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8000 year-old human remains on the sea floor near Atlit, Israel

Our knowledge of prehistoric fishermen in the Eastern Mediterranean area is very scanty since most of the ancient coastal settlements are today inundated by the sea. The present paper describes and analyzes the human remains revealed and excavated in the 8,000 year-old submerged site at Atlit-Yam, Israel. The skeletal material indicates extensivce marine activities among the inhabitants of the village, including deep sea fishing, diving and fishnet production. The morphological similarity to the nearby Natufian population (Nahal Oren) points to population continuity in the region. The possibility of seafaring and relationships to pupulations of major mediterranean islands is also discussed.

Location, environment and burials

Numerous archaeological artifacts have been discovered on the shallow continental shelf along the coast of Israel, particularly in the last 25 years. The findings consist mainly of the remains of wrecked ships and of submerged prehistoric sites (Prausnitz and Wreschner, 1971; Galili and Weinstein-Evron, 1985; Raban and Galili, 1985).

The recent proliferation of findings is due in part to intensified research, and in part to changes in the pattern of coastal sedimentation. Sand quarrying along the coast and various shoreline constructions (breakwaters, etc.) have apparently reduced the availability of transportable sediment and thus may have caused the exposure of offshore areas (and artifacts) formerly covered with sand (Neev et al., 1963). Construction of the Aswan High Dam, blocking the Nile's sediment supply, has also contributed to this phenomenon.

The coast of Israel is mostly smooth and gently graded, with few mountains that slope steeply into the sea. These features have made it a suitable place for human settlement throughout prehistoric and historic periods. The wide and shallow continental shelf tilts slightly westward, with a slope of 0.5 to 1.5 degrees. Most of this shallow shelf is covered with a layer of quartz sand, of varying thickness. Along the coastal plain, there are several eolianite («kurkar») ridges running parallel to the shoreline (Fig. 1). Some of these ridges are partially submerged, forming small islets and discontinuous reefs, 150 to 600 meters offshore. Holocene marshes with alluvial clay deposits, which once (some 10,000 years ago) filled the basins between the ridges, are now inundated by the sea, sometimes covered with sand and sometimes exposed (Galili and Weinstein-Evron, 1985).

Submerged prehistoric sites have been identified along the northern Carmel coast, at a depth of 1 to 12 meters (Galili, 1985, 1987; Galili and Weinstein-Evron, 1985; Raban and Galili, 1985). All of them rest upon, or are embedded in the marshy clay. These sites are usually covered with sand, but become exposed from time to time, particularly following sea storms. When first exposed, these remains appear to be remarkably well preserved, but they can be quickly damaged by abrasion and sea currents after their exposure.

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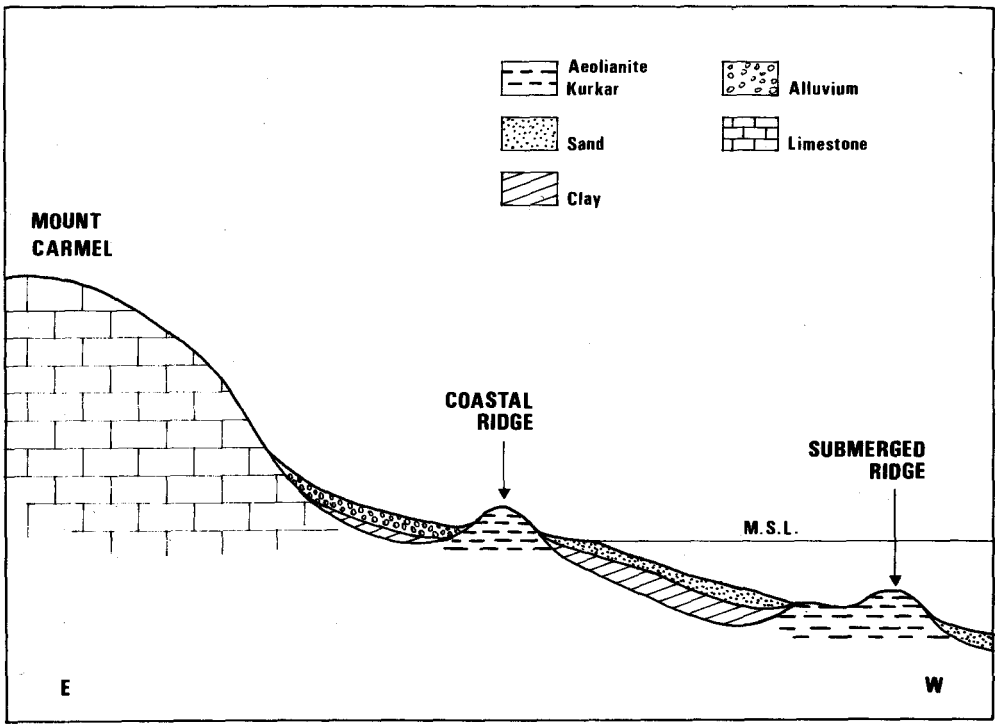

Fig. 1 - Section of the Carmel coast: general patern.

The Atlit-Yam Submerged Site

The site is located 10 km south of Haifa Bay and 400 m north of the Crusader Castle at Atlit (Fig. 2). It is about 300-400 m offshore (34 degrees 56'E, 32 degrees 42.5'N) at a depth of 8-12 m. It is the largest, deepest and most ancient submerged site ever found along the Israeli coast, and the oldest in the world to contain organized human burials. The site stretches over a large area and consists of several rectangular and round stone structures (Fig. 3). The walls were generally built of two lines of rubble stones (40-100 cm in width) and the floors (at least in some of the dwellings) were made of compact mud and gravel. A wall 20 m long at the northern part of the site was also uncovered, probably built to protect the settlement from floodinq of the Oren River.

Finds include flint artifacts (arrowheads, axes, sickle blades, etc.) as well as bone and stone tools (grinding slabs, mortars and pestles, bowls, etc). Faunal remains include goat (*Capra aegagrus*), wild cattle (mostly *Bos primigenus*), pigs (*Sus scrofa*), gazelles (*Gazella gazella*), and fallow deer (*Dama mesopotamia*), as well as fish (Horwitz and Tchernov, 1987). According to the lithic industry and carbon dating (8140 ± 120 yrs. B.P. — RT707) the site was attributed to the late Pre-pottery Neolithic B (PPNB) phase. At that time, the village was located on the southern bank of Nahal Oren, close to the original mouth. The sea level was 14-18 m lower than at present (Galili, 1987). The human remains described and analyzed in the present study include all of the skeletons found by 1987.

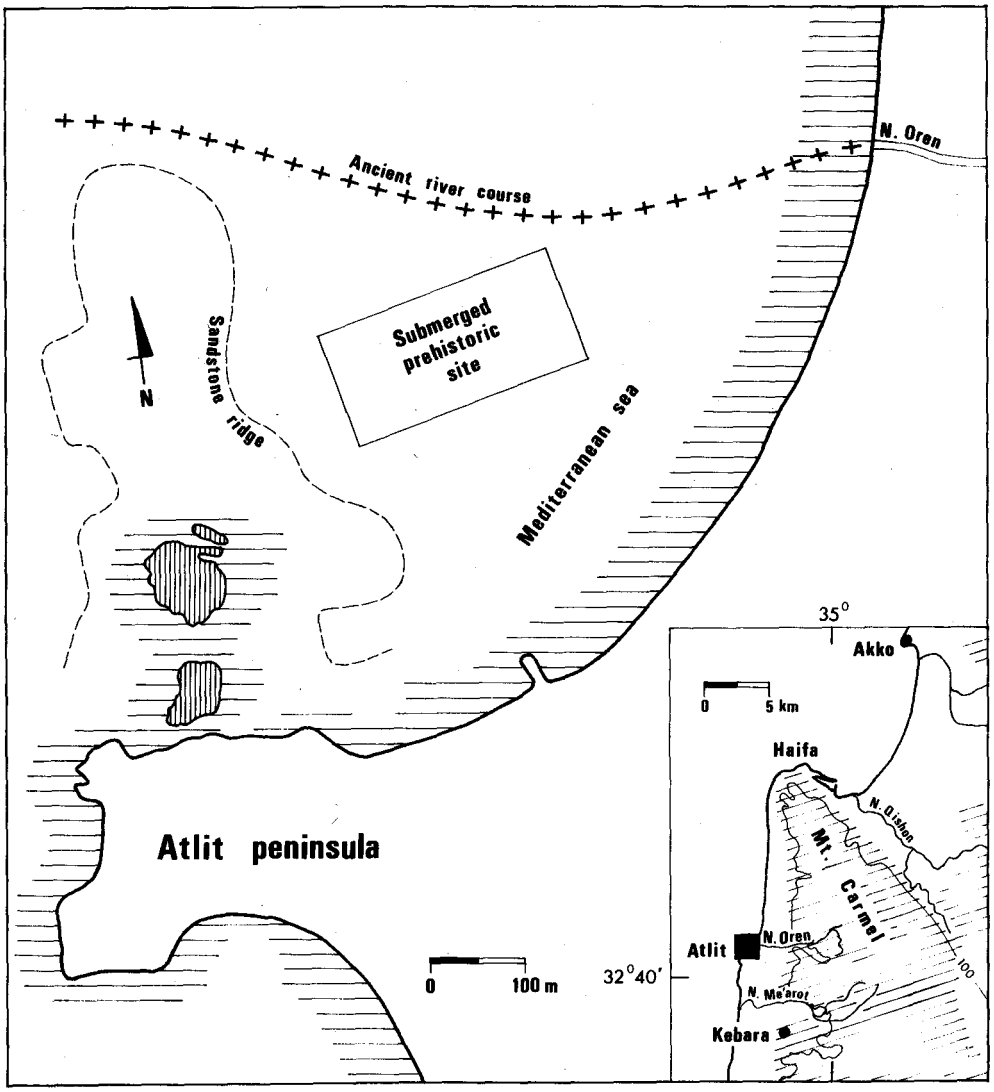

Fig. 2 - Location of the Atlit-Yam submerged site.

The Burials

The burials were scattered over a large area (Fig. 3). Some were found within dwelling structures, and others next to walls outside the structures, or between them. The skeletons uncovered were in various states of preservation, from intact and nearly complete, to merely a few fragmentary bones. The intact skeletons (two) indicate that the dead were placed in the grave in a flexed position (Fig. 4). In two burials, only the skull, or parts of it, were found. A few bones were found «floating» in the area of the site, probably moved from their original position by sea currents.

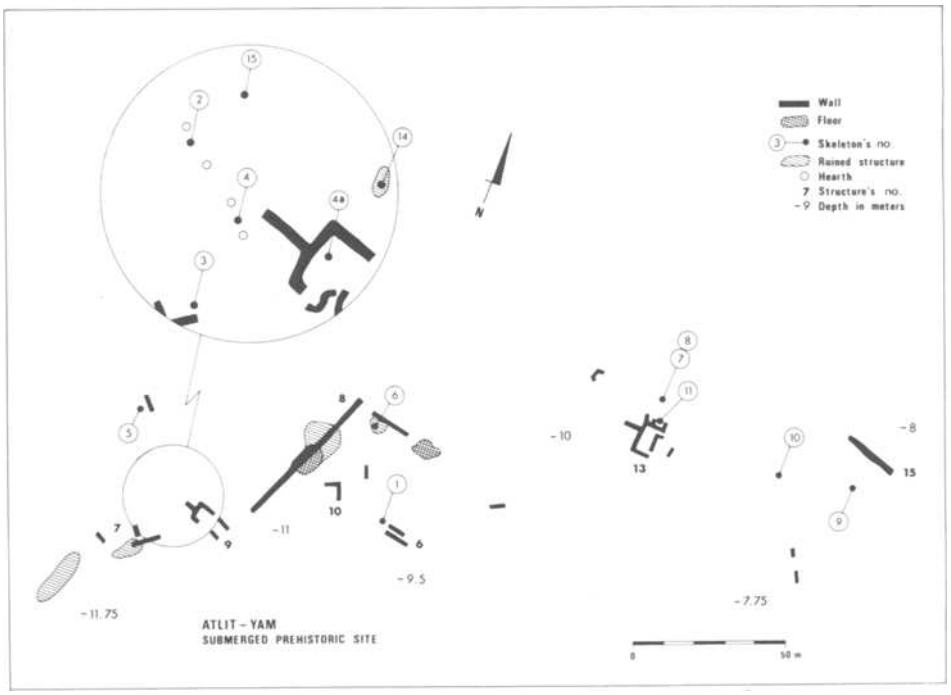

Fig. 3 - Location of the human burials at the site.

Homo I

The skeleton was found at a depth of 9-10 m under the surface of the sea, 3 m west of the northern wall of structure No. 6 (Fig. 3). This individual had been buried under clay, and therefore was in an excellent state of preservation and nearly complete. The bones were found in a flexed position (Fig 4), the knees close to the chest and the forearms at right angles to the arms. The skeleton was lying on its right side. It consists of an almost complete skull, mandible, and most of the postcranial bones. It was identified as a female, 20 ± 2 years of age.

Homo II

The bones of Homo II were found at a depth of 11 m, west of structure No. 9 (Fig. 3). Like Homo I, this was also a primary burial, dug into clay, but was not as well preserved as the former. This individual was placed in the grave in a flexed position, although different from that of Homo I -the knees were flexed completely such that the heels touched the buttocks, and the thighs were not raised toward the chest, but rather were at right angles to the trunk. The skeleton was also lying on its right side. The left upper limb was flexed in the same manner as in Homo I; the right one was extended.

Fig. 4 - Homo I skeleton buried in a flexed position.

When first uncovered, the skeleton was almost complete, with skull intact. However, due to a sea storm excavation had to be postponed, and when it was resumed two days later, most of the bones had been washed away, including the skull. Large fragments of the limb bones were preserved, as well as several vertebrae, part of the mandible, a piece of the skull, and many teeth. This individual was probably a male, 20-30 years of age.

Homo III

This young individual was found at a depth of 11 m, adjacent to the stone wall of structure No. 7. It consists of only part of the calvarium, which was partially buried in clay.

Homo IV

This skeleton was found at a depth of 11 m, partially buried in clay, near structure No. 9. It consists of an almost complete maxilla of a juvenile. The two pieces of the maxilla were found a few meters apart (4 and 4a in Fig. 3), and only in the laboratory was it discovered that they belonged to the same individual. Only the first permanent molar was fully erupted, and the second permanent molar had begun to erupt. The first deciduous molars remained intact.

Homo V

Homo V was found at a depth of 11 m, about 15 m northwest of structure No. 9. It is represented by a few fragmentary, disarticulated long bones, all of which were buried in clay. This individual appears to be an adult female, judging mainly for the clavicle.

Homo VI

This individual was discovered at a depth of 10 m, next to the wall adjacent to structure No. 8c. It consists of an isolated hemi-skull. It seems that the right half, which was buried in clay, remained intact while the left, which had been covered only by sand, became exposed by sea currents and was washed away (Fig. 5). Part of the inner aspect of the calvarium is covered with shell encrustations. No signs of other bones were observed in the vicinity. This individual was identified as a female, no older than 25 years of age.

Homo VII and VIII

Both of these were discovered at a depth of 10 m, north of structure No. 13. The two skeletons, of a child 3-5 years old (VII) and a mature individual (VIII), were lying next to each other. When first uncovered, they were almost complete, representing primary burials in a flexed position. However, after a two-day delay in excavation due to a storm, the skeletons could not be relocated since the entire site had been covered by a thick layer of sand. Only a year later were they again exposed, but by then they had already been badly damaged, with only a few bones remaining in place. The child is represented by

Fig. 5 - Hemi-skull of Homo VI.

three small fragments of the cranium, all showing partial burning, fragments of the femora, and several cervical vertebrae. The adult is represented by fragments of the skull, mandible, vertebrae and long bones.

Homo IX

This skeleton was found at a depth of 8 m, at the eastern part of the site, next to structure No. 15. Above the skeleton was a pile of charcoals. Some of the bones showed signs of burning. The few long bones present were disarticulated. Also present were a few vertebrae, broken ribs, and an almost complete mandible. The skeleton was identified as a middle-aged male.

Homo X

Homo X was found at a depth of 8 m, between structures No. 13 and 15. In its original position it was articulated and indicated a primary burial in a flexed position, very similar to that of Homo II. This was the first skeleton to be discovered at the site, by a diving fisherman, and was at that time almost complete, including the skull. Unfortunately, during the time that passed before excavation was begun, a sea storm washed away most of this skeleton. The remains consist of a complete right humerus and a few fragments of other long bones.

Homo XI

This individual was found at a depth of 10 m, next to structure No. 13. The disarticulated bones, buried in clay, were located between two short walls which were perpendicular to the southern wall of the structure. The skeleton consists mainly of broken ribs, a few vertebrae, and a fragmentary mandible which could be partially reconstructed. From the find, we could not determine the nature of this burial (primary or secondary). The skeketon is of a female, 15-17 years of age.

Homo XII

A small piece of the parietal region of a skull, an atlas, and long bone fragments were collected from the area around structures No. 1, 8, 9 and 10. They are what we consider «floating» bones, and therefore no information as to their original position in the grave, nor the actual location of the grave can be gleaned. The fragments may well belong to more than one individual. Shell encrustations on most of them indicate that they had been «floating» for some time (one to two years) and are probably remains of skeletons which had been displaced by sea currents. In the absence of more precise information regarding their origin, we grouped them all together as one individual.

Homo XIII

Homo XIII consists of an almost complete left parietal bone, uncovered at a depth of 11 m, next to structure No. 9. It was found among stones which were used as a platform

for a plastered floor within the dwelling. Near the skull, a horn and a vertebra of a wild animal of the cattle family (*Bos Primigenus*) were discovered. Its general gracility and the absence of any signs of sutural obliteration indicate that it may well be of a young female.

Homo XIV

This individual was found at a depth of 11 m, west of structure No. 9. Although little remained of the skeleton, the few fragments presented (mainly of the femur, tibia, radius and scapula) had been held in place within the clay, and indicate a primary burial.

Homo XV

This individual was discovered west of structure No. 9 at a depth of 11 m. It appears to have been a primary burial, although most of the skeleton had been washed away prior to excavation.

In sum, prior to the damage caused by sea storms, the burial types were probably distributed as follows: 5 cases represent primary burial and include the skull; 4 cases present only the skull or parts of it; 2 cases present only long bones or fragments thereof; 2 cases present disarticulated bones from the extremities and torso (secondary burials?); one case presents «floating bones»; and one case presents an intact skeleton without the skull. This burial picture from Atlit-Yam is similar to that in other PPNB sites in the Levant, i.e., flexed position, isolated skulls, etc. (Hershkovitz et al., 1986; Hershkovitz and Gopher, 1988). Although many skeletons were found disarticulated, we could not ascertain whether these represent secondary burials, since the extent of the role played by environmental factors could not be determined. Changes in deep sea currents, their varying intensity and direction, and strong sea storms undoubtedly caused continuous displacement and destruction, and disappearance, of skeletons which were wholly or partially buried in sand. Burials exposed on the sea floor and not embedded in clay may be washed away within a day or two, or may become «reburied» by a thick layer (often more than 1 m) of sand. In most cases the deceased were probably only partially buried in clay, and hence those parts of the cadaver covered only with sand were abraded and washed away once exposed to the sea currents centuries or millennia later (Fig. 6). Homo VI is a good example of such a situation — the right half of the skull which was buried in clay was intact, while the other half had been completely washed away. The skull looks as if it had been cut by a knife in the midsagittal plane. It seems that the material in which the individuals were buried (clay only, sand only, or a mixture of the two) may reflect different time periods in the settlement's existence. When the village was first established, the ground consisted mainly of clay (dry marshes). In the course of time, with the slow continuous rising of the sea level, sand began to accumulate in the village surroundings, and in the final phases of the village, just prior to its submersion, the surface consisted of a considerable layer of sand. It is our belief that during this final phase, the deceased were at least partially covered by sand, and therefore when the sand was removed from the site thousands of years later, those bones which had been embedded in it were the first to be washed away. Skeletons of individuals who were completely embedded in clay (probably in the earlier phase of the village) have remained in their original burial positions, such that even the smallest bones have been held in place, making it possible to reconstruct even the grip position of Homo I's fingers (Fig. 4). On

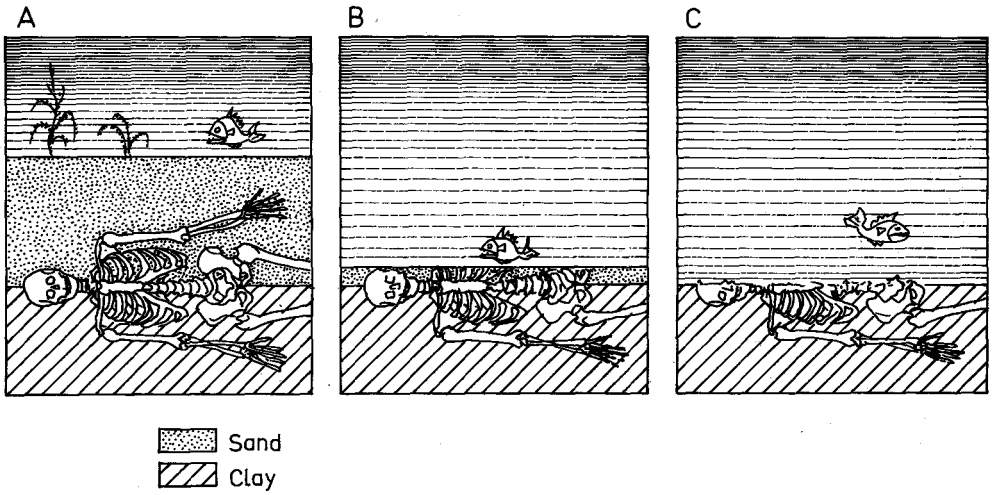

Fig. 6 - Schematic drawing demonstrating gradual abrasion of skeletons. Notice that only those parts which were buried in clay remain unharmed.

the other hand, what apparently saved the site from complete destruction while the shore waves (breakers) reached the site with the continuous rise of the sea level, is the fact that by that time, it was already covered with a thick layer of sand. This sand cover protected the site for thousands of years — until recently when major changes in the coastal environment, made by man, led to dramatic changes in the underwater landscape.

Shell Encrustations on Bones

A few bones and one skull, related to three individuals (Homo VI, X and XIII) are partially covered with calcareous shells of different marine animals. In Homo VI, they cover the interior aspect of the skull, very close to and along the left arm of the lambdoid suture (Fig. 7). Only a few are on the external surface of that region. In Homo X, the shells are located on the posterior aspect of the humeral neck. In Homo XIII, all of the remaining bones are covered in varying densities with shells, the densest encrustations being on the posterior surface of the distal part of the femur; the medial aspect of the midshaft of the left tibia; the posterior preglenoid area of the scapula; and the posterior aspect of the distal edge of a fragmentary radius.

Three different families of marine animals have been identified (by Prof. Fishelson, Tel Aviv University, personal communication): Serpula (sub-class Polychaeta), Balanidae (sub-class Cirripedia), and Membranipora (sub-class Bryozoa). The first two have a brief planktonic existence. The Serpula constructs a calcareous tube which is strongly cemented to the bone surface; the Balanidae also have a calcareous shell, conical in shape. Both reach full size within a few months (Gosner, 1971), are very aggressive creatures, and settle very quickly, encrusting any hard object which it may touch. The third group, the Membranipora family, are colonial animals which form lacy encrustations on the substratum. All three groups are indifferent to light and become permanently fixed to their

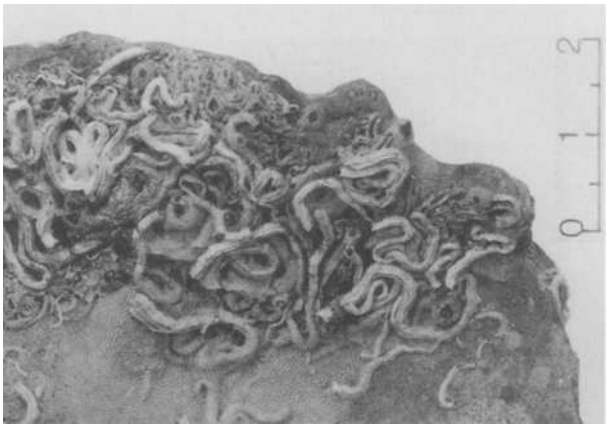

Fig. 7 - Shell encrustations on the interior aspect of Homo VI skull.

substrata. They are always found on the more protected, hidden areas of the substratum, to prevent being eaten by fishes, crabs or sea urchins.

Studying these marine animal encrustations solved one of our preliminary problems: we could determine from them the duration of time that the bones had been exposed to sea currents, which in turn could give us an indication as to the stage of destruction of the site as a whole. Measurements of the length of the Serpula tubes and the height and base diameter of the conical shells of the Balanidae provide us with a time span of approximately two years. The fact that no additional or larger organisms had settled on the bones support the above finding. Hence, we conclude that most of the skeletons, especially those of very young inividuals, who were probably buried closer to the ground surface, as is common in many other PPNB sites (Rollefson, 1985), or those buried in later phases of the site, have been partially or totally washed away by sea currents. Those skeletons which have remained in their original positions were those which had been almost completely buried in the clay. Although the exposure of the bones appears to be a temporal situation, it seems that in certain cases, from time to time, the duration of exposure was long enough — at least several months — to enable marine organisms to settle on the bones.

Another interesting clue given to us by the marine organisms on the bones concerns reconstruction of the burial customs of the Atlit people. All types of marine organisms found attached to the bones are able to grow and develop only on the side of the substratum facing the sea bed, where the predators cannot reach them. Thus, in the case of bones which were found «floating», but were once partially buried in clay, we can reconstruct their probable position in the original burial. For example, the location of the encrustations on the Homo VI bones indicate that this individual was originally placed in the grave on his right side. However, if a bone has been «floating» for a long time, it will either be covered all around by marine organisms, or will be totally clean of them.

Artificial Skull Treatment

On the right parietal bone of Homo VI appears a smooth area, bounded inferiorly by the parieto-temporal suture, anteriorly by the coronal suture, and superiorly by the superior temporal line. The area extends posteriorly from the coronal suture for approximately 6 cm. The polished surface has a slight unevenness to it, and upon closer

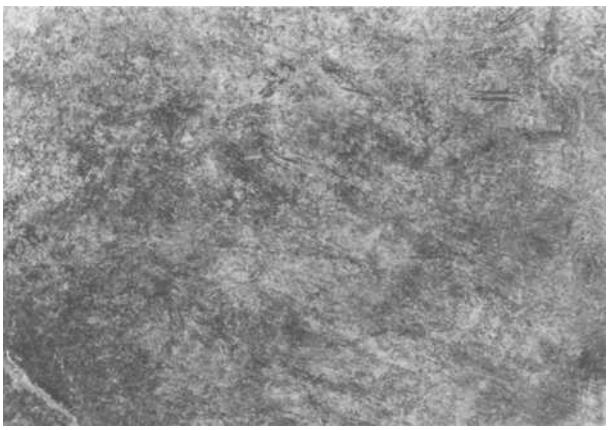

Fig. 8 - Close-up of the polished scratched area of the Homo VI skull.

examination, it is seen to be actually formed by many small, angled plane facets (Fig. 8). At the point where the facets meet, a small polished ridge appears. Through a magnifying binocular small parallel scratches are noted on each facet. Also, on the periphery of the polished area, isolated groups of scratch lines, sometimes at right angles to each other, can be seen. All of the above strongly suggest that this bony region was either scraped or polished repeatedly by a stone implement in an anterosuperior direction, at varying angles to the surface. Similar polished surfaces have been noted on bone tools. The possibility that this polished area was created by abrasion of quartz grains being carried by sea currents after the skull had been partially exposed, or by repeated minor movements of the skull in the sand which covered it, may be rejected on the basis of the nature of the polished area, as described above. Also, no marine or terrestrial organisms that we know of could have produced such polished facets and scratches.

Skull treatment in the PPNB period, mainly plastering, is a well established phenomenon (Ferembach, 1970; Ferembach and Lechevallier, 1973; Rollefson, 1986; Hershkovitz et al., 1986; Arensburg and Hershkovitz, 1988; Hershkovitz and Gopher, 1988; Yakar and Hershkovitz, 1988; and others). The custom is usually related to ancestral cult (de Vaux, 1966; Bar-Yosef, 1977; Yakar and Hershkovitz, 1988). The Homo VI skull was probably treated with a special stone implement either for defleshing or as a preparative procedure for skull decoration. Rollefson (1985) reported on two parietal fragments from a single male skull from'Ain Ghazal which were found with cut marks on the cortex and with traces of a reddish pigment on the ectocranial surface (p.110). However, because of the lack of a more detailed description, we refrain from making any comparison between the two.

Material and Methods

General Characteristics of the Population

Age and sex distributions of the Atlit-Yam people, according to the skeletal finds, appear in Table 1. Our ability to draw from these data a reliable paleodemographic picture is doubtful, since it is largely biased by the present environmental conditions, past burial

TABLE 1 - *Age and sex distribution of the Atlit-Yam population.*

Age group	male	female	unknown sex	Total
0-6	—	—	1	1
7-13	—	—	1	1
14-20	—	1	—	1
20-30	1	2	1	4
30-40	2	2	—	4
adult unknown	—	1	3	4
Total	3	6	6	15

customs, and the interaction between the two. For example, the proportion of children is far too small, possibly because the bones of very young individuals are more fragile, and usually buried closer to the surface, and thus more prone to damage by sea currents.

In general, the excess of females over males is typical of PPNB sites (Hershkovitz and Gopher, 1989), as opposed to the preceding Natufian groups, in which males dominate.

Measurements of the skull and post-cranial bones were generally taken according to Martin and Saller's (1957) methods.

A. *Skull morphology*

Measurements were available on only two female skulls (Table 2).

The cranial indices of Homo I and Homo VI are 79.9 and 75.1, respectively, indicating mesocrania. The calvaria are short, low and narrow. The frontal regions are narrow; the transverse fronto-parietal index is in the eurymetopic category (70.2 and 73.8, respectively). From the various chord-arc indices, the frontal bones are the most curved; both the parietal and occipital bones manifest similar, higher indices.

In *norma frontalis* (*Figs. 9, 10*) the glabellae and supraciliary regions are only slightly developed. The orbits of Homo I are more square in shape (orbital index 81.1), whereas those of Homo VI are more rectangular (O.I. = 78.4). The lateral borders are extremely blunt. The interorbital region of Homo I is very wide in absolute terms (29 mm), as well as relative to the biorbital (interorbital index 31.86) or minimum frontal breadth. The supraorbital region of Homo VI is characterized by a marked horizontal depression of considerable depth. Above it, a prominent frontal tuber is noted. The nasion of Homo I is moderately depressed and the nasal bones are slightly concave; the nasal index (64.1) falls within the platyrrhine category. The inferior margin of the nasal aperture is slightly elevated. On both sides of the anterior nasal spine, two bowshaped depressions (fossae praenasales) are clearly visible. The nasal aperture of Homo VI is high and narrow (N.I. = 56.5) and the nasal sill sharp. The adjacent canine fossae are extremely deep in Homo I and shallow in Homo VI. In general, the face of Homo I is flat and deep, the surfaces of both the nasal and frontal processes of the maxillary bone being arranged more or less on the same coronal plane. The face of Homo VI is low and considerably wide (Table 2). The upper facial index is 47.6 and the bizygomatic-frontal index 77.4.

In *norma lateralis* (Figs. 11 and 12) the foreheads of both Homo I and Homo VI are short and almost vertical. The subnasal regions protrude very slightly, the gnathic indices being 92.9 and 96.0, respectively. The superior temporal lines are noticeable, and the

TABLE 2 - *Skull measurement of two females specimens from Atlit-Yam (mm).*

	Homo I	Homo VI*
Maximum length	164	173
Maximum breadth	131	130
Nasion-basion length	99	99
Biasterion width	102	—
Minimum frontal width	92	96?
Foramen magnum length	34	34
Foramen magnum width	27	—
Frontal chord	99	—
Parietal chord	105	—
Occipital chord	88	97
Frontal arc	117	
Parietal arc	118	
Occipital arc	100	
Basion-prosthion length	92?	96
Biorbital breadth	91?	96
Bizygomatic breadth	118?	124
Bimaxillary breadth	91	100
Zygomaxillae-dental arc length	23	20
Interorbital breadth	29	—
Nasion-prosthion height	59	59
Nasion-gnathion height	101	—
Orbital breadth (R)	37	37
Orbital height (R)	30	29
Nasal breadth	25	26?
Nasal height	39	46
Palate breadth	36	—
Palate height	45	—
Palate depth	10	—
Maxillo-alveolar breadth	—	70
Maxillo-alveolar length	—	52

? = approximate measure
* Only right side completely preserved. Side to side measurements were taken by projecting the right side to the left.

supramastoid crests are pronounced. The mastoid process is short and narrow in Homo I and large and prominent in Homo VI. On the border between the mastoid crest and the external auditory meatus, a large pitted area is noted in both skulls.

Since Homo I lacks the back and base of the skull, descriptions of these areas can be obtained only from Homo VI. In *norma occipitalis* the external occipital crest is clearly noted. In *norma basalis* the most striking feature is the shape of the mandibular fossa. The roof is flattened in both the medio-lateral and antero-posterior directions. The lateral border is not elevated to a ridge and the articular eminence is barely noticeable (Fig. 13); the postglenoid process is pronounced. The inferior margin of the temporal process of the zygomatic bone is thin, projecting antero-medially; together with the short zygomatic process of the maxilla, it creates a convex cheek. The maxillo-alveolar length is 52 mm and

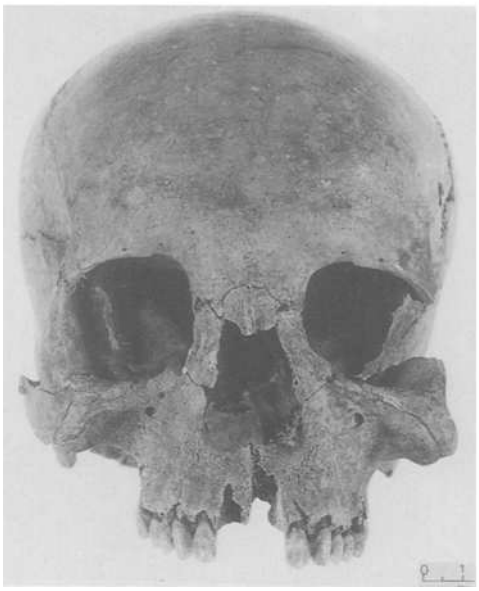

Fig. 9 - Homo I skull, frontal view.

Fig. 10 - Homo VI skull, frontal view.

the breadth 70 mm. The index falls within the brachyuranic category (estimated to be 134.6). More posteriorly, the inferior nuchal line is marked and the area between the line and the posterior margin of the foramen magnum is deeply concave. The groove for the digastric is relatively deep.

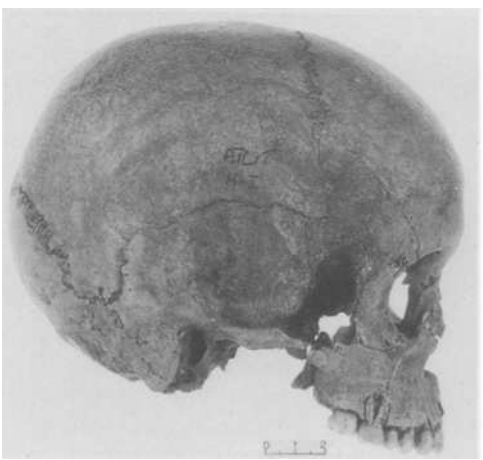

Fig. 11 - Homo I skull, lateral view.

Fig. 12 - Homo VI skull, lateral view.

Fig. 13 - Homo VI skull, basilar view. Note the shape of the mandibular fossa.

Fig. 14 - Homo VIII left maxilla, basilar view.

As for males, the skull fragments of Homo II show considerable development of the supraciliary and glabellar regions. Also here, the orbital margins are thick and rounded. In Homo VIII, the skull fragments show a bow-shaped depression of the inferior margin of the nasal aperture, a shallow canine fossa, and slight protrusion of the subnasal region which extends downward for a relatively long distance; the infero-lateral margin of the orbit, formed by the zygomatic bone, is extremely smooth and rounded; the inferior margin of the temporal process of the zygomatic bone is thick and flat, meeting the zygomatic process of the maxilla at an almost right angle (Fig. 14). In lateral view of Homo VIII, the mastoid is large and thick and the supramastoid crest is prominent; the groove for the middle temporal artery is noticeable (as in all other specimens with the temporal bone present). In basilar view, a deep mastoid notch and deep mandibular fossa is noted.

B. *Mandible morphology*

All available measurements appear in Table 3.

The ramus of the Homo I mandible is low and considerably broad (Fig. 15), with a ramal index of 69.2. The mandibular body is short, broad (bigonial index = 131.0) and moderately high. The coronoid process is short and thick anteriorly. The gonial region is inverted.

The mandible of Homo II is represented by three large fragments of the right side. The ramus was probably very wide (at least 42 mm) and low. From a lateral view, the coronoid process seems to be low and considerably wide, thickening anteriorly, with its maximum width at the tip. From a superior view, its posterior border seems to be split

TABLE 3 - *Mandibular measurements in the Atlit-Yam specimens (mm).*

	Homo I	Homo VIII	Homo IX	Homo XI
Maximum length	93	—	108	92
Body length	69	—	86	72
Projective length	52	58	—	56
Bicondylar breadth	109	—	—	—
Bicoronoid breadth	92	—	—	—
Bigonial breadth	91	—	—	—
Bimental breadth	43	—	43?	—
Ramus width	36	36	41	34
Ramus height	48	55	57?	53
Symphyseal height	30	—	32?	35
Height at mental foramen	28	36	—	27
Height at Pm2-M1	27	—	36	27
Height at M1-M2	25	32	33	25
Height at M2	23	—	—	—
Width at mental foramen	14	15	13	13
Width at M1-M2	15	17	14	—
Mandibular angle (degrees)	121	115	109	114
Symphyseal width	14	—	14	14
Condylar-coronoidal angle (degrees)	71.4	—	—	—
Coronoidal height	56	—	—	—
Molar-premolar chord	27	28	28	—
Condyle breadth (R)	8.5	10	10	8
Condyle length (R)	17	18	19	19

? = approximate measure

into two ridges by a deep groove. The mandibular notch is shallow. The gonial region is thick and everted, and shows prominent muscle markings. The corpus is thick; on its inner aspect the mylohyoid line takes the form of a small crest.

A large piece of the left side of the Homo VIII male mandible was almost completely preserved (Fig. 16); part of its anterior area shows signs of burning. The mental foramen is located between the second premolar and the first molar; its orifice is directed supero-

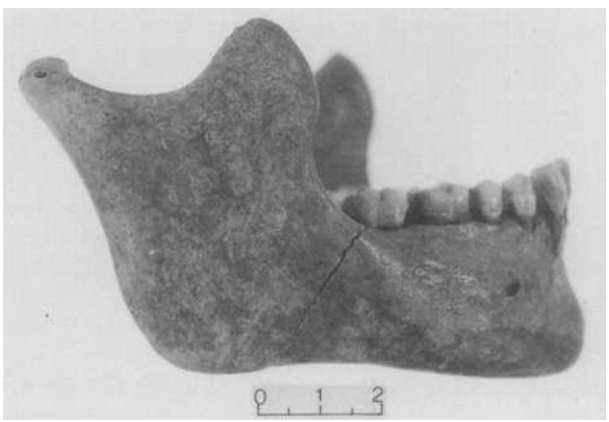

Fig. 15 - Homo I mandible, lateral view.

Fig. 16 - Homo VIII mandible, lateral view.

laterally. The ramal index is 65.4. The gonial region is very broad, everted and rounded, projecting backwards and downwards. Muscle markings on its medial aspect are prominent. The anterior border of the coronoid process is relatively thick and the mandibular notch shallow. The mylohyoid line is represented by a small crest. The pterygoid fovea is represented by a small and deep depression bounded medially by a marked tubercle. The molar-premolar chord is relatively short and the posterior part of the corpus mandibula is relatively thick (Table 3).

The mandible of the Homo IX male was found in pieces and was reconstructed in the laboratory. Hence, all of its measurements (Table 3) should be viewed with caution. The ramus is very wide and high. The height is exaggerated by the fact that the posterior part of the corpus mandibula slopes upwards (Fig. 17). When the height is measured from the gonion (which does not meet the surface when the mandible is placed on a flat plane), the value falls to 57 mm. This type of mandible is known as a «rocking mandible». This unusual shape of the ramal area is also associated with several other morphological characteristics: a) the border between the ramal wing and the mandibular body is sharp. This results from an abrupt narrowing of the ramus; b) inferior to the mandibular notch there is a large, deep depression separating the posterior subcondylar area from the

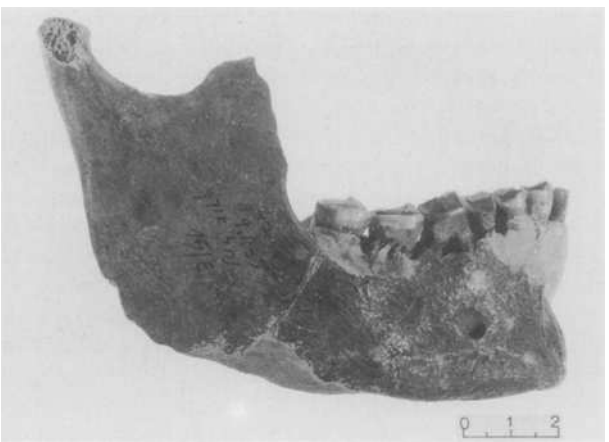

Fig. 17 - Homo IX mandible, lateral view.

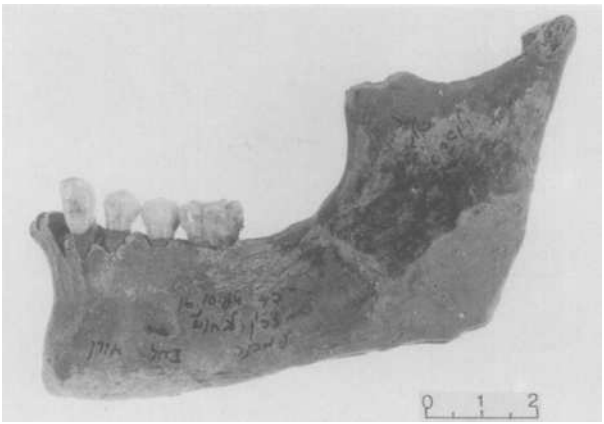

Fig. 18 - Homo XI mandible, lateral view.

anterior subcoronoid area; c) prominent muscle markings appear on the large neck of the lateral surface of the ramus almost to the head of the condylar process. Both the coronoid and condylar processes surmount a deeply concave mandibular notch. The gonial region is straight; the mental foramen is situated between the second premolar and the first molar, and faces upwards and backwards. The menton is pointed. The digastric fossa is represented by a roughened depression.

The left side of the Homo XI female mandible shows a small ramus in both its width and length dimensions, with a ramal index of 64.1, and a shallow mandibular notch. The corpus decreases considerably in height antero-posteriorly (Fig. 18). The chin is pointed; the mental foramen is located below the second premolar, and faces supero-posteriorly.

C. *Upper limb bones*

Available measurements appear in Table 4.

In Homo I, the humerus is disproportionately robust in relation to the radius and ulna. The lateral lip of the intertubercular sulcus projects considerably as a bony ridge and ends distally as a pronounced tubercle. The left forearm bones in general are more robust than those of the right side. The ulna is thick throughout its entire length. On the anterior aspect of its distal end, an irregular, rough and elevated area is present (attachment for the pronator quadratus muscle).

Of the upper limb bones of Homo II, only the shafts were preserved. That of the right humerus is very robust — very thick with strong muscle markings. The deltoid tuberosity is strongly developed, and the attachment area for the pectoralis major is characterized by a rough longitudinal area bounded by two marked lips (Fig. 19). The attachment area for the teres major muscle is similarly characterized, although to a lesser extent. The bicipital groove is very shallow and rough. The most significant morphological characteristic of the radius is the fairly rough area on the lateral aspect of the midshaft, for attachment of the pronator teres. The lower part of the interosseus border of the ulna is rough and thick, in contrast to its upward extension, which is thin and smooth.

The interosseus region of the ulnar shaft of Homo V is also thick in relation to the general size and shape of the entire shaft, and projects considerably. A noticeable

TABLE 4 - *Measurements of the humeri and radii from Atlit-Yam (mm).*

	Homo I (female)	Homo II (male)	Homo IX (male)	Homo XIII (undetermined)
Humerus				
Head diameter	37	—	—	34
Maximum A-P diameter	17	23	21	20
Maximum trans. diameter	20	23	16	16
Minimum perimeter	53	66	63	57
Maximum length	—	—	—	302
Physiological length	—	—	—	295
Radius				
Maximum length	190	—	—	—
Physiological length	180	—	—	—
Diaphysis diameter max.	14	16	15	—
Diaphysis diameter min.	9	11	11	—
Head diameter	19	—	24	—
Minimum perimeter	35	41	40	—

depressed line on both the medial and lateral surfaces separates the elevated interosseus region from the shaft. The inferior surface of the coronoid process is marked by a rough impression. The supinator crest is replaced by a short, deep groove. On the radius, despite the general gracility, the oblique line takes the shape of a wide ridge.

In Homo VIII, the left ulna is represented by a 13 cm segment of its distal end, and reveals significant morphological information. Unlike a typical ulna, which diminishes in size from its proximal to distal end, the shaft of the Homo VIII ulna remains thick until it meets the head (minimum perimeter = 44 mm). This results mainly from the marked development of the insertion area for the pronator quadratus muscle (Fig. 20). The exaggerated thickness of this area is probably responsible for the diminution of the medial curvature of the region. The head of the ulna is relatively robust, as is the styloid process (max. head diameter = 24 mm). The head of the Homo VIII radius is also large (max. diameter = 24 mm); it also was partially burned. The three complete phalanges present no particular morphological characteristics.

As for the upper limb bones of Homo IX, the shafts of both humeri were preserved. Some morphological peculiarities of these humeri are noted: Both are curved medially, giving the impression that the upper part was strongly bent medially (Fig 21). The lateral supracondylar ridge is replaced by a considerable thickening of the shaft in that area; in contrast, the medial supracondylar ridge is markedly developed. The anterior surface of the humerus extends almost to the distal end of the bone as a wide, prominent (elevated) ridge, thus creating a relatively deep fossa between the shaft and the supracondylar ridge. The entire anterior area above the coronoid process and radial fossa is considerably thick and elevated. The bicipital groove is shallow. The lateral lip of the left humerus terminates distally as an elevated, prominent tubercle. As for the Homo IX ulna, the anterior surface of the coronoid process on the right side is marked by an elevated crest encircling a considerable depression. On the left side, the depression is less marked, and is rather replaced by a rough area. The most prominent characteristic of this bone is the very large

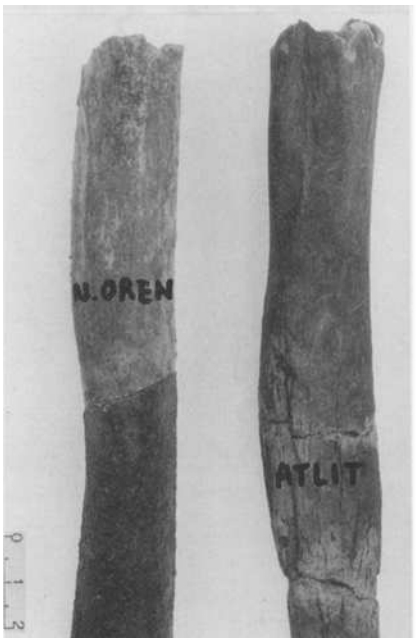

Fig. 19 - Homo II humerus. Note the rough area at the proximal end of the bone bounded by two marked lips.

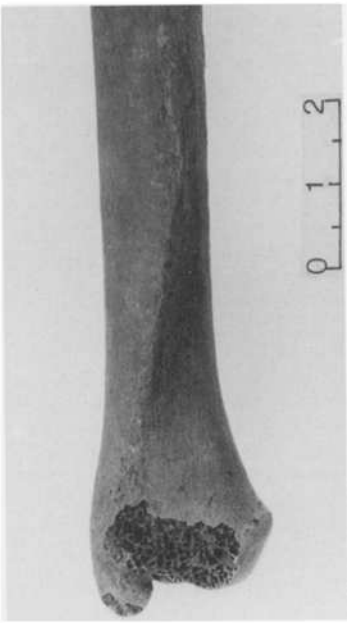

Fig. 20 - Homo VIII ulna, distal end.

elevated crest for the attachment of the pronator quadratus. A deep and wide groove separates this crest from the interosseus crest. There is great morphological asymmetry between the right and left ulnae. The projection of the interosseus border of the right ulna is almost unnoticeable — only at the lower end does it become prominent (Fig. 22). The proximal end of the interosseus border of the Homo IX radius is characterized by its pronounced projection, which is also quite thick and rough and deviates widely from the more distal interosseus margins of the shaft. On the posterior surface there is a marked depression between the elevated crest and the body itself. The anterior oblique line of the radius takes the shape of a developed crest. The overdevelopment of both the interosseus crest in this region and the oblique line create a large flat area for the attachment of the flexor digitorium superficialis and pronator muscles.

In Homo X, the humerus is the only complete bone remaining of this individual. It is relatively long (max. length = 302 mm) and gracile in its general appearance. The most prominent feature is the large crest on the lower border of the lateral lip of the bicipital groove. Also, the upper border of the medial lip is unusually thick and elevated. The medial supracondylar ridge is rounded; the lateral ridge is undeveloped. The midshaft of the radius appears to be consistent with the general gracility of the other bones. The anterior surface of proximal end of the Homo X ulna, just below the coronoid process, is deeply depressed, bounded by elevated crests from both the lateral and medial sides. On the distal end, where the pronator quadratus attaches, a marked crest is noted, in sharp contrast to the general gracility of the bone.

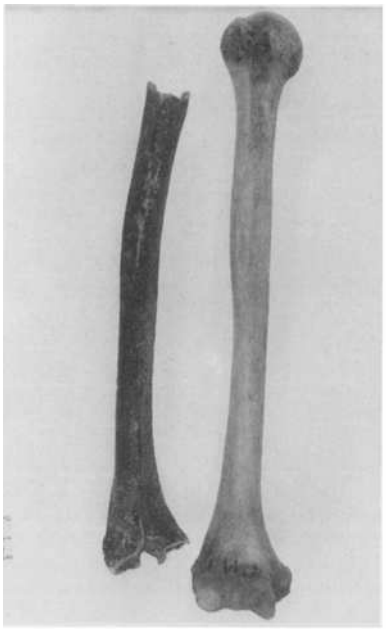

Fig. 21 - Homo IX humerus (left) compared with normal humerus (right).

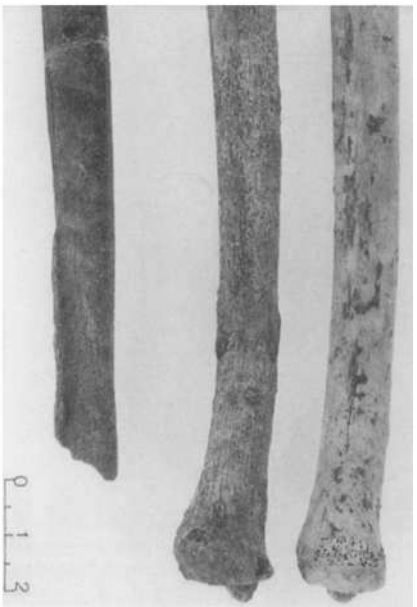

Fig. 22 - Homo IX ulna (left), compared with ulnae from 2 other PPN sites: Abu-Gosh (center) and Nahal Oren (right).

As for Homo XI, the distal part of a humerus was preserved. This area has a very gracile appearance. .No supracondylar ridges are present. The olecranon fossa is patent. The proximal part of the radial shaft manifests the same gracile appearance as the humerus, with no distinct morphological features.

The lateral border of the scapula of Homo XIII is unusually thick along its entire length. The attachment area for the long head of the triceps is especially pronounced and the inferior glenoid tubercle is replaced by a marked oval depression. The radial shaft is small in diameter and gracile in its general appearance.

D. *Lower limb bones*

All available measurements appear in Table 5.

The femora of Homo I manifest pronounced third trochanters. This is in sharp contrast to the general gracility of this bone. The subtrochanteric region is considerably flat and the trochanteric fossa is depressed. On the tibia, the soleal line is marked.

The lower limb bones of Homo II are relatively much more robust than those of its upper limb. The femur is considerably thick. Muscle markings are prominent and even overdeveloped in certain areas — at the spiral line, the gluteal tuberosity, and the intertrochanteric line. Unfortunately, both ends of both femora are missing. The proximal-most part of the shaft is flat, with a platymeric index of 74.3. The linea aspera ridge is broad, rough and prominent, projecting considerably from the shaft; the medial lip on its

TABLE 5 - *Measurements of the femora and tibiae from Atlit-Yam (mm).*

	Homo I (male)	Homo II (male)	Homo IX (male)
Femur			
Maximum length	363	—	—
Physiological length	359	—	—
Diaphysis diameter A-P	22	34	—
Diaphysis diameter trans.	22	29	—
Subtrochanteric diameter A-P	19	26	—
Subtrochanteric diameter trans.	29	35	—
Midshaft circumference	69	98	—
Head diameter	40	—	—
Tibia			
Diaphysis diameter A-P	25	38	40
Diaphysis diameter trans.	20	29	19
Minimum circumference	61	—	—
Maximum length	285	—	—
Physiological length	270	—	—

medial third, where the vastus medialis attaches, is particularly prominent. The tibiae are robust but remarkably flat in relation to their general size; the platycnemic index is 60.5. The anterior border throughout its entire length is rounded. The soleal line on the upper posterior surface is represented by a large, rough and prominent ridge (Fig. 23). The broken talus and calcaneus yield no significant information.

The state of preservation of the Homo VIII lower limb bones is very poor. The midshaft of a fibula, the broken head of a femur and two tarsal bones are all that remain. On the femoral head, directly above the fovea, there is a marked lunate depression, extending over 25 mm. The proximal phalanx of the big toe manifests a deep notch on the lateral side of its distal end; also noted are two small tubercles on the dorsal surface of its proximal end. The small piece of the fibular midshaft appears to represent a robust bone with strong muscle markings. The left talus is complete; it has a short neck and shows no signs of a squatting facet on its dorsal aspect.

The only preserved parts of the Homo IX lower limb are the midshaft of the left tibia and the right fifth metatarsal bone. The tibial shaft is considerably flat, with a platycnemic index of 47.9, and has a rounded anterior surface. The entire piece exhibits anterior convexity (Fig. 24). The metatarsal is robust and deeply concave medially.

Of the lower limb bones of Homo XIII, the femoral fragment is relatively thick. Most of the tibia is covered with sea shells. Its shaft is small and its anterior border is considerably rounded (Fig. 25).

E. *Vertebrae and ribs*

Several vertebral bodies from the Homo II skeleton were preserved, mainly from the lower region. No distinct characteristics were noted. The absence of osteophytes (except for one lumbar vertebra) confirms the suggestion that Homo II represents a young, mature male.

Fig. 23 - Homo II tibia (right) compared with a tibia from Nahal Oren (left). Note the over-development of the soleal line in both bones.

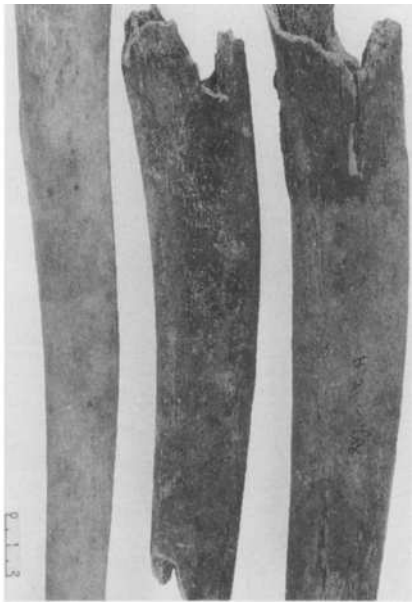

Fig. 24 - Homo IX tibia (center), Homo II tibia (right), and modern «normal» tibia (left).

Fig. 25 - Homo XIII tibia and femur.

Many fragments of the vertebrae and ribs of Homo IX are present, although only four vertebrae are complete: the axis, atlas, the third/fourth cervical, and the first/second lumbar. The atlas is quite robust, the two lateral masses are large and elevated, and the anterior arch is almost straight. The superior articular facets are deeply concave and on both sides are divided into two secondary facets by a noticeable groove. The medial aspect of the lateral masses are rough and prominent, as is the posterior tubercle of the posterior arch. The axis, as the atlas, is generally robust. The dens juts vertically upwards to a considerably height. The laminae are very thick and the spinous process is large. The other complete cervical vertebra has a superior surface which is deeply concave transversely, with prominent lips on each side.

Homo IX is represented by several vertebrae which are complete or almost complete (the axis, two other cervical vertebrae, and two thoracic vertebrae). No unique morphological characteistics were noted, except for osteophyte buds. Both lateral aspects of the dens of the axis are perforated by numerous small holes.

Homo XI is represented by several fragmented vertebrae.

F. *The innominates*

The few fragments of the innominate bones of Homo II show no distinct morphological characteristics. The pubic ramus is short and the pectineal line sharp and elevated. The symphyseal face of the pubic bone is rugged, and traversed by clear horizontal ridges separated by well marked grooves. This may indicate a relatively young age of this individual — according to Todd's (1920) method, no older than 24 years of age. A clear bony ridge, continuous from the ischial tuberosity on the inferior surface of ischiopubic ramus, is noted.

Large areas of both innominates of Homo XI were preserved, but neither could be completely reconstructed. Both are very small, although no precise measurements could be taken. The greater sciatic notch is wide postero-infero-medially, indicating that this individual was probably a female. A small depression below the inferior border of the auricular surface marks the beginning of what would have later developed into the preauricular sulcus. The diameter of the acetabulum is approximately 50 mm.

Bone pathology

A. *Spine Deformity*

In three adult individuals, clear spine pathologies were observed.

Homo VIII. A pathological condition appears in the first lumbar vertebra. Regrettably, it is the only vertebra of that type fully preserved — the other three complete vertebrae are all cervicals. A defect in the vertebral body formation anteriorly is clearly visible (Figs. 26 and 27). The superior and inferior surfaces of the vertebral body are smooth, extremely short, and bevelled anteriorly. There is no bone fusion and the spinous and transverse processes are normal. In two other lumbar vertebrae, the inferior articular surfaces are eroded. Also, advanced vascularization is present on the inferior surface of the sixth cervical vertebra. The first two cervical vertebrae appear more robust than usual, although no pathological condition could be discerned. The fact that a lesion was observed in one of the upper lumbar vertebrae, that only the body was involved with no extension

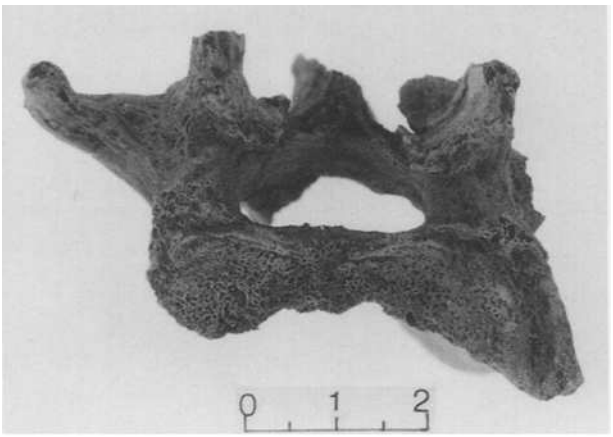

Fig. 27 - Homo VIII lumbar vertebra, anterior view.

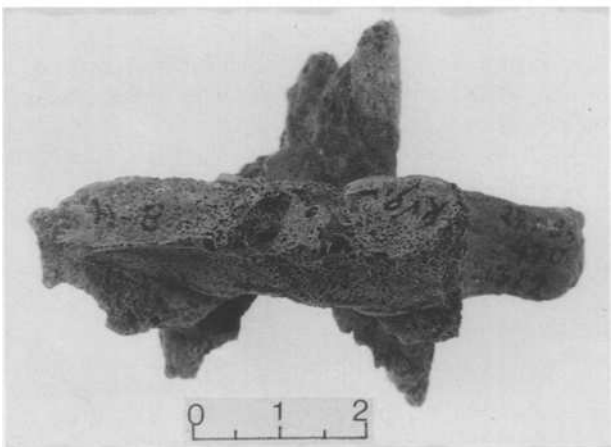

Fig. 26 - Homo VIII lumbar vertebra, vertical view.

into the vertebral arch, that the spinous process was not destroyed, and that there is no bone regeneration, may point to a congenital spine deformity of a particular type — kyphosis due to failure of vertebral body formation.

Homo I. This individual presents an unusual case of spondylolysis. The arch defect is on the fifth lumbar vertebra. The arch is completely free of the vertebra, with a break at the inferior margin of the superior articular surface rather than at the pars interarticularis, as is usual (Fig. 28). The broken edges of the bone exhibit considerable remodeling, indicating that separation had occurred quite some time before death. There is no bone reaction at other areas of this vertebra, or in any other vertebra of this individual.

B. *Long Bone Pathology*

No severe pathologies were observed.

At the distal end of the humeral shaft of Homo IX, towards the lateral epicondyle (above the radial fossa), there is a rugous area encircled by a small and curved ridge (Fig.

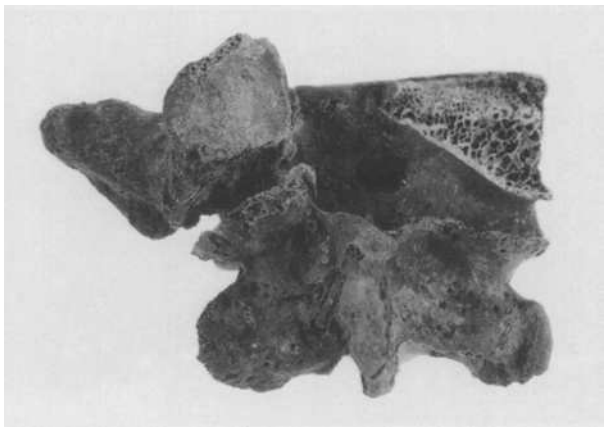

Fig. 28 - Homo I fifth lumbar vertebra, posterior view.

21). At its most lateral part, a small exostosis is present. The pronounced medial curvature of the shaft probably also represents some kind of pathological condition (as yet of unknown etiology).

On the femoral head of Homo VIII, directly below the fovea, a clear semilunar impression is observed. Since the articular surface over the entire head is smooth with no additional signs of pathology, it seems likely that partial necrosis may be responsible for the pathology.

Local periostitis is noted on the distal tibial shaft of Homo XII.

C. *Skull Pathology*

The only pathological condition that could determined is the auditory exostosis present in the Homo VIII skull (Fig. 29).

Fig. 29 - Homo VIII left temporal bone.

Stature

Only Homo I presents several complete long bones, from which accurate estimations of stature can be made. Stature estimations for Homo II, IX and XIII, all males, were calculated from estimated total bone length (from fragments; Steele, 1970).

Compared to other PPNB females (Hershkovitz et al., 1986), the Atlit Homo I female manifests an extremely low stature of only 144 cm (±3.72); the males are much taller in comparison: Homo II, 163.6 cm (±4.41); Homo IX, 167.7 cm (±5.3); Homo XIII, 165.4 cm (±5.31).

Dental wear by tooth class

Incisors

The 15 incisors in this sample range in wear stage from 2 to 7 (according to Holly Smith's method, 1984). In general, the type of incisal wear found is within the category that would be considered «normal». Most wear is level with the incisal plate and flat.

A few teeth show unusual wear patterns. In Homo VIII the left 22 has considerable lingual wear; the dentin exposure is also lingual, and not on the incisal plane. Cervically, at the junction between the root and crown, there is a large, concave exposure of dentin. This type of wear may be associated with chronic overbite. The extreme lingual attrition was probably due to the continual occlusion of the lower incisors or canine. This same type of extreme lingual wear is also found on the left upper canine (Fig. 14).

Other incisors also exhibit unusual types of wear. In Homo II, the right central maxillary incisor has a «notched» occlusal edge. Molnar (1971) describes this type of incisal wear as the '65'pattern. In Homo IX the upper central incisors show marked wear and exposed dentin «cups» cervically. This is probably also due to an overbite. Unlike Homo VIII, however, this specimen has most of the mandibular front dentition. The lower incisors of Homo IX are well worn (stage 5, according to Holly Smith, 1984), and have a very slight, labially sloped, incisal edge. There is no evidence that the labial surface of the upper incisors contacted anything other than the incisal surface of the lower teeth. The right I2 of Homo IX is also notched, and the incisal surface slopes sharply upward and outward.

Canines

Nine canines are present, showing wear stages from 2 to 7. In general, with increasing wear, the pointed cusps are worn down to give the canine a flat and distally sloping occlusal surface.

In Homo I, the right canine and 22 both have small labial facets adjacent to the occlusal plane (Fig. 30). Although the left canine is missing, the left 22 does not show labial wear to the same degree. On the maxilla, however, the left canine is more worn lingually than the right one. The two lateral incisors show equal wear. This may be evidence of a slight overbite and that, considering the individual was a young adult, the teeth may not have had time to form wear facets in response to a particular wear pattern.

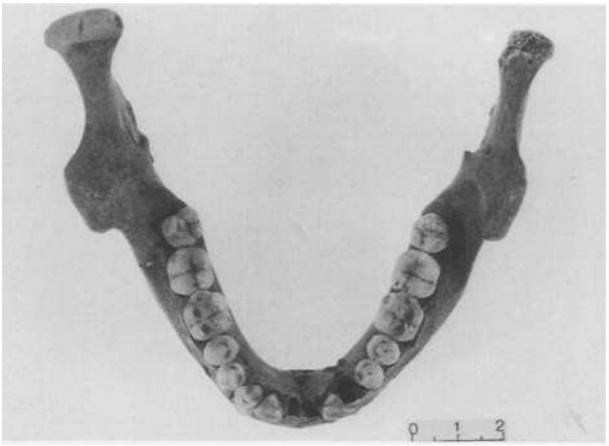

Fig. 30 - Homo I mandible, vertical view.

Premolars

There are 21 premolars in this sample, both upper and lower teeth. The premolars ranged in wear stage from 1 to 7 (Holly Smith, 1984). In general, the premolars follow a wear pattern in the formation of a typical helicoidal plane (Hall, 1977; Butler, 1972): The mandibular premolars are first lingually oriented (sloped); then, as they become worn, they pass through a stage in which they are nearly flat, and finally become buccally sloping. Maxillary premolars, on the other hand, remain lingually oriented even in advanced stages of wear. Unfortunately none of the upper premolars in our sample are in advanced stages of wear (5-8), and therefore, we cannot check this phenomenon. However, it is easy to discern the lingual-to-buccal slope change in the lower premolars.

Lower molars

The molar specimens range in wear from stage 1 to 8. As in the premolars, they follow the pattern typical of the formation of the helicoidal plane (Hall, 1977; Butler, 1972). Upon eruption, the lower molars are flat or slightly sloped lingually. As wear advances, these teeth acquire a buccal orientation. Different stages of this process can be seen on the molars of the Atlit-Yam people.

In Homo XI, the first lower molar exhibits almost no wear.

In Homo I, a young adult, the protoconid, hypoconid and hypoconulid of both lower first molars are worn down to the dentin, while the lingual cusps are still high and barely worn.

In Homo IX, a relatively old individual, the third molar is heavily worn, with exposure of dentin on three of the four cusps (Fig. 31). The wear is extreme (stage 8) on the first molar, but less so on the second (stage 6). Both of these teeth are worn down so that they slope buccally and distally. The highest point on the teeth, and the one with the greatest amount of enamel still remaining, is the mesio-lingual cusp, metaconid. The tooth showing the greatest buccal slope is M1, followed by M2, and then M3. This is to be expected since the formation of the helicoidal plane is dependent on the amount of wear on the tooth, and the first molar, in normal mandibles, is always more worn than either M2 or M3.

Fig. 31 - Homo IX mandible, vertical view.

Upper molars

Ten upper molars are present.

In Homo IV, a juvenile, aged about 11 years, the first and second molars are erupted, and the third molar crown is complete (Fig. 32). The first right deciduous molar is worn such that it slopes lingually. Protocone and hypocone have been worn down so that a large band of dentin has been exposed lingually. The two dentin exposures, one linguo-mesial and the other linguo-distal, are separated by an enamel ridge running transversely across the tooth.

The maxillary molars of Homo II exhibit more wear than those of Homo IV, since the former is a mature adult specimen; all molars are erupted and worn. The wear on the first molars is mainly linguo-mesial. The teeth are lingually oriented in the helicoidal plane. Although the teeth are worn more lingually, the buccal cusps are also worn so that dentin is exposed on all cusps on the right M1, and on three of the four cusps on the left

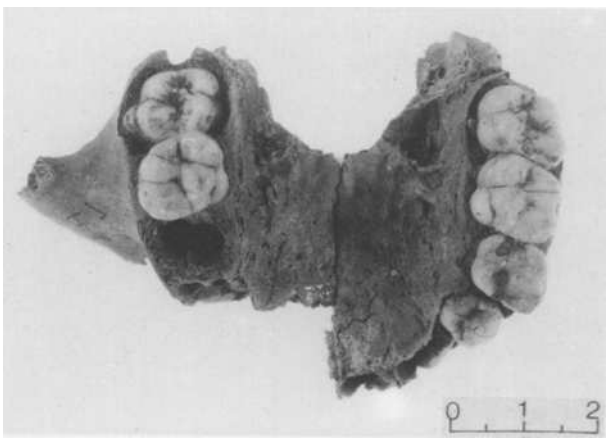

Fig. 32 - Homo IV maxilla, basilar view.

M1. The second and third molars are also generally worn flat and slope lingually. The buccal cusps are moderately worn, some having exposed dentin. The lingual cusps have a high degree of exposure and are in generaly worn linguo-mesially.

Dental pathology

By far the most common pathology found in the Atlit-Yam specimens is calculus, or plaque. The majority had calculus on at least one tooth, and many had several teeth affected. Another fairly common pathology of the teeth was enamel hypoplasia, which is usually used as an indicator of childhood morbidity and malnutrition. It is presented by two or three lines on the incisors and canine of Homos I, II and IX, indicating repeated developmental interuption, and by at least one line on Homo VIII's teeth. In spite of the numerous teeth found in the site, only one (the upper right first molar) was affected by caries (Fig. 33), a suprisingly low incidence. At the roots of this tooth an abscess developed. Alveolar resorption is also very common and is visible in varying degrees in all of the adult specimens (e.g. Fig. 17).

Two individuals show clear signs of pre-mortem tooth loss (e.g. Fig. 14). Homo VIII exhibits major tooth loss associated with alveolar resorption in the maxilla. This individual has two teeth remaining in their sockets, the canine and the third molar on the left side. The first premolar socket is unresorbed, indicating post-mortem loss. The sockets for the second premolar to the second molar are absent, and the alveolus has been almost entirely resorbed around them, indicating their loss premortem. Also, the third molar has been heavily worn and tilts sharply anteriorly, which means that at least the molars may have been missing for a relatively long time pre-mortem.

Homo II also shows pre-mortem tooth loss. This specimen consists of only a piece of the right mandible, approximately 5 cm long, with a second molar still in its socket. The first molar is missing and its socket has been completely resorbed.

Enamel chippiing was also frequently observed in the adult specimens. Measurements appear in Table 6.

In sum, the Atlit-Yam population is characterized by low stature, marked sexual dimorphism expressed by the extreme gracility of the females and the relative robusticity of the males, and by relatively poor health. The flattening of the long bones, together with

Fig. 33 - Incidence of caries in the first right upper molar of Homo I.

TABLE 6 - *Measurements of the permanent teeth from Atlit-Yam****.

MANDIBLE	Homo I (female)		Homo II (male)		Homo IX (male)		Homo XII (female)	
	BL	MD	BL	MD	BL	MD	BL	MD
I1	5.63	6.18	6.20	4.31	6.95	5.35	—	—
I2	7.42	6.26	5.41	5.90	6.78	5.84	—	—
C	6.43	6.20	8.36	6.64	8.51	5.94	7.09	6.25
Pm1	7.50	6.23	—	—	8.80	6.96	7.25	6.88
Pm2	10.30	11.08	8.10	6.58	9.15	7.30	7.90	7.15
M1	9.86	10.48	11.66	11.81	10.95	9.75	9.87	11.63
M2	8.97	8.46	11.03	11.71	10.91	11.51	—	—

MAXILLA	Homo I (female)		Homo II (male)		Other-mixed		Homo IV (child)	
	BL	MD	BL	MD	BL	MD	BL	MD
I1	6.72	8.61	7.04	8.51	—	—	—	—
I2	6.13	6.54	6.64	6.49	6.48	7.01	—	—
C	8.20	7.28	9.40	7.24	8.90*	—	—	—
Pm1	8.56	6.13	9.78	7.31			9.26	7.62
Pm2	9.32	6.47	10.38	7.41			—	—
M1	10.72	10.10	12.28	10.60	11.65**	10.05**	2.53	11.29
M2	10.82	9.61	12.43	10.20	—	10.24**	2.80	10.60

* From Homo VIII (male)
** From Homo VI (sex undetermined)
*** When teeth of both sides were present, the average was calculated

overdevelopment of certain bony regions, may indicate a certain type of occupation. In regard to the teeth, incidence of carious lesions and abscesses are surprisingly low, and calculus formation and alveolar resorption are quite common. From the rate of enamel hypoplasia, it may be theorized that the children suffered repeated episodes of insufficient food supply. The small sample (15 specimens), and the fact that skeletons of newborns and infants are underrepresented in the collection, prevent any valid paleodemographic analysis of the population.

Discussion and Conclusions

Food Producing-Economy

The Land of Israel can be roughly divided into four major topographical and climatological regions: the coastal plain, the elevated regions (central and northern parts),

the Jordan Valley and its fringes, and the Negev (southern desertic) region. In the course of economic transition towards a food-producing economy at the end of the Pleistocene to Early Holocene (ca. 12,400-8,000 yrs. B.P.), differential use of the land in each region began, dependent on the specific advantages that each area could offer. In addition to those plants which are common to almost all PPNB sites, each region presents plants which are unique or predominant. For example, in Yiftahel in the Lower Galilee, the most common plants are legumes, horsebeans and lentils (Hershkovitz et al., 1986). The thousands of grains found in the Atlit-Yam site belong mainly to the primitive, hulled emmer wheat variety (*Triticum dicoccon*), which was the principal wheat species in the PPNB period.

Besides their newly developed food-producing economy, the PPNB people continued to practice hunting on a large scale (Horwitz, 1989). The faunal assemblage in Atlit-Yam is dominated by goat (*Capra sp.*) (45%), followed by cattle (*Bos sp.*) (43%) and pigs (*Sus scrofa*) (9%). Scanty remains of mountain gazelle (*Gazella gazella*) (3%) and deer (*Dama mesopotamia*) (0.3%) were also found. The goat and cattle remains were all of wild animals (Horwitz and Tchernov, 1987). Worth noting is that in many PPNB sites, such as Jericho, Beisamoun and Abu Gosh, there is clear evidence of domesticated animals, while other contemporaneous sites, such as Horvat Galil, Nahal Betzet and Yiftahel, show no such evidence (for review see Horwitz, 1989).

However, the location of the Atlit-Yam population along the sea shore opened a third economical alternative for them — exploitation of sea food resources. The many sea fish bones found in numerous prehistoric sites in Israel, several dated earlier than the Atlit-Yam site (e.g. Hayonim cave) clearly indicate that Levantine man took advantage of these food resources very early in prehistory. The question remains, however, whether the sea shore inhabitants developed proper technology for deep sea fishing (sturdy boats, fishing nets, etc.) during the PPNB period. Thus, we looked for evidence of a sea diet, and of possible rowing activity in the Atlit-Yam skeletal remains.

Diving

A long bony ridge within the posterior part of the external auditory canal, probably auditory exostosis, is observed in one of the Atlit-Yam skulls. According to most recent studies (Kennedy, 1986), the highest frequency of auditory exostosis is found among populations who exploit either marine or fresh water resources. Based on vast clinical and experimental data, Kennedy reached the conclusion that there is a causative relationship between the formation of auditory exostosis and exploitation of resources in cold water, particular through diving. Since the «thermal aquatic hypothesis» is widely accepted (see Di Bartolemeo, 1979 for review), it is tempting to attribute the present case to Atlit-Yam man's activity in fishing and diving. This fits well within the picture of economical activities we have attempted to reconstruct here. In this respect, however, a word of caution is due: in Yiftahel, an inland site contemporaneous with Atlit-Yam in the Lower Galilee of Israel, one case of auditory exostosis was also observed! It may be, however, that this lesion, considering its unusual size and location, was the result of a chronic ear infection. A suitable location for diving was the large shallow lagoon which stretched between the present location of the Atlit-Yam site and the now submerged kurkar ridge further west.

If we regard the present case as indirect evidence of marine activities among the Atlit people — the location of their settlement along the coast supports this theory — then we

might go one step further and conclude that it was the males, and not the females, who were involved in marine exploitation. This agrees with vast ethnographical data (cited by Kennedy, 1986) which clearly show that among most human groups engaged in fishing, the males are predominantly responsible for the livelihood of the population. Occurrence of auditory lesions has already been noted in fossil hominids (e.g. Shanidar I: Trinkaus, 1983) in the Old World and among prehistoric North American Indians (8350 ± 75 y. B.P.) in the New World. Both the Californian Indian and the Atlit-Yam people inhabited coastal areas and present some of the earliest biological evidence for man's exploitation of available marine resources through diving. Recently, Frayer (1988) reported on this type of lesion among prehistoric populations living along the Danube River, and also attributes its presence to diving for catch.

Food Collection Through Diving

Even today, when fishes and other marine animals are less abundant than during Neolithic times, a few hours of free diving are sufficient to collect sea food for a reasonable meal for an entire family. Undoubtedly, during the period when the village of Atlit-Yam was inhabited by prehistoric men, and when the sea along the Eastern Mediterranean coast was much richer in marine life, diving with bare hands or sharp sticks was apparently adequate to collect reasonable amounts of food in a relatively short time. The thousands of seashells scattered today along the Israeli shore is the silent evidence remaining of the abundance and richness of marine life in shallow waters in past ages. Besides crabs, snails and sea urchins which still exist today, the Atlit-Yam man also could easily collect oysters (*Pectunculus glycimerulus*), once common along the Israel coast, but now almost extinct there. In a few hours of fishing activity, including diving, the Atlit-Yam men were able to collect sea food sufficient to fill his family's daily protein requirements. Fishing was probably done along the abraded kurkar ridges and in the shallow lagoon, where many marine species lived. Analysis and identification of fish bones found in the village show that the most abundant fish (80% of all fish bones) was the triggerfish (*Balistes carolinensis*), common along reefs in all parts of the world. The adults can attain a considerable size, and are characterized by very hard and strong skin which can be used for manufacture of sandals, baskets, containers, etc., as even among Polynesians today.

Fishnet Production and Dental Wear

The Homo VIII specimen from Atlit-Yam provides strong evidence that molar teeth may have been used in a cultural context, i.e. not only for chewing food. It consists of a left mandible with condyle, coronoid process and ramus nearly complete, and the posterior portion of the body until Pm3, and four teeth, Pm4-M3, of which Pm4 and M1 are burnt and broken and the top half of M2 is also broken off. The left maxilla has three teeth remaining in the sockets, the canine, lateral incisor and the third molar.

The upper lateral incisor and canine show extensive lingual wear and lingual dentin exposure. On the incisor, a concave «cup-like» exposure is formed, and the entire lingual surface of the canine is completely lacking in enamel. These features strongly indicate an extreme overbite (maxillary overjet) in this individual.

The Pm4 socket is still intact and unresorbed, indicating that this tooth was lost post-

mortem, or just before death. The sockets for the first and third molars are almost totally resorbed, an indication that these teeth were lost antemortem, but not so long before death that the sockets were able to be completely resorbed.

The third molar exhibits very unusual wear. The mesial portion of the tooth is normal and only slightly worn; the distal occlusal portion, however, is completely worn away. The angle of this wear facet is nearly perpendicular (about 70 degrees) to the occlusal plane. Unlike a normal pattern of wear in which the tooth is worn either buccally or lingually, the wear here is almost entirely distal. The distal half of the tooth consists mostly of exposed dentin worn at an extreme angle from the occlusal plane. This wear is so advanced that a portion of the tooth root is also involved. The exposed surface is slightly concave, angled somewhat disto-lingually, and has no apparent pattern of scratch or wear marks; the surface appears smooth and polished.

The mandibular second and third molars also show unusual wear. The third molar has almost exactly the same type of wear as that found on the maxillary third molar, except that it is oriented on the mesial part of the tooth and slopes sharply downwards buccally. Like the upper M3, the wear surface appears relatively smooth and polished, and the entire crown, from cusps to root, is involved in this wear facet. The second molar is worn in the same manner. The curved wear facet slopes downward disto-buccally. If it were not broken, it is evident that this tooth, together with the adjacent M3, would form a single semi-lunar facet sloping buccally. This facet is worn more buccally than lingually, meaning that the semi-lunar (circular) «notch» is wider buccally, and narrows and slopes upwards lingually.

We suggest, then, that this wear type is probably artificial and was caused by continuous action of ropes or thin leather straps being pulled between the teeth. Since Homo VIII was probably handicapped in that he may have suffered from severe kyphosis, it may be postulated that his contribution to his group may have been to make baskets or nets, an activity which could be performed while sitting. It appears that he first used his anterior teeth, and when he lost the antagonist teeth on the maxilla as a result of overuse, he began using the less convenient posterior teeth. The finds in the present site, as well as in others (e.g. Nahal Hemar), clearly demonstrate that PPNB man could produce cordage from very fine string to thick rope (Bar-Yosef, 1985), from which he could construct baskets, containers and mats. His knowledge in weaving technique undoubtedly enabled him to produce also fishing nets.

The people of Atlit-Yam were probably successful hunters, fishermen and farmers, as evident from the vast amount of faunal and floral remains. The different economic strategies enabled them to balance their diet (humans cannot survive on animal protein alone; Noli and Avery, 1988) and to cope better with the changing climatic conditions throughout the year.

Population Continuity

Paleoenvironmental reconstruction (Galili and Weinstein-Evron, 1985) of the Nahal Oren region in the Natufian period presents a picture of fresh water swamps which stretched from the present coastline to the eolianite ridge further west, and now partially under water. This explains why the main Natufian sites in that region are located mostly on the slopes of Mount Carmel, rather than in the fertile valley below. Only later, during the PPNB when the marshes dried up either as a result of sea regression or tectonic movement accompanied by westward downwarping, was man able to leave his former

dwelling places and settle along the coast. However, with the continuous rise in sea waters (which began 20,000 years ago, at which time the sea level was 160 m lower than at present), these new sites had to be abandoned. Considering the regional and time proximity between the Neolithic and Natufian sites, it is logical that some of the morphological characteristics of the Atlit-Yam people would point to biological continuity from Natufian to Neolithic populations in that region. To test our theory, we decided to perform some metrical and morphological comparisons between the Atlit-Yam group and the Natufians of Nahal Oren.

The site of Nahal Oren (Wadi Fallah), located 2 km. east of Atlit on the slopes of Mount Carmel, is among the largest prehistoric sites excavated in Israel (Noy et al., 1973). The time span of its occupation ranges from Late Epipaleolithic to the end of the pre-pottery Neolithic period. More than 50 skeletons have been uncovered there, but only skulls of the Natufian period have been studied and published (Crognier and Dupouy-Madre, 1974).

Metric comparison of the Atlit-Yam and Nahal Oren female skulls (Table 7) shows a similarity in certain traits (minimum frontal breadth, nasal breadth, and orbital height) and great discrepancy in others (calvarian bone indices, nasion-prosthion height, nasal breadth, and orbital breadth). However, any differences and/or similarities in skull measurements should be regarded with caution since sample sizes were small. Nevertheless, we may conclude that the Atlit-Yam females manifest, in general, a smaller skull, lower face, more squared orbits, and a relatively narrow nasal aperture. Morphologically, the Atlit-Yam female skull, mainly that of Homo I, clearly presents some «Natufian» traits (as defined by Arensburg, 1981; Ferembach, 1977; and others): a large interorbital region, a low and narrow nose, a depressed nasion, a rounded lateral margin of the orbit, and thick inferior surfaces of the zygomatic bone. The morphological and metrical resemblance between the two groups is more prominantly seen when we compare the mandibles (Table 7). For some reason, the Atlit-Yam mandibles are more «Natufian» in their general appearance than the skulls, having a low and broad mandibular ramus which extends almost vertically even among the females, and with reduction in corpus height anterio-posteriorly. Morphologically they manifest all major «Natufian» characteristics: a short and wide coronoid process with marked thickening of its anterior border, a pointed chin, and a shallow mandibular notch. As for the teeth, both populations present advanced attrition already at a young age, although the Atlit-Yam people lacked the peculiar wear pattern of the Natufians. More interesting and significant is the presence in the maxilla of Homo IV of a pronounced carabelli cusp, also a typical Natufian trait (mainly in El-Wad), and the congenital absence of the third molar, a phenomenon common in Natufian skulls from Hayonim and Nahal Oren (Smith, 1973).

Regarding the limbs, both the Atlit-Yam and Natufian populations present a high incidence of a third trochanter.

Based on the observed morphological resemblance between the Atlit-Yam and preceding Natufian groups, we may conclude that the Nahal Oren region was inhabited continuously by basically the «same» human group during these two periods. The Atlit-Yam people, besides their archaic («Natufian») traits, also present, as expected from changing diet and microevolutionary processes, other characteristics which are different from those of their ancestors. Hence, we can speak of temporal continuity in the Nahal Oren region accompanied by morphological changes. In addition, in many respects the Atlit-Yam people closely resembled contemporaneous Neolithic groups inland — the overall marked robusticity of Homo II, for instance, is a common morphological feature among Nahal Oren and Abu-Gosh males.

TABLE 7 - *Comparison of some skull and mandibular measurements between Nahal Oren and Atlit-Yam females (in mm).*

Characteristic	Nahal Oren*			Atlit-Yam		
	H24	H42	H34	H48	HI	HVI
Skull						
Minimal frontal	92.0	—	91.0	91.0	92.0	—
Frontal index	—	—	83.6	88.6	84.6	—
Parietal index	—	91.1	86.2	—	89.0	—
Occipital index	—	—	80.8	84.7	88.0	—
Nasio-prosthion	69.0	65.0	—	59.0	59.0	59.0
Biorbital breadth	—	—	—	97.0	91.0	96.0
Interorbital breadth	—	21.0	—	22.0	29.0	—
Nasal height	50.0	48.0	—	45.0	39.0	46.0
Nasal breadth	—	28.0	—	26.0	25.0	26.0
Nasal index	—	58.3	—	57.8	56.5	56.5
Orbital heigth	30.0	28.0	28.0	28.0	30.0	29.0
Orbital breadth	44.0	40.0	40.0	38.0	37.0	37.0
Orbital index	68.2	73.7	70.0	—	81.1	78.4
Mandible						
Maximum length	—	98.0	—	—	93.0	92.0
Body length	—	70.0	—	—	69.0	72.0
Bicondylar breadth	—	119.0	—	—	109.0	—
Bigonial breadth	99.0	90.0	—	—	91.0	—
Symphyseal height	32.0	32.0	26.0	—	30.0	35.0
Height at Pm2-M1	30.0	30.0	29.0	—	27.0	27.0
Height at M1-M2	25.0	27.0	28.0	—	25.0	25.0
Height at M2-M3	26.0	25.0	24.0	—	23.0	—
Gonial angle (degrees)	140.0	124.0	—	—	121.0	114.0
Ramus height	—	58.0	—	—	48.0	53.0
Ramus width	32.0	35.0	—	—	36.0	34.0
Ramal index	—	60.3	—	—	75.0	64.1
Length-breadth index	—	82.3	—	—	85.3	—

* Natufian, after CROGNIER & DUPOUY-MADRE, 1974

Seafaring

The time of initial settlement of Mediterranean islands is still questionable. According to several scholars (Perles, 1979; Cherry, 1981, 1984) Paleolithic man had sufficient boat technology for overseas travel, but the colonization of Mediterranean islands is a post-Pleistocene phenomenon, a rather recent event in mankind's history. It was Neolithic man, some 8000 years ago, who first invaded the islands, taking with him domesticated animals, and establishing the first farming communities there (Evans, 1977; Cherry, 1981; etc.). An exception may be the island of Sardinia where, according to paleontological evidence only (type of faunal equilibrium), Middle Pleistocene hunters had already visited the island (Sondaar et al., 1986). However, the oldest human remains found on this island (Grotta di Corbeddu, Oliena) are dated only to pre-Neolithic times (9120 ± 380 y. B.P.) .

TABLE 8 - *Metrical comparison between Khirokitia and Atlit female skulls and mandibles (mm).*

Variables	Khirokitia (1)		Atlit	Khirokitia	
	n	X	X	n	X
Cranial length	6	172.3	164	6	154.2
Cranial breadth	6	148.3	131.0	6	156.8
Minimum frontal	4	100.0	92.0	6	105.3
Zygomatic breadth	2	132.5	118.0	3	132.3
Upper facial height	2	67.5	59.0	2	68.0
Basion-nasion length	5	97.8	99.0	—	—
Orbital breadth	2	40.5	37.0	2	36.0
Orbital height	3	33.7	30.0	3	33.7
Nasal breadth	3	24.7	25.0	2	25
Nasal height	2	51.0	39.0	2	51.0
Interorbital breadth	6	24.0	29.0	2	28.0
Total facial height	2	111.0	101.0	2	118.0
Ramus height	3	50.0	48.0	6	49.2
Mandibular breadth	3	114.3	109.0	4	125.2?
Ramus breadth	5	36.4	36.0	6	33.2
Mandibular length	3	99.7	93.0	4	94.0
Cranial index	6	86.1	79.9	—	—
Fronto-parietal index	4	68.0	70.2	6	102.5
Cranio-facial breadth index	2	91.0	90.1	3	87.3
Facial index	2	83.8	85.6	2	90.5
Upper facial index	2	51.0	50.0	2	52.1
Nasal index	2	50.0	64.1	2	49.2
Orbital index	2	86.5	81.1	2	90.2

1 female with undeformed skull (ANGEL, 1953)
2 female with deformed skull (ANGEL, 1953)

The vast majority of human and cultural remains from Sardinia, as well as from Cyprus, are dated mainly to the Neolithic period.

An interesting question concerns the origin of the earliest inhabitants of Cyprus. If the Atlit-Yam people had the boat and shipping technology necessary to overcome the distance between the mainland and this island, they or their neighbors from the North may be a suitable candidate for the ancestors of the Cyprus population. To investigate the possibility of such a relationship, metrical and morphological data of both the Atlit-Yam and the Khirokitia skulls will be compared here (Table 8).

Colonization

Angel (1953) has already demonstrated that the Khirokitia skulls are unusual in their shape and size. He argued that all infants at the site were subjected to at least «perfunctory head-moulding» (p.416), and further claims that the resemblance in morphological detail between all Khirokitia skulls, together with the occasional sharply variant individual, presents strong evidence for «inbreeding in a small and parochial population which had few contacts with other breeding groups» (p.421). Angel does not mention any specific geographic region from which the Khirokitia founders may have arrived, but states that «the original source of the first Cyprus colonists' heterogeneity may have been a mixture

between a typical desert-zone linear group and one of stocky build derived from some colder, perhaps sub-glacial, habitat (with Neanderthal-sapiens mixture behind that)» (p.421).

Although differing widely in size and shape, the Atlit-Yam individuals manifest several morphological characteristics which largely resemble those found among the Khirokitia population, namely, the very low stature of the females (144 cm); the robusticity and flattening of the long bone shafts (cnemic index = 63.6, n = 8 in Khirokitia and 62.8, n = 3 in Atlit-Yam); the platymeric index (75.0, n = 7 in Khirokitia and 69.9, n = 2 in Atlit-Yam); the posterior convexity of the tibial shaft; the marked area of origin for the soleus muscle; the extremely short skull, a tendency exaggerated by artificial deformation among Khirokitia skulls; a vertical forehead; non-protruding brow ridges and depressed nasion; a flat and projected face; a wide space between the orbits and narrow nose; a short and broad mandibular ramus; and a square jaw.

At present, the Atlit-Yam skeletal remains are too meager to draw any definite conclusions. However, their morphological characteristics imply a possible biological relationship between the two groups. It is also possible that under similar environmental conditions, both groups developed very similar morphological traits. In any case, the chances of finding a group on the mainland morphologically identical to the Khirokitia population are indeed very slim. Angel (1953) argued that the original colonists who had established sites in Cyprus were «small groups or breeding units, who need not have been at all typical of the populations from which they came» (p.422). Based on the above findings, however, we believe that the Atlit-Yam people, and the PPNB populations in the southern Levant in general, are prime candidates for ancestors of the Cypriotic population. The presence of short and extremely broad skulls in other PPNB sites in Israel (e.g. skull 747.1 from Abu Gosh, which manifests cranial length of 170 mm and breadth of 143 mm) similar to those in the Khirokitian populations, and the fact that they already had the means for sea travel, support the above notion. In addition, the technique of artificial skull deformation, by which the Khirokitian people increased the brachiomorphic shape of the heads, was already practiced hundreds of years earlier by the Jericho population (Kurth and Röhrer-Ertl, 1981) and probably by the PPNB Abu Gosh people as well. If we do not properly estimate the boating technology and seafaring ability of the Levant PPNB people, they could easily have crossed the sea barriers between the eastern Medirerranean shores and Cyprus, and established new colonies there.

The continuing underwater survey and excavation of the Atlit-Yam site will undoubtedly throw more light on early coastal populations of the Mediterranean.

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