

Holocene Sea-Level Changes Based on Submerged Archaeological Sites Off the Northern Carmel Coast in Israel

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A series of submerged archaeological sites found on the continental shelf between Haifa and Atlit indicate a continuous marine transgression between 8000 and 1500 yr B.P. The sites are embedded in the upper part of a marshy clay that fills the trough between the coastal aeolianite (kurkar) ridge and a ridge now submerged some 1000 to 1500 m to the west. The submerged prehistoric sites belong to two main chronological units: Prepottery Neolithic B (8000 yr B.P.) and late Neolithic (ca. 6500 yr B.P.); these were found at depths of 12 to 8 m and 5 to 0 m, respectively. Bronze Age and Byzantine anchors were found at depths of 5 to 3 m and 4 to 1.8 m, respectively. As the archaeological materials are firmly dated, we can reconstruct the rate of marine transgression from 8000 yr B.P. to the present and the eastward movement of settlements through time as related to the transgression. © 1988 University of Washington.

INTRODUCTION

Submerged prehistoric sites from the Neolithic to the Bronze Age are quite common off the Carmel shore, especially along the northern stretch from Atlit to Haifa. The sites are embedded in the upper part of a marshy clay that fills the trough between the coastal aeolianite (kurkar) ridge and a ridge now submerged some 1000 to 1500 m to the west (Fig. 1). Later finds, from the Bronze Age on, have been discovered on top of this clay but never embedded in it. The sites are usually covered by sand, which is the main cause of their long-term preservation. Occasional storms temporarily expose the underlying clays and sites, but usually for a few days only. Rarely, exposure may be longer. Shortly after exposure the archaeological remains are threatened by marine abrasion. The aim of the present study is to reconstruct the stages and rate of the Holocene marine transgression in the area, as indicated by archaeological finds.

METHODS

The brief exposure of the sites and the danger of destruction necessitate rapid sur-

veying and rescue excavation. Surveying includes regular shore and sea patrols (by car or rubber boat) along the coast for location of newly exposed clay areas. This is followed by a scuba diving survey for the archaeological remains, which are registered and photographed as in land excavation. Site mapping is carried out with the aid of a metric (scaled) base line, anchored and buoyed at both edges. The buoys also allow mapping of the site within an area context. Limited excavations are done by a small dredger connected to a water pump on a rubber boat. Samples for ^{14}C dating, and sedimentological and palynological analyses are collected from each site. All this activity is mainly the responsibility of the first author.

So far only one site (Atlit-Yam) has been exposed long enough to permit a systematic excavation, in September 1986. A rope grid of 2×2 -m squares was fixed to the sea bottom, covering an area of 80 m². The covering sand and loose stones were then removed by the dredger. The surface of the underlying clay was thus exposed, and it was possible to trace clearly the plan of the structures embedded in the clay. Several loci were then excavated to a depth of 80

cm. The finds were recorded and collected by the divers, and all the sediments were collected and brought to be sifted on shore. This ensured the retrieval of small implements, bone fragments, plant remains, and grains.

SUBMERGED PREHISTORIC SITES

The submerged prehistoric sites have been classified as belonging to two main chronological units: Prepottery Neolithic B and late Neolithic.

Prepottery Neolithic B remains have so far been found only at the Atlit-Yam submerged site (Fig. 2), located 200 to 400 m off the present shore at a depth of 8 to 12 m. This is the earliest and deepest submerged site ever found off the Israeli coast. The survey and excavations revealed rectangular houses, round pits, hearths, paved floors, and brick walls. The lithic industry includes celts, sickle blades, arrow heads, and various stone tools. Five human burials were found within the site. Faunal remains are dominated by wild cattle, sheep/goat, and pig, together with scanty remains of mountain gazelle, deer, fish, and mouse (L. Kolska-Horowitz and E. Tchernov, personal communication, 1987). Floral remains include *Quercus calliprinos*,

Pistacia palaestina, lentil, and wheat grains.

Charcoal from two hearths gave ¹⁴C dates of 8140 ± 120 yr B.P. (RT 707) and 8000 ± 90 yr B.P. (Pta 3972).

Late Neolithic sites were found at Kfar Samir, Kfar Galim North, Hahotrim, Tel Chreis, and Megadim (Fig. 2), 0 to 180 m offshore at a depth of 0 to 5 m. Structures include floors and numerous stone pits. One pit in Kfar Samir is constructed of alternating wood and stone layers, a combination never found in any other prehistoric site in Israel. The pit was cleaned to a depth of 2 m below the clay surface (7 m below sea level); however, the pit could have reached below sea level at that time owing to the compact clay. Thus, the site position, rather than the pit bottom, will be used to infer corresponding sea level. At the site of Tel Chreis a unique wooden fence made of branches vertically embedded in the clay was found. Finds of the late Neolithic sites include stone tools, flint artifacts, and a few potsherds. Faunal remains include bones of wolf, gazelle, mole rat, wild cattle, domestic goat or sheep, wild boar, and birds. Floral remains include *Q. calliprinos*, *Pinus halepensis*, and olive pips. Wood and bone samples from these

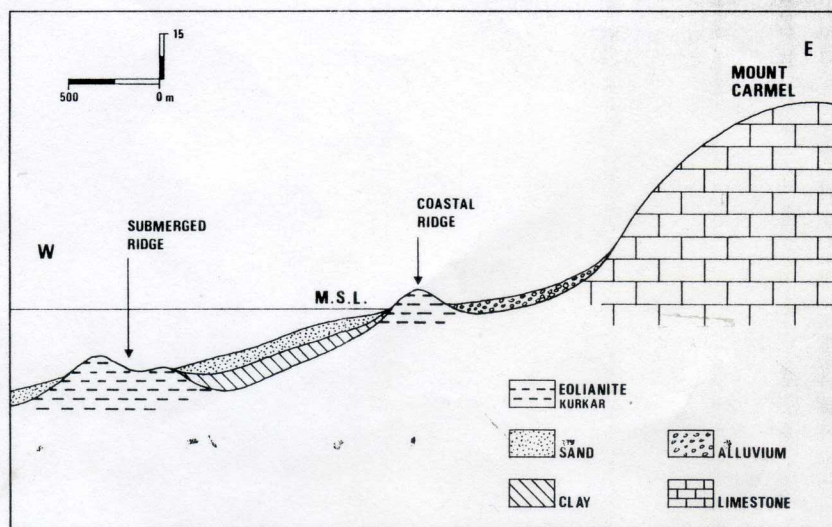


FIG. 1. Schematic stratigraphic section of the Carmel coast.

DOES
DOMESTICATED

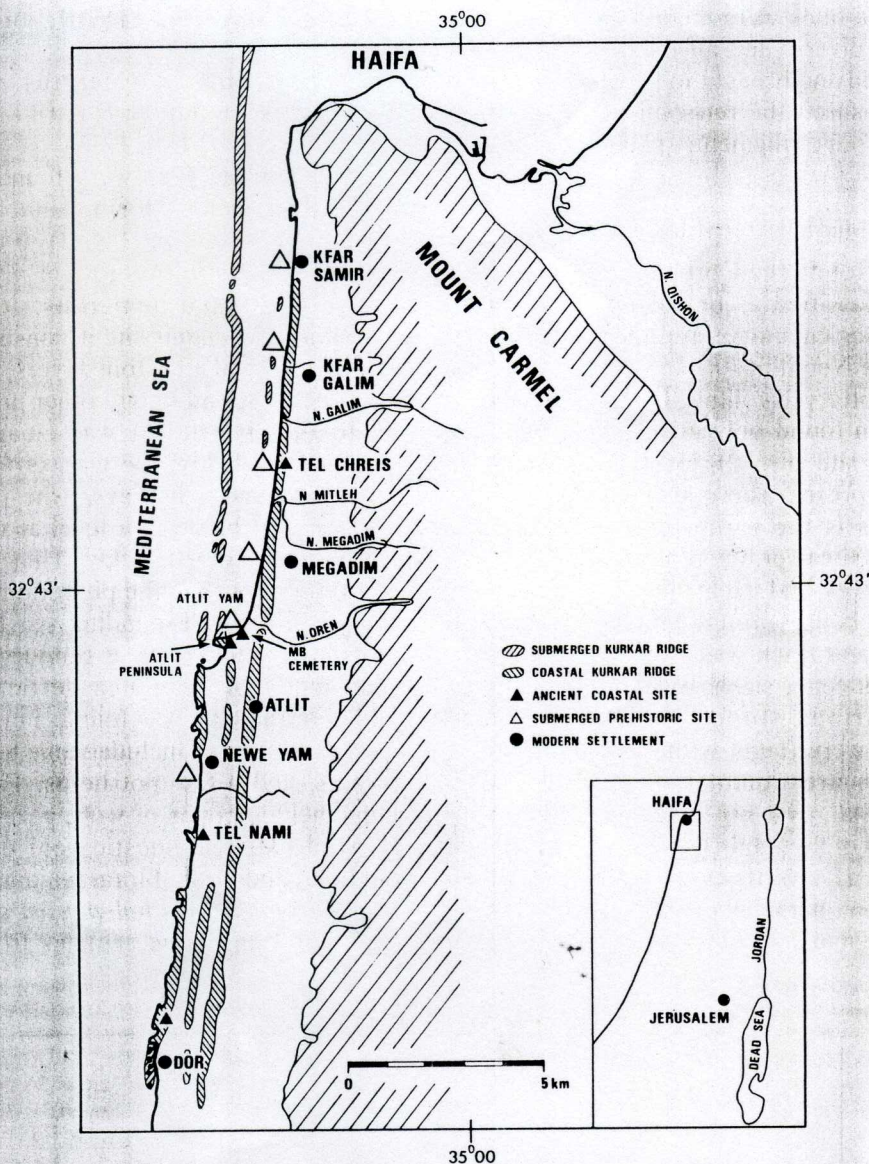


FIG. 2. Map showing location of sites referred to in the text.

sites gave ^{14}C ages of 6830 ± 60 yr B.P. (Pta 3821), 6830 ± 80 yr B.P. (Pta 3820), 6310 ± 70 yr B.P. (Pta 3648), and 6270 ± 50 yr B.P. (Pta 4339). An organic clay sample from Megadim site was ^{14}C dated to 7060 ± 70 yr B.P. (Pta 3652).

The Tel Chreis site was previously referred to as Chalcolithic and early Bronze Age (Ronen and Olami, 1978; Olami, 1984; Raban, 1983; Galili, 1985a; Galili and Weinstein-Evron, 1985). According to the new ^{14}C date of the wooden fence, its

deeper, western area belong to the late Neolithic period.

Another late Neolithic site with similar features was found at Newe-Yam, south of the Atlit peninsula, at a reported depth of 0 to 1 m below sea level (Wreschner, 1983), but subsequent storms and surveys have shown that this site also extends to a depth of 5 m, like the sites north of the Atlit peninsula (Galili, 1985a).

Considering the elevation of recent coastal settlements in the eastern Mediter-

anean, we may assume that the elevation of coastal settlements in any particular period must have been at least 2 to 3 m above the sea level corresponding to that period. Thus, maximum values of 14 and 7 m below present sea level are estimated for the above-mentioned prehistoric settlements (Fig. 3).

HISTORICAL SHORELINE MARKERS

The earliest historical remains pertinent to our study are an early to middle Bronze Age cemetery at Atlit extending from the present shoreline to an elevation of 2 m above sea level (Ronen and Olami, 1978; Raban, 1983). A group of middle Bronze Age anchors provide the oldest evidence of seafaring in the area 3800 to 4000 yr ago and are the earliest archaeological finds discovered on top of the clay, rather than embedded in it. The anchors were found at Newe-Yam, some 4 km south of Atlit, 90 m offshore, and at a depth of about 3 m (Galili, 1985b).

Numerous late Bronze Age anchors occurred off the northern Carmel coast at depths of 3 to 4.5 m. Byzantine and later iron anchors and cargoes (ca. 1500 yr B.P.

on) have been found at a depth of 1.8 to 3 m. Observations of recently wrecked ships along the Israeli coast show that the hulls and much of the cargo is finally deposited at a shallow depth of about 1 to 0.5 m. Therefore, it seems reasonable to assume that the eastern dispersal line of heavy objects submerged at any particular period is located close to the shoreline of that period. The fact that Bronze Age objects are found at a depth no less than 3 m suggests that sea level then lay some 1 to 1.5 m lower than today, and the shore line was 60 to 80 m west of the present shore. This conclusion is in accord with the location of the Bronze Age cemetery mentioned. Byzantine cargoes found at a depth of 1.8 m suggest, for the first time, a sea level approximately equal to the present one at about 1500 yr B.P. (assuming that in antiquity there was approximately 1 m of sand on top of the clay, as at present).

DISCUSSION

The archaeological data, their absolute dates, and their depths enable us to reconstruct the rate of marine transgression from the ninth millennium B.P. to the present (Table 1). The line joining the loci forming the curve in Figure 3 is an estimate; other interpretations are also possible. Unknown factors such as changes in tides and changes in the thickness of the sand layer make it impossible to reconstruct minor changes in sea level. Thus, sea-level fluctuations in the Holocene, as suggested by Ronen (1983) on the basis of alternating sand and loam layers in coastal cliffs, could not be tested by the present study. However the points are joined in our curve, its general shape and the rate of sea rise will not be greatly altered. The curve describes a continuous rise of sea level from 8000 to 1500 yr B.P., within which there are two main stages: Between 8000 and 6000 yr B.P. sea level rose at a mean annual rate of 5.2 mm; from 6000 to 1500 yr B.P. the mean annual rate fell to 0.9 mm.

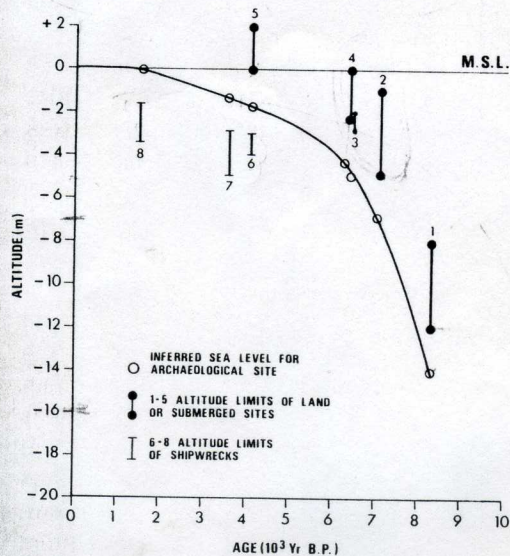


FIG. 3. Curve of Holocene sea-level changes in the northern Carmel area based on archaeological data.

Figure 4 compares the curve of the

TABLE 1. AGE, DEPTH, AND INFERRED SEA LEVEL FOR SUBMERGED ARCHAEOLOGICAL SITES OFF THE CARMEL COAST OF ISRAEL

| Submerged sites | Age (¹⁴ C yr B.P.) | Depth (m) | Inferred sea level (m) |
|------------------------|-----------------------------------|--------------|---------------------------|
| Atlit-Yam | 8140 ± 120 | -12 (max) | -14 |
| Kfar Samir | 6830 ± 60 | -5 (max) | -7 |
| Megadim | 6310 ± 70 | -3 (max) | -5 |
| Tel Chreis | 6270 ± 50 | -2.5 (max) | -4.5 |
| Atlit cemetery | ca. 4000 | 0 (max) | -1.5 |
| Newe Yam anchors | ca. 3800 | -3 (min) | -1.5 |
| Late Bronze anchors | ca. 3500 | -3 (min) | -1.5 |
| Byzantine Iron anchors | ca. 1500 | -1.8 (min) | 0 |

northern Carmel coast with the global average band constructed from several curves taken from regions not affected by glaciation (Van Andel and Lianos, 1983) and with the curve of changing sea level at Tel Dor (Sneh and Klein, 1984). The northern Carmel curve closely parallels the global band and matches its upper section. The sea-level model suggested by Clark *et al.* (1978, Fig. 19) predicts greater depths than our observed data, except from 3000 yr B.P. on.

The Dor curve covers the last 4500 yr. It coincides with the northern Carmel coast

curve between 4500 and 3000 yr B.P. About 2000 yr B.P. the Dor curve shows a fluctuation which reaches a height of 1.5 m above sea level; this has no parallel on the Carmel coast. This fluctuation was defined on account of a number of structures found above present sea level at Dor which are believed to have been located originally at sea level. Because the function of these structures is unclear (Sneh, 1981), the fluctuation to +1.5 m is questionable.

Wreschner (1983) suggests a sea level of -5 m at about 7000 yr B.P. on the basis of his finds at the submerged Newe-Yam site. In view of the recent discovery that the Newe-Yam site continues to a depth of -5 m (see above), a sea level of -7 m would be more likely for this period.

The possibility of tectonics must now be considered. The peninsula of Atlit divides the northern and southern Carmel coast. A SE-NW-trending fault passes there, termed "the north Atlit fault" (Gvirtzman, 1983; Gvirtzman *et al.*, 1986). South of Atlit there are three aeolianite (kurkar) ridges parallel to the coast, while north of Atlit two of the latter disappear in the sea and the shoreline recedes approximately 1 km eastward (Fig. 2), presumably as a consequence of the fault. The question arises as to whether tectonic submersion occurred during the last 8000 yr, as it is sometimes maintained (Neev *et al.*, 1963; Adler, 1986; Gvirtzman *et al.*, 1986), or was concluded at some earlier time. The following observations are relevant here: (1) the late Neo-

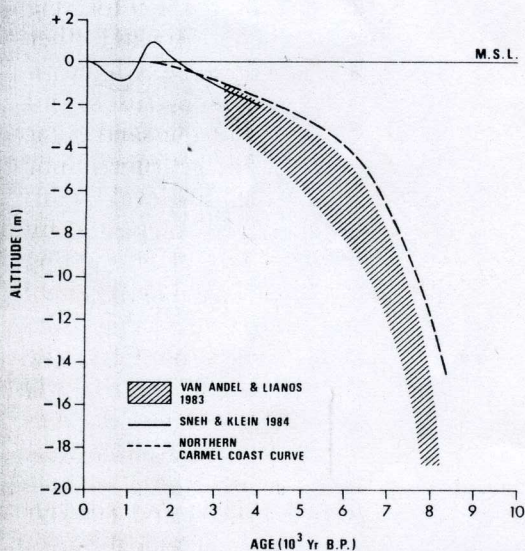


FIG. 4. Northern Carmel coast sea-level changes compared with the general global band (Van Andel and Lianos, 1983) and the Tel Dor curve (Sneh and Klein, 1984).

lithic settlements to the north of Atlit are located at a maximum depth of 5 m. The western part of the Neolithic site at Newe-Yam, south of Atlit, is situated at an identical depth. (2) The eastern dispersal line of the Bronze Age stone anchors found on both the northern and southern Carmel coast is at a depth of 3 m. Had a tectonic submersion of several meters occurred north of Atlit during the Bronze and Iron Ages, as claimed by Adler (1985), the stone anchors north of Atlit would have been much deeper. (3) The curve of Tel Dor, south of Atlit (Sneh and Klein, 1984), shows good correspondence with the curve we have presented for the northern Carmel coast. Furthermore, as shown above, the northern Carmel curve coincides fairly well with the global band of Van Andel and Lianos (1983) throughout most of the period under discussion. The values of the sea stand on the Carmel coast are even slightly higher than those expressed in the global band (Fig. 4). From all the foregoing, we may conclude that insofar as fault movement did occur on the northern Carmel coast, the event is older than the submerged settlements described here.

CONCLUSIONS

The northern section of the Carmel coastal plain between Atlit and Haifa has so far revealed the largest number of submerged prehistoric sites along the east Mediterranean. These sites, and additional finds of anchors and ships' cargo from the Bronze Age onward, indicate a continuous Holocene rise of sea level from -14 or -15 m at 8000 yr B.P. to the present level, which was definitely reached by 1500 yr B.P. and possibly by 2000 yr B.P. These data are in good accord with other data recently presented (Van Andel and Lianos, 1983; Sneh and Klein, 1984). According to our evidence, no tectonic movements have occurred in the area during the last 8000 yr.

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