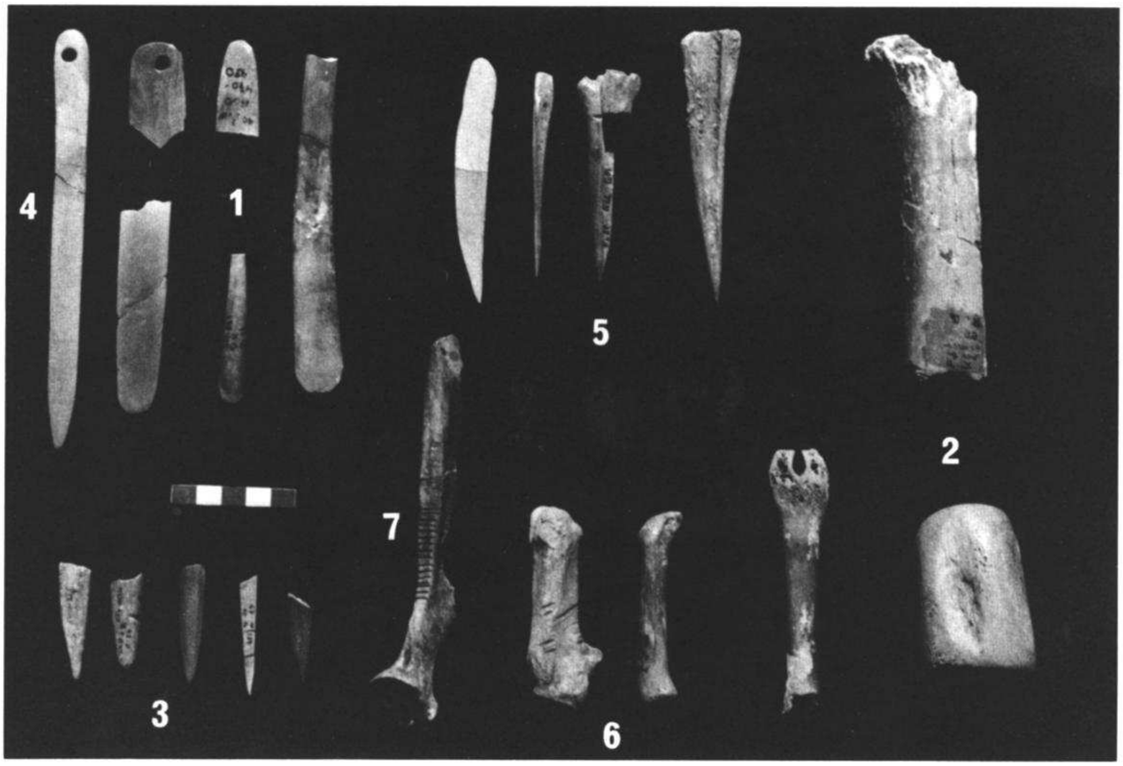
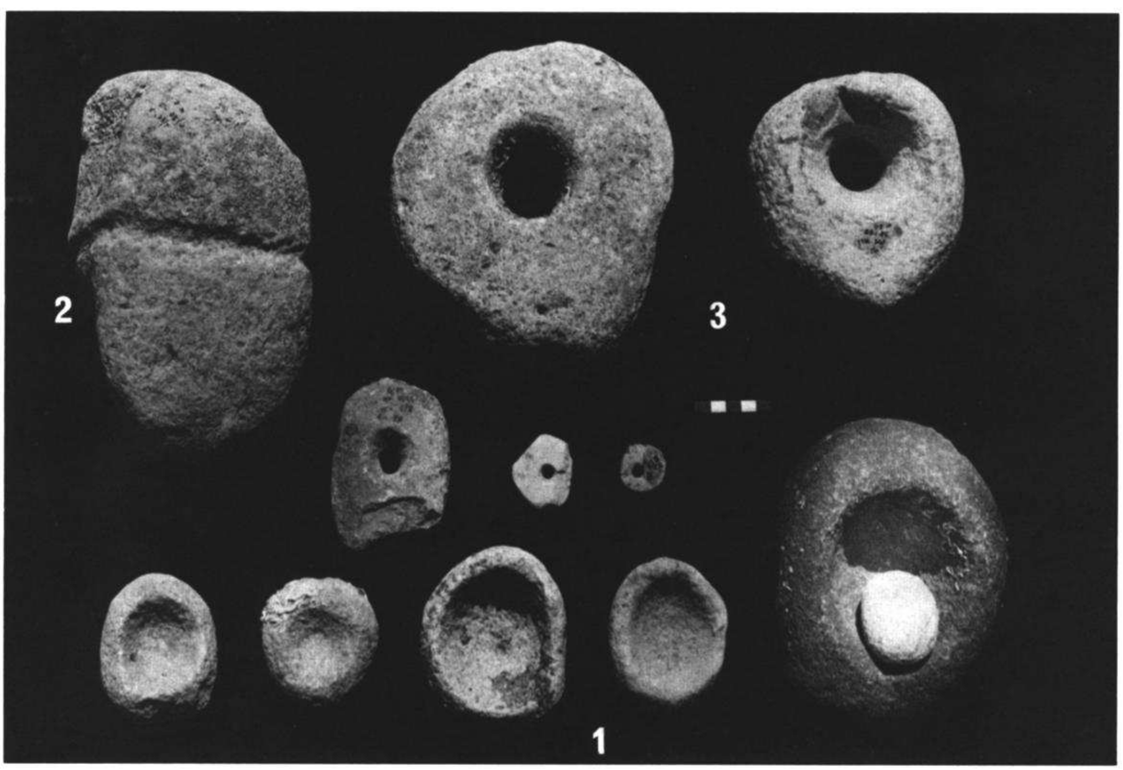


Figure 14. Bone tools found in the Atlit-Yam Site. 1) spatula; 2) blade handles; 3) points; 4) needle with drilled eye; 5) awl; 6) sculptured animal heads (scale in cm).

Figure 15. Various stone utensils found in the Atlit-Yam site (scale in cm).



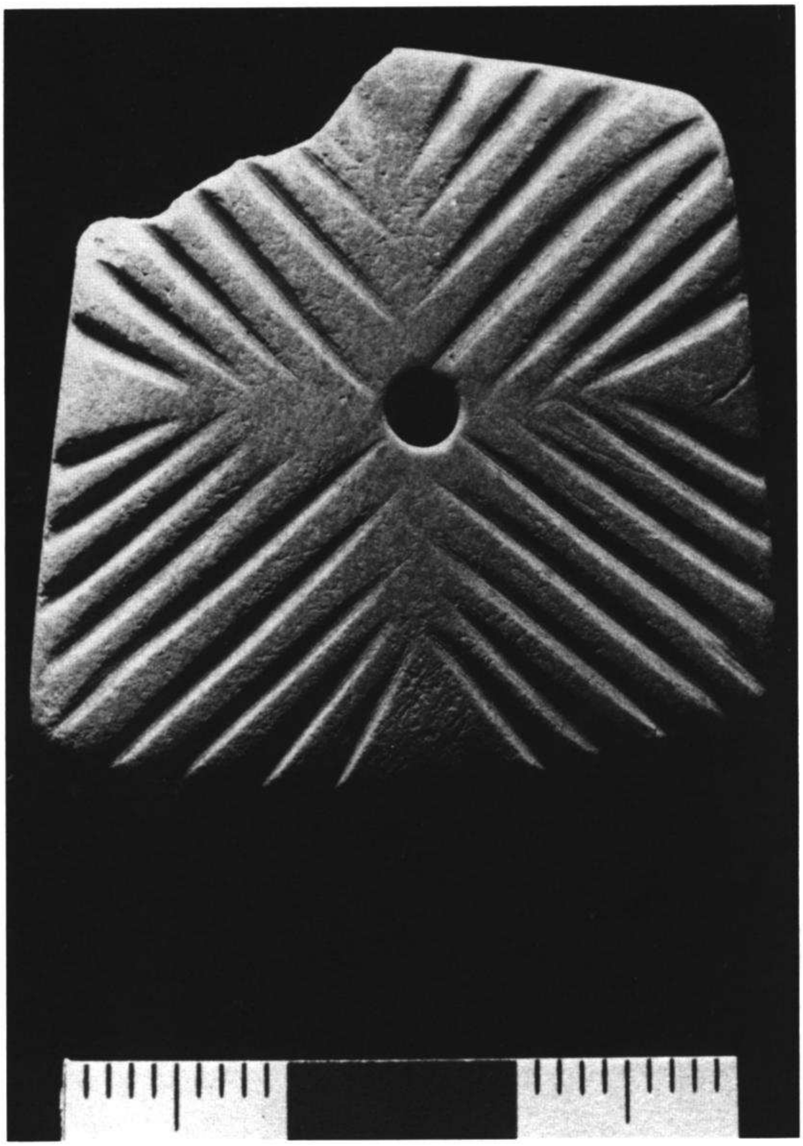


Figure 16. Decorated flat stone (button?) (scale in cm).

ever, is almost certainly not truly representative of the Atlit-Yam population demography; the proportion of children is far too small, possibly because the bones of very young individuals are more fragile, and thus more prone to dispersal by sea currents.

Health, as manifested by the skeletal remains, was quite poor in the village. All individuals show various degrees of dental hypoplasia. One case of spondylolysis was recorded as well as one of a wedged vertebra. Severe dental attrition, probably caused by the processing of ropes or leather straps or ingestion of stone ground food, is also evident. In general, the Atlit-Yam population is characterized by short stature (one female with an estimated stature of 144 cm and two males of 163 cm and 165 cm) and by marked sexual dimorphism, as seen in the extreme gracility of the females and relative robustness of the males.

Faunal Remains

At present we have an assemblage of some 322 identifiable bones from the site, and an additional 177 unidentifiable bone fragments. Species frequencies calculated on the basis of bone counts show the faunal assemblage to be dominated by goat (*Capra* sp., 45%), followed closely by cattle (*Bos* sp., 43%), and pigs (*Sus scrofa,* 9%). Scanty remains of mountain gazelle (*Gazella gazella,* 3%) and deer (0.3%; probably fallow deer, *Dama mesopotamica*) were also identified. No remains of sheep have been iden-

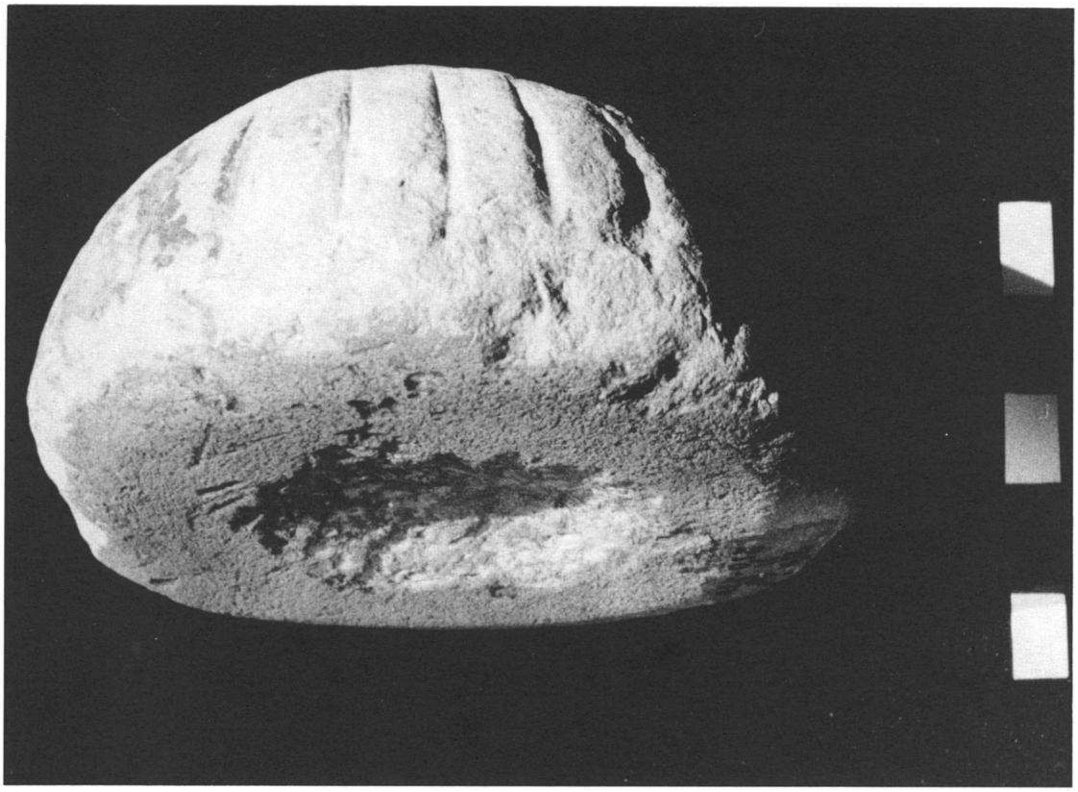


Figure 17. Decorated anvil stone (scale in cm).

Figure 18. Ornamental objects: 1–2) stone figurines; 3) a figurine or pendant; 4) stone phallus; 5) a pebble with a possible vulva on it; 6) broken bracelets; 7) anvil stone (scale in cm).

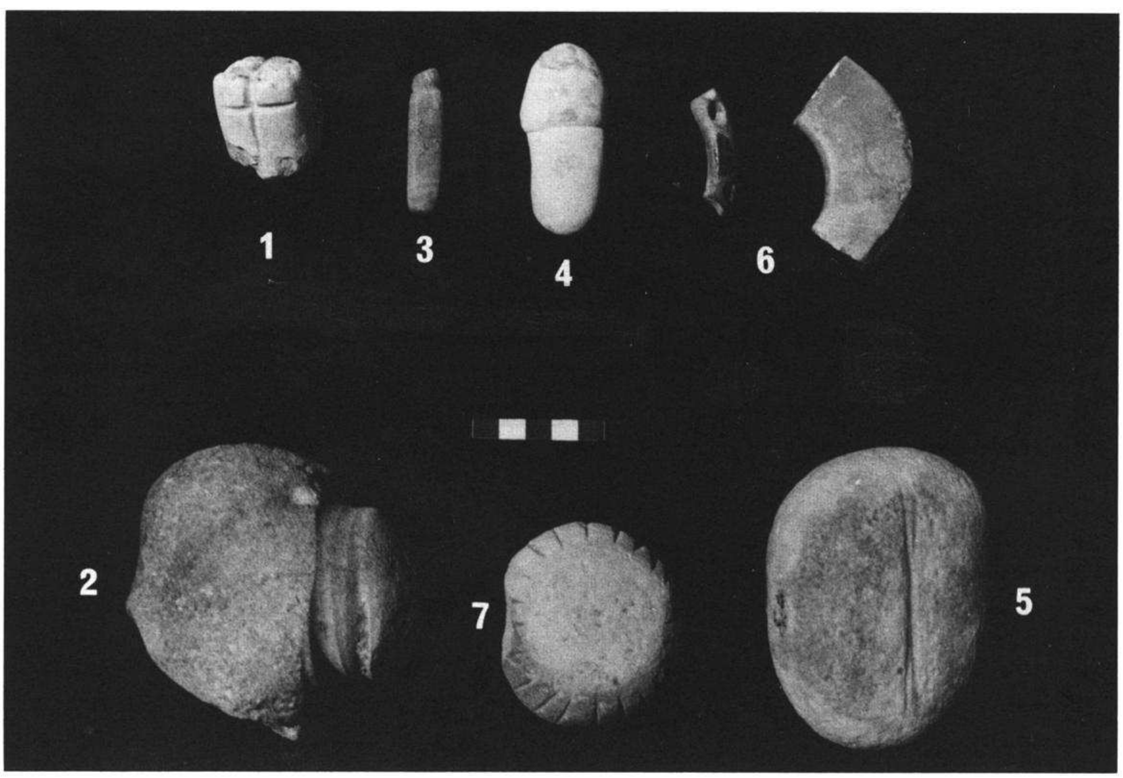


Figure 19. Flexed burial of adult male.

tified thus far. Almost 55% of the total animal bones were recovered from structure 9 and its immediate surroundings. Bone preservation from the site is exceptional, as evidenced by the finds of three complete goat horncores and two well-preserved cattle horncores.

On the basis of the morphological and metrical evidence, the goat and cattle remains recovered from the first two seasons' excavations were identified as representing remains of wild goat (*Capra aegagrus*) and wild cattle (aurochs: *Bos primigenius*) (Horwitz and Tchernov 1987). Horncores of goat and cattle from the 1987 season have proved identical in shape, size, and morphology to those found in the previous seasons, suggesting that we are indeed dealing with the remains of wild, not domestic, animals. The goat horncores all exhibit morphological characteristics typical of *Capra aegagrus:* a backward curvature, oval cross-section, and anterior keel. We therefore feel confident that our previous identification of the goats from Atlit-Yam as morphologically wild is correct. The cattle horncores are less well preserved than those of the goats, but overall are large and robust. Although they are larger than those of early domesticated cattle from Israel, their status as domestic or wild varieties will have to await the results of detailed metrical analysis.

As the majority of the pig bones are those of immature individuals, it has been difficult to establish whether they represent remains of wild or domestic species. The few adult bones that have been measured to date suggest that they are remains of wild boar and not of domesticated pig. As in recent times, however, it is probable that wild and domestic pigs co-existed, a factor that complicates interpretation of the faunal record.

The cattle assemblage is dominated by adult animals, while there is a relatively high frequency of immature goats and pigs represented by unfused long bones. The frequencies of immature (unfused) long bones are: 15.8% of 38 cattle bones; 38.8% of 31 goat bones: and 69.5% of 23 pig bones. There is a high frequency of cattle and goat vertebrae with unfused epiphyses, but these together may represent only one or two animals respectively. Preliminary observations on bones excavated during the 1988–1989 seasons in structure 11 reveal an even higher percentage of immature bones, mainly of goats and pigs. Although it has been claimed that high frequencies of juvenile animals are characteristic of domestic herd manipulation, other factors such as seasonality and selective hunting strategies may also explain this (Horwitz 1987, 1989: 169–170). Goat and cattle are represented by a high frequency of body elements (ribs and vertebrae) relative to limb bones, probably the result of butchery practices and indicative of on-site carcass dismemberment. Further evidence of butchery is found in cut marks present on more than 35% of the bones (FIG. 20). Most of these marks take the form of deep parallel incisions at points of muscle attachment, probably made while dismembering the carcass, though some are more superficial and probably indicate filleting of meat.

Some 228 fish bones from three different structures could be identified. Most of them (196) were excavated 3 m north of a submerged stone wall identified as feature 10 (FIG. 5). Thirty bones were found in structure 20 and two in structure 13. These belong to two species of fish. Two hundred ten bones (including all 32 bones from structures 20 and 13, and 178 bones from structure 10), representing 92% of the total fish bones, belonged to *Balistes carolinensis,* or gray triggerfish (MNI = 9). These included 19 different skeletal elements. Eighteen additional bones from structure 10, including 14 different skeletal elements, belonged to *Epinephelus aeneus*. Al-

Table 3. Pollen spectra from Atlit-Yam: A) fossil pollen; B) recent pollen.

	A. Sample depth (cm)									*B. Water depth (m)*	
Pollen type	*5*	*20*	*30*	*35*	*40*	*50*	*60*	*70*	*80*	*11*	*12*
Quercus calliprinos	4	2	—	5	1	2	2	1	1	22	96
Pinus	1	3	1	2	—	—	2	—	—	31	58
Olea europaea	—	—	—	1	—	1	—	—	—	—	11
Pistacia	—	1	—	—	—	—	—	1	—	—	11
Rhamnus	—	—	—	—	—	—	1	—	—	2	8
Rhus	—	—	—	—	—	—	—	—	—	—	3
Tamarix	—	—	—	—	—	—	—	—	—	—	3
Arbutus andrachne	3	—	—	—	—	—	—	—	—	1	—
Rosaceae	—	—	—	—	—	—	—	—	—	1	11
Total AP	8	6	1	8	1	3	5	2	1	57	201
Gramineae	—	2	1	—	1	—	—	—	—	22	59
Tubuliflorae Compositae	—	1	3	—	—	—	—	—	—	—	8
Centaurea	—	—	1	—	—	—	—	—	—	—	2
Artemisia monosperma	—	—	—	—	—	—	—	—	—	4	19
Chenopodiaceae	1	1	1	1	—	1	6	1	2	10	49
Umbelliferae	3	37	14	5	1	—	4	2	2	5	20
Plantago	—	—	—	—	—	—	—	—	—	7	32
Plumbaginaceae	—	—	—	—	—	—	—	—	—	—	3
Ephedra	—	—	—	1	1	—	—	—	—	3	4
Malvaceae	1	—	5	—	—	—	—	—	—	—	—
Polygonaceae	—	—	—	—	—	—	1	—	—	2	17
Primulaceae	—	—	—	1	—	—	—	—	—	—	2
Cruciferae	—	2	—	—	1	—	—	—	1	2	8
Dipsaceae	2	—	2	—	—	—	—	—	1	6	17
Liliaceae	—	—	—	1	—	—	—	—	—	2	1
Papilionaceae	—	—	1	1	—	—	—	—	—	1	8
Labiatae	5	—	1	1	—	—	1	1	—	20	54
Caryophyllaceae	—	—	—	—	—	—	—	—	—	—	8
Ranunculaceae	—	—	—	—	—	—	—	—	—	—	8
Boraginaceae	5	—	—	—	—	—	—	—	—	2	4
Iridaceae	—	—	—	—	—	—	—	—	—	1	1
Cucurbitaceae	—	—	—	—	—	—	—	—	—	—	1
Sarcopoterium spinosum	—	—	—	—	—	—	—	—	—	7	34
Euphorbia	—	—	—	—	—	—	—	—	—	—	3
Myrtaceae	1	—	—	—	—	—	—	—	—	—	—
Total NAP	18	43	29	11	4	1	12	4	6	94	362
Total counted	26	49	30	19	6	4	17	6	7	151	563
Sparganium	1	12	1	1	—	1	—	—	—	3	8
Cyperaceae	—	—	1	—	—	—	—	—	—	2	10
Total hydrophylous pollen	1	12	2	1	—	1	—	—	—	5	18
Polypodiaceae	1	4	6	2	—	1	1	1	—	10	17

though the fish bones may have accumulated naturally (Ronen 1983), the excavated material provides a few clues to the contrary, since the bones were found embedded in the upper layer of a marshy clay deposit, characteristically of terrestrial, not of marine, origin. The same layer contained an accumulation of wheat grains and mammalian bones. Furthermore, the bones were found in context with three submerged structures, the foundations of which were set in the same clay deposit.

A striking feature of the fish remains in Atlit-Yam is the dominance of one species, *B. carolinensis*. It belongs to a highly specialized family, Balistidae, which is a predatory fish inhabiting sands and rocky bottoms of the sea, 10 to 100 m deep, and commonly attaining a size of 40 cm. It is found today throughout the Mediterranean, including the coast of Israel (UNESCO 1986; Ben Tuvia 1971). The significance of this finding with respect to either the prevalence of this species or fishing specialization is open to speculation; fish bones from this site as well as other neighboring Neolithic sites may shed more light on these points.

Botanical Remains

A hoard of charred wheat in a good state of preservation and comprising ca. 26,000 grains was found near structure 10. This is by far the largest cereal grain sample reported

Table 4. Pollen spectra percentages.

Pollen type	*Fossil, combined*	*Recent (m depth)*	
		11	*12*
Quercus calliprinos	10.98	14.57	17.05
Pinus	5.49	20.53	10.30
Olea europaea	1.22	—	1.95
Pistacia	1.83	—	1.95
Rhamnus	0.61	1.32	1.42
Rhus	—	—	0.53
Tamarix	—	—	0.53
Arbutus andrachne	1.83	0.66	—
Rosaceae	—	0.66	1.95
Total AP	36	37.75	35.70
Gramineae	2.44	14.57	10.48
Tubuliflorae Compositae	2.44	—	1.42
Centaurea	0.61	—	0.36
Artemisia monosperma	—	2.65	3.37
Chenopodiaceae	8.54	6.62	8.70
Umbelliferae	41.46	3.31	3.55
Plantago	—	4.64	5.68
Plumbaginaceae	—	—	0.53
Ephedra	1.22	1.99	0.71
Malvaceae	3.66	—	—
Polygonaceae	0.61	1.32	3.02
Cistaceae	—	—	—
Primulaceae	0.61	—	0.36
Cruciferae	2.44	1.32	1.42
Dipsaceae	3.05	3.97	3.02
Liliaceae	0.61	1.32	0.18
Papilionaceae	1.22	0.66	1.42
Labiatae	5.49	13.25	9.59
Caryophyllaceae	—	—	1.42
Ranunculaceae	—	—	1.42
Boragniaceae	3.05	1.32	0.71
Iridaceae	—	0.66	0.18
Cucurbitaceae	—	—	0.18
Sarcopoterium spinosum	—	4.64	6.04
Euphorbia	—	—	0.53
Myrtaceae	0.61	—	—
Total NAP	128	62.25	64.30
Total counted	164	151	563

from any Aceramic Neolithic site in the Near East (Kislev in press). The grains belong to two species, mainly to primitive, hulled emmer wheat (*Triticum dicoccon*) which was the principal wheat species in the Near East in this period. A smaller portion is attributed to naked wheat, *T. parvicoccum,* now extinct. This species is thought to be a direct descendant of emmer wheat (Kislev 1980).

Morphological distinction, by grain characteristics, between wild (*T. dicoccoides*) and domesticated (*T. dicoccon*) wheat is as yet impossible. There is, however, indirect evidence that hulled wheat was cultivated, if only in terms of its quantity. We know that domesticated and wild species of wheat grew in association with the rushes *Carex extensa, Cyperus laevigatus, C. rotundus,* and *Scirpuus maritimus.* All are plants that grow in marshy, somewhat saline soils. Therefore, it is suggested that the wheat fields of Atlit-Yam bordered one of the marshes in the neighborhood of the site. A rather similar habitat is described at early Neolithic Aswad near Damascus (Zeist and Bakker-Heeres 1985: 239).

Apparently, wheat grains took the place of acorns as the primary carbohydrate constituent of the diet of early agricultural societies in the Near East. This development was especially important in shoreline settlements where fish and other sea animals contributed heavily to the diet.

Pollen analyses were performed on two sets of samples. The first set was taken from the marshy clay, in an 80 cm-deep section, excavated in structure 9 (FIG. 4). The second set consists of two samples collected from a large patch of recently-deposited soft clay from the NW part of the site (Weinstein-Evron and Galili 1987) (TABLES 3, 4). This sediment overlies the ancient marshy clay, ca. 300 m west of the mouth of the Oren River at a water depth of 11–12 m.

Fossil pollen are, for unknown reasons, rather scarce, especially in the lower samples. Because of the strong similarities between the samples they are combined for purposes of discussion. The spectra are characterized by a limited variety of pollen types, relatively low arboreal pol-

Figure 20. Example of cut marks found on more than 30% of the animal bones.

len (AP) levels (especially *Quercus calliprinos*), and high Umbelliferae levels. Other types include Chenopodiacae and Labiatae, with *Sparganium* as the most frequent hydrophylous pollen. The uniformity of the pollen spectra throughout the column and their resemblance to others from similar marshy clays (Galili and Weinstein-Evron 1985) suggest that these pollen grains represent the paleoenvironment of the marshy clay itself, and not of the site within it.

The recent pollen spectra are much more varied. The AP levels are relatively high, with mainly *Quercus calliprinos* and *Pinus halepensis* (which is today mostly artificially planted in the area); *Olea europaea* and *Pistacia* are also relatively frequent. The main components within the nonarboreal pollen (NAP) are Gramineae, Chenopodiaceae, Umbelliferae, *Plantago,* Dipsaceae, Labiatae, *Sarcopoterium spinosum,* and *Artemisia monosperma.*

Unlike the fossil spectra, which probably represent chiefly local vegetation, the composition of pollen spectra from the recent submerged clay suggests that these were mostly transported from Mt. Carmel by present-day streams. The coastal environment is also represented, however, by the relatively high counts of Chenopodiaceae and especially *Artemisia monosperma.*

The wood charcoals found in the hearths indicate that the Atlit-Yam inhabitants used *Quercus calliprinos* and *Pistacia palaestina* as firewood (Lipschitz 1986). A preliminary analysis of wood remains revealed waterlogged wood fragments of olive (*Olea europaea*), carob (*Ceratonia siliqua*), oak (*Quercus calliprinos*), aphylla (*Tamarix aphylla*), *Pistacia palaestina,* and date (*Phoenix dactylifera*) (identified by N. Lipschitz) as well as carbonized and waterlogged seeds of fig (*Ficus carica*), grape vine (*Vitis vinifera*), carob (*Ceratonia siliqua*), *Styrax officinalis,* almond (*Amyodalus communis*), and lentil (*Lens orientalis, L. ervoides,* or *L. esculenta*).

Discussion and Conclusions

The Atlit-Yam village was situated in a very favorable location with a number of vital resources in its vicinity. The peninsula protected the village from SW storms. The sea nearby provided a suitable environment for fishing. Wheat could be grown on the fertile, drained swamp ground, and the kurkar ridge east of the village was probably covered by vegetation, with suitable pasturage for domesticated as well as wild animals.

The Oren River, which still runs nearby, could have supplied fresh water, but only during seasonal floods. Several fresh water springs, however, were discovered on the sea floor off the Carmel coast in the course of recent surveys, some of which are located very close to or within the Atlit-Yam site (Galili 1985: 46; Galili and Inbar 1987: 5, 7). In the Dor region (some 20 km south of Atlit) a fresh-water well, located on the shoreline, was still in use at the beginning of this century (Wachsman and Raveh 1984). The fossil clays that fill the troughs between the kurkar ridges of the Carmel coast enabled fresh water from the coastal aquifer to escape upward. The ancient population probably was aware of this phenomenon and used the springs, although dry-season conditions in antiquity may have required excavation to reach subterranean water tables. Structure 11 is a possible example of an early well, as indicated by its depth and standard of masonry, and seems to have been subsequently used as a garbage pit (Galili and Nir 1991). It is very possible that the encroachment of the sea caused salinization of the water and a change in the function of this structure.

An interesting question is whether Atlit-Yam was a true maritime community or merely a group of farmers and/or hunter-gatherers situated near the sea. We believe that the circumstantial evidence favors the former. Inspection of bathymetric maps of the Carmel coastal region (FIG. 6) reveals a submerged kurkar ridge 1.5 km offshore. The ridge is a few kilometers in length and runs parallel to the present coastline, its peaks extending to about 6 m below present sea level. The sea floor from the coast to the ridge is trough-shaped, with a maximum depth of 18 m. Since the sea level at the end of the PPNB period had already risen to about 16 m below the present level (Fairbridge 1961: 317; Galili, Weinstein-Evron, and Ronen 1988), a large shallow lagoon, several kilometers in length, was apparently created between the ridge and the shoreline. The lagoon, open at its southern edge, was isolated from the open sea by a long tongue of land (today the submerged kurkar ridge) (FIG. 6). This shelter and location could have provided a suitable environment for a maritime community.

The fish bones indicate that some of the Atlit-Yam inhabitants were fishers. Since triggerfish are not found close to the shore, they could only have been caught using an offshore fishing technology. The many perforated stones found in the site may well have served as sinkers for fishnets, and some of the bone points may have been used in spearfishing. Seeds of *Styrax officinalis,* a tree found today in the Mt. Carmel area and western Galilee, are sometimes used for poisoning fish (Zohary 1960: 376). The presence of these seeds in structure 11 suggests that such fishing methods may have been used in shallow lagoon waters.

Evidence of maritime pursuits may also be found in the human skeletons: auditory exostosis in the temporal bones suggests that some of the Atlit-Yam inhabitants spent considerable time in cold water (Hershkovitz and Galili 1990: 344, 350, 351). Economic incentives must have required immersion in cold water in the winter, and we can assume that free diving may have been a fishing method. The artificial dental attrition may be the result of continuous friction of ropes or thin leather straps pulled between the teeth, perhaps to fashion them for use in fishing nets. Signs of elbow abrasion and specific types of muscle markings, typical of rowers, suggest that boats were used in fishing (Hershkovitz and Galili 1990: 354–356). It may well be that the Atlit-Yam people could navigate in the open sea, and hence study of this group may contribute to the question of colonization of the large Mediterranean islands.

It seems then, that the sea played a role in the economy of the Atlit-Yam people. This is the most extensive evidence of a community known from the PPN period in the Levant, and one whose economic strategy also included exploitation of the sea and was probably among the first to develop a technology for this purpose. What remains unclear is whether the dominance of triggerfish was a result of availability or of preference.

In addition to their fishing activities, the Atlit-Yam villagers engaged in intensive hunting, and probably practiced some form of incipient domestication, a phase preceding full domestication with selective breeding. Incipient domestication is characterized by the isolation and maintenance of a sector of a wild herd separate from other wild animals, though without direct interference in breeding patterns by humans (Horwitz 1989). Because of changes in habitat and selective pressures, one may expect the isolated animals to exhibit a wider range of variation in morphological and metrical characteristics than that present in either a wild or domestic herd undergoing selective breeding. Indeed, the preliminary findings from the Atlit-Yam assemblage indicate a wide size range in both goat and cattle bones.

Pending the results of a detailed metrical analysis, the morphological evidence suggests that the goat and cattle remains at the site are those of wild species. These conclusions, however, should be viewed with caution because of the relatively small samples studied thus far, and the difficulties of discriminating between wild and domestic animals. Recent data from PPNB sites in the southern Levant indicate a broad range of subsistence strategies: from sites with domestic animals (or "incipient" domestication) such as Jericho (Clutton-Brock 1979), Beisamoun (Davis 1978), Abu Gosh (Ducos 1978), Basta, and 'Ain Ghazal (Kohler-Rollefson, Gillespie, and Metzger 1988) to others based on hunting such as Yiftahel (Horwitz 1987), Horvat Galil, Nahal Betzet (Gopher 1989b), and several sites in Eastern Jordan (Garrard et al. 1987). At some of these "hunting" sites there is evidence for intensive cereal and legume exploitation and cultivation, but the presence of these domestic plant resources does not necessarily imply a herding economy. The Atlit-Yam assemblage may well fall into this category. The PPNB layer of the Nahal Oren site, only 4 km east of Atlit-Yam on the slopes of Mount Carmel (FIG. 1), exhibits a completely different faunal picture, where the major animal remains were gazelle (76.4% vs. 3% at Atlit-Yam), goat (13.9% vs. 45%), pigs (4.6% vs. 9%), cattle (2.4% vs. 43%), and fallow deer (1.0% vs. 0.3%) (Noy, Legge, and Higgs 1973). The low frequencies of gazelle and deer at Atlit-Yam can be explained by the tendency of these animals to avoid swamps and dunes. Cattle, although not swamp dwellers, have in some instances adapted to such conditions under human guidance (Vita-Finzi and Higgs 1970). The high frequency of goat bones at Atlit-Yam, however, is hard to explain considering the environmental setting outlined above. This fact, together with the high percentages of immature bones of pigs and goats in the site, may indicate that these animals were under some degree of human control. The coexistence of hunting and sedentary groups in close proximity to each other, and even in the same site, is a characteristic of the PPN period in the southern Levant, reflecting variations in local adaptation to the environment.

All previous evidence for PPNB wheat cultivation comes from inland sites (e.g., Jericho, 'Ain Ghazal). Atlit-Yam is the first site to supply substantial evidence for wheat cultivation by coastal inhabitants of the southern Levant. The general size of the *T. parvicoccum* grains is attributed to their presumed domesticated state. The earliest record of *T. parvicoccum* comes from several sites in Syria and southern Turkey dated to the 7th millennium B.C. If our identification is correct, this is the earliest find of this species in Israel. It may also be that the plump grains, though not characteristic, actually belong to emmer wheat. It is suggested that the wheat types, either as separate crops or mixed ones, were cultivated in wet alluvial soils on the banks of the Oren River or on low ground with a high water table.

The Atlit-Yam pollen studied so far most likely represents the paleoenvironment of the underlying marshy clay and not of the site itself. This is probably the reason that no palynological indications of cereal cultivation have yet been recorded. Pollen analysis of features such as pits, which were probably used during the time of occupation, may provide data concerning this issue (Weinstein-Evron in press).

The Atlit-Yam olive remains call for a special discussion. Sections of branches and pollen grains of olive trees found at Atlit-Yam indicate that the plant likely grew in the vicinity of the site during its occupation, but in spite of the great masses of other plant material recovered, including grains, fruits, and seeds, no olive pits have been found at the site to date. In contrast, hundreds of olive pits have been found in every submerged Pottery Neolithic site off the Carmel coast (Galili and Weinstein-Evron 1985; Galili 1985: 68). Thus it seems that a massive exploitation of olive fruit started at some point between the early and late 6th millennium B.C. This may represent evidence for domestication of olives (Galili, Weinstein-Evron, and Zohary 1989) at least 1000 years earlier than at Chalcolithic Tuleillat al Ghassul (Zohary and Hopf 1988: 131–136).

Undoubtedly, the Atlit-Yam people were successful hunters and fishermen. Why, then, was it apparently important for them to grow wheat, when this entailed additional work for the community? The answer may be that in the long term, humans cannot depend solely on unstable food resources such as hunting or fishing. Storing grains (cultivated or wild) was the insurance of the family against starvation. In addition, in the short-term, there are severe limitations on the amount of protein-rich foods that can safely be consumed (Noli and Avery 1988). We cannot yet estimate the relative proportions of marine-based and terrestrial-based protein consumed by the Atlit-Yam inhabitants. In studies of present-day coastal tribal communities (e.g., Australian Aborigines), however, it was found that the marine/terrestrial protein ratio was about 1:1, and that plant foods were an important food supplement, in spite of the abundance of alternative protein sources (Hobson and Collier 1984).

The dwellings in Atlit-Yam, as in Beisamoun and Yiftahel, are scattered over a large area, with many stone structures and linear walls between them. The rectangular shape of the dwellings is typical of the PPNB period. The straight stone walls may have served as animal pens or as partitions between cultivated fields, or perhaps as part of a drainage system. The plastered floors so common in PPNB sites are completely absent. It may well be that in clayey, compact ground, which hardens easily, plastering was superfluous. Cooking in the PPN Atlit-Yam village may have included boiling in stone bowls using heated stones ("potboilers"), and grilling directly on a fire or hot stones. None of the limestone bowls found in the site showed signs of burning, whereas a large number of the pebbles found at the site, especially in the well, were cracked and fractured in a pattern typically resulting from heating.

From all of the above, we may generally conclude that the subsistence base of the Atlit-Yam people was complex and included farming; possibly some level of incipient herding; and hunting, fishing, and gathering. These probably enabled year-round occupation and optimal use of local resources. Concentrations of specific finds (fish bones, wheat, and flint artifacts) may reflect different activity areas in the site. The possible reasons for the abandonment of the site could have been the continuous changes in sea level and shorelines, the resultant contamination of fresh water wells with salt water, and perhaps the coverage of the site by advancing sand dunes prior to its flooding by the sea. The excellent state of preservation of the finds confirms that the sand cover preceded the flooding, for direct contact between the waves and the site remains would have resulted in total abrasion.

The site appears at present to be a one-phase settlement and lacks many of the structural characteristics of inland, multiphase PPN sites in Israel. It may represent a short period of exploitation of dried-up swamps before the encroachment of the sea. This suggests that the rise in sea level could have played a role in the abandonment of the settlement.

Submerged ceramic Neolithic settlements are located only 10–100 m offshore at a depth of 1–6 meters (Galili, Kaufman, and Weinstein-Evron 1988); by the ceramic Neolithic period (ca. 7000 B.P.) the lagoon had already disappeared, and so only a few islands remained of the land tongue that once separated the lagoon from the sea. To conclude, we would like to recall a prediction made by Vita-Finzi and Higgs (1970) in their study of the prehistoric economy in the Mount Carmel area that evidence for marine pursuits will come only from sites now beneath the sea.

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