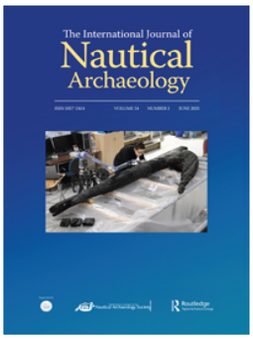

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A Roman Fish-Processing Facility at Tel Dor, Israel: Reinterpreting the Roman 'Purple Dye Factory'

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ABSTRACT

In this article we suggest that the Roman industrial complex on the coast of Tel Dor in Israel, previously interpreted as a purple dye factory, should be reinterpreted as a *cetaria* of similar scale to those in the western Mediterranean. We use analogous evidence from *cetariae* in Spain and Morocco to support this new interpretation. The identification of the Tel Dor fish-processing facility sheds new light on the participation of Dor in the globalisation of the Roman Mediterranean economy.

KEYWORDS

Roman coastal industry; *salsamenta*; murex purple dye; eastern Mediterranean; *chaîne opératoire*

Una instalación romana de procesamiento de pescado en Tel Dor, Israel: reinterpretando la 'fábrica de tinte púrpura' romana

RESUMEN

En este artículo sugerimos que el complejo industrial romano de la costa de Tel Dor en Israel, previamente interpretado como una fábrica de tintes púrpura, debería reinterpretarse como una cetaria de escala similar a aquellas del Mediterráneo occidental. Utilizamos evidencia análoga de cetariae en España y Marruecos para apoyar esta nueva intrepretación. La identificación de la instalación de procesamiento de pescado de Tel Dor arroja nueva luz sobre la participación de Dor en la globalización de la economía mediterránea romana.

PALABRAS CLAVE

industria costera romana; salsamenta; tinte púrpura de murex; Mediterráneo oriental; chaîne opératoire

以色列特尔多尔罗马时期鱼类加工厂：对罗马"紫色染料坊"的重新解读

摘要

位于以色列特尔多尔沿海地区的罗马时代工业建筑群，过去一直被认为是一座紫色染料坊，我们认为其更应被重新解读为一座规模与西地中海地区已知鱼类加工厂（*cetaria*）相类似的设施。本文通过西班牙和摩洛哥的同类遗址证据来支持这一新观点。对特尔多尔鱼类加工设施的识别，为分析多尔城在罗马时代地中海经济全球化进程中所处地位提供了新的诠释。

关键词

罗马时期沿海工业; 咸鱼（*salsamenta*）; 骨螺紫色染料; 东地中海; 产业链

以色列特爾多爾羅馬時期魚類加工廠：對羅馬「紫色染料坊」的重新解讀

摘要

位於以色列特爾多爾沿海地區的羅馬時代工業建築群，過去一直被認為是一座紫色染料坊，我們認為其更應被重新解讀為一座規模與西地中海地區已知魚類加工廠（*cetaria*）相類似的設施。本文通過西班牙和摩洛哥的同類遺址證據來支持這一新觀點。對特爾多爾魚類加工設施的識別，為分析多爾城在羅馬時代地中海經濟全球化進程中所處地位提供了新的詮釋。

關鍵詞

羅馬時期沿海工業; 鹹魚（*salsamenta*）; 骨螺紫色染料; 東地中海; 產業鏈

منشأة رومانية لتجهيز الأسماك في تل دور، إسرائيل: إعادة تفسير "مصنع الصبغة الأرجوانية" الروماني

المُستخلص

نقترح في هذه المقالة أن المُجمع الصناعي الروماني على ساحل تل دور في إسرائيل، والذي تم تفسيره سابقاً على أنه مصنع للصبغة الأرجوانية، يجب إعادة تفسيره على أنه مستنقع أسماك مشابه لتلك المتواجدة في غرب البحر الأبيض المتوسط. وتم استخدام أدلة مماثلة من مستنقعات الأسماك في إسبانيا والمغرب لدعم هذا التفسير الجديد. ومن الجدير بالذكر أن تحديد هويه منشأة تل دور لتجهيز الأسماك، يلقي ضوءاً جديداً على مشاركة تل دور في عولمة الاقتصاد الروماني في البحر الأبيض المتوسط.

الكلمات الدلالية

الصناعة الساحلية الرومانية
السالسامنتا
صبغة المواريكس الأرجوانية
شرق البحر الأبيض المتوسط
سلسلة التشغيل

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Introduction

The manufacturing of salted-fish products like *salsamenta*, *liquamen* and *garum* (salted fish and different types of fish sauce) was among the most prominent Mediterranean coastal industries in the Imperial and Late Roman Periods (1st century BCE–4th century CE) (Grainger, 2021). Murex dye production sites dot the coast from north-western Africa to the north-eastern corner of the Mediterranean (see Sussman, 2015, pp. 96–100). Archaeological evidence of fish-processing facilities, however, is not so evenly distributed. Roman *cetariae* – coastal facilities with large salting vats for making *salsamenta* and fish sauces – are ubiquitous in the western Mediterranean (see Arévalo & Bernal-Casasola, 2007; Bernal-Casasola, 2005; Bernal-Casasola et al., 2018; Busana, 2018; Expósito et al., 2018; Pinto et al., 2014; Slim et al., 2007; Trakadas, 2005, 2015; Wilson, 2005). Excavations around the Black Sea (Bekker-Nielsen, 2005a; Højte, 2005) indicate that the *cetariae* structures and associated technologies existed farther east and beyond the Mediterranean. Such facilities are very rare in Israel, with only a single positively identified example of an early Roman *garum* production facility at Khirbet er-Rasm, 2 km south-east of Ashkelon (Erickson-Gini, 2021). Curiously, this is an inland structure, not located on the coast but rather 2 km from the present coastline.

Zooarchaeological and chemical residue analyses can help one differentiate between fish processing (Expósito et al., 2018, p. 290) and other activities that make use of marine resources, such as purple dye (Michel & McGovern, 1987, 1990). Mollusk shells and fish bones can be clear indicators of production processes, and both purple dye and processed fish products leave residue signatures in the vessels used to prepare them. Still, it is often impossible to recover data after a site has been exposed for a long period of time, due to rising sea levels and other natural processes. Furthermore, past traditions in archaeological practice could overlook, contaminate, or destroy data during an excavation (Mylona, 2018, pp. 427–430). Therefore, in cases of legacy data – where the site has been exposed for many years, zooarchaeological data were neither collected nor preserved, and radiocarbon samples were not taken – researchers must rely on comparison of architectural features at sites with confidently identified murex dye and fish processing facilities, with products such such as *salsamenta* and *garum*. This is in addition to an analysis of accompanying pottery, to provide at least a relative chronology.

This is the case for the legacy data from the Roman coastal industry site at Tel Dor in Israel, presented here. A team from the Center for Maritime Studies at the University of Haifa (later the Recanati Institute for Maritime Studies), led by Avner Raban, conducted surveys, probes, and trial excavations along the coast of Dor from 1979 to 1984. At the conclusion of these seasons, the industrial facility found south of the North Bay of Dor, excavated in 1983, was interpreted as a murex purple dying factory, a first of its kind found in Israel. It was thought to be active from the late Hellenistic Period to the Byzantine Period (Raban, 1995, pp. 298–301; Raban & Galili, 1985, pp. 343–347) (Figures 1, 2). What led Raban to believe it was a purple dying factory was a spot of purple colour on the floor of one of the structure's rooms:

> Though the chemical components of this dye are still being checked in laboratories, the colour does add some strength to our initial assumption as to the original function of the entire complex as a purple dyeing factory. (Raban & Galili, 1985, p. 343)

With this notion in mind, the basins with their supply of salt and fresh water were consequently interpreted as instrumental for the process of dyeing cloth, the salt water for better attachment of the pigment to the cloth, and the fresh water for rinsing the dyed cloth later (Raban & Galili, 1985, p. 343).

Later, in the excavation report, Raban (1995, p. 300) noted that an analysis of the material 'failed to detect chemical resides of *murex* purple or any other organic components'. Still, he continued to favour the possibility that this was a purple dying complex rather than a complex for salting fish, based on his assumption that fresh water was used in the process, which fits a scenario of dyeing fabrics (Raban 1995, p. 301).

To date, no further study aimed to compare the Tel Dor coastal industrial complex to existing archaeological remains of coastal industrial installations in the Mediterranean. Furthermore, the pottery excavated by Raban remained unpublished. The current study, based on a new spatial analysis using aerial photogrammetry, and a re-examination of the legacy data from the unpublished notebook of Raban's excavations, as well as an analysis of the unpublished ceramic data, highlights intriguing similarities between the Tel Dor complex and *cetariae* found in the western Mediterranean. An examination of relevant pottery assemblages supports this interpretation and dates the use of the facility to the 2nd–3rd centuries CE.

Spatial Analysis of the Dor Industrial Complex

Tel Dor is located in the north of the Mediterranean coast of Israel, *ca*. 35 km south of Haifa and 13 km north of Caesarea. The Tel Dor industrial complex is located on a rocky promontory separating the North Bay and the Love Bay, about 400 m north-west of the tell (see Figure 1). A *kurkar* (local aeolianite)

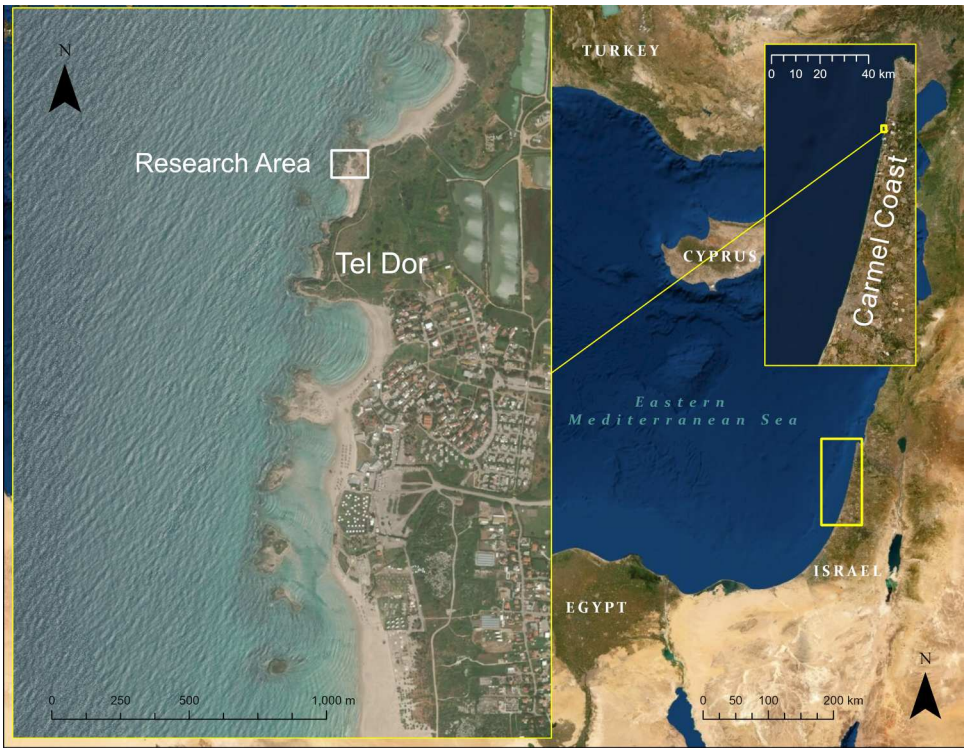

Figure 1. Regional map of the eastern Mediterranean showing the research area at Tel Dor (by J. Reece; Satellite images by Google Earth, with data from CNES/Airbus, Data SIO, NOAA, U.S. Navy, NGA, GEBCO, Mapa GISrael.

shelf protrudes through the beach sand here, upon which the research area occupies 635 m^2. An aerial view of the research area taken in 2019 (Figure 2) reveals a half-buried complex comprising rock-cut pools, water channels, plastered rectangular vats and oval basins cut into the *kurkar* bedrock, a central structure with numerous plastered features, and a plastered central courtyard.

The two rock-cut pools are set directly into the *kurkar* to the west of the complex, near the termination of the shelf in the Mediterranean (Figure 2). The northern pool has a volume of roughly 13 m^3, and the southern pool is slightly larger at 14.5 m^3. Due to natural sand fill and calcareous accretion from seawater, neither pool has a modern depth of more than 0.6 m; both were likely deeper in antiquity. A bench or shelf with an average width of 0.5 m sits about 0.3 m below the current rims of both pools. A short channel cut on the rock surface connects the pools, allowing water to flow freely between them. The pools are not plastered, nor do they have any other waterproofing surface layer, but this could be the result of centuries of erosive action in the intertidal zone.

A salt-water channel, *ca.* 15 m long, cut directly into the *kurkar* facilitate the flow of seawater into the south pool. Another channel, going towards the sea from the junction north of the north pond may be connected to draining surplus fresh water (see below). Vertical cut marks are located on both sides of the salt-water channel near their entry into the pool and likely held a circular stone or some other damming mechanism (e.g., sluice gate), allowing for the circulation of seawater in and out of the system with semidiurnal tides. Archaeological indicators such as coastal structures and wells demonstrated that during the Hellenistic Period, sea levels were *ca.* 2 m lower than in Roman Period (Yasur-Landau et al., 2021, p. 8). These channels could have therefore operated only in the Roman Period, in which sea levels were similar to the ones today, and not before (Yasur-Landau et al., 2024).

Raban (1995, p. 298) mentions also a channel of fresh water coming from the north, parallel to the coast, different in construction and function from the salt-water channels. The channel splits into two subsidiary channels north of the northern pool: the first enters the rock-cut pools from the north, and the second runs through the central building, distributing fresh water to the plastered features within (Figure 2d). These U-shaped in profile channels are built from small cut stones rather than cut into the *kurkar*, and their interiors are plastered. The source of fresh water may have been an aqueduct originating in the Dalia Stream, some 4 km south–east of Tel Dor (Raban 1995, p. 298).

Four rectangular vats, named so as they do not direct access to water, as the pools do (Figure 2: V1–V4), form an east–west line along the southern edge of the industrial complex. These are cut directly into

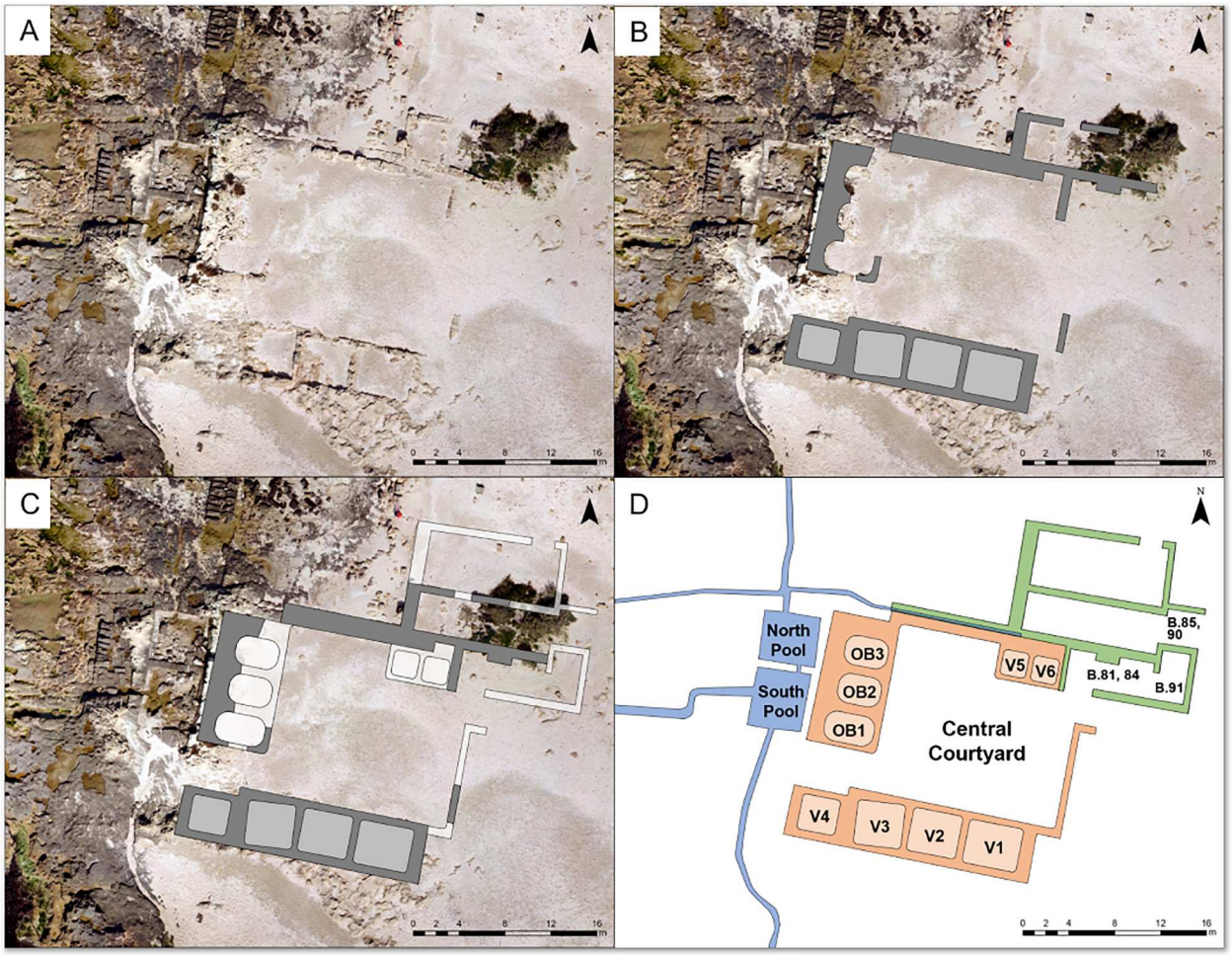

Figure 2. Imagery of the industrial facility showing: (A) the architectural remains; (B) highlighted architectural features (grey) visible during the 2019 survey; (C) additional architectural features (white) visible in 1984 and described by Raban (1995, pp. 299–300); and (D) the rock-cut pools and channels (blue), salting vats and basins (orange), and central structure (green). Also shown are the approximate locations of the pottery baskets from Raban's excavation in the central structure (drone images by A. Tamberino; plan by J. Reece and A. Yasur-Landau).

the *kurkar* outcrop, with eroded *opus signinum* plaster visible at current sand level on the walls of V1 and V2. The 1983 Haifa excavation top plan (Raban, 1995, fig. 9.5) also indicates the northern edges of two smaller rectangular vats (V5, V6), which lay beneath the sand along the northernmost edge of the central courtyard. These six vats were not measured prior to the authors' geospatial survey in 2019; therefore, minimum depths in Table 1 are calculated from the surviving top surface of the feature to the lowest elevation within the vat (i.e., the top of the sand fill). Estimated depths in Table 1 are calculated from the surviving top surface of the feature to 0.4 m above local relative sea level (RSL; see Yasur-Landau et al., 2021, pp. 7–9) during the Roman Period, to account for tidal changes in the salt-water table (see Vunsh et al., 2018).

A trio of oval-rectangular basins, different in shape and construction technique then basins (Figure 2: OB1–OB3), cut into the *kurkar* outcrop and built up with rubble, form a north–south line east of the

Table 1. Dimensions of salting vats (V1–V6) and oval basins (OB1–OB3) at the Tel Dor facility.

Feature	Surface (m^2)	Minimum Depth (m)	Estimated Depth (m)	Minimum Volume (m^3)	Estimated Volume (m^3)	Visible at Present
V1	18.6	0.5	1.8	9.3	33.5	Y
V2	17.0	0.7	1.8	11.9	30.6	Y
V3	15.5	1.1	1.8	17.1	27.9	Y
V4	13.0	0.4	1.8	5.2	23.4	Partial
V5	4.0	-	0.6	-	2.4	N
V6	4.0	-	0.6	-	2.4	N
OB1	10.4	0.4	1.5	4.2	15.6	Partial
OB2	14.1	0.3	1.5	4.2	21.2	N
OB3	14.1	0.3	1.5	4.2	21.2	N
Total	**110.7**	**-**	**-**	**56.1**	**178.1**	

rock-cut pools. These are shown as square in the Raban field plan (Raban, 1995, fig. 9.5), yet their outline is more oval in our 2019 field study. The basins are 'plastered with an impermeable cement' (Raban & Galili, 1985, p. 342), likely referring to a plaster similar to the *opus signinum* found in the nearby rectangular vats. The only exposed remains are the south-eastern corner (built of plastered rubble) and the western edge (cut directly into the *kurkar*) of the southern basin, although Raban (1995, p. 299) describes two more oval basins of dimensions similar to OB1–OB3 adjacent to the north.

The 1983 excavation also uncovered part of a large (215 m^2) plastered floor surface atop ashlar stones and the *kurkar* bedrock. Raban referred to it as a 'rectangular ashlar paved court' in later publications (Raban & Galili, 1985, p. 342), indicating it was more exposed in the early 1980s and spans what is now an unbroken expanse of beach sand.

The 1983 University of Haifa excavation (Raban, 1995, pp. 299–300) focused primarily on a multiroom central building in the north-eastern corner of the complex (highlighted green in Figure 2). Notably, the central structure is rich with plastered features – basins, pits, channels, and the floors of entire rooms. Conduits and channels connect many of these features, and the abundance of plastered surfaces indicates the frequent storage and movement of liquids. Currently, much of this structure is covered in sand, yet the unpublished pottery from some of its context remained in the Recanati Institute for Maritime Studies and is presented below.

Archetypes of *Cetariae* Architecture: Nine Facilities at Baelo Claudia (Spain) and Cotta (Morocco)

The Tel Dor facility exhibits striking similarities to the *cetariae* typology of the western Mediterranean with numerous examples (e.g. Trakadas, 2015) of which two well-documented fish-processing facilities were selected for this study: Baelo Claudia in Spain (Figure 3) and Cotta in Morocco (Figure 4). The *cetariae* of Baelo Claudia, eight industrial complexes (designated C.I. I–XI) dating from the 2nd century BCE to the 5th century CE (Bernal-Casasola et al., 2018, p. 329), are within the city limits and constrained by adjacent buildings (see Figure 3). The complex has recurring features that, regardless of layout, are present in nearly all cases – rectangular vats, smaller round basins, and open preparation areas, all plastered with *opus signinum*. The Cotta *cetaria* follows a similar typology but in a more rural setting. The complex is large likely due to the space available and the profitability of *salsamenta* and *garum* production (see Figure 4). The facility dates to the 1st–3rd centuries CE (Marzano, 2013, p. 103), with most of the material coming from the middle of the 1st century CE (Trakadas, 2015, p. 40).

The vats at both sites vary in size but follow standard shape and construction. Of the nearly 70 vats at Baelo Claudia, all but five are quadrangular, and most of the medium-sized vats are square. Despite their variations in size, each is built of cut stones set with mortar and sunk into the ground with the top

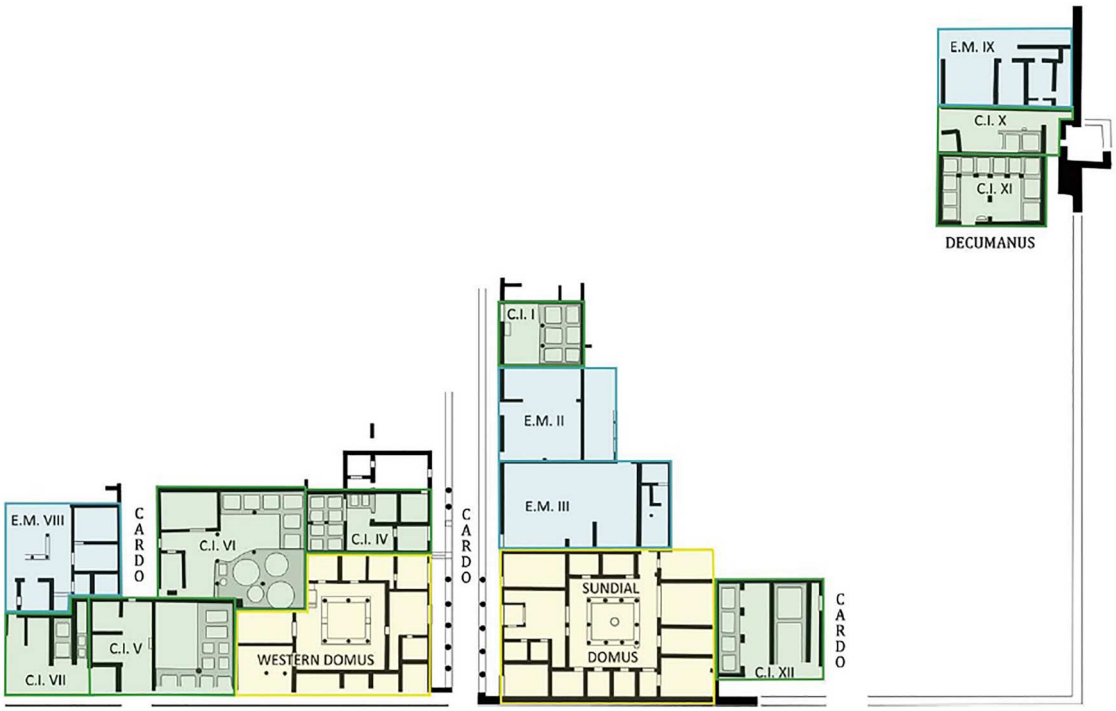

Figure 3. Baelo Claudia plan of the industrial area with eight cetariae (green), three domus (yellow), and buildings of unknown function (blue; E.M.) (plan after Bernal-Casasola et al., 2018, p. 331, fig. 2C; modified by J. Reece).

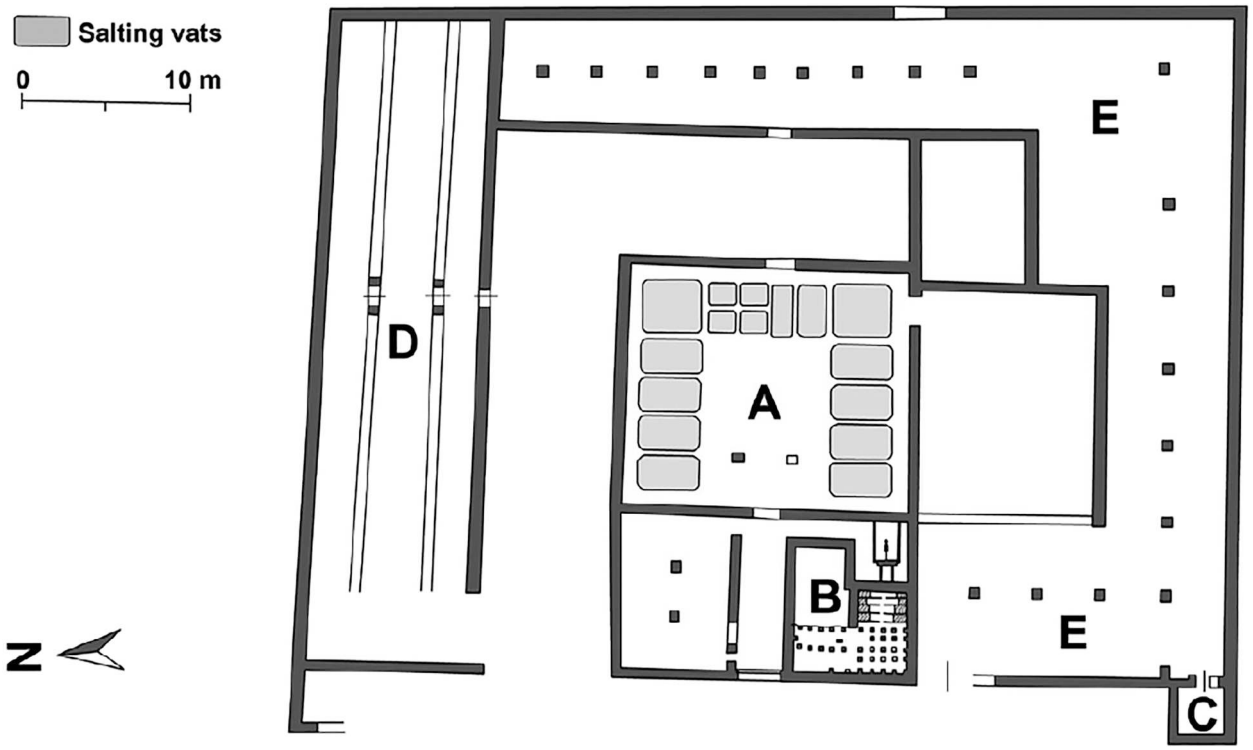

Figure 4. Top plan of the *cetaria* at Cotta, Morocco: (A) large, paved floor surrounded by salting vats; (B) room with hypocaust heating system; (C) possible watchtower; (D) preparation area; (E) storage area. Note the centralised location of the preparation floor within the salting vats (after Marzano, 2013, p. 103, fig. 18).

at or slightly above ground level, with an *opus signinum* plaster coating. The 16 salting vats at Cotta vary in size from 1.3 × 1.3 m (the four smallest, grouped on the eastern side) to 3.5 × 3.5 m (the two square vats in the north-eastern and south-eastern corners) and are set into the floor so that their top is slightly above the walking surface. Depths are difficult to determine due to collapse, but all of the vats are deeper than 2 m (Marzano, 2013, p. 103). *Opus signinum* plaster is ubiquitous on most surfaces, including the large open workspace at the centre of the facility. It is possible that multiple vats were used in the production of *garum*, to control consistency, volume, taste, and salinity, as well as to rebrine the residue left from previous production activities (Grainger, 2020, p. 185).

All but one of the Baelo Claudia factories (C.I. VII) have a similar courtyard preparation area within the facility: in the front (C.I. I), in the back (C.I. IV, VI), in the middle surrounded by vats (C.I. XI), and in the middle with vats off to one or both sides (C.I. VII, XII) (Bernal-Casasola et al., 2018, p. 344). In all cases, the preparation area is adjacent to or surrounded by the salting vats and plastered with *opus signinum*. These areas served an essential function in large-scale fish-salting operations, where great quantities of fish could be washed, gutted, and cleaned prior to the fish being stacked into vats for processing. The 'rectangular ashlar paved court' (Raban & Galili, 1985, p. 342) at the Tel Dor facility afforded its users a similar scale of processing.

Ancillary features present at some of the *cetariae* provide a clearer picture of the *salsamenta* and *garum chaîne opératoires* implemented in such facilities. At Baelo Claudia, a channel buried under the buildings and the street during a 1979 survey of the area pre-excavation, was identified by Trakadas (2005, p. 57) to have carried fresh water to the *cetariae* for cleaning. At Cotta, Ponsich and Tarradell (1965, pp. 60–61), interpreted a large fresh-water cistern and hypocaust as related to fishing and fish-sauce production and saw them as cohesive part of that facility's production process. The hypocaust is also noteworthy, as it could suggest the demand for Cotta fish sauce warranted a dedicated artificial heating mechanism on-site perhaps to speed up processing (Trakadas, 2005, pp. 67–68, 2015, p. 40).

A New Interpretation: The Roman *Cetaria* of Tel Dor

The abovementioned facilities in the western Mediterranean follow a similar typology that establishes an archetype model to reassess the 'purple dye factory' at Tel Dor. Architectural analysis strongly supports our argument that the site's function from the 1st to the 3rd centuries CE was for *salsamenta* and *garum* production – a proper Roman *cetaria*.

The six rectangular vats at Tel Dor are analogous to the vats at Baelo Claudia and Cotta in both dimension and distribution, and they are emblematic of the salting stage of *salsamenta* production. Waterproofing

Table 2. Production volume of the facilities from Baelo Claudia, Cotta, and Tel Dor (after tab. 4 in Bernal-Casasola et al., 2018, p. 343).

Site	Facility	Whole Surface (m^2)	No. of Vats	Volume (m^3)	Courtyard/ Cutting Rooms	Surface (m^2)	Plastered Surfaces	Additional Rooms	Surface (m^2)
Baelo Claudia	CI-I	87.36	6	54.44	1	31.50	Y	-	-
	CI-IV	141.81	9	41.32	1	30.72	Y	3	38.43
	CI-V	239.40	10	51.75	1	37.59	Y	5	61.87
	CI-VI	263.29	13	90.45	1	36.75	Y	4	97.15
	CI-VII	73.15	6	37.48	-	-	-	3	34.27
	CI-X	100.50	3/5	17.5/29.16	1	17.51	Y	3	30.72
	CI-XI	137.20	11	90.00	1	40.88	Y	-	-
	CI-XII	168.14	8	106.00	1	36.76	Y	1	12.50
	Total	*1210.85*	*66/68*	*488.94/500.60*	*7*	*231.71*	-	*19*	*274.94*
Cotta	-	2240.00	16	258.00	1	475.00	Y	10	1765.00
Tel Dor	**-**	**635.00**	**7/9**	**56.10/178.10 (min/est.)**	**1**	**215**	**Y**	**4**	**155.00**

plaster on the inner surfaces of the vats further supports this interpretation and indicates a standardisation of fish-salting technologies across the Mediterranean. The cumulative volume of the six vats at the Dor complex is well within the expected range for a large fish-processing facility. The estimated capacity of the Dor facility is 178.1 m^3, smaller than the rural facility at Cotta at 258 m^3 and perhaps larger than C.I. XII at Baelo Claudia at 106 m^3 (see Table 2). This is of course bearing in mind that the capacity does not directly indicate the amount of production (Trakadas, 2018, p. 359).

Tel Dor's three oval basins are similar to but do not directly parallel any of the features at Baelo Claudia or Cotta; however, Wilson (1999, p. 42) notes that similar features in *cetariae* at Sullecthum (Tunisia), Neapolis (Tunisia), and Lixus (Morocco) also have rounded corners, perhaps an intentional variation to enable easier stirring of fish sauces (see Curtis, 1991, p. 52). Interpreting the basins at Tel Dor as part of a *garum* production facility also accounts for their smaller size and shallower depth compared to the neighbouring rectangular vats, as *garum* was often fermented in open jars or cookware vessels (Carannante et al., 2011, p. 73; Corcoran, 1963, p. 206; Wilkins, 2005, p. 29), in addition to permanent fermentation basins like those in C.I. X and XII at Baelo Claudia (Expósito et al. 2018, p. 290). Ponsich and Tarradell (1965, pp. 55–68) interpret the four smaller vats at Cotta as receptacles used in *garum* production, for similar reasons.

The rock-cut pools adjacent to the facility at Tel Dor may have been used as *piscinae* to raise or store fish (such as the grey mullet, according to Raban [1995, p. 301]). Elsewhere, Roman aquacultural practices employed small compartments or separate tanks to segregate fish by species or size (for example, see Higginbotham, 1997, pp. 140–151, figs 55–61, pp. 153–154, figs 162, 163, p. 166, fig. 72), protecting smaller fish from larger predators until they had grown to a sufficient size. Additionally, Kron (2008, p. 182) notes that smaller tanks built by the Romans 'are often furnished with aqueducts supplying fresh water so as to create the brackish conditions which promote the development of the fry of the popular euryhaline [able to tolerate a wide range of salinity] species which were generally farmed'. While the *cetariae* at Baelo Claudia and Cotta lack dedicated *piscinae*, those at Dor may have been a nonessential yet practical feature for supplying the facility with fresh fish.

Finally, the central courtyard is analogous to the preparation areas of all the *cetariae* at Baelo Claudia and Cotta and plays a basic yet crucial role in the fish-salting process. Plastered and with easy access to both fresh and salt water, this area served as a staging area for the multistep *salsamenta* and *garum* production processes. Fish caught nearby at the North Bay or Love Bay or further away in the open sea could then be cleaned with fresh water at the central building or salt water from the sea, and subsequently gutted and rinsed in the courtyard, prior to salting. The plastered courtyard could then be cleaned with readily available fresh or salt water, where its natural seaward slope would channel the waste into the sea through the opening between the rectangular vats and the *kurkar* wall. This space convincingly mirrors the preparation areas of the urban *cetariae* at Baelo Claudia and, from an aerial view, exhibits a spatial organisation that is almost an exact copy of Cotta's floor plan (Figure 5).

The Chronology of the Dor Structure

The historical context of the construction and use of the Tel Dor structure, now likely identified as a Roman *cetaria*, may be strengthened by establishing its period of use. The unpublished ceramic assemblages from this structure at Tel Dor provide evidence of the chronology of the main period of the structure's use, as well as later activities in the area (also see Tables 3–7). The pottery contexts are presented here according to the basket numbers in Raban's original, unpublished excavation diary entries for 5 December 1983 and 8 December 1983. The location of these unpublished contexts (Figure 2D) is established according to the same notes. However, as Raban did not delineate the lateral extent of each context, the

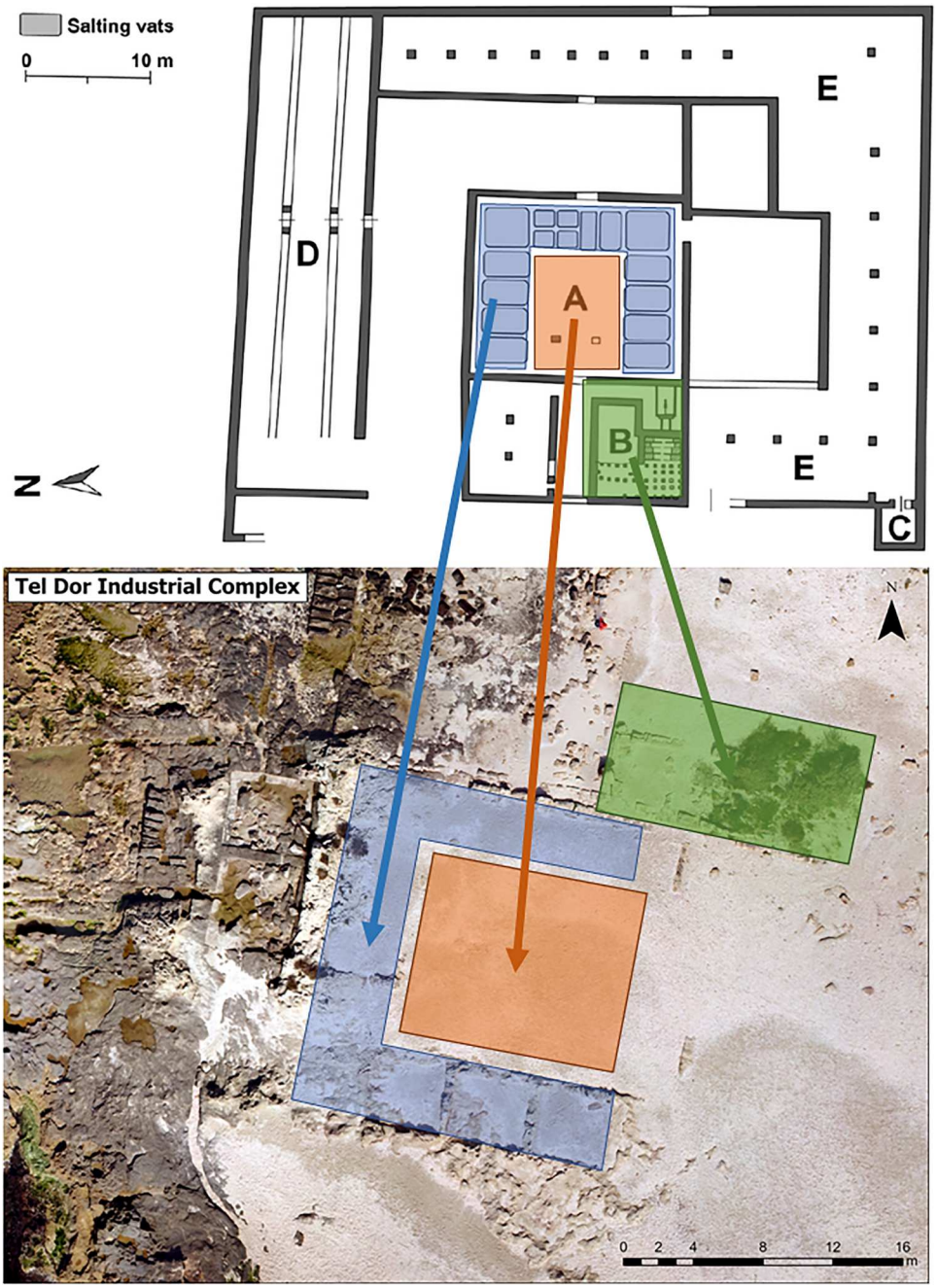

Figure 5. Spatial comparison of Cotta (top) and Tel Dor (bottom) with plastered preparation area (orange), plastered vats and basins (blue), and adjacent structure (green) shown (Cotta plan after Marzano, 2013, p. 103, fig. 18) (image by J. Reece).

area attributed to each basket is inferred from the brief text of the diaries on the work done each day.

Pottery Discussion

The ceramic material from five baskets recovered from contexts relevant to our understanding of the complex. Basket 91 (Figure 6, Table 3) comes from a from a rock-cut pit filled with red sand and silt sediment (*hamra*) (elevation 1.10–0.72 m asl), located adjacent to the eastern wall of the main building and close to its south-eastern corner (Figure 2) the material provides a *terminus post quem* for the initial infilling of the building with refuse, likely after the 2nd century CE. Some of the fill material was likely taken from earlier 1st- and 2nd-centuries CE dwellings in the nearby city, as attested by a variety of vessel types that are consistent with domestic assemblages, such as a range of cooking pots and casseroles, tableware, storage jars, lamps, mortaria, and a roof tile. These are unlikely to represent industrial activity within the structure.

The assemblage of Basket 90 (Figure 7, Table 4) was collected in the north end of the central building's eastern ashlar wall, north of Basket 91 and likely stratigraphically equivalent, at least in part, to Basket 85 (elevation 1.80 m asl) (Figure 2). The typology for this basket is dominated by regional storage jars,

Table 3. Basket 91 assemblage.

Fig. No.	Reg. No.	Date	Typology	Description
6.1	DY83 7/91	2nd–3rd c. CE	Holemouth jar (Johnson no. 347; GZ fig. 6.50.4–6; Elg pl. XIX:142–150)	Diameter 10 cm; thickness 1.0 cm
6.2	DY83 10/91	2nd–3rd c. CE	Holemouth jar (Johnson no. 347; GZ fig. 6.50.4–6; Elg pl. XIX:142–150)	Diameter 13 cm; thickness 1.3 cm
6.3	DY83 21/91	2nd–3rd c. CE	Holemouth jar (Johnson no. 347; GZ fig. 6.50.4–6; Elg pl. XIX:142–150)	Diameter 11 cm; thickness 0.7 cm
6.4	DY83 8/91	Early–mid-1st c. CE	Cooking bowl (Berlin 2020)	Diameter 32 cm; thickness 0.9 cm
6.5	DY83 15/91	1st c. BCE–1st c. CE	ESA globular chalice (Hayes Type 30A; Slane no. FW 249; RFL, fig. 185:11a–b)	Diameter 26 cm; thickness 0.4 cm
6.6	DY83 20/91	2nd–1st c. BCE	ESA plate (Hayes Form 36; Slane 1997)	Thickness 1.3 cm; ring base
6.7	DY83 19/91	1st c. CE	'Herodian' knife- pared lamp (Suss nos. 19–23)	Thickness 0.5 cm
6.8	DY83 22/91	1st–2nd c. CE	Round Syrian discus lamp (Suss no. 86)	Thickness 0.5 cm

Pottery Abbreviations: AB = Adan-Bayewitz, 1993; Berlin = Berlin, 2020; BN = Bar-Nathan, 1986; BNG = Ben-Nahum & Getzov, 2006; B&H = Briend & Humbert, 1980; B&S = Berlin & Stone, 2016; Cost = Constantine, 2019; Elg = Elgavish, 1977; GZ = Guz-Zilberstein, 1995; Hayes = Hayes 1972; Johnson = Johnson, 2008; Loff = Loffreda, 1974; Mag92 = Magness, 1992: Mag93 = Magness, 1993; Maj = Majcherek, 1995; Oleson = Oleson et al., 1994; PW = Peacock and William, 1986; Raban = Raban 1989; Ratzlaff = Ratzlaff et al., 2017; RFL = Reisner, Fisher, & Lyon, 1924; RH = Rosenthal-Heginbottom, 1995; Riley = Riley, 1975; Sherwood = Sherwood 1994; Slane = Slane 1997; Sussman = Sussman, 2008; vA = van Alfen, 1996, Wic = Wicenciak, 2016

Table 4. Basket 90 assemblage.

Figure No.	Reg. No.	Date	Typology	Description
7.1	DY83 1/90	Mid-1st c. BCE–mid-1st c. CE	Jiyeh amphora handle (Wic no. 246, Subtype 8.1)	Body and oval handle with deep gutter down the center
7.2	DY83 2/90	Mid-1st c. BCE–mid-1st c. CE	Jiyeh amphora handle (Wic no. 247, Subtype 8.2)	Amphora handle
7.3	DY83 7/90	2nd–5th c. CE (prob. 2nd c.)	Palestinian bag jar (PW 46/62)	Thickness 1.1 cm
7.4	DY83 8/90	2nd–5th c. CE (prob. 2nd c.)	Palestinian bag jar rim (PW 46/62)	Diameter 6 cm; thickness 0.6 cm; PH 4.1 cm
7.5	DY83 10/90	2nd–3rd c. CE	Holemouth jar (Johnson no. 988; GZ p. 323-4)	Diameter 10 cm; thickness 1.2 cm; PH 1.9 cm
7.6	DY83 17/90	1st c. BCE–2nd c. CE	Amphora handle (local)	PH 5.6 cm
7.7	DY83 11/90	Late 1st–2nd c. CE	Amphora rim (local)	Diameter 30 cm; thickness 0.7 cm; PH 3.8 cm
7.8	DY83 4/90	Late 1st c. BCE–2nd c. CE	Amphora (Dressel 2–4 Kos; PW10; Oleson A7 & A8)	Descending double-barreled handle and tight curvature of neck
7.9	DY83 14/90	1st c. BCE–1st c. CE	Cooking Pot rim	Thickness 0.4 cm; PH 7.4 cm
7.10	DY83 19/90	1st c. BCE–1st c. CE	Kfar Hananya cooking pot rim (AB Form 3A, pl. 3A; Johnson no. 780)	PH 4.4 cm
7.11	DY83 20/90	2nd–4th c. CE	Kfar Hananya cooking pot rim (AB Form 4C, pl. 4C)	PH 4.2 cm
7.12	DY83 21 + 22/90	Late 1st c. BCE–2nd c. CE	Casserole rim (GZ fig. 6.39.6, fig. 6.1)	PH 4.6 cm
7.13	DY83 13/90	2nd c. BCE–1st c. CE	Shallow bowl with ring base (GZ fig. 6.52.8)	Thickness 0.6 cm; PH 2.0 cm; Phoenician semi-fine ware

mostly forms of Palestinian bag jars and holemouth or early-form Gaza jars. The majority of pottery from this basket dates to the 2nd–3rd centuries CE, with a few later outliers. The dominance of amphorae may indicate that at least some of the material in this basket comes from the main use period of the structure in the 2nd century CE, as an industrial facility.

Material from the area adjacent to the central building's eastern ashlar wall was recollected as Basket 85 (Figure 8, Table 5), and likely corresponds stratigraphically to Basket 90, at least partially (elevation 1.80 m. asl) (Figure 2). This is the largest assemblage related to the building complex, with 54 diagnostic sherds. There is an undeniably domestic character to the pottery found here, with functionally utilitarian vessels, such as table jugs and jars, a dipper juglet, cooking vessels, and oil lamps, as well as local and imported storage jars. The majority of material dates to a span of the 1st–2nd centuries CE, with a few earlier outlying material from the 2nd–1st centuries BCE. Like Basket 90, it is representative of the structure's main period of use. It is possible that the earlier, Hellenistic, material comes from constructional fills connected with the construction of the industrial structure, as the plan shows uneven bedrock surface in this area.

A sparse assemblage of only a few diagnostic sherds (Basket 84; Figure 9, Table 6) was recovered from the floor of the southern room of the main building (elevation 1.35 m asl) (Figure 2). The chronology of this small group falls comfortably within the 1st–2nd centuries CE and is also indicative of the use period of the building. The occupational debris (Basket 81; Figure 10, Table 7) directly on the surface of the

Table 5. Basket 85 assemblage.

Fig. No.	Reg. No.	Date	Typology	Description
8.1	DY83 11/85	Comparable example from Caesarea at 1st c. BCE–1st c. CE	Holemouth Jar with knob rim (Johnson no. 988)	Thickness 0.7 cm
8.2	DY83 19/85	1st half of 2nd c. CE (100–150 CE)	Palestinian bag jar (PW 46/62; Riley, 1975, 1°; Mag92 pp. 130-132; Ratzlaff pp. 131-136)	Diameter 11 cm; thickness 0.6 cm
8.3	DY83 28/85	1st BCE–5th c. CE	Palestinian bag jar (PW 46/62; Riley, 1975, 1A; Mag92 pp. 130-132; Ratzlaff pp. 131-136)	Diameter 11 cm; thickness 1.0 cm
8.4	DY83 30/85	2nd–3rd c. CE	Short Gaza jar (Johnson no. 1188)	Diameter 13 cm; thickness 1.5 cm
8.5	DY83 32/85	50–325 CE	Palestinian bag jar (PW 46/62; Diez Fernandez Type 1.9; Johnson no. 1007–1008)	Thickness 0.7 cm
8.6	DY83 45/85	1st half of 2nd c. CE (100–150 CE)	Palestinian bag jar (PW 46/62; Riley, 1975, 1A; Mag92 pp. 130-132; Ratzlaff pp. 131-136)	Diameter 8 cm; thickness 0.6 cm
8.7	DY83 52/85	1st c. BCE–2nd c. CE	Amphora toe (Dressel 5; Koan) (Oleson A7/A8)	Solid toe (base)
8.8	DY83 53/85	1st–2nd c. CE	North African *garum* jar (Dressel 14 or imitation) (PW Form 20)	
8.9	DY83 54/85	2nd c. BCE	Dipper juglet (GZ fig. 6.28, nos. 1–7)	Cylindrical juglet with a flat base
8.10	DY83 18/85	Late Hellenistic–Roman	Misc. table jar	Diameter 14 cm; thickness 0.5 cm
8.11	DY83 25/85	1st c. BCE–1st c. CE	Rhodian amphora rim (Oleson A80)	Diameter 14 cm; thickness 0.7 cm
8.12	DY83 24/85	Comparable example from Caesarea at 1st c. BCE–1st c. CE	I-handle of table jug (Johnson no. 435)	Diameter 11 cm; thickness 0.7 cm
8.13	DY83 10/85	2nd–late 1st c. BCE; may continue into 1st c. CE	Dipper juglet elongated base GZ fig. 6.28, nos. 1–7)	Diameter 3.5 cm; thickness 0.5 cm; joins with DY83 2/85
8.14	DY83 1/85	2nd–4th c. CE	Kfar Hananya cooking pot (Form 4C, AB pp. 128–130; Johnson no. 809)	Diameter 11 cm; thickness 0.3 cm
8.15	DY83 6/85	2nd–4th c. CE	Kfar Hananya cooking pot base (Form 4C, AB pp. 128–130; Johnson no. 809)	Thickness 0.4 cm
8.16	DY83 13/85	2nd–4th c. CE	Kfar Hananya cooking pot (Form 4C, AB pp. 128–130; Johnson no. 809)	Thickness 2.2 cm
8.17	DY83 16/85	1st–late 3rd c. CE	Kfar Hananya cooking pot (Form 1A)	Thickness 0.3 cm
8.18	DY83 34/85	2nd–4th c. CE	Kfar Hananya cooking pot (Form 4C, AB pp. 128–130; Johnson no. 809)	Diameter 18 cm; thickness 0.5 cm
8.19	DY83 35/85	1st–late 3rd c. CE	Kfar Hananya cooking pot (Form 1A)	Diameter 23 cm; thickness 0.4 cm
8.20	DY83 36/85	2nd–4th c. CE	Kfar Hananya cooking pot (Form 4C, AB pp. 128–130; Johnson no. 809)	Diameter 22 cm; thickness 0.4 cm
8.21	DY83 37/85	2nd–4th c. CE	Kfar Hananya cooking pot (Form 4C, AB pp. 128–130; Johnson no. 809)	Diameter 13 cm; thickness 0.5 cm
8.22	DY83 39/85	2nd–4th c. CE	Kfar Hananya cooking pot (Form 4C, AB pp. 128–130; Johnson no. 809)	Diameter 12 cm; thickness 0.6 cm
8.23	DY83 51/85	1st c. BCE–5th c. CE	Roman roof tile	Local fabric

Table 6. Basket 84 assemblage.

Fig. No.	Reg. No.	Date	Typology	Description
9.1	DY83 6/84	1st c. BCE–1st c. CE	Trefoil jug rim (Jiyeh Type 1, Wic pl. 12, no. 77)	Diameter 6 cm; thickness 0.5 cm
9.2	DY83 12/84	Roman	Section of piping	Thickness 1.2 cm
9.3	DY83 13/84	1st c. BCE–5th c. CE	Roman roof tile	Thickness 2.2 cm

Table 7. Basket 81 assemblage.

Fig. No.	Reg. No.	Date	Typology	Description
10.1	DY83 2/81	Comparable example from Caesarea at 1st c. BCE–1st c. CE	Holemouth jar (Johnson no. 347; GZ fig. 6.50.4–6; Elg pl. XIX:142–150)	Diameter 10 cm; thickness 0.7 cm
10.2	DY83 5/81	1st c. BCE–1st c. CE	Imported amphora handle (likely a Dressel 4-6 or Koan/pseudo-Chian) (PW 39; Oleson A14)	Thickness 2.6 cm; double-barreled handle of imported amphora
10.3	DY83 6/81	Late 2nd c. BCE–early/mid-1st c. CE	ESA hemispherical cup rim and section of body (Hayes Type 3A; Slane FW 182, TA Type 25; Const, pl. 5:18–19)	Diameter 12 cm; thickness 0.4 cm
10.4	DY83 8/81	Early 1st c. CE	Cooking ware lid (Berlin pl. 37, no. 337)	Diameter 25 cm; thickness 0.7 cm
10.5	DY83 3/81	2nd–3rd c. CE	Kfar Hananya cooking pot (Form 4C; AB pl. 4C)	Diameter 19 cm; thickness 0.5 cm
10.6	DY83 10/81	2nd–3rd c. CE	Kfar Hananya cooking pot (Form 4C; AB pl. 4C)	Diameter 10 cm; thickness 0.5 cm; possibly same as DY83 15/81
10.7	DY83 13/81 + 15/81	Late 4th–late 2nd c. BCE	Tell Keisan cooking pot (Type 1) (B&H pl. 11: a–n; Johnson nos. 766–768)	Diameter 11 cm; thickness 0.4 cm
10.8	DY83 14/81	2nd–3rd c. CE	Kfar Hananya cooking bowl (Form 1B)	Diameter 22 cm; thickness 0.4 cm

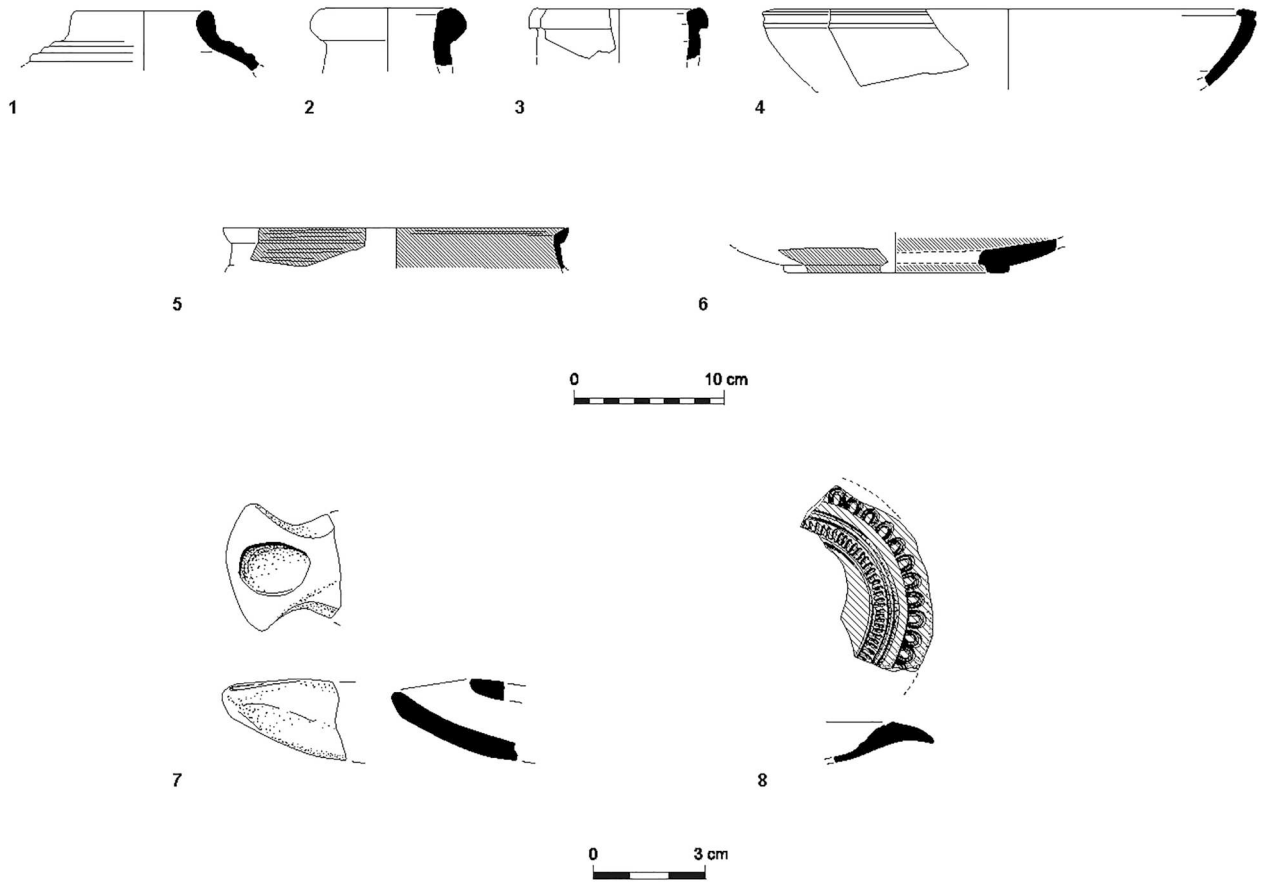

Figure 6. Basket 91 ceramic assemblage (drawings by N. Earon).

central building, possibly above the floor level of Basket 85 (yet mentioned with the same elevation of 1.35 m asl) (Figure 2) consists of 19 diagnostic sherds and several more body sherds, that are characteristically domestic, with representative examples of tableware and cooking pots, alongside imported and local storage jars. The latest material from this basket is dated to the 2nd–3rd centuries CE and possibly provides a date for the end of the main period of activity in the structure.

Despite the limitation of the legacy material documentation, it is possible to distinguish between several contexts: (1) deposits from the floor within the south room of the main building (Baskets 81, 84); (2) deposits the may be an accumulation of trash discarded against the external eastern wall of the structure (Baskets 85, 90); and (3) fill inside a pit outside the structure (Basket 91). The pottery associated with the main use phase of the industrial structure dates to the 2nd century CE and possibly into the beginning of the 3rd. The structure went out of use not long after, likely in the late 2nd or beginning of the 3rd century CE. Subsequently, sporadic sherds indicate some activity in the 3rd–5th centuries CE. Examining the legacy data, we could not identify with certainty ceramic deposits that originated in the foundation trenches of the walls or material below floors that could provide a *terminus post quem* for the construction of the building or elements within it. It is possible, however, that the Hellenistic pottery in Basket 85 came from a constructional fill deposit associated with this phase.

Discussion: The Dor *Cetaria* in its Historical Context

The identification of the Dor structure as a *cetaria* using the legacy archaeological data by no means exhausts the archaeological potential of this site. The unexcavated part of the structure, as well as the vats, holds promise for future research using current analyses to understand production patterns and fish procurement. These may include conducting residue analysis on the vats and pottery found within the structure, stable isotope analysis of the fish teeth, if such are found, to understand fishing patterns, and additional archaeoicthyological, archaeomalacological studies to determine the species of marine fauna exploited at the site (e.g., Barkai et al., 2013; Harding et al., 2023; Sisma-Ventura et al., 2018; Sukenik et al., 2017). Furthermore, additional surveys in the Dor bays may provide indication of the mooring place of the Roman Period fishing boats, perhaps indicated by the presence of Byzantine, and later lead fishing net sinkers found in the Dor/Tantural Lagoon (Kingsley & Raveh, 1996, pl. 20).

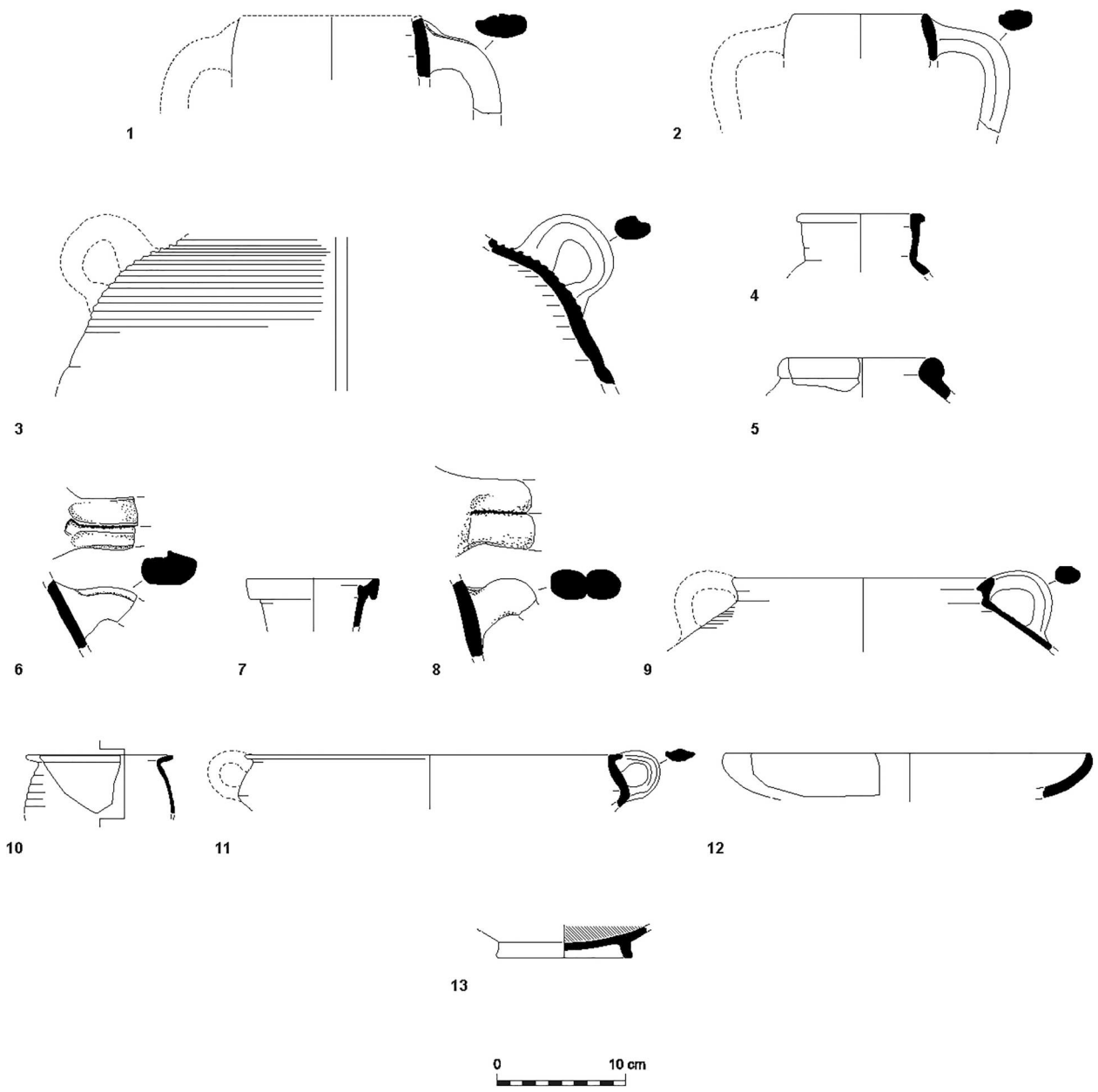

Figure 7. Basket 90 ceramic assemblage (drawings by N. Earon).

The construction of the Dor *cetaria* was no doubt motivated by local demand for *garum* and *salsamenta*. Evidence of *garum* consumption at the Herodian stronghold of Masada (Berdowski, 2008; Cotton et al., 1996) and treatises on the 'cleanliness' of Jewish versus non-Jewish produced salted-fish products from Talmudic literature (Curtis, 1991, p. 145; Weingarten, 2018) make it clear that locally produced *salsamenta* and *garum* were prominent in the Judaean diet. Local production of these commodities at medium- to small-scale enterprises likely boosted imports from the western Mediterranean to help satisfy the populace's appetite for salted-fish products. The date of the ceramic deposits on the floor of the main building suggests a use of the facility from the 2nd to the 3rd century CE, with a lower probability that it was first used in the 1st century CE. During the 2nd century CE, Dor was a well-developed coastal city, with public structures to the east of the mound, a piazza in its centre, and a theatre to the north of the mound (Nitschke et al., 2011, fig. 20). Industrial areas were found at the south of the tell in Area D (Eliyahu-Behar et al., 2009), as well as in its north-west, which included the fish-salting facility. Major changes occurred in the 2nd century with the construction (but not the completion) of two massive coastal temples at the west of the site (Nitschke et al., 2011, pp. 145–152). The maritime infrastructure of the city was also strengthened, following the loss of earlier infrastructure due to sea level changes (Yasur-Landau et al., 2024). A large 37×35 m rectangular coastal structure, dating from the 2nd century CE, was excavated by Raban by the North Bay of Dor (Raban, 1995, pp. 289–290). It was very likely an administrative building related to the consistent maritime activity in the same bay,

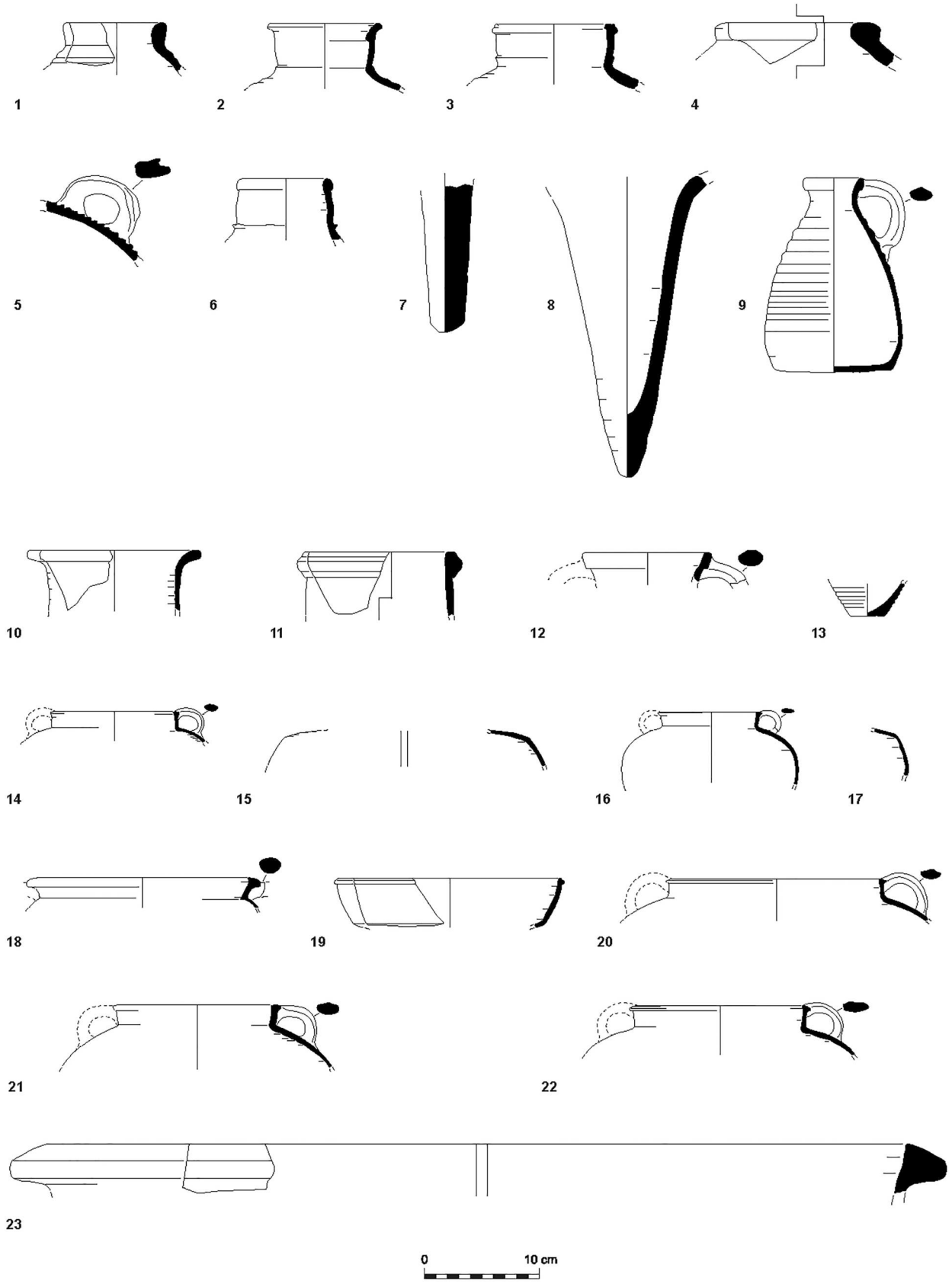

Figure 8. Basket 85 ceramic assemblage (drawings by N. Earon).

which recently yielded a massive Roman quay (Arkin Shalev et al., 2019; Kingsley & Raveh, 1994; Yasur-Landau et al., 2024). The maritime status of the city is seen also in coins minted throughout the 2nd century CE, during the reigns of Trajan, Hadrian, and Antoninus Pius, some bearing the inscription (in Greek) '… Dora, holy, city of asylum, autonomous, ruler of the seas' (Meshorer, 1995, pp. 260, 263–264). These all indicate it was a thriving urban centre with strong maritime connectivity. The presence at

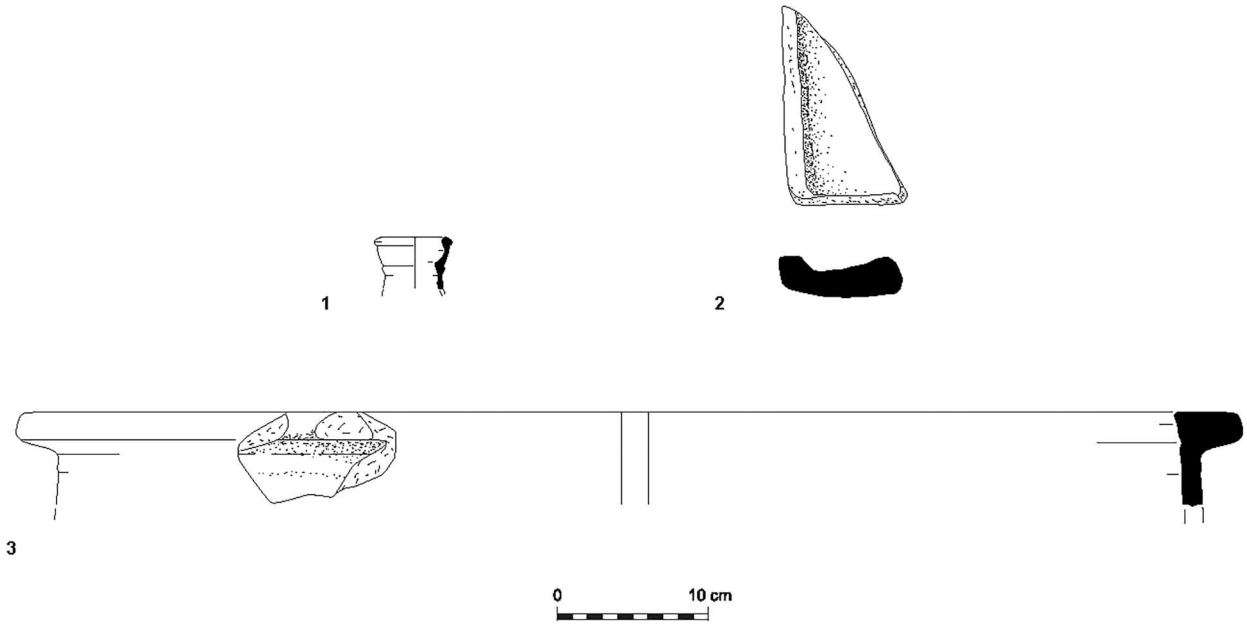

Figure 9. Basket 84 ceramic assemblage (drawings by N. Earon).

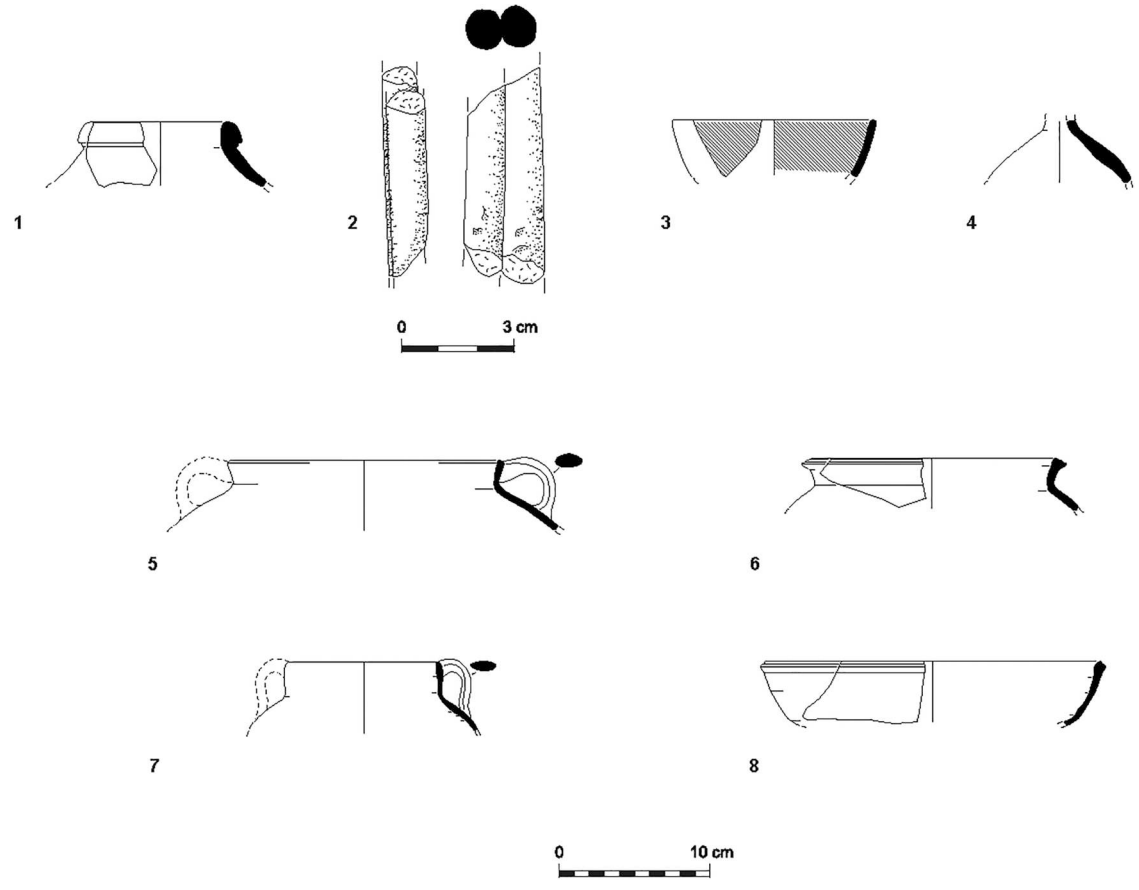

Figure 10. Basket 81 ceramic assemblage (drawings by N. Earon).

Dor of a rare Roman industrial facility for producing *salsamenta* and *garum* can be explained therefore as an innovation related to the Roman urban renewal of the 2nd century CE, as well as to the will to benefit from Dor's coastal location and maritime connectivity. We may cautiously presume the identity of an individual who would have had the needed knowledge, connections, and power to bring this western-Mediterranean-style facility to the eastern Mediterranean. Two inscriptions from Dor honour the governor of Judea and Syria, Gargilius Antiquus (Judea 123–125 CE; Syria 125–128 CE) – described as a patron of the city in one of the two – possibly for facilitating some of these ambitious construction

projects (Gambash & Yasur-Landau, 2018). Gargilius Antiquus's family originated in Africa (Dąbrowa, 1995). His son, who was the governor of Thracia, is honoured as a patron of the city of Thugga in the province of Africa Proconsularis – present-day Tunis (Gera & Cotton, 1995, p. 408). During the 2nd century CE, Africa Proconsularis (parts of modern day Lybia, Tunisia and Algeria), as well as other parts of North Africa, was a centre for numerous fish salteries (e.g., Slim et al., 2007). It is likely that the Gargilius Antiquus's affluent family, with their connections in North Africa, had a first-hand knowledge of the huge economic value of *cetariae*. Gargilius Antiquus, as governor of Judea, certainly had the opportunity and power to bring this technology to Dor. Naturally, this remains within the boundaries of a plausible hypothesis. The introduction of this innovation was short-lived. The political upheavals of the 3rd century CE had a significant role in the sharp decline in the activity of salting plants in Spain and North Africa (Grainger, 2021, p. 77), and it seems that contemporary political upheavals in the eastern Mediterranean are also connected with the end of use of the Dor facility. During this century, Dor was in a crisis, reflected in the excavations by a scarcity of coins post-dating the reign of Severus Alexander (222–235 CE), with no new structures on the tell from that time, and with the huge temples of the previous period that appear to have been left unfinished (Yasur-Landau et al., 2024).

Conclusions

The industrial facility at Tel Dor provides compelling evidence supporting its reinterpretation as one of the first documented fish-salting facilities in the eastern Mediterranean coast. Mylona (2018) argues that the invisibility of fish-processing facilities in eastern Mediterranean archaeology is likely a product of their small size compared to the large enterprises common in the West – a problem further compounded by archaeological practices in the region that are less conducive to preserving the microscale evidence necessary to identify what marine flora and fauna were processed at a given site.

A new interpretation of the coastal facility at Tel Dor, using new field methodologies and legacy data, suggests large-scale fish-salting technologies were more widespread across the Roman Mediterranean than previously thought. It is highly likely that the technology to make *salsamenta* and *garum* industrially arrived in Dor following demand for the products themselves. However, the incentive to build a western-Mediterranean type of industrial design in the eastern Mediterranean during the 2nd century CE may have been related to a specific affluent Roman family. This innovative design was not accepted in other parts of the southern Levantine coast, and the Dor fish-processing plant went out of use by the 3rd century CE.

Acknowledgments

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Permission Statement

The Leon Recanati Institute for Maritime Studies, University of Haifa, granted the authors the permit to access and publish to the unpublished legacy data and pottery from the excavation of the late Prof. Avner Raban at Dor, stored in the institute.

Renewed aerial photography, modelling and measurements took place in 2018, and additional measurements took place in 2019. During 2018–19 the project held the following permits: IAA Underwater Survey Permit no. S828/2018 (permit holders: A. Yasur-Landau and A. Gilboa), IAA Land Excavation Permit no. G-64/2018 (permit holders: I. Sharon, A. Yasur-Landau and S.R. Martin), and IAA Excavation Permit no. G-14/2019 (permit holder: A. Yasur-Landau). All survey data were submitted to the IAA, with a copy kept in the Recanati Institute for Maritime Studies.

Author Contributions

JR: Conception, data acquisition, analysis and interpretation, writing.

TEL: Conception, supervision of data acquisition, analysis and interpretation, writing, acquisition of funding.

AT, MR: Data acquisition, mapping and modelling, writing.

AR: Analysis and interpretation (Roman pottery), writing.

AYL: Conception, general project design, supervision of data acquisition, analysis and interpretation, writing, acquisition of funding.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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