The Inland Late Bronze – Iron Age Anchorage of Dor: Ancient Reality or Fantasy?

Gilad Shtienberg and Katrina Cantu

Abstract Around the Levantine coast, ancient anchorages facilitated urban center establishment by enabling travel that connected between sites and civilizations, leading to expanding trade network possibilities. Various scholars previously hypothesized that this growing maritime economic prosperity was permitted along the Israeli coast in Yaffo, Dor, Tel Naami, Tel Akko, and Tel Achziv due to a natural process in the marine-terrestrial interface subsequent development of lagoonal systems. Once formed, these natural, brackish, protected aquatic systems were postulated to have been utilized by the coastal inhabitants as inland harbors constructed adjacent to the settlement. Here the complex long-term relationships between sea-level rise, sedimentation variation, and resulting coastal morphogenesis are examined in the area of tel-Dor. This investigation relies on a high-resolution spatial and temporal paleoenvironmental record combining dated terrestrial and shallow marine sediment cores with sedimentological and faunal analysis as well as seismic profiles collected from the shallow marine south bay of Dor. The current stratigraphic framework indicates that the coast of Dor has undergone morphological changes over the Holocene. These consist of a brackish wetland environment (ca. 9000–7000 years ago) that then changed to a high energy beach (ca. 7000–4000 years ago) to finally settle as a backshore influenced by anthropogenic activity of the coastal inhabitants (4000 years ago–present). The time constraint stratigraphy, the surface elevation of each lithological unit, and association to sea level variation over the last 9000 years rule the existence of a lagoon out. As a result, it is unlikely that the area facilitated an inland anchorage, making previous hypotheses on this matter unplausible. The holistic approach utilized in Dor provides a unique opportunity for studying ancient coastal processes, which are essential for properly understanding the interplay between the varying environment and coastal settlers.

G. Shtienberg (✉) · K. Cantu
University of California, San Diego, La Jolla, CA, USA
e-mail: gshtienberg@ucsd.com; kcantu@ucsd.edu

E. Ben-Yosef, I. W. N. Jones (eds.), *"And in Length of Days Understanding" (Job 12:12): Essays on Archaeology in the Eastern Mediterranean and Beyond in Honor of Thomas E. Levy*, Interdisciplinary Contributions to Archaeology,
https://doi.org/10.1007/978-3-031-27330-8_63

Keywords Landscape reconstruction · Environmental change · Sea level rise · Inland anchorage · Tel-Dor · Middle-bronze age · Coastal habitation patterns · Lagoon

1 Introduction

The ancient coast of Israel (Fig. 1a) has a long history of maritime connectivity, with several ancient port cities such as Jaffa, tel Dor, tel Nami, tel Abu-Hawam, tel Akko, and tel Achziv located along the central to north coast of Israel (Fig. 1; Giaime et al., 2018; Zviely et al., 2006). The environmental setting of these cities is often of great interest to historians and archaeologists as the modern coastline may not be ideal or even compatible with the needs of a port – mainly, that the harbor must be deep enough to accommodate ships, be safely accessible from the sea, and be protected against wave action (Burke et al., 2017; Marriner & Morhange, 2007; Marriner et al., 2012). One such city, Akko, on the north end of Haifa Bay in Northern Israel, was a regionally significant port beginning in the Middle Bronze age. Historical texts and archaeological evidence attested to the presence of a port, but the ancient settlement on the tel is located several hundred meters landward from the modern shoreline. Sediment coring revealed that the tel had once been located adjacent to a lagoon, which over time filled with fluvial and later Nile sand deposits (Giaime et al., 2021; Morhange et al., 2016). Similarly, the anchorage at Jaffa, near Tel Aviv, has long been considered problematic and even dangerous for ships to sail and dock in, and the city's function as a port was somewhat puzzling.

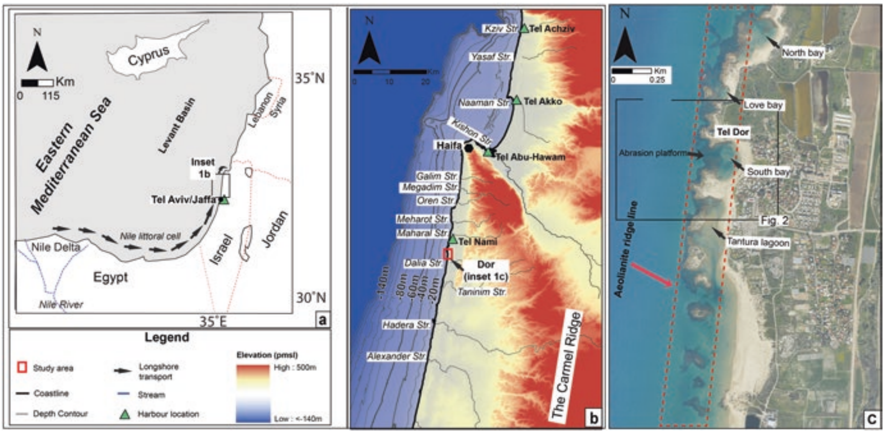

Fig. 1 Locality maps. (**a**) The direction of longshore transport along the eastern Mediterranean shown by black arrows. Dashed blue line represents the Nile; dashed red lines represent approximate international borders. Outlined rectangle shows location of inset (**b**), which illustrates the area of investigate in North-central coast of Israel and (**c**) the coast of Dor annotating its geomorphological properties

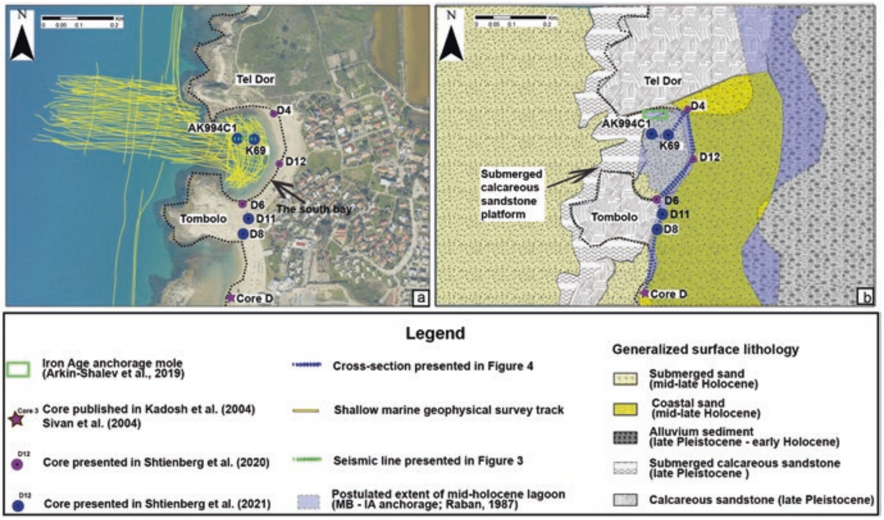

Fig. 2 Maps representing coring and sampling locations of the south bay of Dor and its pocket beach (see Fig. 1 for inset locations). (**a**) Aerial photographs with drilling locations and seismic profiles discussed in the current paper and seismic section location presented in Fig. 3 (**b**) surface lithologies, archeological remains of the MB Anchorage, and location of cross-section presented in Fig. 4

Investigation of historical maps, topography, and sediment cores suggests that the anchorage was, prior to the Classical period, located in an inland body of water to the east of the tel which has since filled in with sediment (Burke et al., 2017). With these examples in mind, we turn to the ancient port city of tel Dor, on the Carmel Coast of Northern Israel (Fig. 2).

In his 1987 article, “The Harbor of the Sea Peoples at Dor”, Avner Raban posited that during the Late Bronze Age to Iron age Dor’s South Harbor was connected to the sea by a long, North-South oriented lagoon stretching approximately one mile south of the tel (proposed location of the Dor’s lagoon is presented in Fig. 2b). According to Raban, this body of water also wrapped around the east side of the tel, creating a “haven” for ships after entering the lagoon and sailing north toward the settlement. This hypothesis was based on Raban’s understanding of the coastal sedimentary profile of Dor as well as the assumption that sea level was approximately a half-meter lower than today’s, too low to allow access to the harbor from the Mediterranean due to an aeolianite ridge blocking its western side. While this ridge has an opening wide enough for boats to pass through today, Raban suggested that it would have been much less eroded in the thirteenth century BCE, thereby closing off the west side of the harbor. A recent geophysical investigation of the area found evidence of an ancient channel connecting Tantura Lagoon to Dor’s South Harbor through what is now a tombolo (Figs. 1c and 2), seemingly supporting Raban’s hypothesis (Lazar et al., 2021).

Was the lagoonal harbor proposed by Raban a reality? If not, what did the landscape surrounding ancient Dor look like? To answer these questions, we present several lines of stratigraphic evidence from seismic profiles conducted in the shallow south bay of Dor along with seven sediment cores collected in the vicinity of the South Harbor (Fig. 2) and examine the Carmel coast relative sea level curve that has been largely constructed after the publication of Raban's, 1987 paper with correlative chronostratigraphic data of Dor.

2 Regional Setting

In general terms, the morphology of the narrow, 3 km wide Carmel coast – from east to west – consists of alluvial plain, embayments and sand beaches separated by aeolianite ridges which trend parallel-subparallel to the current coastline (Fig. 1c; Gvirtzman et al., 1983 among others). The late Pleistocene to Holocene unconsolidated sedimentary sequences of the Carmel coast accumulated in a terrestrial–coastal environment composing of alternating aeolianites and red-brown sandy-loam paleosols. In the lowlands between the ridges, the paleosols are covered by a dark silty clay unit, rich in organic material (Shtienberg et al., 2017). As sea level rose during the late Pleistocene-Holocene transition (15,000–12,000 years ago; Rohling et al., 2014), the shoreline migrated eastwards, flooding the shallow shelf around 9000 years ago (depth shallower than −20 m; Sivan et al., 2004a). Archaeological observations from the coast (Sivan et al., 2001; Galili et al., 2019) confirm that sea level continued to rise during the early stages of the Holocene until ca. 6000 to 7000 years ago, when transgression slowed considerably. As sea level and the coastline neared their present elevation and location ca. 6000 to 4000 years ago (Sivan et al., 2001) the volume of windblown sand which accumulated along the coast increased (Roskin et al., 2015; Shtienberg et al., 2016, 2017). Although sea level was believed to have been relatively stable from ca. 3000 years ago to present, some archaeological coastal structures and their base elevation and location compared to the present shoreline point toward lower levels of up to 2.5 meters compared to present (Anzidei et al., 2011; Galili et al., 1993; Yasur-Landau et al., 2021). Based on these anthropogenic constraints sea level finally reached its current elevation, fluctuating in magnitudes lower than ±0.5 ca. 2000 years ago (Toker et al., 2012).

The ancient city of Dor is located in the Carmel coast (Fig. 1) 21 km south of present-day Haifa, and 50 km north of Tel Aviv and presents an ideal location for studying long term dynamics between natural – human interactions since the prehistory. The sedimentological, geomorphological, and historical characteristics of this location include a shallow lagoon (Tantura lagoon) and three low-energy embayments located adjacent to the site (Fig. 1c). From north to south, these are the North Bay, the Love Bay, and the south bay with the latter located immediately south of the tel Dor. The Tantura lagoon and the three bays have an extensive and detailed evidence of human remains (Arkin Shalev et al., 2019a; Arkin Shalev et al., 2019b; Yasur-Landau et al., 2021 and reference therein) and sedimentary deposits (Kadosh et al., 2004; Shtienberg et al., 2020, 2021; Sivan et al., 2004b) covering most of the Holocene period. In the past, the bays served as anchorages which can be directly linked to Dor as a successful port with long-term continuous occupation and includes structures on land (Raban, 1995; Marriner et al., 2014) and underwater (Gilboa & Sharon, 2008).

Occupation at tel Dor (Fig. 2) began in the Middle Bronze Age II (3900–3500 years ago) and the settlement continued to grow and develop throughout the Roman (2000–1700 years ago), Byzantine (1700–1400 years ago), and Crusader (1100–750 years ago) periods (e.g., Stern, 1994; Raban, 1995; Gilboa & Sharon, 2008; Nitschke et al., 2011). On the seashore an immense record of maritime constructions was previously identified. These include massive coastal fortifications dated to the Iron 1b period (3100 years ago; Gilboa & Sharon, 2008; Sharon & Gilboa, 2013) and an artificial mole, currently covered by a biogenic rock, serving as the main harbor installation of the city (Arkin et al., 2019a; Raban, 1995). In the ninth century BCE maritime activity continued in Dor and by the seventh century BCE it became a maritime center under the Assyrian empire with a sea-gate and fortifications (Arkin et al., 2019a). During the Hellenistic period (2300–2100 years ago) it seems that Dor continued to be a sturdy coastal city, fortified with defense structures (Nitschke et al., 2011) guarding the entrance to the bay. These structures were identified in underwater excavations and coastal geophysical surveys at the southern edge of the south bay of Dor (Lazar et al., 2021). The rich settlement history of Dor and its long-lasting existence as a coastal port site make it an ideal case for examining the possible usage of the natural coastal characteristics of Dor for establishing a Bronze Age inland harbor.

3 The Holocene Coastal Stratigraphy of Dor

In order to test Rabans' hypothesis (Raban, 1987) regarding the possible existence of an inland harbor (Figs. 1c and 2), a multidisciplinary approach was applied incorporating interpreted shallow marine geophysical profiles (Figs. 2 and 3), sedimentological, bio-stratigraphical, and chronological results previously published in Kadosh et al. (2004); and Shtienberg et al. (2020, 2021) (Figs. 4 and 5). The correlation between the previously dated sequences of Dor, identification of their depositional environment and association with the Carmel coast relative sea level curve (Galili et al., 2019; Sivan et al., 2001, 2004a; Yasur-Landau et al., 2021) enabled us to determine whether an inland lagoon existed in the area from the Late Bronze to Iron age during occupation of the tel.

Based on this integration (Fig. 5), the coastal zone sequence of the area consisted of two main units (F4; F5) that comprise of loam and quartz sand: at the base of the sequence, a 9200–7000 years ago (pre-pottery Neolithic LB-C to Pottery Neolithic) dark grey – dark brown homogenous silty loam sediment containing shallow shelf and fresh-brackish ostracods, gastropod shells, foraminifera, and sea urchin spine remains. The surface elevations of this unit range from −2.2 to −3.2 relative to

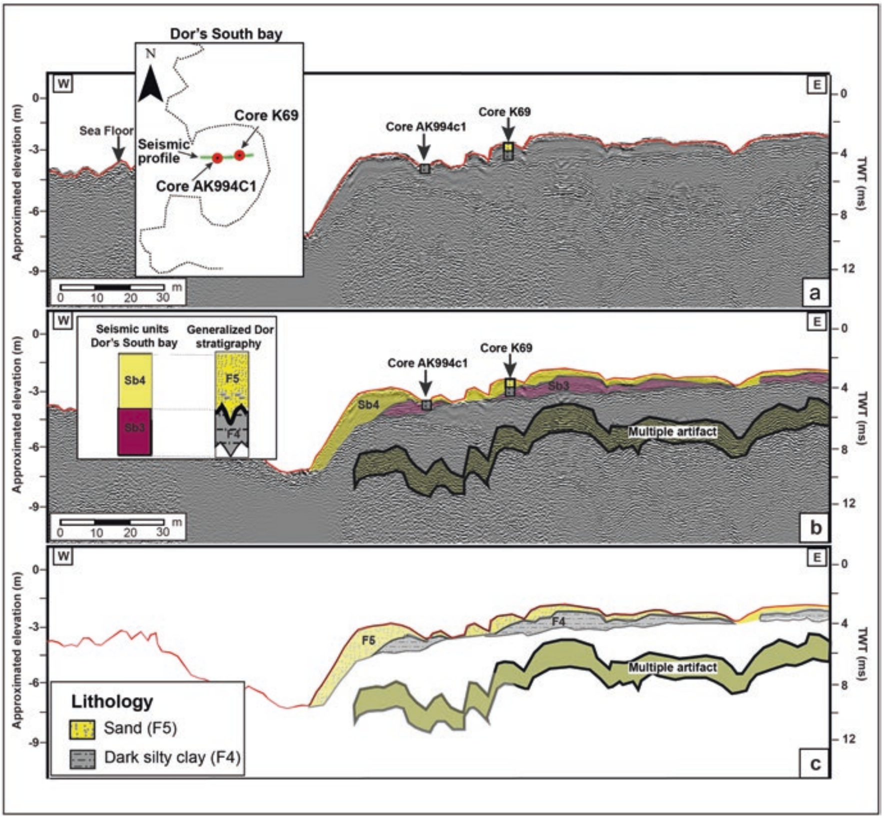

Fig. 3 Results from the geophysical survey (modified after Shtienberg et al., 2021): (**a**) Shore-perpendicular seismic section from the south bay of Dor; (**b**) the interpretation of the seismic section (**c**) transformation from acoustic units to lithologies was achieved based on boreholes AK994C1, K69 as well as surface lithologies identified on the shallow seabed of the south bay. The locations of the seismic section and boreholes are displayed in Fig. 2b

mean sea level (msl) with thickness of ~1 m. Relying on the sedimentological properties of the unit and its skeletal assemblage, unit F4 was interpreted as a brackish wetland deposit.

Covering the brackish wetland, a 2 to 6-meter-thick quartz rich sand unit was identified throughout the study area. This unit, which was chronologically constraint from 7000 years ago to present, has been broken down into three sub-units, and is described here from bottom to top:

Sub-unit F5a (Fig. 2) comprises of surface elevations ranging from −3.5 to −0.5 m relative to msl, and thicknesses of up to 2.5 m. The deposit consists of sub-rounded, course to medium grained, light brown to yellow sand. Glycymeris shells, unidentifiable gastropod and bivalve shells and abraded shallow shelf foraminifera were evident all through the sub-unit with abundance and size increasing upward. The chronostratigraphic correlation of the core data (Fig. 4b) constrains the beach

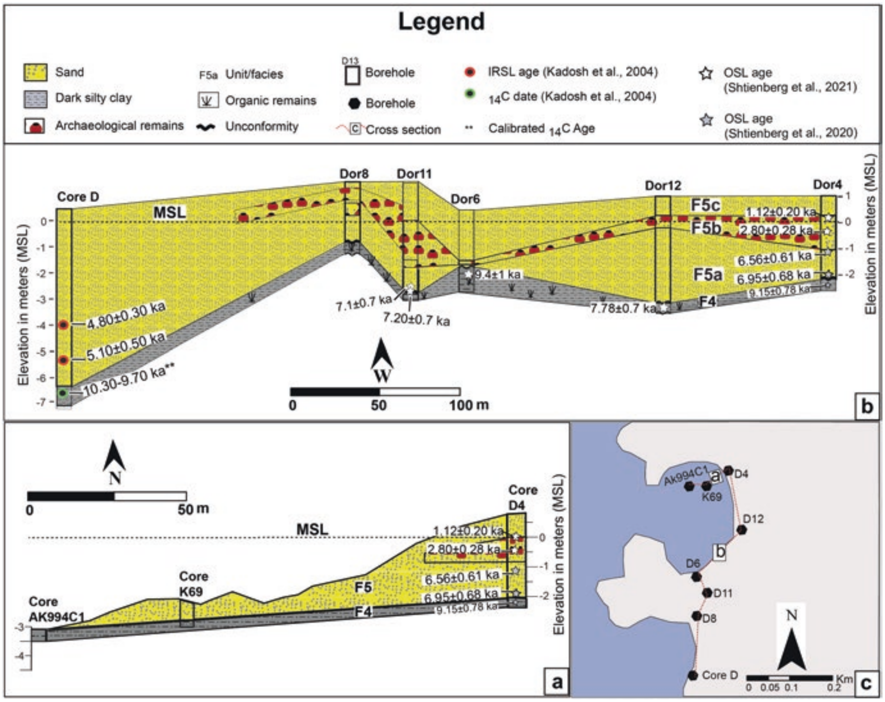

Fig. 4 Fence diagram presenting the chronostratigraphy of the South Bay coastal zone. The chronostratigraphic correlation based on the cores D4, D12, D6, D11, D8, AK994C1, K69 previously published in Shtienberg et al. (2020, 2021) of the (**a**) terrestrial – shallow offshore; (**b**) shoreline. The annotated ages are listed in ka (thousand years ago). Follow the cross-section in space in (**c**)

sand deposit, typically found in an area with high depositional energies, from 7000 to 4500 years ago (Chalcolithic – Middle Bronze age).

Overlying the beach sand deposit sub-unit F5b was identified with surface elevations of 0 to 0.3 m relative to msl, and a thickness of 0.4 m to 1 m (Figs. 4 and 5). The sub-unit is characterized by a light gray to light yellow medium-coarse grain sand abundant with Glycymeris shells, aeolianite fragments, chert and limestone pebbles. F5b also contains cultural material such as pottery sherds, pieces of iron, and charcoal fragments. OSL results from the base and upper portions of this anthropogenic rich deposit produced an age constraint of 2.8 to 1100 years ago, associating it with the Bronze Age–Crusader settlement at Tel-Dor.

F5c is the uppermost facies identified in the south bay of Dor with surface elevations of 1 to 1.5 m above msl and a thickness of 0.5 to 1 m (Fig. 5). This deposit is light gray to light brown with medium – fine grain sand littered with modern anthropogenic remains in its upper 0.3 m. Relying on the accompanying contemporary features and its base limiting age constraint of 1100 years sub-unit F5c is interpreted as an aeolian deposit which started to accumulate once the tel was deserted and continued until the modern settlement of Israel.

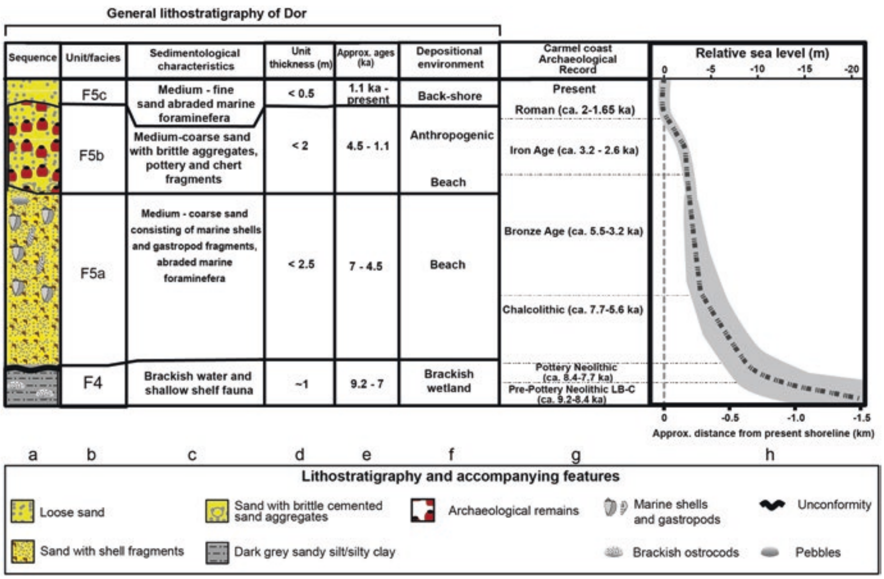

Fig. 5 The time constraint lithostratigraphy of Dor (**a**, **b**); with sedimentological characteristics (**c**, **d**); approximate age constraints (**e**); associated depositional environments (**f**); correlative Carmel coast archeological period. The annotated ages are listed in ka (thousand years ago) (**g**) and associated relative sea level based on Galili et al. (2019), Sivan et al. (2001, 2004b) and Yasur-Landau et al. (2021) (**h**). This generalization is based on the results presented in Figs. 3 and 4

4 The Coastal Evolution of Dor and Associated Shoreline Location

The temporal constraint of the sequence enables us to reconstruct the coastal evolution of Dor and link these geomorphic changes with the Holocene sea level rise to the cultural periods of the site (Fig. 5). Coastal wetlands of brackish salinity (Sivan et al., 2011, 2004b; Shtienberg et al., 2021) developed in the depressions of the south bay of Dor reflecting the wet climate conditions (Bar-Matthews et al., 2003; Grant et al., 2016) of the African Humid Period (ca. 15,000–8000 years ago; Natufian to Pottery Neolithic period). Relying on the youngest age constraint of the wetland surface (ca. 7200 years ago; Fig. 5) and initial deposition of the overlying coastal sand at 7100 years ago; the south bay bathymetry of the wetland surface (presented in Shtienberg et al., 2021) which was around 3 to 1 meter lower then present, relative msl (Galili et al., 2019; Sivan et al., 2004b) and the submerged rectangular building associated with a Pottery Neolithic settlement (Shtienberg et al., 2020) we postulate that during this time the entire south bay of Dor was a terrestrial environment. The ages from the surface of the wetland and overlying coastal sand confine the termination of wetland deposition to ca. 7000 years ago. This suggests that the environmental transition from a wetland to a coastal site is linked to the advancing shoreline which deposited and buried the wetland surface under increasing volumes of coastal sand (Shtienberg et al., 2017).

A 2 m-thick bioclastic sand facies (F5a; Fig. 5) found in the current study area was dated between 7000 and 4500 years ago (Chalcolithic Period to Middle Bronze age). Based on its location, elevation range of 1.5 to −0.5 relative to msl, bathymetric data, relative sea level elevation of −5 to −2.5 (compared to present sea level) and the high percentage of the worn marine fauna, it seems that during this period the shoreline was still a few hundred to tens of meters west of its current location (Fig. 6a). Overlying the coastal sand facies (F5a), sub-unit 5b consists of poorly sorted, medium-coarse grain sand that was found to be rich with marine gastropod and bivalve fragments as well as archaeological remains. These sedimentological characteristics, the two late Holocene ages (2800 and 1100 years ago), and correlation with the relative sea-level curve of the Israeli coast, indicate that sub-unit F5b was deposited in a coastal environment when sea level was nearing its present elevation (Yasur-Landau et al., 2021) while the archeological remains (sherds, iron fragments) are the result of extensive human habitation from at least since Middle Bronze Age II and into the Roman period (Stern, 1994; Raban, 1995; Shahack-Gross et al., 2005; Sharon et al., 2005; Gilboa & Sharon, 2008). Unit F5 is topped by facies F5c which is a ~ 0.5 m thick deposit, comprised of a medium- to fine-grained sand distributed with abraded shell material. Given that the seasonal beach profile changes of the Carmel coast can fluctuate between 1–1.5 m (Shtienberg et al., 2014) and the presence of glass and other recent artifacts, this facies is interpreted as modern pocket-beach sands. In the next section we use this chronostratigraphical data to evaluate the possible existence of an inland anchorage during the Late Bronze – Iron Age as well as test possible sailing routs for reaching the south bay anchorage of Dor.

5 Evaluation of the Possible Late Bronze – Iron Age Anchorage of Dor and Summary

In order for an inland anchorage to have existed during the Late Bronze – Iron Age (3500–2600 years before present), the elevation of the area around Dor's South Harbor would need to be deep enough to allow ships to enter. Comparing the dated sediment units from the cores collected around the harbor and the temporal correlation with the local sea level curve shows that not only were the evaluated locations not deep enough for ships to pass, but they were already above msl and likely tens to hundreds of meters from shore during the Chalcolithic and up to the middle Bronze Age, from circa 6500 to 4500 years before present (see Fig. 6). The characteristics of the sediment support this interpretation, as the coarse sand and poorly preserved marine fauna are consistent with a beach environment. As sea level continued to rise through the Late Bronze to Iron Ages before largely stabilizing during the Roman Period, the sediments continue to reflect a beach depositional

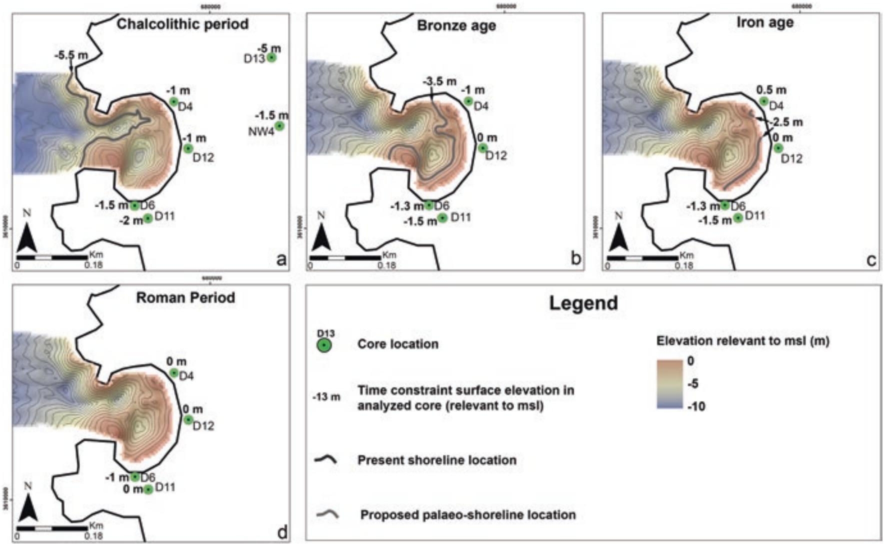

Fig. 6 Time constraint surface maps of Dor's shallow marine-terrestrial coastal side for the following periods: Chalcolithic period (7700–5600 years ago); Bronze Age (5500–3200 years ago); Iron age (3200–2600 years ago); Roman (2000–1600 years ago). The green dots illustrate core location with their surface elevation relative to modern mean sea level for each time constraint map while the thick grey contour line annotated the proposed shoreline location

environment, with the addition of anthropogenic materials. This stratigraphy is consistent across the examined cores which surround south bay of Dor demonstrating that there was no channel across the tombolo on the south side of the bay as Lazar et al. (2021) proposed, nor did a harbor extend inland to the eastern side of the tel (see Figs. 2b and 4). If Dor's harbor was not connected to the Mediterranean via a channel through the tombolo, then boats must have entered the western entrance to south bay. The bathymetric and sub-bottom survey results discussed in Shtienberg et al. (2021) show a 5-m deep west-east trending channel (relevant to msl) cutting across the aeolianite platform found in at the entrance of the south bay of Dor (Fig. 6). Subtracting two meters in consideration of the lower sea level during the middle to late Bronze Age (Galili et al., 2019; Sivan et al., 2004b; Yasur-Landau et al., 2021) still yields a depth of approximately 3 meters, likely deep enough for many ancient ships that possessed shallow keels (Polzer, 2011; Wachsmann, 2009).

Raban (1987) suggested that the submerged aeolianite ridge blocking much of the entrance to the south bay of Dor was higher during the Bronze Age, because it has been eroded in the intervening time. However, it seems that the aeolianites found around the entrance of the bay were only subjected to wave erosion for a period of 1000 years, during this time when the shoreline was situated right against the entrance of the bay. This is based on sea level rise (Fig. 5), the resulting shoreline transgression (Fig. 6) during most of the Chalcolithic (7000–6000 years before present), and erosional rate constraints of calcareous sandstones evaluated at 0.02–0.91 mm/year (Flemming, 2011). Taking these factors into account, it seems that the submerged aeolianite platform could have been eroded up to a magnitude of 1 meter, which still allows the channel to be suitable for sailing during the Late Bronze – Iron Age.

The evidence presented in this analysis shows that Raban's vision of an inland harbor was not possible during the Late Bronze and Iron Ages, and that the south bay of Dor was surrounded on three sides by a beach environment rather than a lagoon. This further demonstrates that the western entrance to south bay of Dor was the only way for ships to access the port.

References

Anzidei, M., Antonioli, F., Benini, A., Lambeck, K., Sivan, D., Serpelloni, E., & Stocchi, P. (2011). Sea level change and vertical land movements since the last two millennia along the coasts of southwestern Turkey and Israel. *Quaternary International, 232*, 13–20. https://doi.org/10.1016/j.quaint.2010.05.005

Arkin Shalev, E., Gilboa, A., & Yasur-Landau, A. (2019a). The Iron Age Maritime Interface at the South Bay of Tel Dor: Results from the 2016 and 2017 excavation seasons. *International Journal of Nautical Archaeology, 48*, 439–452. https://doi.org/10.1111/1095-9270.12360

Arkin Shalev, E., Gambash, G., & Yasur-Landau, A. (2019b). Disheveled tenacity: The North Bay of Roman and Byzantine Dor. *Journal of Maritime Archaeology, 14*, 205–237. https://doi.org/10.1007/s11457-019-09235-y

Bar-Matthews, M., Ayalon, A., Gilmour, M., Matthews, A., & Hawkesworth, C. J. (2003). Sea–land oxygen isotopic relationships from planktonic foraminifera and speleothems in the Eastern Mediterranean region and their implication for paleorainfall during interglacial intervals. *Geochimica et Cosmochimica Acta, 67*, 3181–3199. https://doi.org/10.1016/S0016-7037(02)01031-1

Burke, A. A., Peilstöcker, M., & Burke, K. S. (Eds.). (2017). The history and archaeology of Jaffa 2. *Cotsen Institute of Archaeology Press at UCLA*. https://doi.org/10.2307/j.ctvdmwwr7

Flemming, B. W. (2011). Geology, morphology, and sedimentology of estuaries and coasts. In E. Wolanski & M. L. DS (Eds.), *Treatise on estuarine and coastal science* (Vol. 3, pp. 7–38). Academic.

Galili, E., Dahari, U., & Sharvit, J. (1993). Underwater surveys and rescue excavations along the Israeli coast. *The International Journal of Nautical Archaeology, 22*(1), 61–77.

Galili, E., Benjamin, J., Eshed, V., Rosen, B., McCarthy, J., & Kolska Horwitz, L. (2019). A submerged 7000-year-old village and seawall demonstrate earliest known coastal defense against sea-level rise. *PLoS One, 14*, e0222560. https://doi.org/10.1371/journal.pone.0222560

Giaime, M., Morhange, C., Marriner, N., López-Cadavid, G. I., & Artzy, M. (2018). Geoarchaeological investigations at Akko, Israel: New insights into landscape changes and related anchorage locations since the Bronze Age. *Geoarchaeology, 33*, 641–660. https://doi.org/10.1002/gea.21683

Giaime, M., Jol, H. M., Salmon, Y., López, G. I., Hamid, A. A., Bergevin, L., Bauman, P., McClymont, A., Sailer-Haugland, E., & Artzy, M. (2021). Using a multi-proxy approach to locate the elusive Phoenician/Persian anchorage of Tel Akko (Israel). *Quaternary International, 602*, 66–81. https://doi.org/10.1016/j.quaint.2021.06.008

Gilboa, A., & Sharon, I. (2008). Between the Carmel and the sea: Tel Dor's iron age reconsidered. *Near Eastern Archaeology., 71*, 146–170.

Grant, K. M., Grimm, R., Mikolajewicz, U., Marino, G., Ziegler, M., & Rohling, E. J. (2016). The timing of Mediterranean sapropel deposition relative to insolation, sea-level and African monsoon changes. *Quaternary Science Reviews, 140*, 125–141. https://doi.org/10.1016/j.quascirev.2016.03.026

Gvirtzman, G., Shachnai, E., Bakler, N., & Ilani, S. (1983). *Stratigraphy of the Kukar group (Quaternary) of the coastal Palin of Israel* (pp. 70–82). Geological Survey of Israel.

Kadosh, D., Sivan, D., Kutiel, H., & Weinstein-Evron, M. (2004). A late quaternary paleoenvironmental sequence from Dor, Carmel coastal plain, Israel. *Palynology, 28*, 143–157. https://doi.org/10.1080/01916122.2004.9989595

Lazar, M., Basson, U., Himmelstein, A. G., Levy, T. E., Arkin Shalev, E., & Yasur-Landau, A. (2021). The door to Dor: Tracing unseen anthropogenic impact in an ancient port. *Geoarchaeology, 36*(2), 203–212. https://doi.org/10.1002/gea.21825

Marriner, N., & Morhange, C. (2007). Geoscience of ancient Mediterranean harbours. *Earth-Science Reviews, 80*(3–4), 137–194. https://doi.org/10.1016/j.earscirev.2006.10.003

Marriner, N., Goiran, J. P., Geyer, B., Matoïan, V., al-Maqdissi, M., Leconte, M., & Carbonel, P. (2012). Ancient harbors and Holocene morphogenesis of the Ras Ibn Hani peninsula (Syria). *Quaternary Research, 78*(1), 35–49. https://doi.org/10.1016/j.yqres.2012.03.005

Marriner, N., Morhange, C., Kaniewski, D., & Carayon, N. (2014). Ancient harbour infrastructure in the Levant: Tracking the birth and rise of new forms of anthropogenic pressure. *Scientific Reports, 4*(1), 1–11. https://doi.org/10.1038/srep05554

Morhange, C., Giaime, M., Marriner, N., Hamid, A. A., Bruneton, H., Honnorat, A., Kaniewski, D., Magnin, F., Porotov, A. V., Wante, J., Zviely, D., & Artzy, M. (2016). Geoarchaeological evolution of Tel Akko's ancient harbour (Israel). *Journal of Archaeological Science: Reports, 7*, 71–81. https://doi.org/10.1016/j.jasrep.2016.03.046

Nitschke, J. L., Martin, S. R., & Shalev, Y. (2011). Between Carmel and the sea: Tel Dor: The Late Periods. *Near Eastern Archaeology, 74*, 132–154. https://doi.org/10.5615/neareastarch.74.3.0132

Polzer, M. E. (2011). Early eastern Mediterranean ship construction (Ch. 16). In A. Catsambis, B. L. Ford, & D. L. Hamilton (Eds.), *The Oxford handbook of maritime archaeology* (pp. 349–378). Oxford University Press.

Raban, A. (1987). The harbor of the sea peoples at Dor. *The Biblical archaeologist, 50*, 118–126.

Raban, A. (1995). *Dor-Yam: Marine and coastal installations at Dor in their geomorphological and stratigraphic context* (pp. 286–354). Final Report. Institute of Archaeology, Hebrew University of Jerusalem.

Rohling, E. J., Foster, G. L., Grant, K. M., Marino, G., Roberts, A. P., Tamisiea, M. E., & Williams, F. (2014). Sea-level and deep-sea-temperature variability over the past 5.3 million years. *Nature, 508*, 477–482. https://doi.org/10.1038/nature13230

Roskin, J., Sivan, D., Shtienberg, G., Roskin, E., Porat, N., & Bookman, R. (2015). Natural and human controls of the Holocene evolution of the beach, Aeolian sand and dunes of Caesarea (Israel). *Aeolian Research, 19*, 65–85.

Shahack-Gross, R., Albert, R.-M., Gilboa, A., Nagar-Hilman, O., Sharon, I., & Weiner, S. B. (2005). Geoarchaeology in an urban context: The uses of space in a Phoenician monumental building at Tel Dor (Israel). *Journal of Archaeological Science, 32*, 1417–1431. https://doi.org/10.1016/j.aeolia.2015.09.007

Sharon, I., & Gilboa, A. (2013). The SKL Town: Dor in the Early Iron Age. In A. E. Killebrew & G. Lehmann (Eds.), *The philistines and other "sea peoples" in text and archaeology* (pp. 393–468). Society of Biblical Literature. Available: http://www.jstor.org/stable/j.ctt46n483

Sharon, I., Gilboa, A., Boaretto, E., & Jull, & A.J.T. (2005). The early Iron Age dating project: introduction, methodology, progress report and an update on the Tel Dor radiometric dates. In T. Levy & T. Higham (Eds.), *The Bible and radiocarbon dating: Archaeology, text and science* (pp. 65–92). Acumen Publishing Ltd..

Shtienberg, G., Zviely, D., Sivan, D., & Lazar, M. (2014). Two centuries of coastal change at Caesarea, Israel: Natural processes vs. human intervention. *Geo-Marine Letters, 34*, 365–379. https://doi.org/10.1007/s00367-014-0355-5

Shtienberg, G., Dix, J., Waldmann, N., Makovsky, Y., Golan, A., & Sivan, D. (2016). Late-Pleistocene evolution of the continental shelf of Central Israel, a case study from Hadera. *Geomorphology, 261*, 200–211. https://doi.org/10.1016/j.geomorph.2016.03.008

Shtienberg, G., Dix, J. K., Roskin, J., Waldmann, N., Bookman, R., Bialik, O. M., Porat, N., Taha, N., & Sivan, D. (2017). New perspectives on coastal landscape reconstruction during the Late Quaternary: A test case from Central Israel. *Palaeogeography, Palaeoclimatology, Palaeoecology, 468*, 503–519. https://doi.org/10.1016/j.palaeo.2016.12.045

Shtienberg, G., Yasur-Landau, A., Norris, R. D., Lazar, M., Rittenour, T. M., Tamberino, A., Gadol, O., Cantu, K., Arkin-Shalev, E., Ward, S. N., & Levy, T. E. (2020). A Neolithic mega-tsunami event in the eastern Mediterranean: Prehistoric settlement vulnerability along the Carmel coast, Israel. *Plos one, 15*(12), e0243619. https://doi.org/10.1371/journal.pone.0243619

Shtienberg, G., Gadol, O., Levy, T. E., Norris, R. D., Rittenour, T. M., Yasur-Landau, A., Tamberino, A., & Lazar, M. (2021). Changing environments and human interaction during the Pleistocene – Early Holocene from the shallow coastal area of Dor, Israel. *Quaternary Research, 105*, 64–81. https://doi.org/10.1017/qua.2021.30

Sivan, D., Widowinski, S., Lambeck, K., Galili, E., & Raban, A. (2001). Holocene sea-level changes based on archeological sites off northen Israel. *Palaeogeography, Palaeoclimatology, Palaeoecology, 167*, 101–117.

Sivan, D., Eliyahu, D., & Raban, A. (2004a). Late Pleistocene to Holocene wetlands now covered by sand, along the Carmel Coast of Israel, and their relation to human settlement: An example from the coastal site of Dor. *Journal of Coastal Research, 204*, 1035–1048. https://doi.org/10.2112/03503A.1

Sivan, D., Lambeck, K., Toueg, R., Raban, A., Porath, Y., & Shirman, B. (2004b). Ancient coastal wells of Caesarea Maritima, Israel, an indicator for relative sea level changes during the last 2000 years. *Earth and Planetary Science Letters, 222*, 315–330. https://doi.org/10.1016/j.epsl.2004.02.007

Sivan, D., Greenbaum, N., Cohen-Seffer, R., Sisma-Ventura, G., & Almogi-Labin, A. (2011). The origin and disappearance of the late Pleistocene–early Holocene short-lived coastal wetlands along the Carmel coast, Israel. *Quaternary Research, 76*, 83–92. https://doi.org/10.1016/j.yqres.2011.04.006

Stern, E. (1994). *Dor Ruler of the Seas* (p. 348). Israel Exploration Society.

Toker, E., Sivan, D., Stern, E., Shirman, B., Tsimplis, M., Spada, G. (2012). Evidence for centennial-scale sea level variability during the Medieval Climate Optimum (Crusader Period) in Israel, eastern Mediterranean. *Earth and Planetary Science Letters, 315–316*, 51–61.

Wachsmann, S. (2009). *Seagoing ships & seamanship in the Bronze Age Levant*. Texas A & M University Press.

Yasur-Landau, A., Shtienberg, G., Gambash, G., Spada, G., Melini, D., Arkin-Shalev, E., Tamberino, A., Reece, J., Levy, T., & Sivan, D. (2021). New relative sea-level (RSL) indications from the Eastern Mediterranean: Middle Bronze Age to the Roman period (~ 3800–1800 y BP) archaeological constructions at Dor, the Carmel coast, Israel. *PloS one, 16*(6), e0251870. https://doi.org/10.1371/journal.pone.0251870

Zviely, D., Sivan, D., Ecker, A., Bakler, N., Rohrlich, V., Galili, E., Boarreto, E., Klein, M., & Kit, E. (2006). Holocene evolution of the Haifa Bay area, Israel, and its influence on ancient tell settlements. *The Holocene, 16*, 849–861. https://doi.org/10.1191/0959683606hol977rp