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Middle and late Holocene sea-levels along the Israel Mediterranean coast – evidence from ancient water wells

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ABSTRACT: During the course of a study of historical water wells along the Israeli shore, which has been in progress since 1984, an innovative method for investigating sea-level fluctuations was developed. Eighteen ancient water wells were re-dug, 14 by the author, and four by archaeologists. Most of the re-dug wells are found at archaeological sites located a very short distance inland from the present shoreline. Evidence of ancient ground-water levels found in the wells directly reflects on historic eustatic sea-level changes, and the rate at which the end of the post-glacial transgression advanced. A critical question concerns the durability and life span of these wells, as the true age is very important for the accurate reconstruction of a sea-level curve. The Pre-Pottery Neolithic well of Atlit-Yam, which is the oldest known well in the world (ca. 8000 yr old), enabled the most accurate sea-level reconstruction for early Holocene times. Sea-level rise during that period of the Atlit-Yam site was of the order of 20 mm yr^{-1} at the beginning, slowing to 6–8 mm yr^{-1} at the abandonment of this site at ca. 7.5 ka BP, when it was flooded by the advancing and rising sea. After reaching its present level, sea-level fluctuations for the past 2.5 millennia were not greater than 1.5 to 2 m. © 1997 by John Wiley & Sons, Ltd.

KEYWORDS: Israel Mediterranean coast; Holocene sea-levels; ancient water wells; rapid sea-level rise.

Introduction

Ancient water wells discovered at archaeological sites have seldom been cleaned and re-dug to their base by archaeologists, the few that have often provided a rich collection of ceramic and other finds. Examples include the re-digging of the (?) Iron Age (ninth to tenth century BC) well at Tel 'Arad in the northern Negev (Amiran *et al*. 1985), the Persian Age (fifth to sixth century BC) well at Tel Qasilé near Tel Aviv (Mazar, 1983), and the Iron Age well of Tel Sheva near Be'er Sheva in the Negev Desert (Z. Tsuk, Tel Aviv University, pers. comm., 1994).

Since 1984 the author has been involved in many recent discoveries of ancient well sites along the Mediterranean coastal plain of Israel, from Ashqelon in the south to Akko in the north (Fig. 1) (Nir and Eldar, 1986, 1987; Nir and Eldar-Nir, 1988; Galili and Nir, 1991, 1993; Nir, in press). The earliest well studied, indeed the earliest known well in the world, is from the Mount Carmel offshore Neolithic village at Atlit-Yam, situated at present under 10 m of water, which is dated to the eighth millennium BP. As well as their archaeological significance, these wells can provide information about the tectonics of the coastal region of Israel, and also offer a means for reconstructing past sea-level changes. This method of sea-level reconstruction is based upon the fact that the former ground-water table level found in the re-dug wells is wholly dependent on sea-levels. Therefore, each archaeologically dated well may give a most accurate 'level-point' for past sea-level curve reconstruction. In this paper data from some of these well sites are described, and the sea-level evidence is discussed in relation to records of sea-level change from other parts of the Mediterranean region.

The Mediterranean coastal region of Israel is known to have been inhabited since prehistoric times, perhaps a few hundred thousand years (Ofer BarYosef, Harvard University, pers. comm.). Because of the low population density, requirements of water resources, such as seasonal streams, springs, and swamps, were sufficient for daily use. The existence of shallow ground-water that could be found a few tens of centimetres below ground was probably known from prehistoric periods, and there is no doubt that the settlers were able to exploit these waters, using simple means and techniques.

When larger coastal settlements, such as Acre, Jaffa, Yavneh Yam, and Ashqelon (Fig. 1) developed during the Middle Bronze Age IIb period, ca. 3700 yr BP, there was an increasing need for water of better quality and from more permanent sources. The oldest well so far discovered along the shores

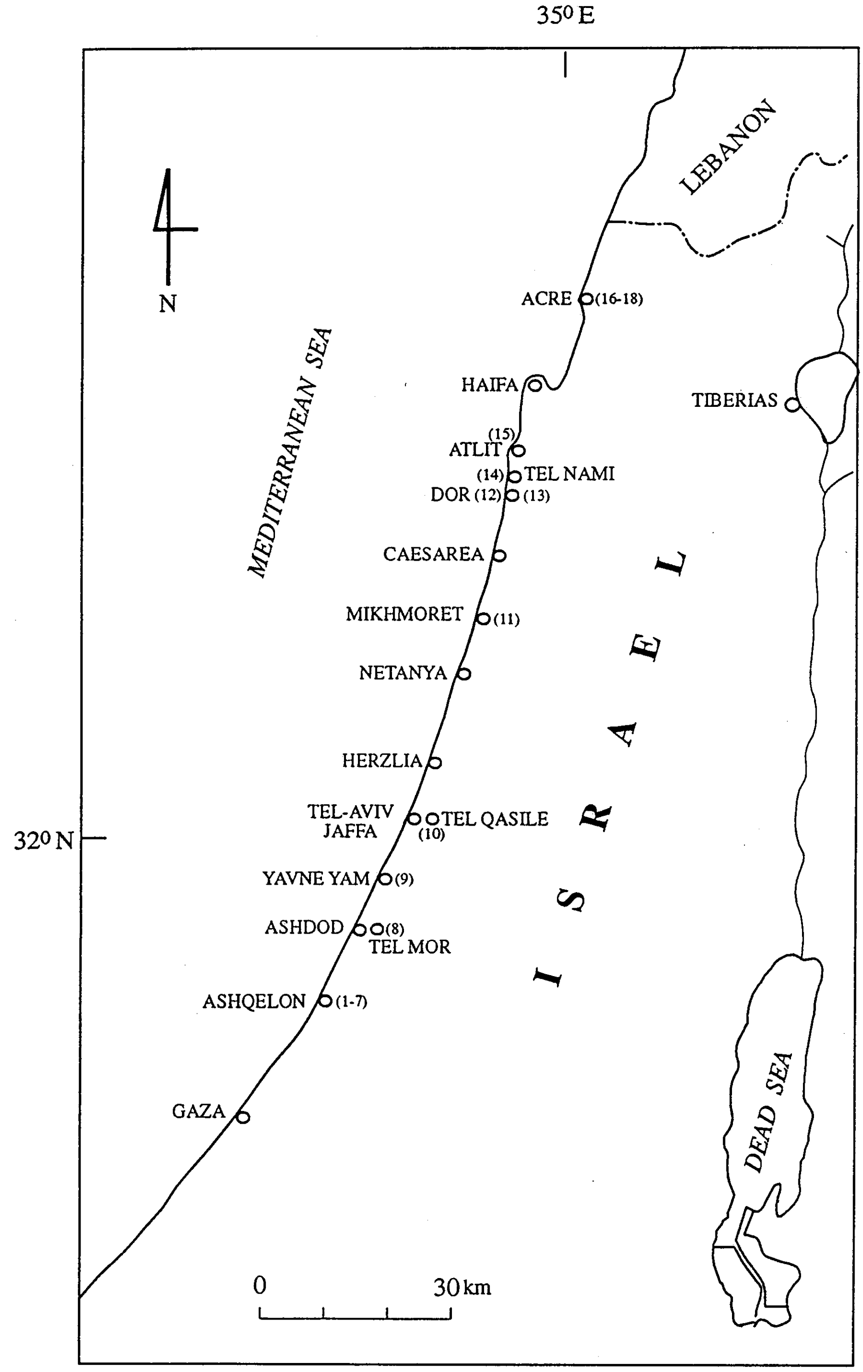

Figure 1 Water-well locations along the Israel Mediterranean coast (numbers in parentheses refer to Table 1).

of Israel (also the oldest yet discovered in the old world) was found offshore near Atlit, 10 m below sea-level, and is from the Pre-Pottery Neolithic Period (PPNB), dated to the beginning of the sixth millennium BC (Galili and Nir, 1991, 1993). The second oldest along the coast is a well at Tel Nami, a few kilometres south of Atlit (M. Artzy, Haifa University, pers. comm., 1990; Marcus, 1991), and is dated to the Middle Bronze Age IIa — ca. 3700 yr BP. From the Persian Period up (about 2500 yr BP) to the present, the digging techniques became more sophisticated and, as a result, more wells were dug. These provide a basis for more accurate sea-level reconstruction, and small changes in water level are much more easily identifiable.

Ancient sites along the Israel Mediterranean coastline have been studied quite thoroughly during the past 30 yr. Many sites are known to have existed along the coasts, some have underwater sections, including Acre, Atlit, Dor, Caesarea, Appolonia, Jaffa, Ashqelon and Gaza. Although these sites were studied mostly for their archaeological 'components', many coastal installations, such as mooring stones, quays, slipways, piscinas, docks, water-tanks, and channels, provide very accurate tools for the reconstruction of ancient sea-levels. The eastern Mediterranean archaeological sites, and especially ancient harbours and other coastal installations, are reported on by Bloch (1965), Flemming (1968, 1978, 1983), Flemming *et al.* (1973, 1978), Sneh (1981), Sneh and Klein (1983), Ronen (1983), Flemming and Webb (1986), Raban (1982, 1987), Raban and Galili (1985), Wreschner (1977, 1983), El-Sayed (1988), and Galili *et al.* (1988), and other parts of the Mediterranean have been described by Blackman (1973), Pirazzoli (1976), and Frau (1985).

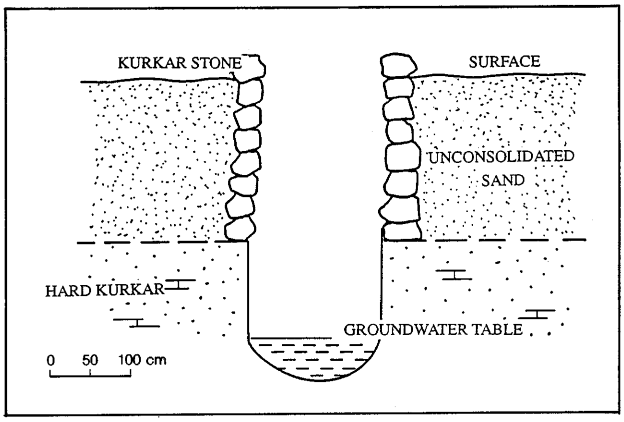

Figure 2 Schematic section through an ancient well dug in the friable (upper) and hard (lower) formations of the coastal plain of Israel.

Excavation methods and problems

Owing to the typically friable nature of the strata into which wells were dug along the coastal plain of Israel, construction of the lining walls of the wells usually commenced at the top and progressed downwards row by row until ground-water was reached. Some wells, mainly the most ancient ones, were lined with undressed stones, whereas others were constructed from local carbonate-cemented quartz sandstone, named 'kurkar', dressed in most cases to fit the circular shape of the well. However, if the well was dug in compact clay where there was no collapse-problem, the laying of stones proceeded from the bottom upwards. Whenever the diggers reached the hard kurkar layer, usually found beneath the friable, loose surficial sediments, digging of the shaft continued without any lining (Fig. 2). Most wells are cylinder shaped (Fig. 3), with inner diameters from 80 to 200 cm.

As water requirements in historical times were relatively small, there was no necessity for a deep 'pool' at the bottom of the well. Avitzur (1976) estimated that the productivity of *shallow* wells, through normal drawing of water, could not have exceeded 3 $m^3 h^{-1}$ by manual hauling, or 7 $m^3 h^{-1}$ when drawn by animals. This, together with the limited excavation techniques available in ancient times, did not permit diggers to extend very much below ground-water level and resulted in wells that terminated approximately 0.5–0.6 m below the local water table. Subrecent water wells, which were constructed along the coastal plain of Israel by Arab settlers using the same digging and exploitation methods, showed that the estimation of 0.4–0.5 m water column in open wells is a quite reasonable figure (Lass, 1989). Seasonal ground-water table fluctuations in the semi-arid conditions of the region did not greatly affect the water production of the wells, nor the level of their ground-water. After their abandonment, a situation that resulted mainly from political or social rather than hydrological circumstances, the wells were filled with refuse from the site by people and by natural agents. This fill was usually composed of sand, ash, pottery fragments, animal bones, coins, etc. All the wells investigated in this study were found to be almost entirely filled with such deposits.

Hydrological conditions and the ancient wells

The Pleistocene ground-water aquifer of the coastal plain of Israel drains from the foothills to the Mediterranean Sea, which controls regional ground-water levels. The average gradient of the ground-water table in the 6–10 km wide coastal strip is about 1 in 1000 (Kafri and Arad, 1978; A. Ecker, Geological Survey of Israel, pers. comm., 1985) (Fig. 4). Every change in sea-level is reflected in the ground-water level. Because tides in this part of the Mediterranean typically have an amplitude of no more than 30–40 cm, with annual fluctuations of up to 70 cm, the ground-water level in the area studied can be predicted whenever sea-level is known. Sea-level changes during the past 6000 yr have not been of significant amplitude and are less than ± 2 m, therefore, changes in ground-water level in the wells of more than ca. 1.5 m would not be expected.

Figure 3 The mouth of the Evtakh well, south of Ashdod and some 1 km inland from the present shoreline during digging operations. Some wells are well-built, with dressed cemented stones (mostly or kurkar origin) whereas others use irregular undressed kurkar stones.

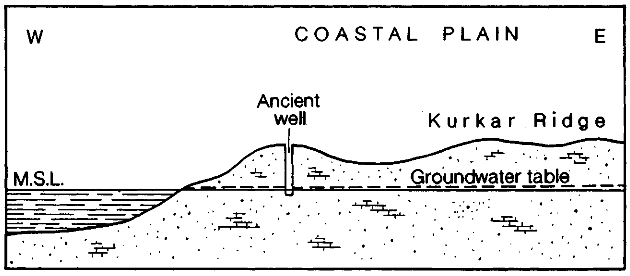

Figure 4 Schematic section of the ground-water table in the Mediterranean coastal plain of Israel showing the 1 in 1000 slope.

The 14 wells excavated in this study (Table 1) are located within a short distance of the present shoreline, which was in most cases within a few tens of metres or, at most, about 100 m inland from the ancient shoreline that existed during the life of the excavated wells (Nir, 1973, 1984). To understand the historical conditions, it is necessary to calculate the normal existing ground-water level (or the theoretical level unaffected by overpumping during modern times) in order to be able to compare this level with the ancient level found in the wells. As mentioned above, the technical limits of digging below the water table in ancient times on the one hand (Fig. 2), and the high productivity of groundwater in this region on the other, enables us to estimate that the ground-water column in the wells was around 50–70 cm only. This is an important figure, which provides a relatively accurate estimate of the ground-water level in each of the wells studied.

The accuracy of this new method for detecting historical ground-water levels is therefore in the range of 0.4–0.5 m. Any difference of more than 2.0 m found between the ancient ground-water table for the past 6000 yr, and the present theoretical ground-water level, may perhaps be an indication of vertical tectonic events, rather than of eustatic sea-level changes.

Any tectonic movement greater than 1 m, either uplift or downwarp, that occurred while a normal well was in operation should have left its mark on the walls of the well. A phase of deeper digging and a second stage of well construction should have followed uplift, whereas several water-table marks on the inner walls of the well would indicate a downwarp of the region. However, no additional construction or water marks have been found in any of the 14 wells. This suggests that the region has been relatively stable within a vertical range of ±0.5 m during the period represented by each individual well, which, according to the latest evidence, could have been of the order of 200 yr (Carmi *et al.*, 1994). Integrating the data from the different individual wells leads to the conclusion that the coastal region under discussion has been stable over the past four millennia. Such vertical tectonic stability, which has been noted previously (Nir and Eldar, 1987), contradicts previous theories that suggested tectonic movements of relatively large magnitudes in the Israeli shoreline region over the last few millennia

Table 1 Re-dug wells at archaeological sites along the Israel Mediterranean coast (from south to north)

Site	Age	Years BP[a]	Distance from present shore-line (m)	Reconstructed Sea-level (m)
1. Ashqelon (S)	Roman	2000	25	0.0
2. Ashqelon (N)	Roman	2000	25	0.0
3. Ashqelon (W)	Byzantine	1600	20	0.0
4. Ashqelon	Late Roman	1800	25	0.0
5. Ashqelon	Byzantine	1600	200	0.0
6. Ashqelon	Crusader	800	200	+0.5
7. Ashqelon	Byzantine[b]	1600	0	−0.2
8. Ashdod (T.Mor)	Late Roman	1800	1000	+0.5
9. Yavneh-Yam	Hellenistic	2300	25	−0.7
10. Tel Qasileh[c]	Persian	2400	1800	0.0
11. Mikhmoret	Persian	2500	20	−1.4
12. Dor[d]	Late Bronze	3300	10	−1.0
13. Dor	Byzantine	1600	400	0.0
14. Tel Nami[e]	Mid Bronze Iia	3700	80	ca. −0.2
15. Atlit-Yam[f]	Pre-Pottery Neolithic B	7900	Under sea-water (10 m)	−18.0
16. Acre I[g]	Crusader	750–700		
17. Acre II	Crusader	750–700		
18. Acre	Turkish	300		

[a]Although a definite age is given here, one should always take into consideration the fact that wells 'survived' and functioned for a long time, therefore each well might represent a much wider range of ages (see Fig. 6)
[b]This is a problematic well, as its structure was very much physically destroyed and deformed
[c]Was re-dug by Mazar (see Mazar, 1983)
[d]Was re-dug by Raban (see Raban, 1982)
[e]Was re-dug by Artzi and Marcus (see Marcus, 1991)
[f]Was re-dug by Galili (see Galili and Nir, 1993)
[g]All three wells re-dug at Acre (only partially re-dug by the author), show a present water column of around 1 m. It seems therefore that due to the special hydrological conditions prevailing on Acre's semi-peninsula where ground-water supply is very poor, wells had to be dug to greater depths below the ground-water table, in order to accumulate more water. As a result, these wells are more difficult for the reconstruction of ancient sea-levels

(Neev *et al.*, 1973, 1978, 1987; Bakler *et al.*, 1985; Lewy *et al.*, 1986).

Assuming tectonic stability of the region, therefore, a new eustatic sea-level curve for the past 2500 yr was developed by Nir and Eldar (1987). It is encouraging that sea levels indicated by most of the 18 wells for the last 2500 yr coincide approximately with those suggested for the same period of time by Raban and Galili (1985), who based their curve on other archaeological evidence.

The wells ceased to operate for three main reasons.

1. Political: a military occupation, which caused destruction and total abandonment of the settlement.
2. Technical: collapse of the walls, which were not repaired subsequently.
3. Salinisation: although salinated wells were not found during the present research, historical wells located originally on or very close to the beach, could have been influenced directly by storm waves or sea-level rise, causing immediate salinisation, as appears to have been the case in the Atlit-Yam Neolithic well, where rising seawater has penetrated into the well (Galili and Nir, 1991, 1993).

It seems that none of the wells studied (with the exception of the Atlit-Yam well) (Fig. 1 and Table 1), however, was abandoned as a result of changes in the hydrological regime.

Dating the wells

Dating ancient wells is based on three major related data-sources:

1. The pottery, coins and ^{14}C age-determination of material found at the bottom of the well, representing in most cases the last stages of usage, or datable material found in the walls' cement, representing the age of construction.
2. Different well-construction methods representative of the various periods.
3. The architectural contents of the surroundings into which the well was built.

In some cases, dating of the well's operational period was difficult as debris from various periods had fallen into the well after it ceased to operate. In these cases, dating was determined by the youngest contents found. In some wells the lowermost fill is composed mainly of a dark-coloured clayey layer containing sufficient diagnostic ceramics (Fig. 5) to enable accurate dating of the last period of operation. In some cases the pottery shards found in the fill above this layer showed a normal chronological succession from bottom to the top. In other cases, however, the rest of the overlying fill was composed of a mixture of different shards of various periods. The dating of these two last types was decided by the diagnostic material found in the bottom layer, even though this does not eliminate a possible earlier age. One should also take into account the periodic cleaning of the well's bottom that may have taken place, a well-known and well-documented technique, which employs special tools for hauling objects from wells (Mishna). By removing all the 'refuse' found at the bottom of the well, principally to clean the water column, most diagnostic pottery was taken out and therefore the material now found at the bottom may represent only the last few stages of the well's exploitation.

Although ceramic evidence is a useful means of dating ancient water wells, the fact that the ceramics occur in sediments that accumulated either at a late stage in the well's operations or, indeed, after the wells had ceased to

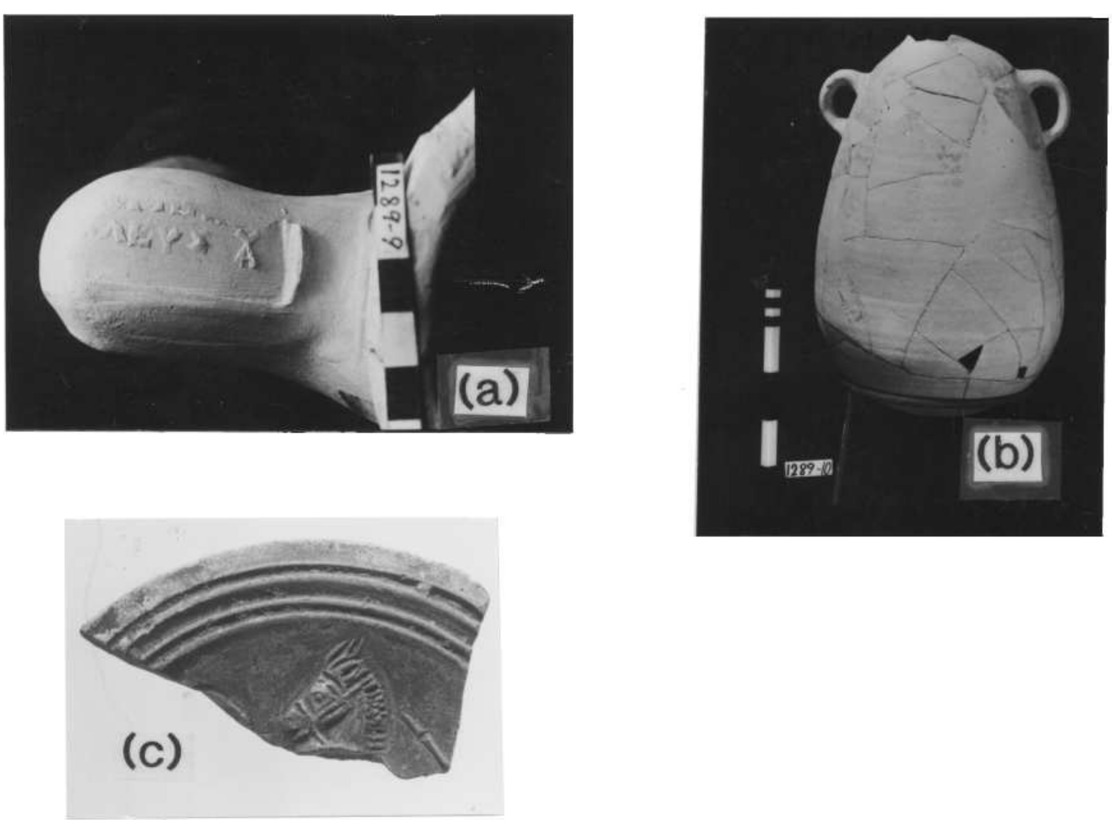

Figure 5 Diagnostic pottery found in the bottom-most layer of the Hellenistic well (a and b) of Yavneh-Yam; and (c) Tel Mor. (a) Handle of imported Greek Amphora with inscription of wine producer; (b) water jar; (c) small section of an oil lamp.

function, means that ceramic dates will post-date by perhaps one or two centuries the date of construction of the wells. For example, in a Roman well in the western section of Tel Ashqelon, a radiocarbon date on a sycamore branch found *in situ* under the lowermost layer of the well walls, suggests well construction around the beginning of the second century BC. By contrast, the average age of the ceramics in the well sediments is some 200 yr younger. By implication, therefore, the main phase of well operation which, in turn, will be reflected in former ground-water levels, will also pre-date the ceramic evidence. Hence, where palaeo-groundwater tables and former sea-levels are dated on the basis of ceramic evidence from water wells, the ages should be increased, on average, by 100–200 yr. It should also be kept in mind, however, that the history of individual wells may be different and, due to war or other disasters, the life span of the wells could have been very short, perhaps covering just a few decades. Therefore the final sea-level curve should be considered as representing a somewhat wider time span.

Reconstruction of sea-level for the past 8000 years

The ancient wells re-dug along the Mediterranean coast of Israel provide relatively accurate data on sea-level elevations for the past 3700 yr, with a most important 'benchmark' sea-level point at about 8000 yr BP (Fig. 6). Although there are some large gaps, where no wells have yet been discovered, notably between the Pre-Pottery Neolithic B′ (PPNB, ca. 7800 yr BP) and the Middle Bronze (ca. 3700 yr BP), a gap of about 4000 yr, the evidence provides valuable new insights into former sea-level fluctuations. The most ancient, and probably the most important well from both archaeological and sea-level change points of view is the subsea Atlit-Yam well (Galili and Nir, 1991, 1993). This PPNB well, which is cut into a clay soil found in the Pre-Pottery Neolithic submerged village, provided excellent information with regard to the latest stages of the post-glacial transgression to early Holocene sea-levels (Fig. 6), information missing from most other parts of the Mediterranean. The data from the well are in good agreement with reconstructed levels in other parts of the world during the eighth millennium BP (Fairbridge, 1961; Shepard, 1963; Milliman and Emery, 1968; Bloom, 1971; Kraft, 1977; Mörner, 1971, 1982; Van Andel and Lianos, 1984; Carter *et al*., 1986; Fairbanks, 1989; Lambeck, 1990). It therefore seems likely that the Atlit-Yam region has been relatively stable tectonically at least since 8000 yr BP. If any tectonic movement has affected the region, as suggested by, among others, Adler (1985), these must have occurred prior to the Neolithic period. On the basis of the evidence from the Atlit-Yam well, Galili and Nir (1991, 1993) conclude that sea-level was at least 17 m below present during the well's first stages of operation, and at about 8 m below present some 400 yr later. Altogether, sea-level rise of at least 9 m occurred in 400 yr, an average rise of about 22 mm yr^{-1}! This rate slowed to 6–8 mm yr^{-1} for the following 1000–1500 yr, when sea-level stabilised around 6500–6000 yr BP at its present level.

Shepard's (1963) summary of the world-wide rise of post-glacial sea-level shows a composite curve with very similar values to those of the East Mediterranean. Stanley and Warne (1993) conclude about the Nile delta, some 300–500 km to the southwest of the present study area, rapid sea-level rise took place between uncalibrated 11 500 to 8500 yr BP (ca. 9 mm yr^{-1}), followed by a deceleration at about 8500–7500 yr BP. At about 7500 yr BP, sea-level was at about −12 m.

Bloch (1965, 1976) summarised sea-level changes in historic and prehistoric times for European and Mediterranean waters as deduced from fluctuations in the salt trade, location of ports, coastal buildings, and the usability of river and canal beds for shipping and milling. He presented a very detailed curve for the last 4200 yr, which showed marked fluctuations of up to 4 m between the Persian (ca. 2500 yr BP) and the Early Moslem (ca. 1200 yr BP) periods, a time span of about 1300 yr, with an average sea-level rise during this period of 3 mm yr^{-1}.

Flemming *et al*. (1978) give a relative sea-level chart for the various archaeological periods studied along the Israeli coastline, showing very shallow minimum depths of only −3.5 m for the Neolithic, about −2.5 m for the Chalcolithic, whereas from Middle Bronze and on to the Crusader period the levels are almost uniform, fluctuating between −0.80 m to −0.30 m only.

Using geomorphological and sedimentological data, combined with the archaeological finds of Dor (Fig. 1), Sneh and Klein (1983) provide a curve of sea-level changes for the past 4000 yr. They show a rise from about −2 m at 4000 yr BP to the present level at 2000 yr BP, and to +1 m in the Early Moslem Period. The discovery of a submerged Neolithic village at an average water depth of 5 m at Newe Yam, some 2 km south of Atlit, led Wreschner (1977, 1983) to conclude that sea level was at least at −5 m between 7000 and 6000 yr BP.

Raban and Galili (1985) reconstructed historical sea-level changes at Dor (Figs 1 and 6B), based on about 100 coastal points that relate to old sea-levels. They summarise their findings in a curve that covers the past 7000 yr. However, due to the fact that the earliest occupational level reported by them is the Middle Bronze II period (4000–3800 yr BP), it seems that their curve is somewhat speculative for the early periods because it is not based upon empirical data.

In their most comprehensive work on Holocene tectonic and eustatic sea-level changes in the circum-Mediterranean coasts, Flemming and Webb (1986) concluded that the sea was at −6 m at 8000 yr BP, at −3 m at 7000 yr BP, and at −1.7 m at 6000 yr BP. Their specific Syria–Israel curve does not show any data prior to 6000 yr BP.

Examination of the present hydrological conditions at the Crusader well (16 in Fig. 1), situated on the Acre small semi-peninsula, shows that the +0.30 cm level of its ground-water is in full accordance with its distance inland from the present shoreline. On the basis of submerged sites of both prehistoric and historic ages along the Carmel coast, Galili *et al*. (1988, Table 1) reconstructed sea-levels based on the depths of the various submerged sites. They showed that in regions not seriously affected by tectonic or isostatic complications, sea-level was at about −14 m at ca. 8000 yr BP. They also suggested that the sea rose rapidly during the period up to 8000 or 7000 yr BP, a conclusion also reached by Galili and Nir (1993).

Evaluation of sea-levels inferred from Roman installations in the northwestern Mediterranean (ca. 2000 yr BP) along the French and Italian coasts (Pirazzoli, 1976) shows sea-levels only 40 to 60 cm below that at present. This figure differs from that of the Israeli coast for the same period, where sea-levels were then close to the present day.

Inman (1983) has suggested that sea-level rose in southern California at a rate of 10–15 mm yr^{-1} between 8000 and

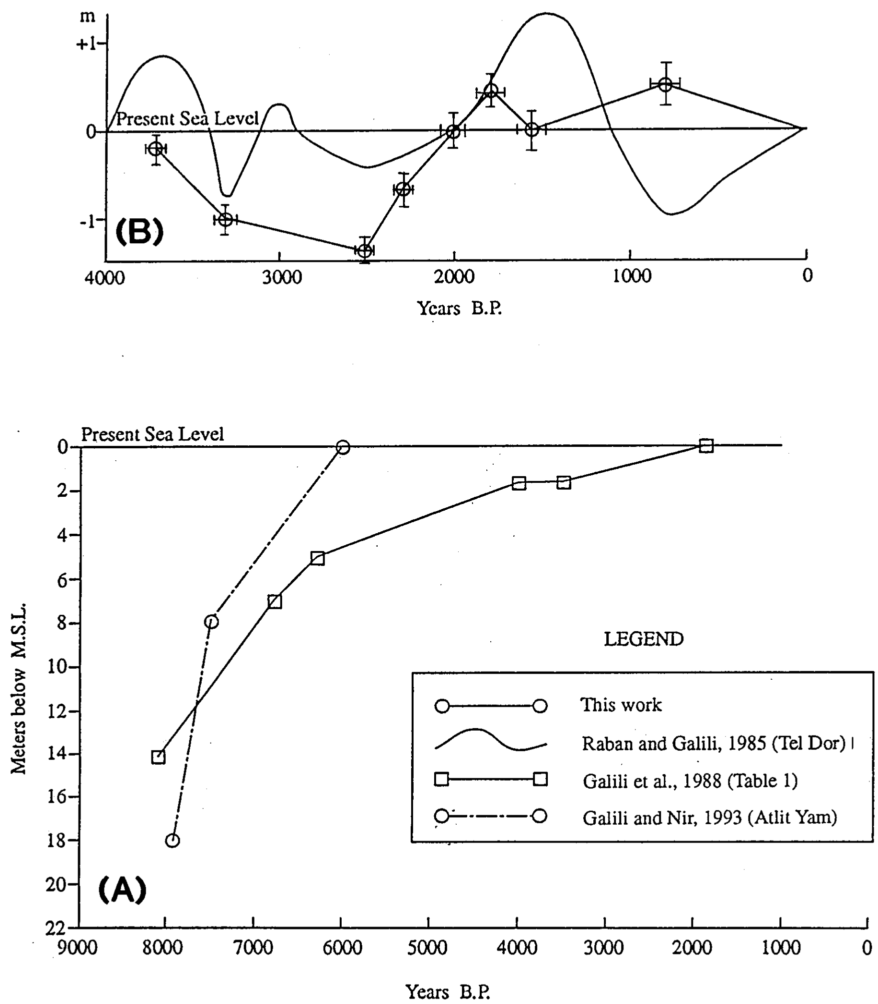

Figure 6 Suggested sea-level fluctuation curve for Mediterranean coast of Israel for the past eight millennia, compared with relevant data from other sources. (A) For most of the Holocene; (B) For the past 4000 yr).

Table 2 Based on Galili's table 1 (see Galili *et al.*, 1988), showing various submerged sites and archaeological finds located off the Carmel coasts. This data preceeded the re-excavation of the Pre-pottery Neolithic well of Atlit-Yam, a site that has proven a lower sea-level for that period (Galili and Nir, 1993)

Submerged sites	Age ^{14}C yr BP	Depth (m)	Inferred sea-level
Atlit Yam	8140 ± 120	12 (maximum)	14
Kfar Samir	6830 ± 60	5 (maximum)	7
Megadim	6310 ± 70	3 (maximum)	5
Tel Chreis	6270 ± 50	2.5 (maximum)	4.5
Atlit cemetery	ca. 4000	0 (maximum)	1.5
Newe Yam anchors	ca. 3500	3 (minimum)	1.5
Late Bronze anchors	ca. 3500	3 (minimum)	1.5
Byzantine iron anchors	ca. 1500	1.8 (minimum)	0

6000 yr BP, which resembles the rate reported by Galili and Nir (1991, 1993) for Israel. This high-speed sea-level rise resembles the rates found for the same period of time by Thom and Roy (1985) for New South Wales, by Carter and Johnson (1986) and by Larcombe *et al.* (1995) for the Great Barrier Reef, Australia; and by Chapell and Polach (1991) for Papua New Guinea.

Mörner (1971) and Berger (1983) provide non-calibrated and calibrated sea-level curves and changes from various locations around the globe. According to Mörner (1971), from −20.3 m at 7800 yr BP the sea-level started to rise rapidly to −10.0 m at 7000 yr BP (ca. 13 mm yr^{-1}); and to −6.6 m at 6500 yr BP (ca. 7 mm yr^{-1}). Their reconstructed sea-level rise resembles that of Galili and Nir (1993).

The Barbados sea-level curve of Fairbanks (1989), corrected for local seawater δ^{14}C, gives a −23 m level for 8000 yr BP. Lambeck (1990) in his Antarctic ice sheets study concludes that the Antarctic melting occurred at about the same time as the Arctic ice sheet, but lasted 1000 yr longer, and did not cease at 6000 yr BP but continued to the present, with about 2–3 m of global sea-level rise resulting from it in the past 6000 yr. Again, these figures fit well with those obtained for many parts of the Mediterranean.

Summary and conclusions

The present study provides a relatively accurate method (based on former ground-water levels in ancient nearshore wells) for reconstructing historical sea-level changes in tectonically relatively stable regions of the Mediterranean Sea coasts, although the author is in full agreement with Kidson (1982) that 'No part of the earth's crust can be regarded as wholly stable'.

The Atlit-Yam underwater well proves that the region of the Pre-Pottery Neolithic Village and its surrounding area have been tectonically stable since at least early Holocene times. If, as suggested previously, vertical tectonic activity has occurred here, then this must be dated to an earlier period. In other locations along the Israel Mediterranean coastline, no apparent uplift in late Holocene times took place, and the coastal region under discussion has been stable since Middle Bronze IIa times, i.e. ca. 3700 yr.

In spite of the fact that the definition of eustasy as a world-wide and simultaneous uniform sea-level is obsolete (Tooley, 1993), reconstruction of sea-level for the Israel Mediterranean coastline is in broad agreement with early Holocene curves from various locations around the globe. The western and central Mediterranean data are based mostly upon finds from the classical periods, and therefore relate only to about the last 3000 yr. Middle and early Holocene sea-levels have not been reported from elsewhere in the Mediterranean.

The curve for the younger period, that from the classical–Hellenistic period and on to the present, has many more reference points, and the one proposed here differs considerably from that of Raban and Galili (1985). Their curve was based on only one site, Tel Dor, although there is very good agreement for the Roman period when sea-level was similar to that of the present.

Future discovery and re-digging of more coastal wells, in Israel or other circum-Mediterranean coastal zones, especially from the Neolithic, and through the Chalcolitic and Early Bronze ages, should enable further refinement of sea-level reconstruction to be made, and will allow better estimates of the time at which sea-level stabilised at its present level.

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