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Spanish Olive Jars from the Tortugas Shipwreck, Florida (1622)

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The collection of 209 olive jars excavated from the Tortugas shipwreck, lost in the Straits of Florida in 1622, contains three types of *botijas* and one type of *orza*. Comparison of the assemblage's liquid capacity with the outward-bound manifest of the *Buen Jesús y Nuestra Señora del Rosario* identifies the jars as ship's stores used to contain staple victuals – wine, vinegar and olive oil – for an entire journey from Seville to Havana and back. The elongated Type 1 jars probably held wine and vinegar, the small globular Type 2 olive oil, and the Type 3 conceivably honey. Type 4's low quantity on the wreck suggests use as domestic assemblage in a kitchen or dining environment.

Analysis of the jars' metrologies in relation to the volume of the Castilian *arrobas*, and fractions of this unit of measurement, reveals an absence of precise standardization in manufacture. The Type 1 jars equate very broadly to vessels of 0.75-1.5 *arrobas* size, and the Type 2 jars from under 0.25 to over 0.5 *arrobas*, but with excess volume for each *botija*. The Tortugas assemblage's wide differentiation in metrology suggests assembly piecemeal over a lengthy period of time and recycling following former commercial transactions on land and sea. The *Buen Jesús*'s non-standardized *botijas* may reflect a time-cutting economic strategy that evolved amongst Seville's potters and merchants in an era when demand far outstripped supply.

1. Introduction

The most conspicuous cultural surface characteristics of the Tortugas shipwreck in the Straits of Florida were dense clusters of intact and fragmented Spanish olive jars (Figs. 1-12).[1] The policy of total sherd recovery implemented during the 1990-91 excavation of the 400m-deep wreck, identified as the 117-ton Spanish-operated *Buen Jesús y Nuestra Señora del Rosario*, produced 86 intact olive jars, 123 whole rims and 1,344 sherds. The *Buen Jesús* was thus transporting a reconstructed minimum assemblage of 209 *botijas* when she sank on 5 September 1622. The olive jars account for 40.2% of the wreck's total pottery by count. Today a significant sample of 54 intact and near-intact olive jars, 90 rims and 100 body sherds are preserved in the collection of Odyssey Marine Exploration, Tampa.

The terms olive jars and *botijas* are used interchangeably in this report in line with the contemporary literature to generically describe the ceramic vessels concerned and undergoing transport within the *Buen Jesús*. This does not mean that all of the jar types are interpreted as having contained olive oil (see below). Type 4 vessels are technically defined as *orzas*.

The Tortugas wreck is a type-site for the first half of the 17th century. Similar type-sites exist for different periods. Parallel counterparts are represented by the limited number of exclusively Middle Style B jars recovered from the 1588 Armada wrecks off Ireland (Martin, 1979) and by at least 108 jars associated with a section of the *Atocha*'s hull from the same 1622 Tierra Firme fleet as the *Buen Jesús* (Marken, 1994: 66). A large collection of 602 olive jars are associated with the *Conde de Tolosa* and *Nuestra Señora*

Fig. 1. Type 1 olive jar rims excavated from the Tortugas shipwreck.

Fig. 2. Type 1 olive jars from the Tortugas shipwreck.

Fig. 3. Type 2 olive jars from the Tortugas shipwreck.

de Guadalupe, sunk off the Dominican Republic in 1724 en route from Cadiz with provisions and mercury for the mines of New Spain (James, 1985).

The Tortugas collection is the largest associated with a 17th-century Iberian shipwreck found off Spain, Portugal and the American continent. Unlike the other ships referenced above, whose functions were tied to State interests, the *Buen Jesús* was a private commercial venture carrying civilian olive jars, an extensive collection of which has been examined for the first time.

The *botijas* were recorded across an area 32.8m north/south and 21.5m east/west (Fig. 5). Only 26.4% of the jars overlay the main ballast and hull area, while 73.6% was distributed outside their perimeter. The majority of the outliers (74.2%) were clustered along the starboard western edge of the wreck. The northwestern site quadrant contained 45.8% of the total olive jars deposited beyond the main ballast and hull area; 28.3% overlay the southwestern site quadrant; 24.2% the southeastern quadrant; and just 1.7% the northeastern quadrant.

The above statistics do not reflect balanced cargo stowage. Assuming the packaged foodstuffs were originally evenly secured in the hold above the ballast, the containers have clearly been extensively displaced. The suggested ship's list to starboard may partly explain this pattern, but does not satisfactorily clarify why such a low quantity of olive jars overlay the central ballast mound. The scattering effect may be interpreted as the result of modern bottom trawling, which swept the olive jars off the pronounced ballast mound. The site was initially discovered in 1965 when three olive jars and other remains were snagged in a shrimp trawler's net (Stemm *et al*., 2013: 19, 21). Similar impacts are recorded across Florida, Louisiana and Texas (Kingsley, 2012: 12-13). Once re-deposited in lower levels beneath the elevated ballast mound, the jars became inundated with up to 30cm of sediment, which contributed to their subsequent preservation.

The majority of the Tortugas olive jars (Tortugas Type 1: 92.4%) adhere to the generic Middle Style A form (Goggin, 1968: 283) (Figs. 2, 15-18, 19A-C). The collection includes nine small globular jars (Tortugas Type 2: 4.9%) defined as Middle Style B forms (Figs. 3, 19D-H), as well as three small conical-shaped jars classified as Middle Style C (Tortugas Type 3: 1.6%) (Figs. 12, 20). Two flat-bottomed jars (Tortugas Type 4: 1.1%) are represented within the assemblage (Figs. 19I, 21). The *botijas* fit closely within detailed established typologies and morphological analyses, especially related to rim profile change over time, formulated by Marken (1994) and Avery (1997: 113-15, fig. 20), who examined the Tortugas collection as part of his doctoral thesis.

Inventory Number	Average Top Diam. (cm)	Average Bottom Diam. (cm)	Maximum Th. (cm)
Corks			
F12005.0015	4.01	3.50	2.98
F22004.0001	5.85	5.08	1.55
F22004.0002	5.37	4.97	1.82
F3335.0001	5.10	4.51	2.29
Type 1			
TOR-90-00113-CS	5.80	4.72	2.25
TOR-90-00120-CS	5.05	4.14	2.26
TOR-90-0121A-CS	4.51	4.51	1.29
TOR-90-0121B-CS	4.61	4.61	1.49
TOR-90-01239-CS	5.26	4.76	1.68
TOR-90-01241-CS	4.68	4.17	1.90
Average	4.98	4.48	
Type 2			
TOR-90-01270-CS	5.27	4.29	2.30
TOR-90-01268-CS	4.66	4.00	1.46
TOR-90-1A-000675	4.34	4.34	1.00
Average	4.76	4.21	

Table 1. Dimensions of cork olive jar stoppers from the Tortugas shipwreck (updated from Avery, 1997: 123, table 2).

The bodies of the Tortugas jars were seemingly thrown in one piece, with the rim added separately (Avery, 1997: 100). Some of the collection's clay fabrics contain small flecks of gold-colored mica, along with sand temper. Spalling of the walls is extensive, indicating that the jars were fired when not thoroughly dry and/or that the clay was improperly or insufficiently wedged. Traces of rilling, or throwing rings, and small pieces of clay within the vessels' interiors, indicate that the jars were thrown in upright positions. Evidence of green lead glaze is apparent on the interior and dripped onto the exterior of a small minority of sherds (including interior glaze on intact Type 1 jar TOR-90-00134-CS and exterior glaze on intact Type 2 jar TOR-90-01272-CS; Fig. 18D).

During the ship's descent onto the seabed, or soon after deposition, the pressure exerted on the jars forced their cork seals to implode inwards. Intact and fragmentary corks were found inside some vessels (Fig. 14). On average, stoppers for the Tortugas Type 1 jars measured 4.98cm on the upper plane, 4.48cm on the lower plane and ranged in thickness from 1.29-2.26cm. Stoppers used for the Tortugas Type 2 jars measured on average 4.76cm on the upper plane, 4.21cm on the lower plane and ranged in thickness from 1.0-2.3cm (as measured by Avery, 1997: 123, table 2) (Table 1).

Small parallel cuts on and near the rims have been suggested to result either from rodent gnawing (Flow, 1999: 35) or more plausibly from vessel reuse when stoppers were opened. Pitch was detected within some jar interiors. Based on vessel morphology and capacities in relation to descriptions within the historical record, the Tortugas Type 1 *botijas* are interpreted as containers for wine and vinegar, while the Type 2 examples almost certainly held olive oil (see section 6). The interior lining of a few sherds were coated with a chalky red stain that may conceivably have been red ocher, a product listed as ship's provisions for carpenters in the 'Nautical Instructions' of 1587. Alternatively, the stain may constitute remains of cochineal, the insect used to produce a highly prized crimson dye. By the late 1500s cochineal had become the third most valuable export from the Spanish colonies after gold and silver (Kassinger, 2003: 53).

The geographic distribution of olive jars over time is well characterized and is not expanded further here. These vessels are ubiquitous within the main colonial Spanish ports from Seville and Cadiz to the Canary Islands, Havana, Panama (47% of ceramics in the House of the Genoese), and Nueva Cadiz in Venezuela (Willis, 1976: 107; Arduengo García, 2008; Gaitán Ammann, 2012: 283). *Botijas* dominate all Spanish ceramic deposits from Mission sites in Florida, by 40% at Fig Springs and 60%

Jar Type 1: Height (Cm)		
Range	**Number**	**% of Sample**
43.5-45	1	1.2
45-50	7	8.6
50-55	71	87.6
55-56.5	2	2.5
Sample Size: 81		
Variation: 43.5-56.5cm (13.0cm differentiation)		

Jar Type 1: Body Diameter (Cm)		
Range	**Number**	**% of Sample**
17.9-20	1	1.2
20-25	0	0
27-30	60	74.1
30-33	20	24.7
Sample Size: 81		
Variation: 17.9-34.1cm (16.2cm differentiation)		

Jar Type 1: Body Circumference (Cm)		
Range	**Number**	**% of Sample**
87.4-90	17	21
90-95	49	60.5
95-100	14	17.3
100-105	0	0
105-107	1	1.2
Sample Size: 81		
Variation: 87.4-107cm (19.6cm differentiation)		

Jar Type 1: Weight (Kg)		
Range	**Number**	**% of Sample**
5.9-6.0	1	1.4
6.0-6.5	9	12.5
6.5-7.0	15	20.8
7.0-7.5	25	34.7
7.5-8.0	15	20.8
8.0-8.5	5	6.9
8.5-9.0	0	---
9.0-9.5	1	1.4
9.5-10.0	1	1.4
Sample Size: 72		
Variation: 5.9-9.9kg (4.0kg differentiation)		

Tables 2-5. Tortugas Type 1 olive jars maximum dimensions and weight range.

at San Luis de Talimali (Deagan, 1972: 34-5; McEwan, 1991: 48, 50), and are equally common at 40% of the pottery on settlements such as Puerto Real, Haiti (McEwan, 1986: 47; 1995: 211). Olive jars accounted for 93% of the 1554 fleet ceramics recovered off Padre Island, Texas (Skowronek, 1987: 106).

Functional contexts are not purely embedded in colonial Spanish commerce. Olive jars were used on myriad Indian sites (Goggin, 1960: 6). An olive jar and Spanish sword were recorded in two ritual Mayan caves within Roaring Creek Valley in central Belize.[2] Olive jars shipped on Portuguese vessels via Macau, partly as gifts to magistrates, reached as far as Osaka and Nagasaki in Japan at the easternmost geographical extreme (Kawaguchi, 2011).

The general shape of Tortugas Type 1 is a long-lived vessel form that spans the entire colonial period from 1475-1800 (Cobo and Martin, 1999: 184). Type 1 is the most common olive jar form encountered from Seville and the Bay of Cadiz to the Americas (de Amores Carredano and Chisvert Jiménez, 1993: 308; Ruiz Gil, 2010). *Botija* wasters used in the construction of the Sagrario of Seville Cathedral reflect the massive scale of production in Triana on the west side of the Rio Guadalquivir (Lister and Lister, 1981: 72-3).

The globular Type 2 jar was also long-lived, extremely common and reached as far as Havana and Guatemala (Carruthers, 2003: 43; Arduengo García, 2008). The conical Type 3 tradition was manufactured in Seville (de Amores Carredano and Chisvert Jiménez, 1993: 310), and travelled extensively from Spain to the Americas and beyond as part of the core *botija* transport package (Cobo and Martin, 1999: 200). The type is represented at the Convento de Domingo in Guatemala (Curruthers and Pasinski, 2004: 14), and occurs on both the wrecks of the *Atocha* and *Santa Ana Maria* lost off Ireland in 1627 (Marken, 1994: 71).

Botijas commonly penetrated European markets, including the Low Countries, Scandinavia and Poland (Dąbal, 2010). Olive jars are known from around 110 sites in Britain and Ireland (Hurst, 1995: 46). In the latter country, they are attested on virtually every medieval and post-medieval site excavated (Meenan, 1992: 186). Port records refer to the shipment of "Portugual oyle" from Plymouth to the English colonies, which presumably explains the distributive mechanism whereby olive jars ended up at Martin's Hundred in Virginia and in Port Royal, Jamaica (Donachie, 2001: 47, 50, fig. 4.3c; Hume and Hume, 2001: 329, fig. 33.4).

The current study of the Tortugas shipwreck's olive jars reflects shipment from Seville as part of the Americas fleet and focuses on:

Jar Type 1: Volume (Liters)		
Range	**Number**	**% of Sample**
14.2-17.5	25	34.2
17.5-20.0	29	39.7
20.0-22.5	18	24.7
22.5-26.9	1	1.4
Sample Size: 73		
Variation: 14.2-26.9 liters (12.7 lts differentiation)		

Jar Type 1: Rim Height (Cm)		
Range	**Number**	**% of Sample**
2.1-2.5	2	2.6
2.5-3.0	4	5.3
3.0-3.5	28	36.8
3.5-4.0	24	31.6
4.0-4.5	18	23.7
Sample Size: 76		
Variation: 2.1-4.5cm (2.4cm differentiation)		

Jar Type 1: Rim External Diam (Cm)		
Range	**Number**	**% of Sample**
8.5-9.0	8	10.5
9.0-9.5	33	43.4
9.5-10.0	28	36.8
10.0-10.5	4	5.3
10.5-11.0	2	2.6
11.0-11.9	1	1.3
Sample Size: 76		
Variation: 8.5-11.9cm (3.4cm differentiation)		

Jar Type 1: Rim Internal Diam (Cm)		
Range	**Number**	**% of Sample**
3.6-4.0	1	1.3
4.0-4.5	10	13.0
4.5-5.0	26	33.8
5.0-5.5	26	33.8
5.5-6.0	10	13.0
6.0-6.5	3	3.9
6.5-8.8	1	1.3
Sample Size: 77		
Variation: 3.6-8.8cm (5.2cm differentiation)		

Jar Type 1: Rim Circumference (Cm)		
Range	**Number**	**% of Sample**
27.5-30.0	32	44.4
30.0-35.0	39	54.2
35.0-40.0	1	1.4
Sample Size: 72		
Variation: 27.5-37.5cm (10.0cm differentiation)		

Tables 6-10. Tortugas Type 1 olive jars maximum volume and rim dimensions range.

1. Assessing the *botija* assemblage's internal typological composition.
2. Comparing the assemblage size to the *Buen Jesús*'s outward-bound manifest.
3. Defining the collection as cargo or crew/passenger victuals.
4. Identifying the vessels' origins through Inductively-Coupled Plasma Spectrometry (ICPS) analysis (see Hughes, 2014).
5. A comprehensive examination of the jars' metrologies as indices of standardization or variability in production.
6. Estimating the number of batches present as reflections of different workshops and merchants' belongings, incorporating evidence for stamp marks.
7. Assessing the assemblage's magnitude and character in relation to crew staple victual requirements (wine, olive oil, vinegar) during round voyages to the Americas and Casa de Contratación economic policy.

In terms of a site-specific classification, the following typology and vessel characteristics are applicable to the Tortugas shipwreck.

2. Tortugas Type 1 (Middle Style A)

Tortugas Type 1 corresponds to Goggin's Middle Style A and has been interpreted on the basis of volume as a receptacle for wine (Figs. 2, 15-18, 19A-C). The 81 intact Type 1 jars and 90 Type 1 rims recorded within the collection account for 92.4 % of the wreck's *botija* assemblage. The form is characterized by the classic shape of a tall ovoid body surmounted by a short, high-set rim above a rounded shoulder inclining relatively smoothly to a gently rounded base. Type 1 rim profiles are angular and incorporate a wide overhang above and covering the neck (Shape A in Avery, 1997: 113-15) (Figs. 13, 22-25, 26A-E). The lip is often pinched to form a vertical terminal. Broad rilling occurs across the upper shoulder and lower quarter of the

Jar Type 2: Height (Cm)		
Range	**Number**	**% of Sample**
27.0-30.0	4	44.4
30.0-32.0	3	33.3
32.0-34.0	2	22.2
Sample Size: 9		
Variation: 27.0-34.0cm (7.0cm differentiation)		

Jar Type 2: Body Diameter (Cm)		
Range	**Number**	**% of Sample**
15.9-20.0	2	22.2
20.0-25.0	6	66.7
25.0-26.0	1	11.1
Sample Size: 9		
Variation: 15.9-25.8cm (9.9cm differentiation)		

Jar Type 2: Body Circumference (Cm)		
Range	**Number**	**% of Sample**
49.8-60	2	22.2
60-70	0	---
70-80	6	66.7
80-85	1	11.1
Sample Size: 9		
Variation: 49.8-81.0 (31.2cm differentiation)		

Jar Type 2: Weight (Kg)		
Range	**Number**	**% of Sample**
1.8-2.5	3	33.3
2.5-3.0	4	44.4
3.0-3.5	1	11.1
3.5-4.0	1	11.1
Sample Size: 9		
Variation: 1.8-3.6kg (1.8kg differentiation)		

Jar Type 2: Volume (Liters)		
Range	**Number**	**% of Sample**
2.8-4.0	2	22.2
4.0-6.0	2	22.2
6.0-8.0	4	44.4
8.0-8.5	1	11.1
Sample Size: 9		
Variation: 2.8-8.1 liters (5.3 liters differentiation)		

Tables 11-15. Tortugas Type 2 olive jars maximum dimensions, weight and volume range.

Jar Type 2: Rim Height (Cm)		
Range	**Number**	**% of Sample**
2.1-2.5	2	22.2
2.5-3.0	3	33.3
3.0-3.5	2	22.2
3.5-4.0	2	22.2
Sample Size: 9		
Variation: 2.1-4.0cm (1.9cm differentiation)		

Jar Type 2: Rim External Diam (Cm)		
Range	**Number**	**% of Sample**
8.0-8.5	5	55.6
8.5-9.0	2	22.2
9.0-9.3	2	22.2
Sample Size: 9		
Max Variation: 8.0-9.3cm (1.3cm differentiation)		

Jar Type 2: Rim Internal Diam (Cm)		
Range	**Number**	**% of Sample**
4.3-4.5	2	22.2
4.5-5.0	5	55.6
5.0-5.5	0	-----
5.5-6.0	1	11.1
6.0-6.2	1	11.1
Sample Size: 9		
Variation: 4.3-6.2cm (1.9cm differentiation)		

Jar Type 2: Rim Circumference (Cm)		
Range	**Number**	**% of Sample**
25.1-27.5	3	42.9
27.5-29.3	4	57.1
Sample Size: 7		
Variation: 25.1-29.3cm (4.2cm differentiation)		

Tables 16-19. Tortugas Type 2 olive jars maximum rim dimension range.

body; lighter rilling occupies the central body area. Small air bubbles are common in the body walls.

The Tortugas Type 1's dimensions vary widely (Appendix 1, Tables 21-26). Heights range from 43.5-56.5cm, body diameters from 17.9-34.1cm, body circumferences from 87.4-107cm, weights from 5.9-9.9kg and volumes from 14.2-26.9 liters (Tables 2-6). Rims are 2.1-4.5cm high, 2.1-2.9cm thick, with 8.5-11.9cm external diameters, 3.6-8.8cm internal diameters and 27.5-37.5cm circumferences (Tables 7-10). On average, necks are 0.6cm

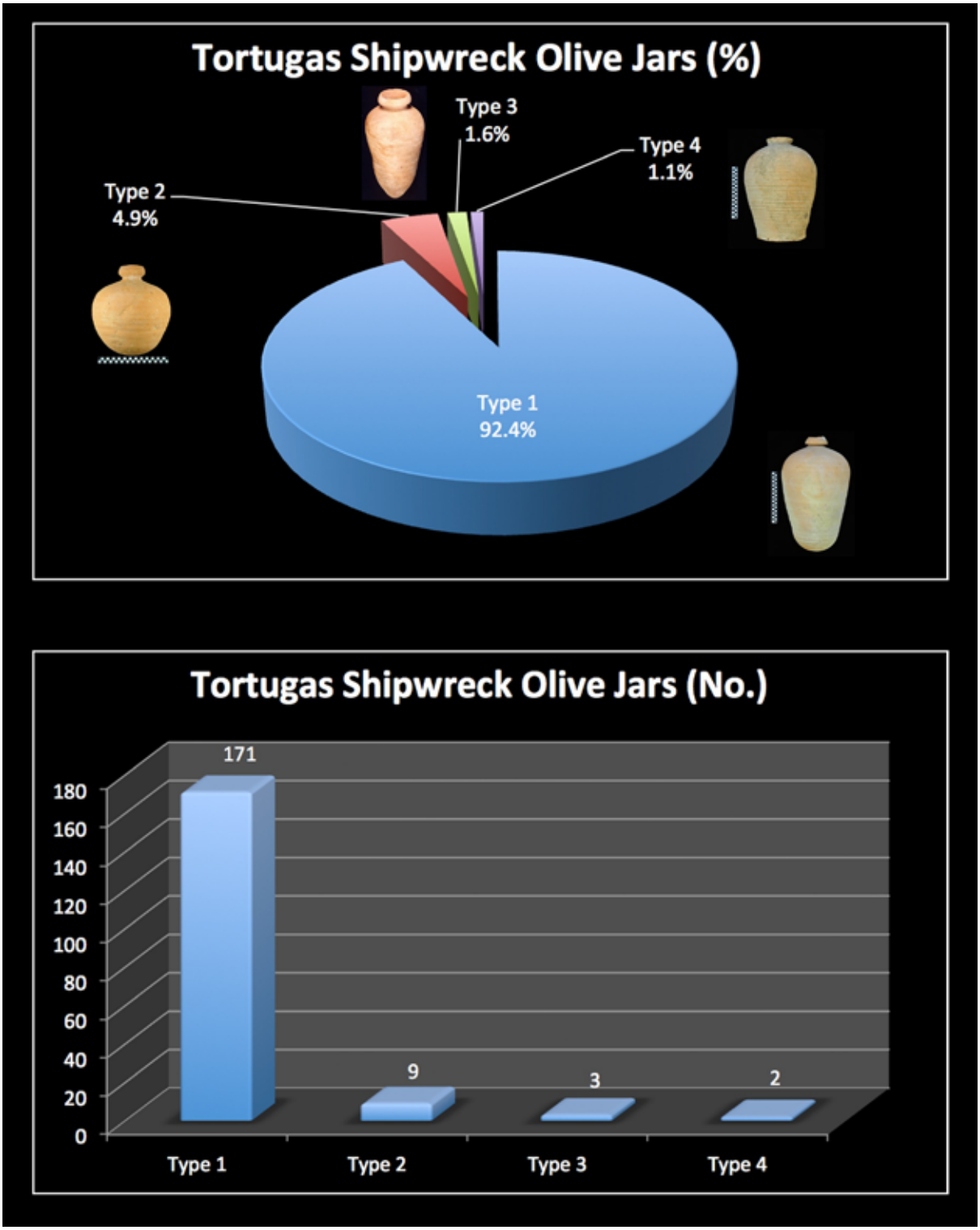

Fig. 4. Comparative Tortugas shipwreck olive jar volumes.

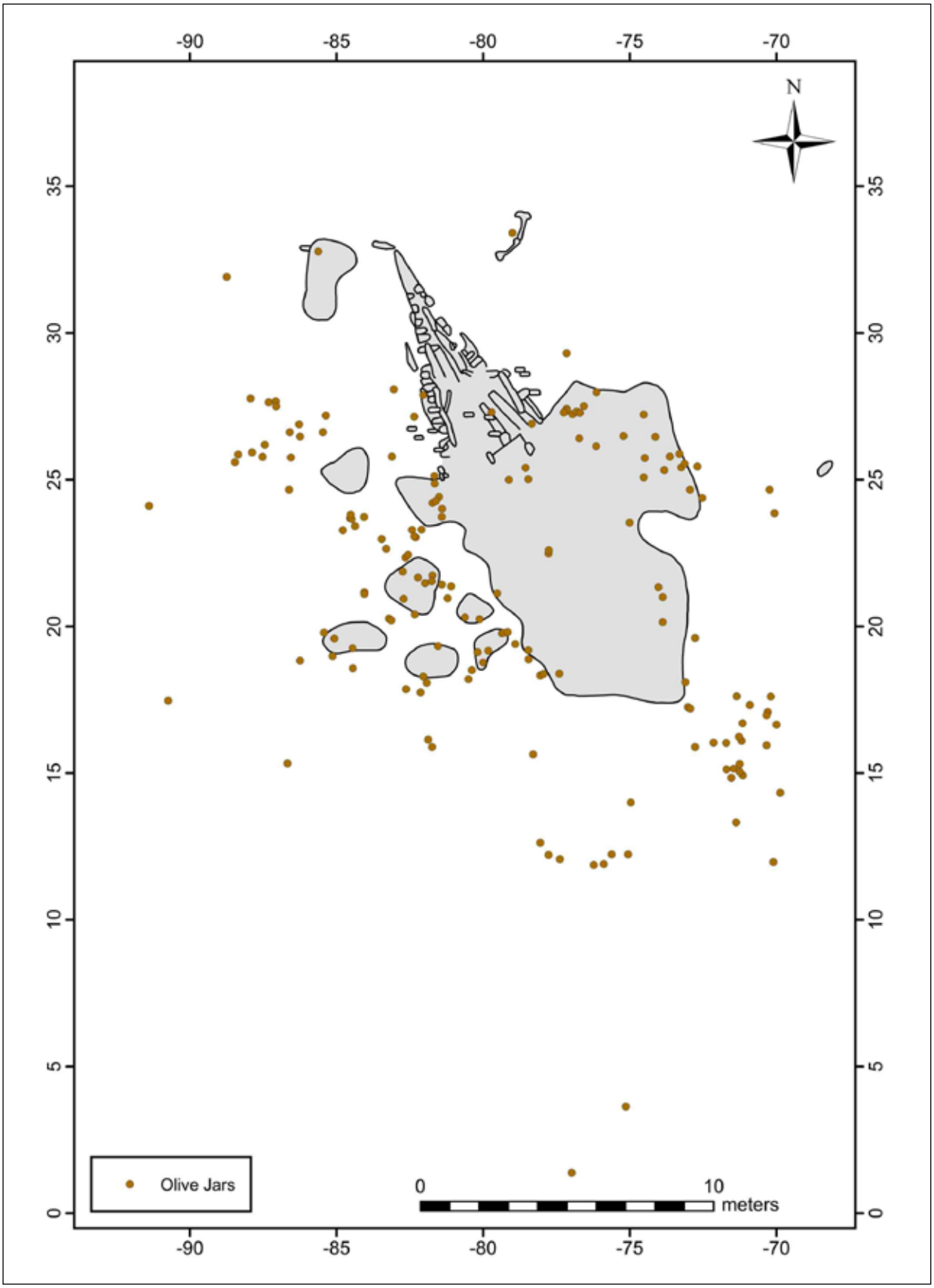

Fig. 5. Distribution of olive jars on the Tortugas shipwreck.

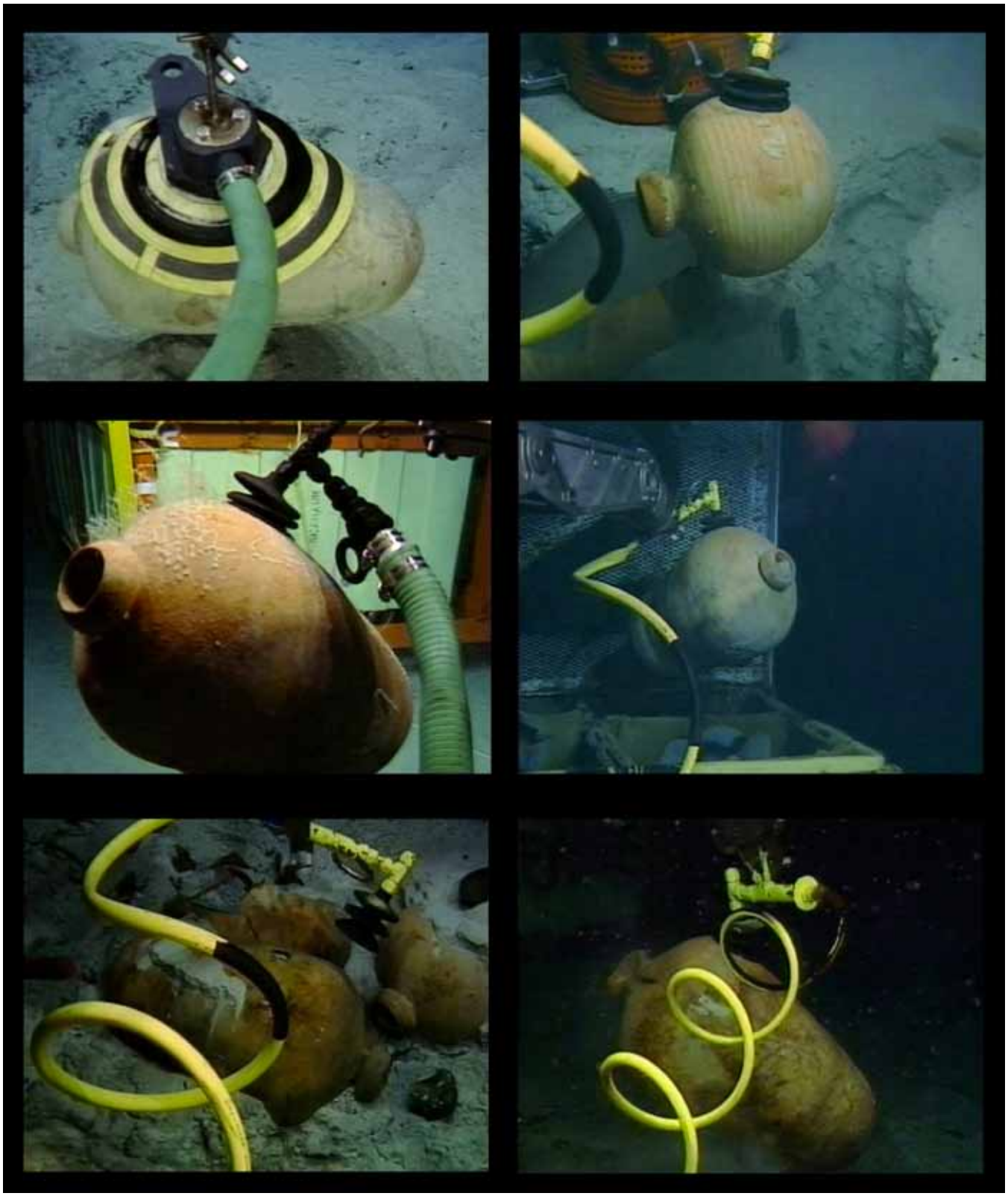

Fig. 6. Olive jars being recovered from the Tortugas shipwreck using the limpet suction device.

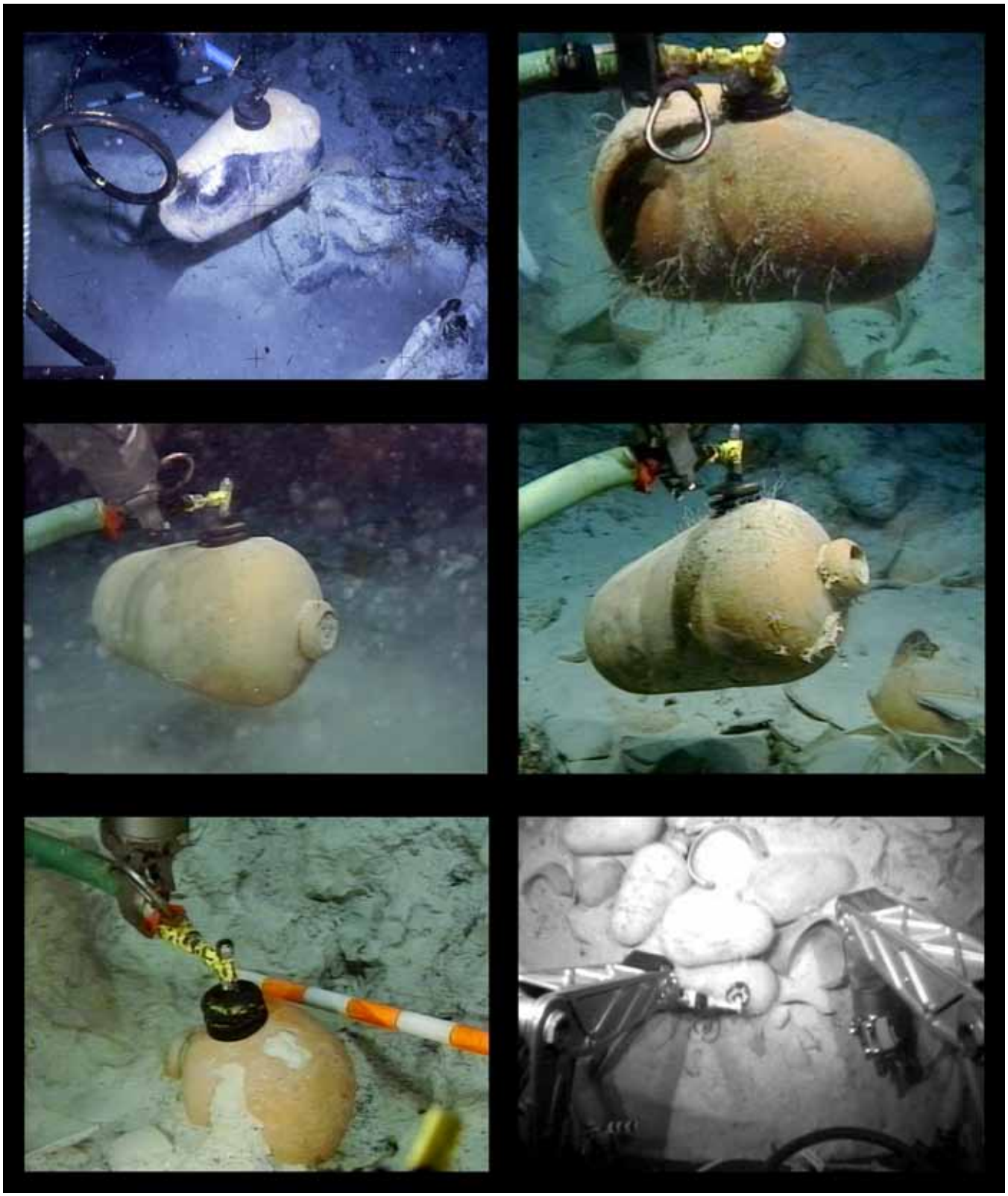

Fig. 7. Olive jars being recovered from the Tortugas shipwreck using the limpet suction device.

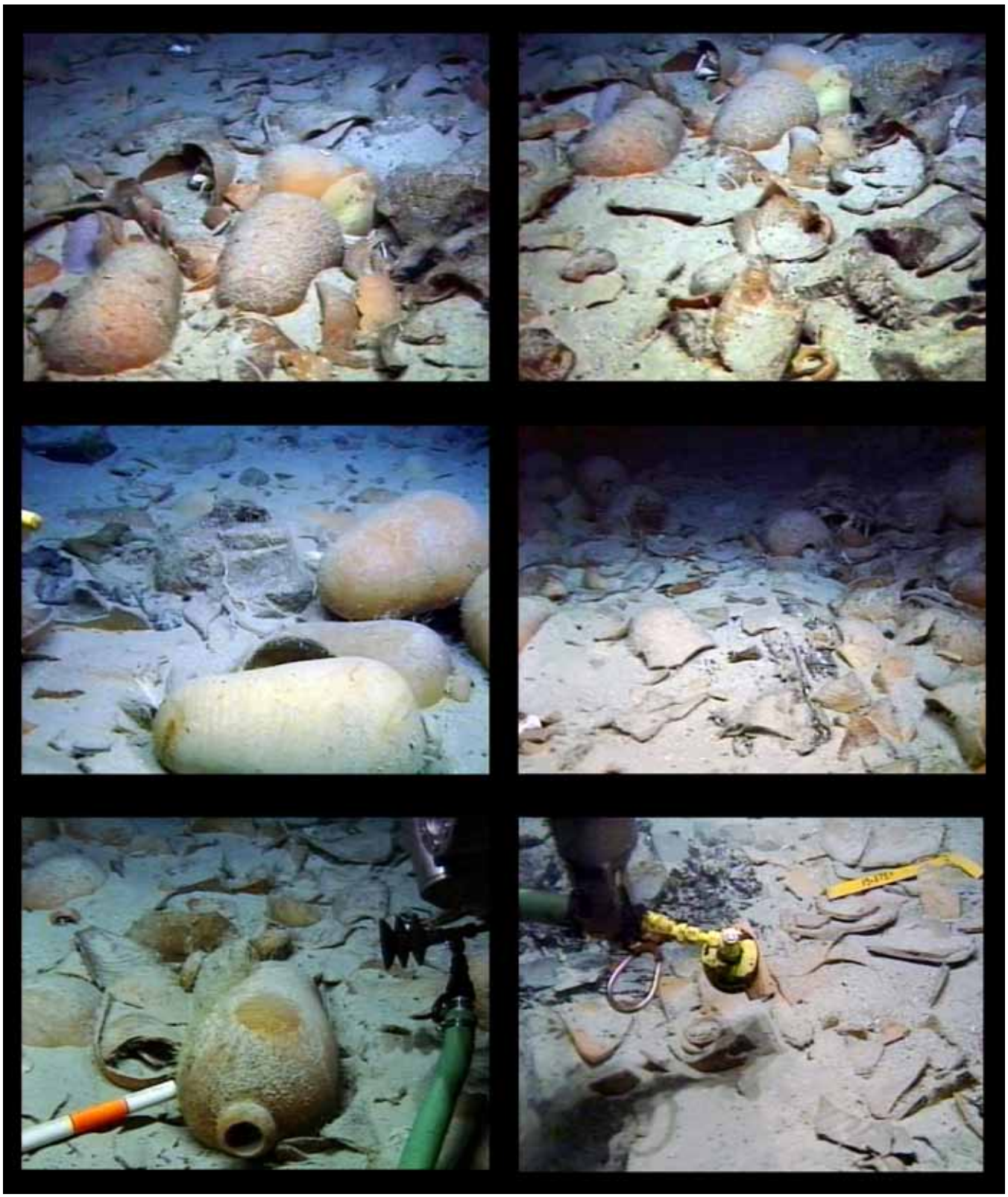

Fig. 8. Olive jars in situ *on the Tortugas shipwreck.*

Fig. 9. Olive jars in situ *and under excavation on the Tortugas shipwreck.*

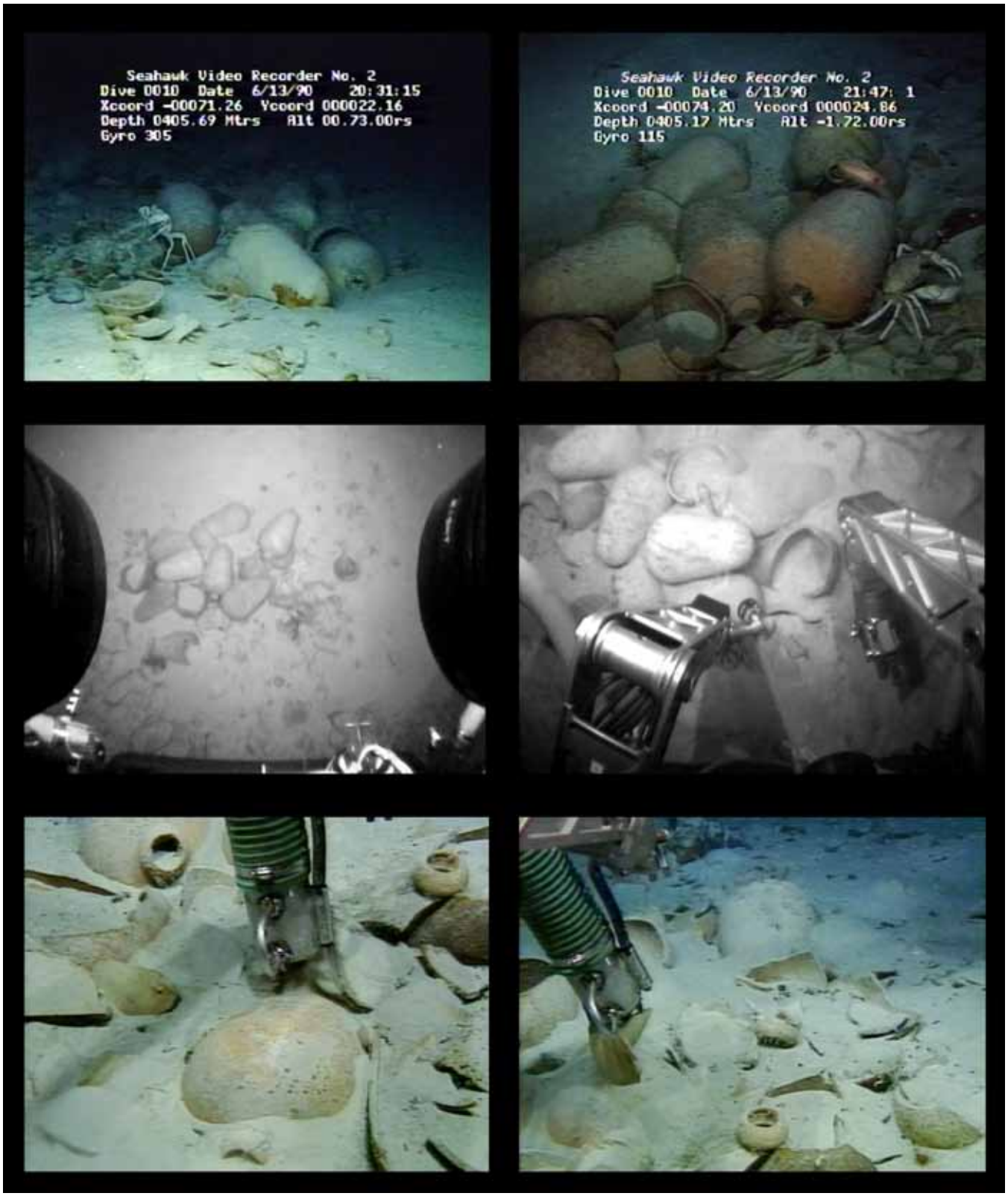

Fig. 10. Olive jars in situ *and under excavation on the Tortugas shipwreck.*

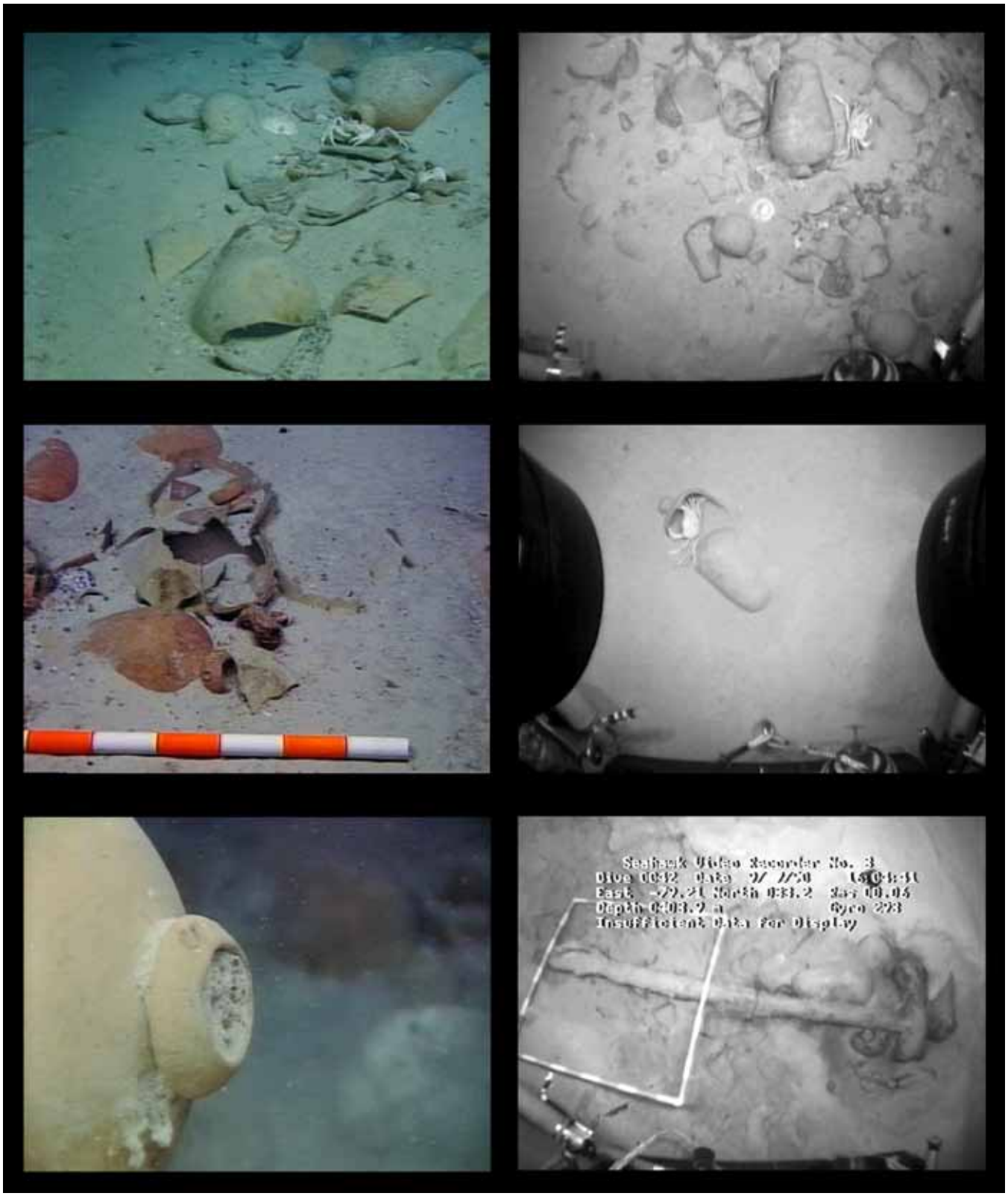

Fig. 11. Olive jars in situ *on the Tortugas shipwreck.*

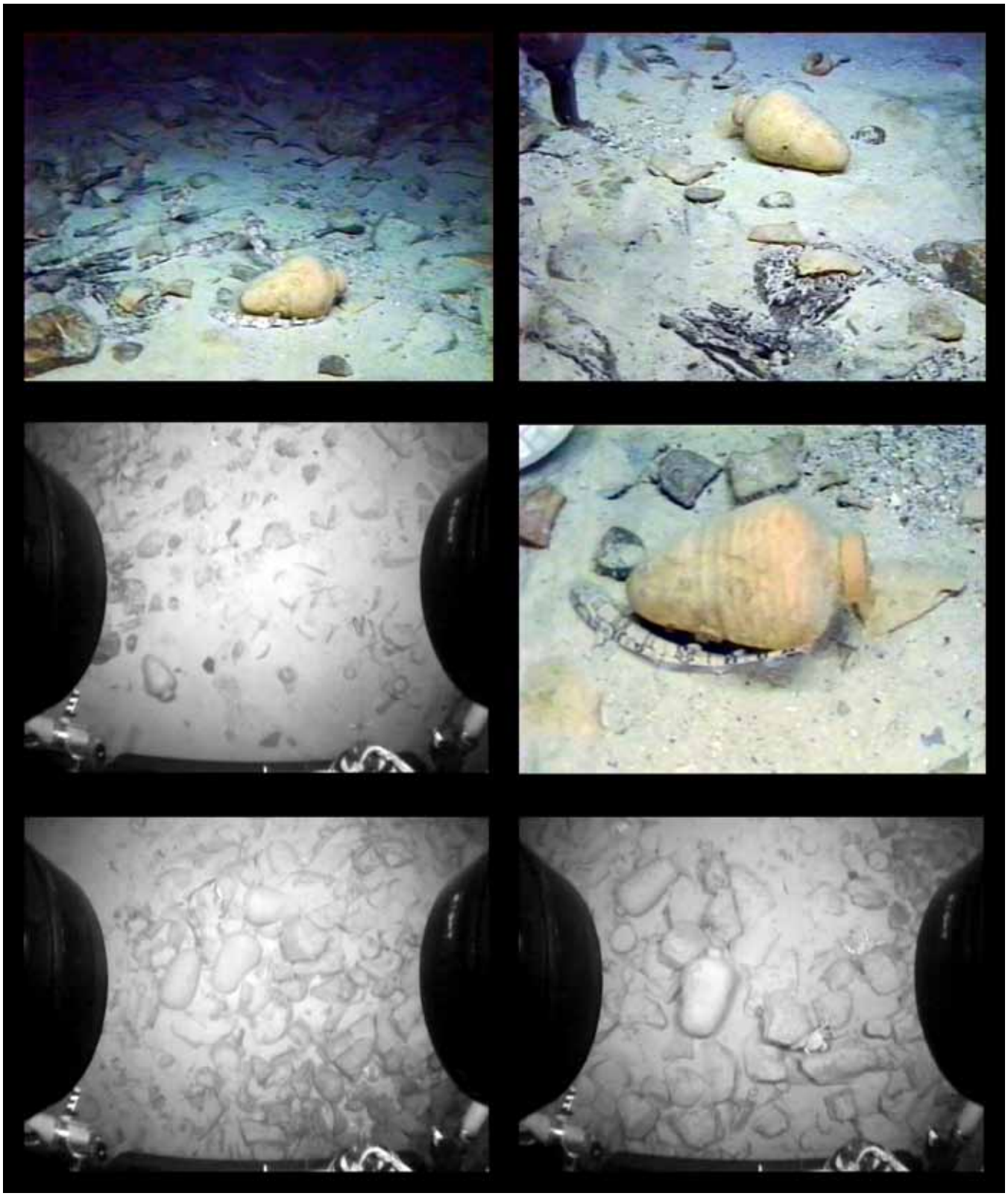

Fig. 12. Olive jars in situ *on the Tortugas shipwreck, including a Type 3 vessel (top and middle rows).*

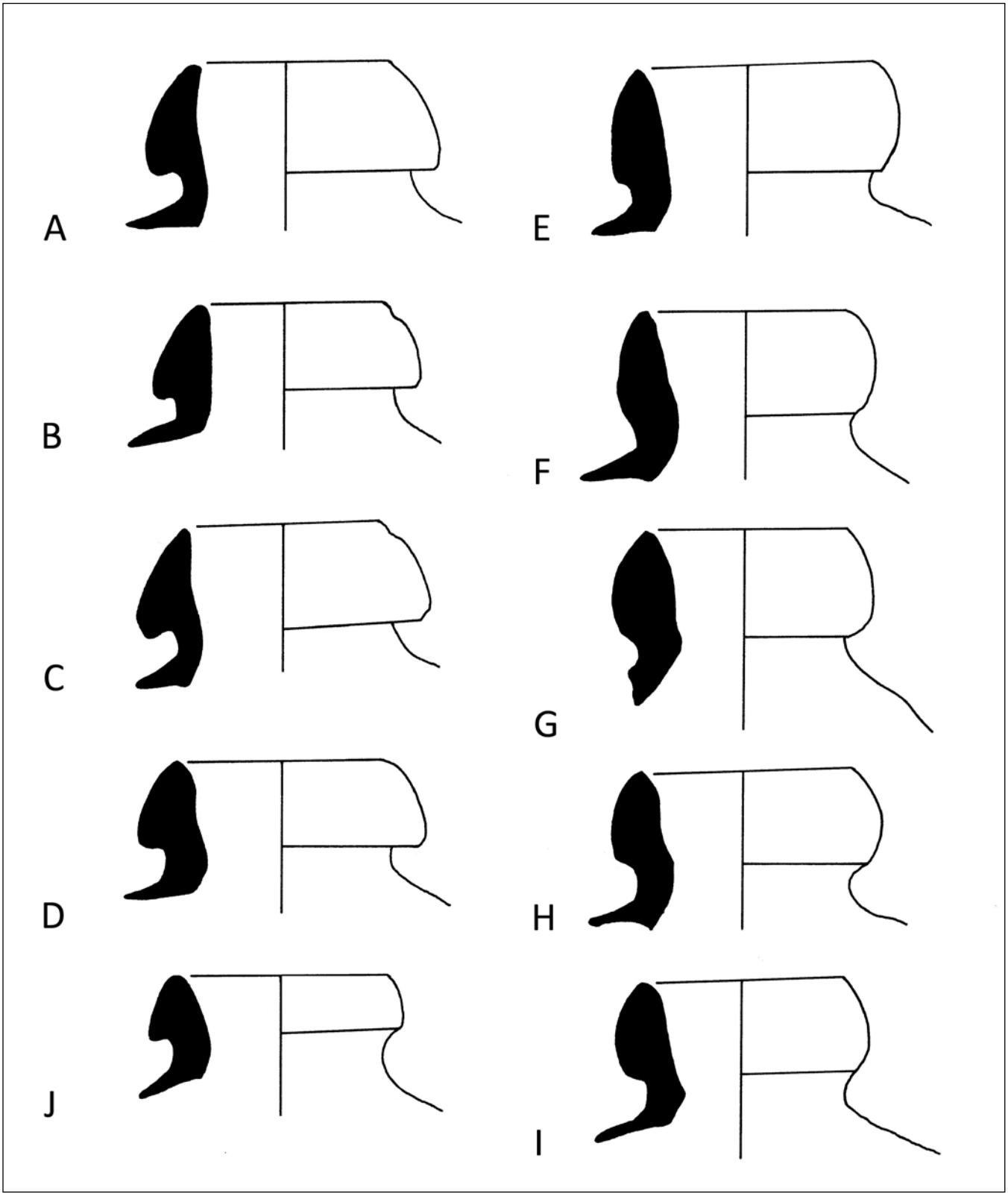

Fig. 13. Drawings of Type 1 (nos. A-D), Type 2 (nos. E-I) and Type 3 (no. J) olive jar rims from the Tortugas shipwreck (after Avery, 1997: 115).

Fig. 14. Cork olive jar stoppers from the Tortugas shipwreck.

thick, upper bodies 1.3cm thick, lower bodies 1.1cm and bases 0.9cm thick. Colors range from light red (7.5YR 6/6) to pink (2.5YR 8/3), reddish yellow (7.5YR 6/8) and very pale brown (10YR 7/4). Inductively-Coupled Plasma Spectrometry (ICPS) analysis indicates production for this jar type in the region of Cordoba, 121km northeast of Seville (Hughes, 2014: 23).

Merchants' marks stamped into the clay prior to firing are restricted to the Type 1 jars, on which 12 examples are attested, in addition to two incised post-firing (Figs. 28-39). Six occur on the upper shoulder and eight are positioned on the rim. Four consist of an upper case 'Y' attached to a 'W' (Fig. 34); a lower case 's' with 'f' running through it and both surmounting an 'n' (Figs. 28A, 29); and a lower case 'f' on two examples (Figs. 28C, 30). Three marks comprise a lamp-shaped motif with the lower case letters 'nco' above (Figs. 28B, 28D, 32, 33), perhaps an ecclesiastical motif symbolizing the "lamp which burns before the Holy Sacrament", attested for example in the convent of San Francisco in 1595-96 (Marken, 1994: 48). In such a scenario the stamp might reflect original ecclesiastical mercantile ownership of the jar and content.

A single jar seems to be marked with an inverted capital letter 'R' facing left rather than right (Fig. 35). One example seems to assume the form of the Greek letter Pi (Fig. 36). Another single stamp is a Christian cross above two upper case letters 'E' placed back to back (Fig. 28F), while Christian crosses occur on two additional jars (Figs. 38, 39). One of these resembles a Portuguese cross (Fig. 38; pers. comm. Beverly Straube, 19 March 2014). Hollow circles are present on one rim and one shoulder (Figs. 28E, 31, 37) (Table 20).

Such stamps are interpreted as signs of the merchant who owned the *botija* and its content, part of a sequence of produce batch identification that included marks painted onto esparto matting covering each olive jar (Avery, 1997: 201). Examples have been recorded far and wide, for instance two separate jar rim stamps depicting a lamp symbol grafted onto a Christian cross, as well as the letters 'CA', from Nueva Granada in Colombia (Therrien *et al.*, 2002: 105, pl. 16). The hollow circle rim stamp form dates to *c.* 1610 at Jamestown, Virginia (Straube, 1999: 40, fig. 47).

The largest collection from a Spanish colonial site are 39 different marks found on 113 rims in the Dominican monastery of Santo Domingo at Santiago de Guatemala, which was established in 1543 and destroyed by an earthquake in 1773. Most common are 23 schematized shields or escutcheons. Stamped letters include 'AC', 'BS', 'XX', 'DoD', 'B' and 'D' (Carruthers and Pasinski, 2004: 31). Three sets of marks are comparable to the Tortugas shipwreck: a single letter 'f' of the same typography, an identical cross surmounting two capital 'E' letters set back to back, and 11 impressed circles. The marks are almost exclusively restricted to Type 1 jars and confined to the period 1583 to 1641 (Carruthers, 2003: 39-40, 43-46, 48, 53).

The shipwreck evidence confirms the narrow timeframe for stamped rims, which are absent off Ireland on Spanish Armada wrecks of 1588. These marks appear at earliest on the *San Martin*, part of the Honduran fleet carrying indigo, cochineal and hides that sank off Florida in 1618. Examples are attested in 1622 on 10% of the *Atocha* jars ('DD', 'MB', 'HIS'), and occur on the *San Antonio* lost off Bermuda in 1621. The latest dated examples were recorded on the *Concepción*, wrecked off Hispaniola in 1641. Parallels between the Tortugas and *Atocha* wrecks include the 'sn' mark set vertically with a 'f' through the upper letter, a cross set above two back to back letters 'E', post-firing incised crosses on body walls (three times on a single rim) and the Greek letter Pi (Marken, 1994: 75, 77, 78, 79). The cross surmounting two upper case letters 'E' set back to back is also paralleled on the *San Martin* (Avery, 1997: 110, fig. 18). No marks are attested amongst the large jar collection of 1724 from the *Tolosa* and *Guadalupe* wrecked off the Dominican Republic (James, 1985).

The Tortugas Type 1 olive jars may be sub-divided into three sets of sizes based on height and diameter (Tables 2-3). Heights range from 43.5-45cm (one example) to 45-50cm (seven examples) and 50-56.5cm (73 examples), a category that dominates the assemblage at 90.1%. Body diameters are more carefully standardized, with 80 jars (98.8% of the sample) clustered between 27.2-33.0cm wide (Table 4). These largely correspond to jars of 50-56.5cm height, but also encompass all the vessels of 45-50cm height. The sole anomaly is one jar of 50.8cm height registered at 17.9cm wide.

Execution of the jar rims displays strong standardization (Tables 7-10). Some 68.4% of rim heights range from 3.0-4.0cm with a further 18 ranging within the 4.0-4.5cm

Inv. No.	Merchant's Mark	Location	Dimensions
TOR-90-00114-CS	Y' attached to W'	Upper shoulder	H. 6cm; W. 7.8cm
TOR-90-01227-CS	's' and 'f' surmounting 'n'	Rim	H. 2.7cm; W. 1.9cm
TOR-90-01232-CS	Lower case 'f'	Rim	H. 3.4cm
TOR-90-01233-CS	Lower case 'f'	Rim	H. 3.4cm
TOR-90-00108-CS	Inverted 'R'	Upper shoulder	H. 3.3cm; W. 1.9cm
TOR-90-00138-CS	Lamp-shaped motif, letters 'nco' above	Rim	H. 1.5cm; W. 2.8cm
TOR-90-01234-CS	Lamp-shaped motif, letters 'nco' above	Rim	H. 3.9cm
TOR-90-01235-CS	Lamp-shaped motif, letters 'nco' above	Rim	H. 3.9cm
TOR-90-00124-CS	Thin hollow circle	Upper shoulder	Diam. 4.9cm
TOR-90-01230-CS	Small hollow circle	Rim	*c.* 2.0cm
TOR-90-01236-CS	Christian cross above two upper case 'E' letters back to back	Rim	H. 4.1cm
TOR-90-01229-CS	Large simple Jerusalem cross	Upper shoulder	----------
TOR-90-01228-CS	Large crude Jerusalem cross (incised post-firing)	Upper shoulder	H. 4.3cm; W. 3.9cm
TOR-90-01231-CS	Greek Pi	Lower shoulder/ upper body juncture	----------

Table 20. Stamped marks recorded on the Tortugas Type 1 olive jars.

limit (23.7%). A total of 92.1% exhibit a variance of just 1.5cm in height. Although 90.7% of the external rim diameters are tightly clustered between 8.5-10.0cm, internal rim diameters, the crucial measurement for determining pre-cut cork stopper sizes, range surprisingly widely from 3.6-8.8cm, most tightly clustered between 4.0-6.0cm (72 examples, 93.6%).

In terms of capacities, four sets of variable volumes are identifiable (Table 6). Some 25 jars range between 14.2-17.5 liters (34.2%). A further 29 jars span 17.5-20.0 liters (39.7%), and another 18 cluster from 20.0-22.5 liters (24.7%). A single outlier was recorded at 26.9 liters (1.4%). The volumes thus demonstrate a far broader diversity than the jar heights. By contrast, although four categories can be identified for the jar circumferences (Table 4), the majority clusters between 90-95cm (60.5%). A further 21% of circumferences range from 87.4-90cm, 14 from 95-100cm (17.3%) and one at 105-107cm (1.2%).

Jar weights display an equally wide range from 5.9-9.9kg (4.0kg differentiation), which can be sub-divided into four categories plus two outliers (Table 5). Some 25 jars cluster between 5.9-7.0kg (34.7%), 40 from 7.0-8.0kg (55.5%), five from 8.0-8.5kg (6.9%), while two individual jars weighing 9.4kg and 9.9kg are outliers (2.8%).

As a single data set the comparative dimension-to-volume ratios overall reveal an identifiable standardization in the production of the Tortugas shipwreck jars. To summarize, 87.6% of jar heights range from 50-55cm, 98.8% of bodies are 27-33cm wide and 81.5% of jar circumferences occur within 87.4-95.0cm. Rims display similar tight clusters: 92.1% are 3.0-4.5cm high, while 90.7% of external diameters span 8.5-10.0cm.

In light of this broad regularity, the divergence within the four categories of volume (three relatively even in jar numbers per division, one an outlier) must be assumed to be deliberate rather than random. Volume was not controlled by careful selection of clay weights, however, which proved not to increase systematically with volume. Within the lowest jar volumes of 14.2-17.5 liters, 25 jars range from 6.4-8.1kg, extending across all three main jar weight categories. Jars with the second highest capacities, 17.5-20.0 liters, correspond to 29 vessels that weigh between 6.2-9.9kg, crossing all four weight categories. The third highest volume set, 20.0-22.5 liters, comprise 16 jars weighing 6.4-9.4kg, once more covering all four weight sub-divisions. The inference is that clay was selected by eye and feel rather than weight. Other than in general terms, weight did not condition volume. Instead, volume was primarily determined by a combination of vessel height, body width and body circumference standardization.

3. Tortugas Type 2 (Middle Style B)

The Tortugas Type 2 *botijas* correspond to Goggin's Middle Style B, a form that has been interpreted on the basis of *arrobas* volume capacity as a receptacle for olive oil. The nine Type 2 jars represent 4.9% of the total *botija* assemblage

Fig. 15. Type 1 olive jars from the Tortugas shipwreck.
A. TOR-90-00102-CS; B. TOR-90-00103-CS; C. TOR-90-00104-CS;
D. TOR-90-00105-CS; E. TOR-90-00106-CS; F. TOR-90-00107-CS;
G. TOR-90-00108-CS; H. TOR-90-00109-CS; I. TOR-90-00110-CS.

Fig. 16. Type 1 olive jars from the Tortugas shipwreck.
A. TOR-90-00111-CS; B. TOR-90-00112-CS; C. TOR-90-00113-CS;
D. TOR-90-00114-CS; E. TOR-90-00115-CS; F. TOR-90-00116-CS;
G. TOR-90-00117-CS; H. TOR-90-00118-CS; I. TOR-90-00119-CS.

Fig. 17. Type 1 olive jars from the Tortugas shipwreck.
A. TOR-90-00120-CS; B. TOR-90-00121-CS; C. TOR-90-00122-CS;
D. TOR-90-00123-CS; E. TOR-90-00124-CS; F. TOR-90-00125-CS;
G. TOR-90-00126-CS; H. TOR-90-00127-CS; I. TOR-90-00128-CS.

Fig. 18. Type 1 olive jars from the Tortugas shipwreck.
A. TOR-90-00129-CS; B. TOR-90-00131-CS; C. TOR-90-00133-CS;
D. TOR-90-00134-CS; E. TOR-90-00135-CS; F. TOR-90-00136-CS;
G. TOR-90-00137-CS; H. TOR-90-00138-CS; I. TOR-90-00139-CS.

Fig. 19. Olive jars from the Tortugas shipwreck.
A-C: Type 1. D-H: Type 2. I: Type 4.
A. TOR-90-00140-CS; B. TOR-90-00141-CS; C. TOR-90-00142-CS;
D. TOR-90-00011-CS; E. TOR-90-00130-CS; F. TOR-90-00132-CS;
G. TOR-90-00328-CS; H. TOR-90-00332-CS; I. TOR-90-00018-CS.

Fig. 20. A Type 3 olive jar from the Tortugas shipwreck.

from the Tortugas shipwreck (Figs. 3, 19D-H). Type 2 is a squat, globular jar, almost circular anatomically, with a continuously rounded base, body and shoulder. The style displays a more pronounced neck and higher rim than Type 1 (Figs. 13E-13I).

Its dimensions are surprisingly diverse for such a small sample: H. 27.0-34.0cm, Diam. 15.9-25.8cm, circumference 49.8-81.0cm, rim H. 2.1-4.0cm, rim Th. 1.5-1.7cm, volume 2.8-8.1 liters and weight 1.8-3.6kg (Tables 11-19). Necks on average are 1.0cm thick, upper bodies 0.8cm thick, lower bodies 0.7cm thick and bases 0.7cm thick. The clay colors range from very pale brown (10YR 7/3) to pink (7.5YR 8/4), yellowish red (5YR 5/8) and reddish yellow (5YR 6/6). ICPS analysis indicates that the Tortugas Type 2 *botijas* bear the chemical signature of Seville clays (Hughes, 2014: 21-22).

Vessel heights are relatively uniform. Body diameters, by contrast, are less standardized with a 9.9cm maximum variation, which results in circumferences of 31.2cm variation and a 1.8kg weight difference between the lightest and heaviest vessel. The 5.3-liter capacity differentiation suggests the Type 2 jars were manufactured to different volumetric standards. The rims also exhibit almost a 100% difference in height from 2.1-4.0cm, while the internal mouth diameters range of 4.3-6.2cm, once more seemingly indicative of a range of sizes (Tables 11-19).

4. Tortugas Type 3 (Middle Style C)

Tortugas Type 3 corresponds to Goggin's Middle Style C and has been interpreted on the basis of volume as a possible receptacle for honey (Avery, 1997: 217). The three Tortugas Type 3 olive jars account for 1.6% of the total *botija* assemblage (Figs. 12, 20). The form is conical, far narrower than the above series, with a slender body, more v-shaped in profile, leading to a more pointed toe. The triangular angled rim, surmounting a short neck, is far wider in relation to the vessel's diameter than Tortugas Types 1 and 2, equating to half the size of the jar's width (Fig. 13J). Dimensions for a single recorded example are: H. 33.0cm, Diam. 15.9cm, circumference 49.8cm, rim H. 2.1cm, rim Diam. 8.5cm, volume 2.8 liters, weight 1.8kg, reddish yellow clay (7YR 5/8).

5. Tortugas Type 4

Two examples of Tortugas Type 4 vessels of *orza* form represent 1.1% of the overall *botija* assemblage (Figs. 19I, 21). This form is anatomically similar to the neck and upper body shape of Tortugas Type 1, but clearly differentiated by a short and slender everted rim. The shoulder is bulbous before assuming a vertical profile along the lower third of the vessel and terminating at a flat base. Type 4 is covered with closely aligned body ribbing. Functionally its slender rim and neck and flat base make this vessel better suited for use as tableware or for storing foodstuffs in the kitchen, rather than as a transport jar. The dimensions of the intact example are: H. 43.5cm, Diam. 31.2cm, circumference 99.6cm, rim H. 2.8cm, rim Th. 1.2cm, rim Diam. 11.9cm, volume 20.8 liters, weight 6.4kg, reddish yellow clay (7.5YR 8/6). ICPS analysis suggests that the Tortugas Type 4 *botijas* were produced in Seville (Hughes, 2014: 22).

Examples of Type 4 jars recorded in Seville are indicative of production within this city (de Amores Carredano and Chisvert Jiménez, 1993: 290, 318, no. 142; Gutiérrez, 2000: 57). The form is not well known on either terrestrial sites or shipwrecks outside Spain amongst *botija* typologies (Cobo and Martin, 1999: 199-200), but reached Santa Clara de Asis in Havana (Arduengo García, 2008). This limited distribution is best explained by the vessel's function mainly for the storage of food in the home (Gutiérrez, 2000: 58).

Fig. 21. A Type 4 olive jar from the Tortugas shipwreck.

The argument for Type 4's suitability as a galley ware is perhaps strengthened by the functional restriction of the form to the stern area of the *Nuestra Señora de Guadalupe* off northeast Hispaniola (James, 1988: 46). However, the presence of multiple pitch-lined examples onboard the *Atocha* has suggested a bulk transport function. A flat-based olive jar was also recovered on the wreck of the *Santa Ana Maria*, sunk off Ireland in 1627 (Marken, 1994: 80-1).

6. Content Mythology

As the most abundant ceramic tradition shipped long distances within the far-flung territories of colonial Spain, the myths and facts engulfing the 'olive jar' have been discussed in detail (Lister and Lister, 1987; Pleguezuelo-Hernandez, 1993; Marken, 1994; Avery, 1997; Gutiérrez, 2000: 58-60). First and foremost, historical documents housed in the Casa de Contratación dealing with 'Proveeduría de la Casa de Contratación' specify that *botija* contents could be extremely varied.

The main foodstuffs held by *botija*s were wine, olive oil and vinegar, followed in a common second tier by olives, almonds, hazelnuts, raisins, honey, liqueur, capers and rice (Pleguezuelo-Hernandez, 1993: 48). Less common products included butter, sweet wine, salted meat, pickles and even gunpowder. The main commodities of the 1588 Spanish Armada were reckoned in *quintales, fanegas* and *pipas* – including wine, biscuit, bacon, cheese, tuna, salt beef, rice, beans, chickpeas and garlic – and were thus seemingly transported in sacks or casks (Martin, 1979: 284). No Tortugas Type 1 elongated jar was represented amongst the Armada wrecks.

Seville's archival record suggests that wine was shipped most frequently in the Tortugas Type 1 sized vessel form of 1.25-*arroba* capacity, as well as minor volumes of vinegar, olives, capers and almonds. A document written by José Veitia Linage, 'Norte de la Contratación de las Indias, 1672' (AGI *Contratación* 3283), specified that "The wine is packaged in jars of *arroba* and quarter, this is the size that they have by the laws of Seville."

Historical sources refer to Tortugas Type 2 jars as receptacles for olive oil, while internally glazed examples of one-third *arroba* capacity (5.38 liters) held liqueur. The absence of interior glaze on any Tortugas Type 2 jars favors a logical content of olive oil. Olive oil is described as transported in jars of 0.5-*arroba* capacity (6.213 liters) (de Amores Carredano and Chisvert Jiménez, 1993). Honey was an especially common content for the Tortugas Type 3 conical jar.

Superficially, the system of stamping rims as an expression of merchant ownership appears rather simplistic, not least compared to Rome's tracking system for Dressel 20 amphoras produced in Andalusia (Kingsley *et al.*, 2014). The evidence for *botija*s is restricted by realities of archaeological preservation. The surfaces of jars exported to the New World were originally covered with a plaited strand of esparto grass called a '*pleita*' tied in a spiral across the vessel, often including markings specifying prices and shipping notations (AGI *Contratación* 1080; *Contratación* 1100). The Spanish *nao San Miguel*, which sailed to Panama in the fleet of Matías Escobedo in 1583, provided further details about jars' marking, whereby "500 jars of wine filled with cazalla [anisette liquor] of ten *reales* each... are stamped with an almagre mark, with a rod on top covering the mouth with almagre and some of them with a large 'G'..."

Jar mouths were sealed with conical corks on average 25 millimeters thick, and secured with rabbit or goatskin again held in place with a fine length of esparto rope. Both were reinforced with an additional cover of gypsum onto which a seal was sometimes stamped. Merchants' identification marks appeared twice on each vessel, burnt into the esparto matting and painted onto the mouth with black ink or red iron oxide (Pleguezuelo-Hernandez, 1993: 48). In 1591, a wine jar cost 40 *maravedís*, esparto matting 10 maravedís, while a *botija* filled with wine was 306 *maravedís.* A *botija* and its packaging can thus be calculated as costing 16% the price of the wine (Avery, 1997: 208). The reality underlying *botija* markings to track merchant owners and contents within ship consignments, not identifiable from the physical remains preserved on wrecks, is a classic example of the need to adopt a broad historical archaeological perspective to avoid misinterpreting the evidence.

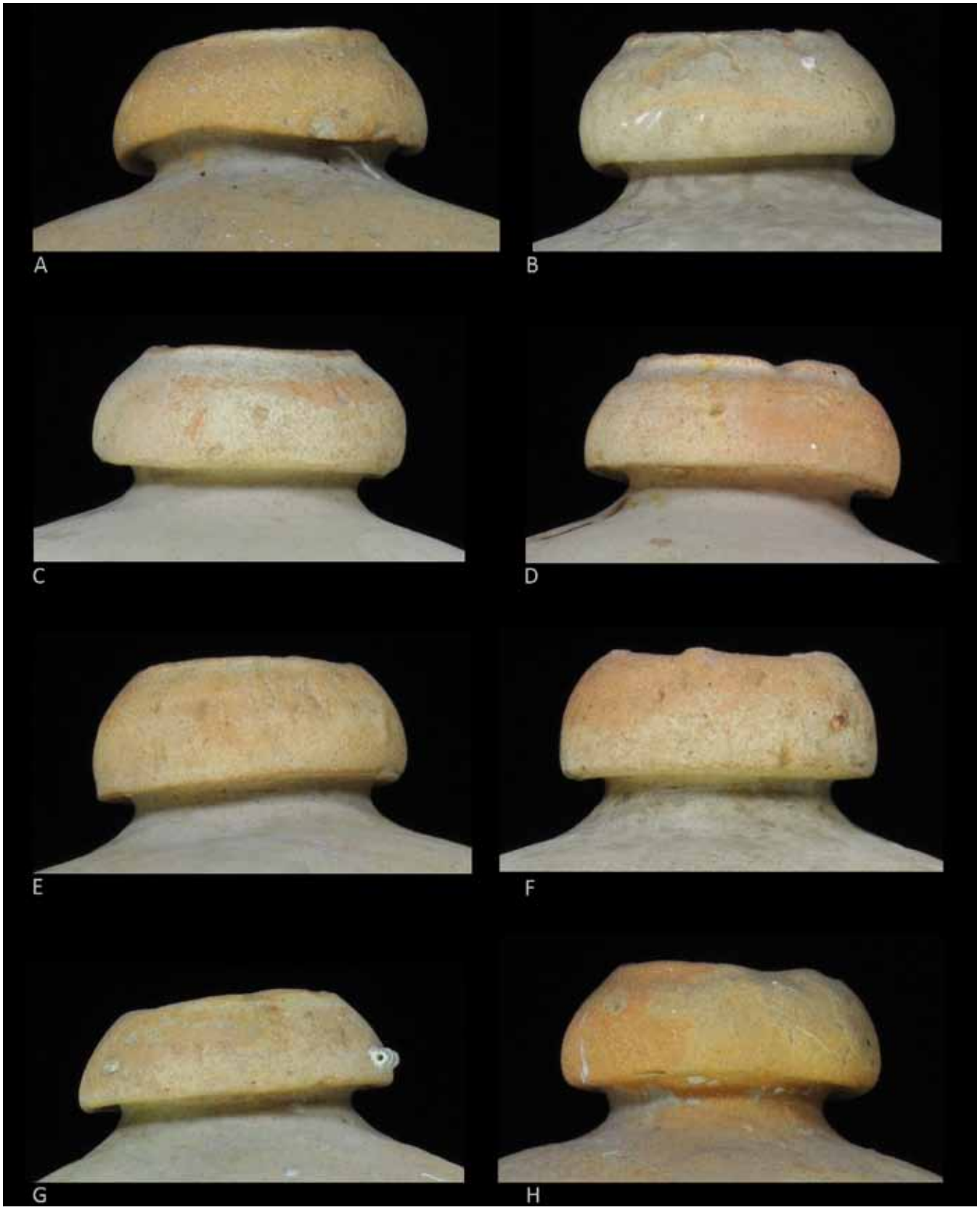

Fig. 22. Type 1 olive jar rim profiles from the Tortugas shipwreck.
A. TOR-90-00102-CS; B. TOR-90-00103-CS; C. TOR-90-00104-CS; D. TOR-90-00105-CS;
E. TOR-90-00106-CS; F. TOR-90-00107-CS; G. TOR-90-00108-CS; H. TOR-90-00109-CS.

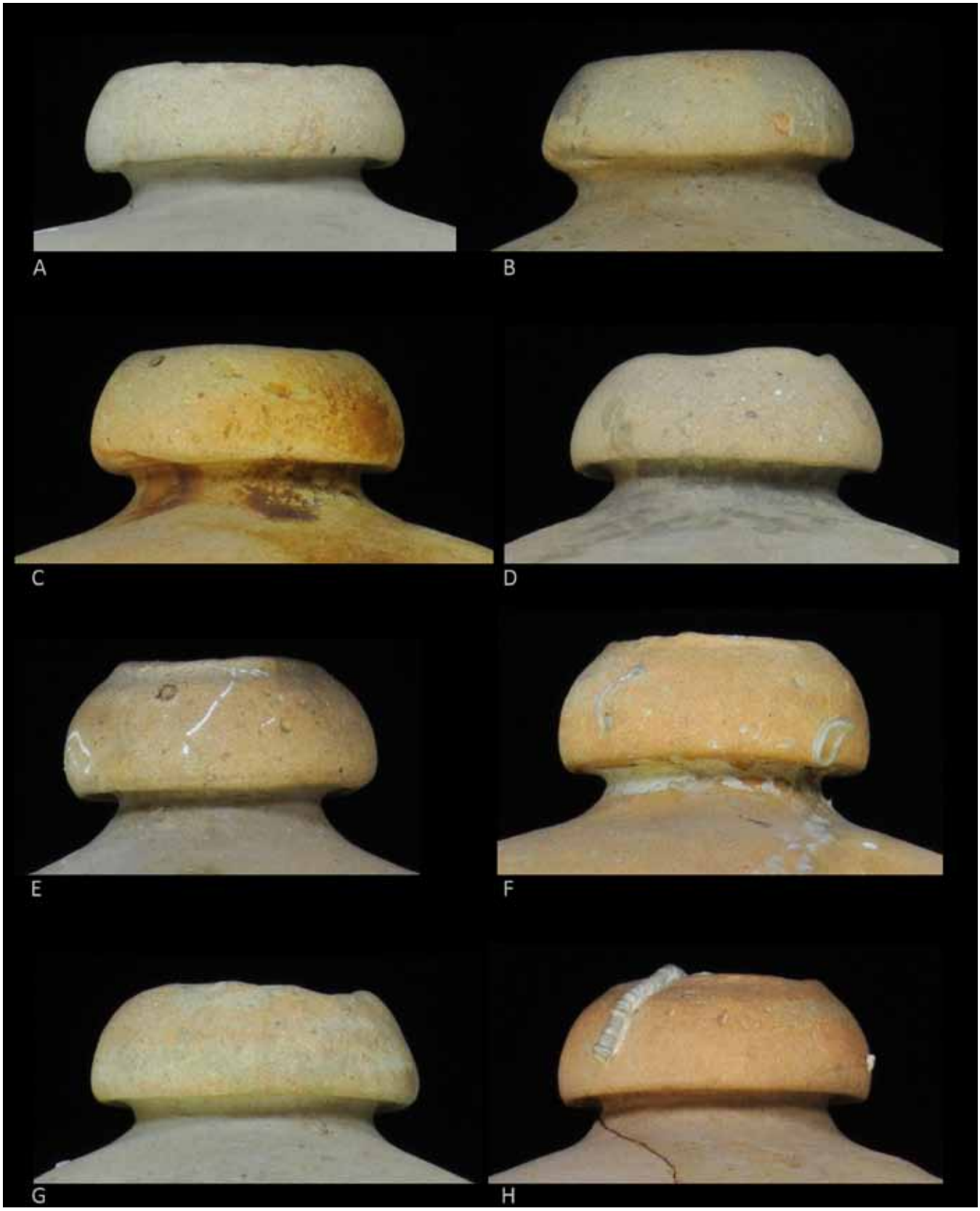

Fig. 23. Type 1 olive jar rim profiles from the Tortugas shipwreck.
A. TOR-90-00110-CS; B. TOR-90-00111-CS; C. TOR-90-00113-CS; D. TOR-90-00114-CS;
E. TOR-90-00115-CS; F. TOR-90-00116-CS; G. TOR-90-00117-CS; H. TOR-90-00118-CS.

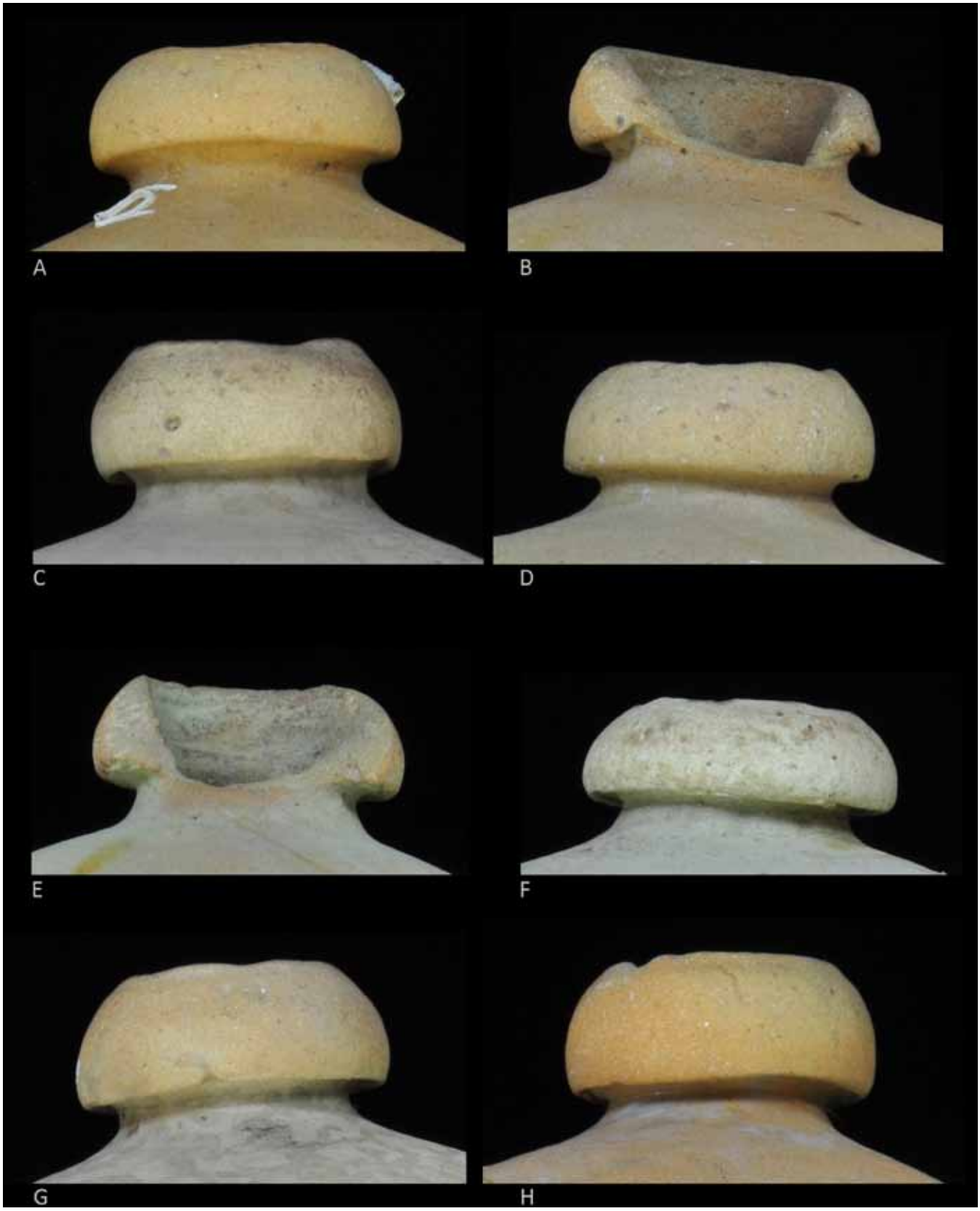

Fig. 24. Type 1 olive jar rim profiles from the Tortugas shipwreck.
A. TOR-90-00119-CS; B. TOR-90-00120-CS; C. TOR-90-00121-CS; D. TOR-90-00122-CS;
E. TOR-90-00123-CS; F. TOR-90-00124-CS; G. TOR-90-00126-CS; H. TOR-90-00127-CS.

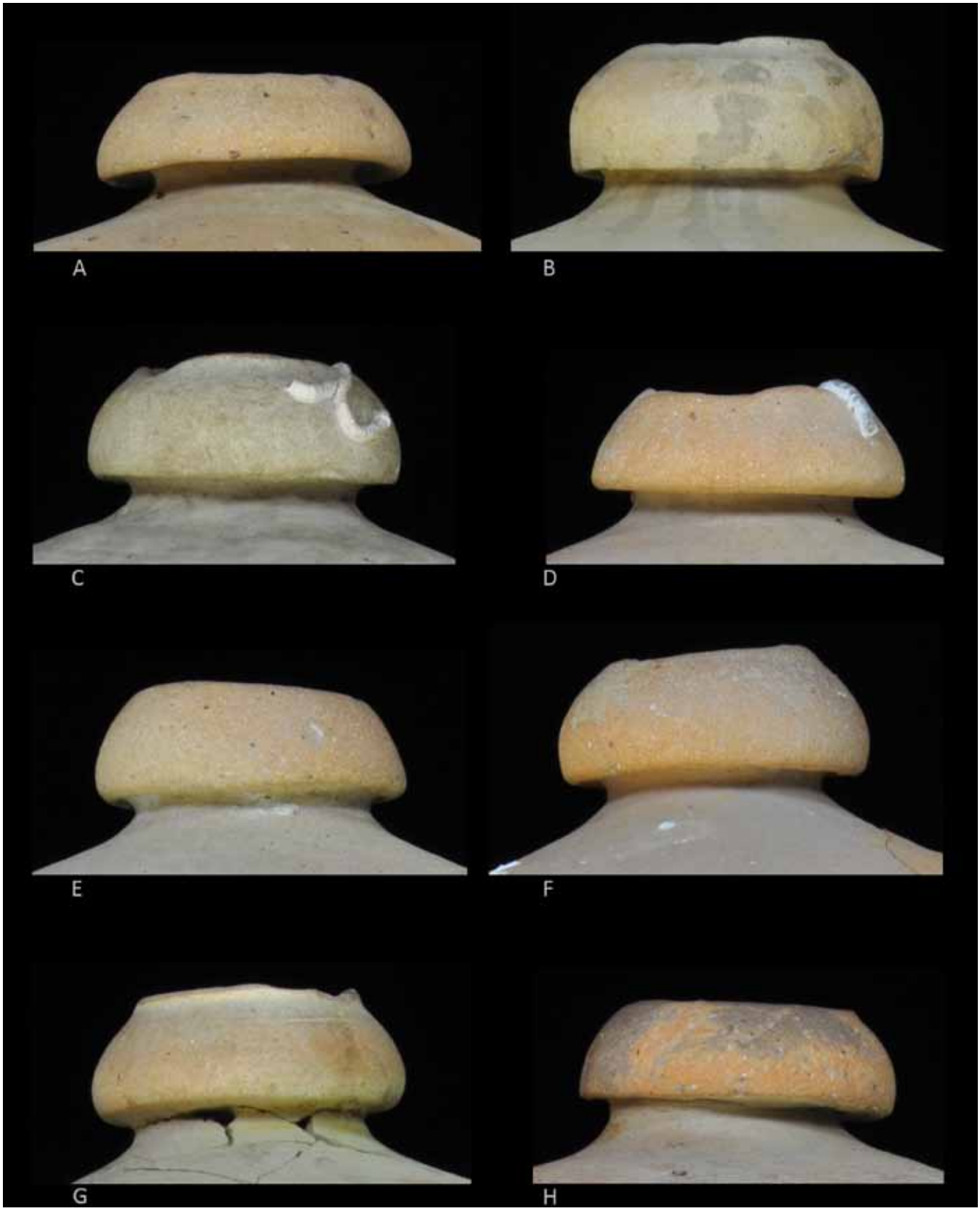

Fig. 25. Type 1 olive jar rim profiles from the Tortugas shipwreck.
A. TOR-90-00128-CS; B. TOR-90-00129-CS; C. TOR-90-00131-CS; D. TOR-90-00133-CS;
E. TOR-90-00134-CS; F. TOR-90-00135-CS; G. TOR-90-00136-CS; H. TOR-90-00137-CS.

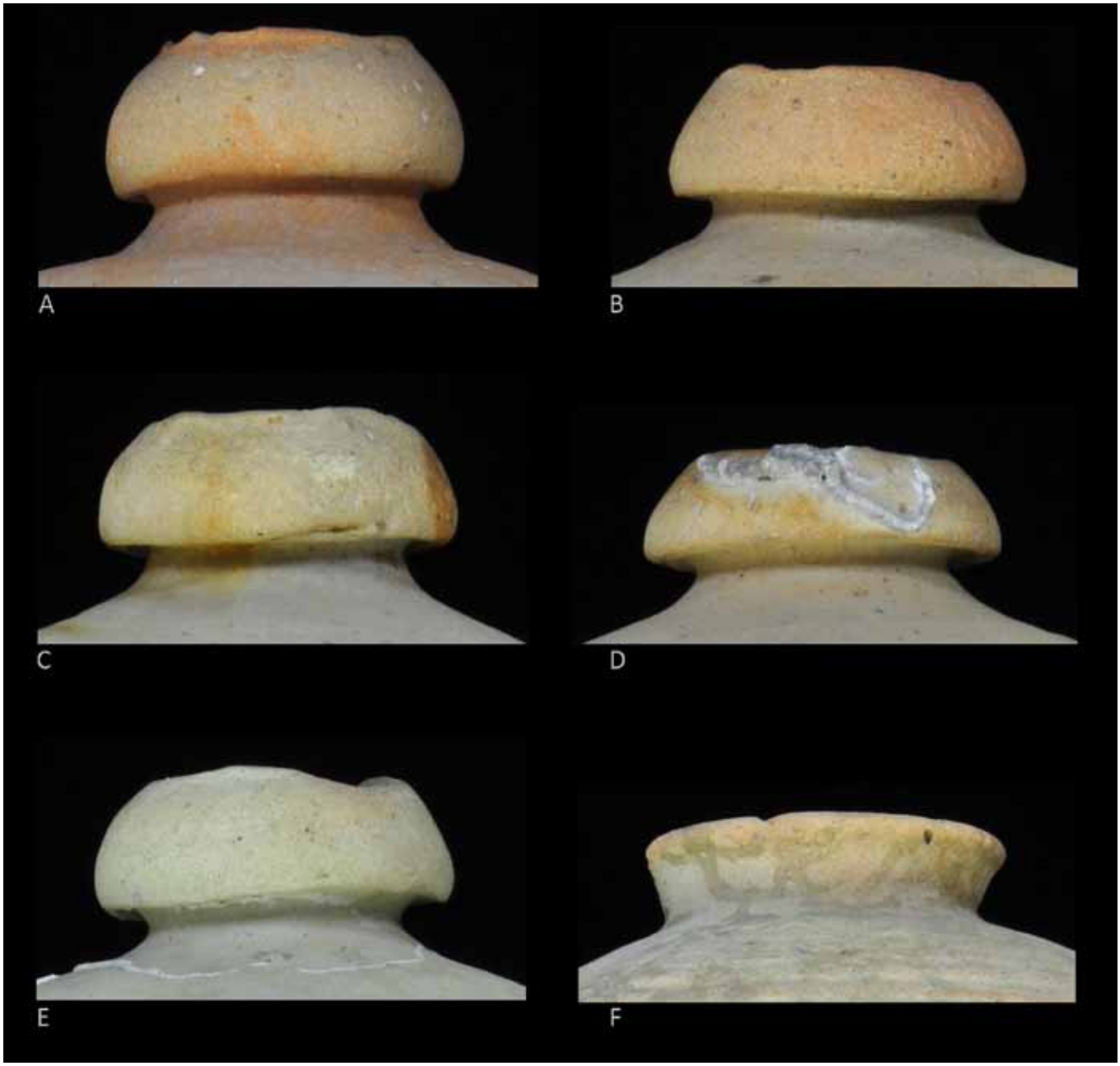

Fig. 26. Type 1 (A-E) and Type 4 (F) olive jar rim profiles from the Tortugas shipwreck. A. TOR-90-00138-CS; B. TOR-90-00139-CS; C. TOR-90-00140-CS; D. TOR-90-00141-CS; E. TOR-90-00142-CS; F. TOR-90-00018-CS.

7. Tortugas *Botija* Metrologies

The large sample size of the Tortugas wreck *botijas* has enabled their metrological structures to be assessed for uniformity and diversity (sections 2-5 above). Despite the multiplicity of vessel heights, widths, circumferences and weights, a general standardization within cluster sizes has been identified. Merchants seemingly permitted potters a degree of flexibility in jar production as long as they were capable of accommodating a pre-defined volume of content. Empty capacity emerges as the crucial manufactory attribute of the early 17th-century colonial olive jars associated with the Tortugas shipwreck.

The diversity in jar manufacture does not reflect lax industrial standards. Spain took the subject of weights and measures extremely seriously to guarantee efficiencies of shipping and consumption, and to prevent fraudulent transactions. "Nothing took firmer root in the native economy than the Spanish system of weights and measures",

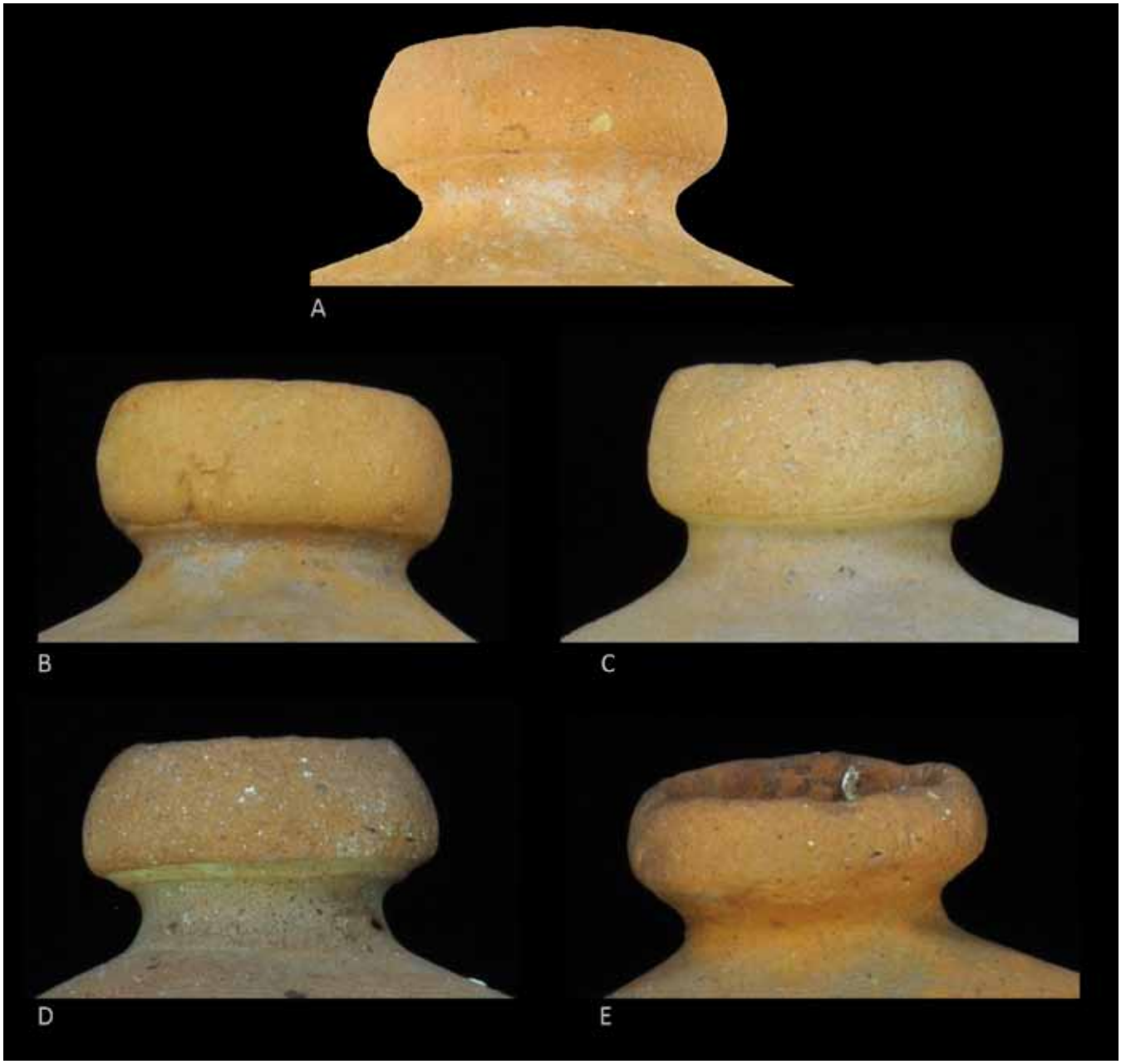

Fig. 27. Type 2 olive jar rim profiles from the Tortugas shipwreck.
A. TOR-90-00011-CS; B. TOR-90-00130-CS; C. TOR-90-00132-CS; D. TOR-90-00328-CS; E. TOR-90-00332-CS.

reasoned Stampa (1949: 2), and "So completely did the European standards supplant native practices that even today the weights, measures, and monetary standard of Mexico derive almost exclusively from the metrology of colonial times."

As early as 1524 Hernán Cortes decreed that every town in Mexico should possess a standard *arroba*, a *cuartillo* and a half-*cuartillo* sealed with the stamp of the respective town. A sealer of weights and measures was based in towns to inspect incoming provisions, to enforce the use of standard weights and measures and to certify their use by merchants. Merchants operating across New Spain were sporadically compelled to present their weights and measures to the *fiel marcador* for adjustment and marking, as in 1574 (Stampa, 1949: 3-4).

Control was tightened further through the 'Ordinances on Weights, Seals, Scales and Measures' promulgated by Viceroy Marqués de Guadalcázar in July 1620, whereby merchants were compelled to have their weights and measures stamped every four months. By this time the City

of Mexico preserved in its archives standard measures of a 2-*arroba* weight, with fractional weights of one, one-half, and one-quarter *arroba*; a bronze *cántara* of one-half *arroba* for wine and a quarter-*arroba*; a bronze *cántara* of one *arroba* for honey, with fractional measures of one-half and one-quarter *arroba*; and a *cuartillo* and a half-*cuartillo* for oil (Stampa, 1949: 6-7). This system needed to correspond to Seville's weighing and measuring standard.

Some scholars have questioned whether metrological standardization to establish uniformity and reduce fraudulent practices was universally applied (Lister and Lister, 1987: 130). The numerous customary measures used on a daily basis are considered practically impossible to establish, including those for the *botija* for wine, alcohol and other liquids ranging from 5-8 liters (Stampa, 1949: 12-13, 15).

The most common unit of measurement used across Spain's colonial territories from Seville and Portugal to Caracas was the Castilian *arroba*, which equated to 25lbs (or 11.3kg today) in Mexico, Peru, Colombia and Chile (Bowman, 1951: 318; Chevalier, 1963: 320; Barnes *et al*., 1981: 72; Ferry, 1989: 325; Drelichman, 2009: 14; Rice, 2011: 224). The *arroba* of 25lbs was relied on to weigh wool (Bilbao and Fernández de Pinedo, 1994: 101; Moreira, 2007: 103), sugar was sold in Chuquisaca and Potosi in Peru at 8 *pesos* per *arroba* (Cushner, 1980: 41), and chocolate supplies were similarly reckoned in *arroba*s (Grivetti and Howard-Yana Shapiro, 2009: 34).

This basic unit remained the standard in subsequent centuries. In his *Travels Through Spain in the Years 1775 and 1776*, Henry Swinburne recorded the relevant weights of Castille as including 1 *arroba* at 25lbs; the *media arroba* at 12lbs, 3oz; the *quarto de arroba* at 6lbs, 4oz; and the *media quarto de arroba* of 3lbs, 2oz. The *arroba* of wine equated to 16.13 liters and one *arroba* of olive oil to 12.56 liters from Spain to the Americas (Wight Washburn, 1926: 12; Barnes *et al*., 1981: 72; Carrión Arregui, 1996: 70).[3]

Attempts have been made to define the specifics of some *botija* capacities. One Type B jar from the Dominican Santo Domingo monastery at Santiago de Guatemala, Antigua (H. 29.5cm, W. 24cm), holds 6.4 liters and has been correlated to just over one-half of an early Castilian oil *arroba* of 12.56 liters (Carruthers, 2003: 45). All olive jars identified off Ireland on Armada wrecks of 1588 are Middle Style Type B forms (Tortugas Type 2), of which an intact example from *La Trinidad Valencera* had a capacity of 6.25-7.1 liters, a *media arroba* again believed to equate to half of the old Castillian oil *arroba* of 12.56 liters (Martin, 1979: 283).

A total of 129 of 602 intact olive jars recovered from the *Conde de Tolosa* and the *Nuestra Señora de Guadalupe,* lost off northeast Hispaniola in 1724, conform to Goggin's Middle Style A (Tortugas Type 1), and range from 47-52cm high (average 51cm), 29.3-32.8cm maximum diameter, 6.58-10.1kg empty weight (mainly 8.5-9.5kg) and with volumes of 15.0-20.1 liters. Goggin's Middle Style B (Tortugas Type 2) predominated on both wrecks with 442 intact examples. They ranged from 23.5-29.5cm in height, 22-27cm maximum diameter, empty weights differed by 2kg, and they held volumes of 3.3-7.2 liters (half of the examples were restricted to 5.01-6.01 liters). Study of the *Tolosa* and *Guadalupe* jars concluded that the archaeological record does not readily support equating a Middle Style B jar to a half-*arroba* volume. The wide variation in the jars' volumes implies that the jars were not manufactured with a specific capacity in mind (James, 1988: 48, 52, 61-2).

The Tortugas shipwreck's Spanish jar metrologies exhibit similar wide capacities and reflect comparable conclusions one hundred years earlier. The Type 1 examples have a 12.7-liter differentiation ranging from 14.2-26.9 liters (Table 6). In a sample of 73 jars they are equally represented in three different capacity categories: 14.2-17.5 liters (34.2%), 17.5-20.0 liters (39.7%) and 20.0-22.5 liters (24.7%).

The capacities of the nine Tortugas Type 2 olive jars exhibit a differentiation of 5.3 liters that span 2.8-8.1 liters (Table 15). Two range from 2.8-4.0 liters (22.2%), two from 4.0-6.0 liters (22.2%) and four 6.0-8.0 liters (44.4%), while one occurs in the 8.0-8.5 liter range (11.1%).

Based on a conversion rate for the *arroba* equating to 16.1 liters for wine and 12.5 liters for olive oil, and subdivisions of this unit, the sample of 73 Tortugas Type 1 jars range from fractions of 0.75-1.5 *arroba*s and correspond generally to: nine jars of 0.75 *arroba*s (12.3%), 38 jars of 1.0 *arroba*s (52.1%), 25 jars of 1.25 *arroba*s (34.2%), and one outlier of 1.5 *arroba*s (1.4%). However, these statistics conceal major variations and very few close fits.

The smallest Type 1 wine jars' capacities very generally correspond to a 0.75-*arroba*s capacity of 12.0 liters. However, none are exact or arguably even close volumetric matches that fit within a 10% margin. Vessels ranging up to 15.7-liter maximum were used to accommodate this unit size. Overall, to accommodate a precise 0.75-*arroba*s capacity, 100% of the Tortugas Type 1 jars would have been shipped between 2.2-3.7 liters empty.

Seven Type 1 jars are an exact fit for 1-*arroba* vessels of 16.1-liter capacity (19% of the 1-*arroba* jars sample), while three occur within a 5% variation (8%) and a further seven with a 10% variation (19%). Vessels ranging up to 19.5 liters maximum were used to accommodate this unit size. Overall, to accommodate a precise 1-*arroba* capacity, 54% of the Tortugas Type 1 jars would have been shipped between 1.7-3.4 liters empty.

Five Type 1 jars may be defined as an exact fit for the 1.25-*arroba* of 20.1-liter capacity (20% of this sample), while six occur within a 2.5% variation (24%, five of which exceed the jar size by 0.3-0.4 liters), three within a 2.5-5% range (12%), and a further nine with a 5-10% variation (36%). Vessels ranging up to 22.5 liters maximum were used to accommodate this unit size. Overall, to accommodate a precise 1.25-*arroba* capacity, two vessels (8%) of the Tortugas Type 1 jars would have been 2.4 liters empty.

One jar of 26.9 liters equates closest to a volume of 1.5 *arroba*s of 24.15 liters of wine, which would have been shipped 2.75 liters empty to accommodate this precise volumetric unit.

The nine examples of Tortugas Type 2 olive jars span three colonial Spanish units of volume. One 2.8-liter vessel has 0.32 liters less capacity than a 0.25-*arroba* jar, and its original standard of measurement is unidentifiable. Two jars equate to a possible 0.25-*arroba* of 3.12 liters, but to accommodate this unit would have been shipped 0.58 liters and 2.58 liters empty. A further six jars fit most closely the 0.5-*arroba*s volume of 6.25 liters: two vessels are precise matches, two would have been shipped 1.0 liter and 1.8 liter empty, while another two are in excess of the unit by 0.3 liters.

A further examination of the Tortugas *botija*s' capacities according to weight, adhering to the conversion rate of 1 *arroba* to 25lbs/11.3kg, revealed a similar non-systemized pattern.

8. Function & Ownership

The sample size of the Tortugas *botija* assemblage enables the nature of the jars' production and shipboard composition to be examined in relationship to ownership issues. The clay chemistry reveals just two origins: Cordoba for Type 1 and Seville for Type 2 and Type 4 (Hughes, 2014). The jars' internal type chemical profiles are uniform. However, within the Type 1 group samples VB5 and VB6 exhibit similar, but consistently higher, levels of aluminium, calcium and potassium and lower magnesium than the other jars examined. For the Type 2 vessels, VB10 seems to have a different pattern to the rest in terms of low aluminium, higher iron, and distinctly lower magnesium and calcium (pers. comm. Michael Hughes, 6 January 2014). These profiles hint at possible different workshop origins within an overall single geographic productive context for these types.

The Type 1 jars' metrology points to production according to four formulas of presumably pre-conceived dimensions, perhaps indicative of origins in four different workshops. Assuming that each unique stamped or incised mark is a reflection of an individual merchant, and that every owner is represented by some form of distinguishing sign, then a minimum of 11 owners and subsequently jar batches may be identified amongst the Tortugas *botija* assemblage.

The seven merchants who are documented as having loaded consignments onto the *Buen Jesús y Nuestra Señora del Rosario* are less numerous than the total number of *botija* marks, which serves as an immediate indication of compositional complexity. The 1,400 commercial jars of wine from Aljarafe, Trebujena and Salteras in Seville, as well as Sierra Llana, transported on the outward voyage to Venezuela were mostly unloaded at journey's end, Nueva Cordoba, with 200 jars dispatched onwards at Rio de la Hacha in modern Colombia (AGI *Contratación* 1172, N.2, R.1). This volume obviously far exceeds the 209 *botija*s excavated from the Tortugas shipwreck, which cannot be a residual component of the outward-bound cargo because manifests specify that they were intended to be sold at source.

Thus, Juan de Céspedes's 400 jugs of wine were "consigned to Luis de Lemos, in his absence to Diego López Aries, and in the absence of both to Gaspar Fernández Rebelo, all citizens of Cartagena, so that the merchandise's recipient had to sell it and send the profits to Spain on account of Juan de Céspedes, to whom the merchandise belonged and on whose account and risk it was loaded" (AGI *Contratación* 1172, N.2, R.1). The outgoing consignments of ten flasks of brandy/sherry and food, quince meat, raisins, hazelnuts, almonds, chestnuts, oil, capers and olives, many conceivably packaged in *botija*s as well, were also sold at Nueva Cordoba. Manifests again confirm that the profits of these sales were to be returned to the merchant owner.

The manifests for the *Buen Jesús* usefully specify that permits were initially granted for the shipment of 2,500 wine jars owned by Xpoval de Biedma, Baltasar de León, Pedro Fernández Hidalgo, Juan de Neve, Francisco de Gandía and José del Bosque (AGI *Contratación* 3041), which gives an indication of this 117-ton ship's upper capacity. In the eventuality only three of these merchants stowed a total of 1,400 wine jars as cargo on the *Buen Jesús* (AGI *Contratación* 1172, N.2, R.1). These were supplemented by 500 jugs of wine for which Juan de la Torre Ayala only paid tax on 200 jars in Seville and was compelled to pay further tax on the remainder to the Royal Officials of Cartagena on 27 July 1622 (AGI *Contaduría* 1394). The manifest specifies that these additional jars were intended for use by the crew, with the surplus seemingly expected to be sold in the Americas.

The transport of hundreds of jars containing staple foodstuffs per leg of a sea voyage to and from the Americas sounds excessive to the modern mind. A sound method

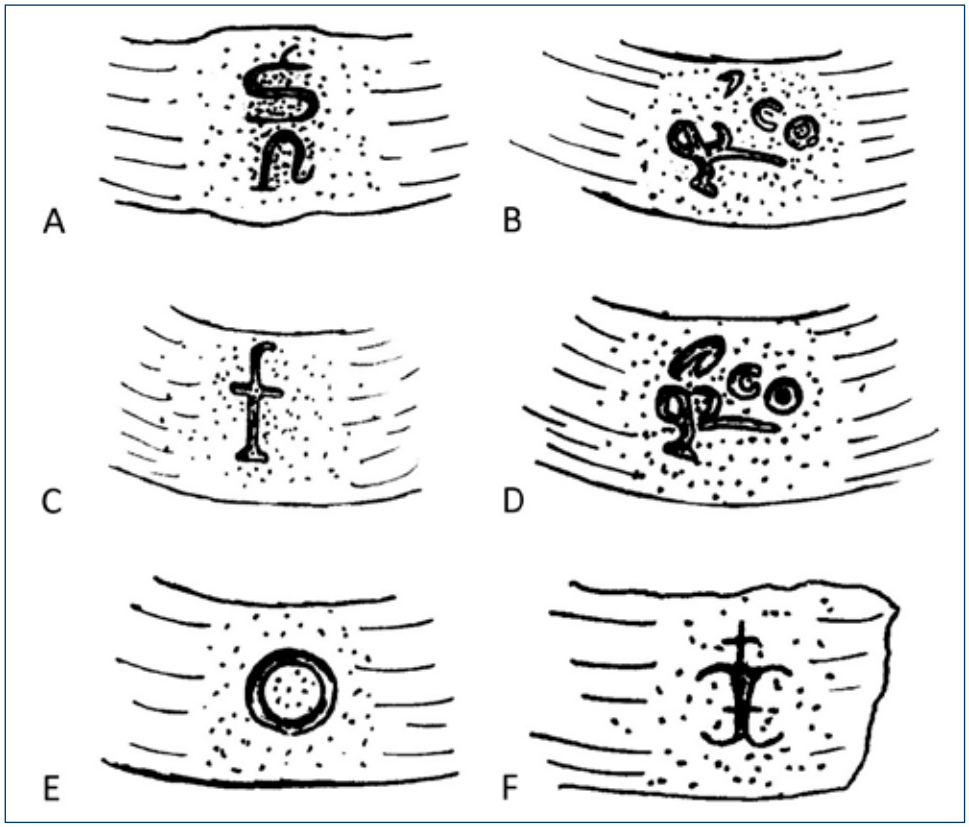

Fig. 28. Merchants' marks stamped on Tortugas shipwreck olive jar rims.

underlay a system infamously dismissed as "veritable economic lunacy" (Chaunu and Chaunu, 1974: 120). The Casa de la Contratación strove to secure adequate provisions within Spain for a *flota*'s entire journey because purchasing staple foodstuffs in the Indies was estimated to cost twice as much as in Seville and its hinterland, a proposition demonstrated statistically by data in the Archivo General de Indias (Hamilton, 1929: 431-32).

Most provisions were supplied from the territory within carting distance of Seville. Fish came from Cadiz, pork from Ronda, Sierra de Aracena and other towns in the oak-covered hills fringing the Sierra Nevada and Sierra Morena mountains. Raisins originated in Almería and rice further afield in Valencia. Cheese and wheat were bought at market in Seville often following importation from Germany, Flanders, the Canaries, France and North Africa (Hamilton, 1929: 431).

A sharp decline in Andalusian agriculture after the early 17th century shook up the supply chain, for instance requiring salt pork to be imported from Flanders and salt beef from Ireland. All these products were processed via Seville. Only meat was procured in the Americas by 1660 because abundant grazing land and low prices made this produce more competitive than in Spain. Keeping *flota* food costs low was in the Merchant Guild of Seville's economic interests, and procurements for men-of-war were financially offset by the *avería* convoy duty tax (Hamilton, 1929: 431-32), which was applied to official fleets to cover the Crown's cost of providing military protection. In 1596 the *avería* was set at 14%, but due to dangers associated with shipping during the Thirty Years War escalated to 35% in 1631 (Márquez, 2006: 416). At war against the Dutch from 1621, this tax can be assumed to have been towards the higher figure when the *Buen Jesús*'s merchants paid the convoy tax in 1622.

Whether shipmasters were responsible for passengers' food through the *avería* on small merchant vessels such as the *Buen Jesús* is unclear, but may be assumed to have been logical and most efficient. Irrespective of the victualing model concerned, in 1622 foodstuffs for the *Buen Jesús*'s complete round journey would have been purchased largely, if not exclusively, in Seville. The basic Spanish mariner's diet consisted of a daily ration of 1.5lbs of biscuit, six ounces of pork a day for four days of the week and on the remaining days six ounces of cod, plus two ounces of a mixture of rice and chick-peas. Most daily calories came from bread (1,695), salt beef (395), beans or chickpeas (361). Cheese on Mondays and Wednesdays yielded 667 calories daily and salt cod on Fridays and Saturdays 163 calories. When fully provided, the diet's energy value of

4,130 calories on meat days and 3,743 calories on fish days is considered well balanced (Hamilton, 1929: 434, table 1; Goodman, 1997: 157).

On both a ship of the Armada of the Indies and an *Almirante* of the 1570s, sailors received weekly seven liters of wine, 0.25 liters of olive oil and 0.625 liters of vinegar (Super, 1984: 61-2, table 2). These victuals would have originated in the agricultural hinterland surrounding Seville and have been packaged primarily in *botija*s in the case of the Tortugas wreck.

The crew of the *Buen Jesús* numbered 28 people, including the master, Manuel Diaz, assuming the ship's owner, Juan de la Torre Ayala, was also onboard (based on references to his name in relation to the loss of his ship in the Straits of Florida) (Kingsley, 2013: 10-11). Seven liters of wine equates to a weekly demand of 196 liters and 784 liters per month. Similarly, 0.25 liters of oil corresponds to seven liters a week and 28 liters a month. Vinegar needs would have reached 17.5 liters a week for the whole crew and 70 liters monthly. The combined weekly demand may have reached 220.5 liters weekly and 882 liters each month.

The 8,000km journey from Seville to Veracruz led from Sanlucar in Andalusia past the Canary Islands, thence west by southwest to catch the trade winds at about 16º, rarely changing course until Deseada, Guadalouope or one of the other West Indies' Leeward Islands. Spanish ships sailed southwest from Deseada to Cabo de la Vela and on to Cartagena. The route forward to Havana was circuitous, running from Cartagena to Nombre de Dios or Porto Bello. Due to the prevailing east winds and dangerous reefs, cays and shoals extending far out to sea along the Mosquito coast, to reach Havana ships were initially forced to head back to Cartagena on the eastwards coast eddy to get well of windward of Nicaragua before heading for the Yucatan Channel.

The fleet then anchored at Cartagena for a week or ten days to receive the king's revenues and was rejoined by ships that had traded along the Spanish Main at Margarita, such as the *Buen Jesús*. From Cartagena the united fleet then sailed northwest past Jamaica and the Caymans to the Isle of Pines, and thence round Cape Corrientes and San Antonio to Havana, a run generally of about eight days, where vessels were refitted and re-stocked (Haring, 1918: 223, 226-27).

Depending on weather conditions the duration of a Tierra Firme's round voyage normally took between two and three months (Márquez, 2006: 402). Haring (1918: 223-27) estimates the run at 38 days from Andalusia to Deseada, while Cartagena was reached six or seven weeks after departure from Spain. The indirect route from New Spain to Havana took another 18-20 days.

Fig. 29. A 'snf' stamp on an olive jar rim, Tortugas shipwreck.

According to the specific itinerary for the 1622 Tierra Firme fleet, its ships took around 88 days to reach Havana, as follows (Chaunu and Chaunu, 1956: 26):

- Departure Cadiz, 24 April 1622
- Sailed passed the Canaries, 3 May 1622
- Sailed passed Dominique, end of May 1622
- Arrived at Cartagena, 14 June 1622
- Departure Cartagena, 22 June 1622
- Arrived at Porto Bello, 1 July 1622
- Departure Porto Bello, 22 July 1622
- Arrived at Cartagena, 27 July 1622
- Departure Cartagena, 3 August 1622
- Arrived at Havana, 22 August 1622[4]
- Departure Havana, 4 September 1622

Based on average comparable voyages without any misadventure, the 1622 Tierra Firme fleet could have been expected to reach Cadiz from Havana in 47 days (pers. comm. Luis Camacho, 18 February 2014). This provides a complete voyage duration of 135 days or 19 weeks.

Fig. 30. A 'f' stamp on an olive jar rim, Tortugas shipwreck.

Fig. 31. A hollow circle stamp on an olive jar rim, Tortugas shipwreck.

Fig. 32. A lamp and 'nco' stamp on an olive jar rim, Tortugas shipwreck.

A round journey from Andalusia to Havana and back to Seville of 19 weeks would have required 3,724 liters of wine, 133 liters of oil and 332.5 liters of vinegar or a total 4,189.5-liter combined capacity. Taking the mean average of 17.4 liters per jar for the combined intact 73 Type 1 and nine Type 2 Tortugas olive jar sample suggests that an estimated 240 *botija*s would have been needed to fulfill the *Buen Jesús*'s staple liquid requirements. The 209 olive jars excavated from the Tortugas shipwreck are numerically inferior, but close to this figure, and provide a high degree of confidence in generally interpreting the *botija* assemblage as ship's stores required for an entire round trip to the Americas. If the Type 3 jars contained honey, their combined capacity of 8.4 litres would have supplied 28 people with a share of 0.063 liters daily.

Biases inherent within this calculation include the unknown precise size of the ship's crew and passengers, plus the reality that the majority of the ship's jars (171 of 185: 92.4% of the total assemblage) are Type 1 examples of greater average capacity (18.6 liters rather than 17.4 liters). The nine Type 2 olive jars associated with the Tortugas wreck would have been insufficient to transport the requisite oil: 133 liters of olive oil equates to a demand for 23 vessels of average 5.8-liter capacity.

Examining the olive jars exclusively by type volume yields the same result. The average capacity of the Type 1 jars is 18.6 liters. To meet the demand for 3,724 liters of wine would have required 200 *botijas* and an additional 18 vessels to hold 332.5 liters of vinegar. The average volume of Type 2 olive jars is 5.8 liters, for which 23 jars would be needed to contain 133 liters of olive oil. The total set of Type 1 and Type 2 olive jars required based on this calculation would be 241 jars. Although the different types constituting the total number of jars associated with the Tortugas shipwreck is unknown, the quantity is again sufficiently close to the overall number of 209 *botijas* excavated to propose that the olive jars represent ship's stores rather than cargo.

Examining the staple food requirements solely for the return leg from Havana to Spain, estimated at 47 days, refines the close fit between the calculated demand and the archaeological evidence. The foodstuffs required for this seven-week journey would have consisted of 1,372 liters of wine, 122.5 liters of vinegar and 49 liters of olive oil. Using the above average *botija* capacities for the Tortugas wreck yields a total need for 74 wine jars, seven vinegar jars and nine olive oil jars. The 81 wine and vinegar *botijas* could have been comfortably accommodated by the 81 intact and 90 rims of Type 1 jars recorded on the Tortugas shipwreck. The nine olive oil *botijas* correspond precisely with the nine Type 2 olive jars recovered from the wreck. The 204

Fig. 33. A second lamp and 'nco' stamp on an olive jar rim, Tortugas shipwreck.

Fig. 34. 'YW' incised post-firing onto the body of an olive jar, Tortugas shipwreck.

Fig. 35. An inverted 'R' incised post-firing onto the body of an olive jar, Tortugas shipwreck.

Fig. 36. Pi incised onto the body of an olive jar, Tortugas shipwreck.

Fig. 37. A hollow circle incised onto the body of an olive jar, Tortugas shipwreck.

Type 1 and Type 2 jars associated with the Tortugas ship account for 41% of the 500 vessels seemingly stowed in Seville for crew and passenger use (AGI *Contaduría* 1394). In this model the surplus 59% would have been sold in the Americas to free up space for the return cargo.

9. Conclusion

The Tortugas shipwreck's *botija* type series fits into a well-recognized structure for colonial Spanish production and consumption. Both the *San Antonio* of 1621 and *Atocha* of 1622 were equipped with Type 1-4 jars and are direct typological matches to the Tortugas wreck's assemblage (Marken, 1994: 65-71). The more unusual flat-bottomed Tortugas Type 4 *orzas* have also been reported from the *Santa Ana Maria*, wrecked in 1627 off Castletownshend, County Cork, Ireland (Marken, 1994: 81). Based on functional form and numerical rarity within the archaeological record, this variant is not technically definable as a *botija*.

The question of *botija* origins is becoming increasingly complex. Conspicuous distribution, including wasters re-cycled for building programmes, has long made Seville the obvious and most widely accepted candidate (de Amores Carredano and Chisvert Jiménez, 1993: 309).

Fig. 38. A Portuguese cross stamped onto the shoulder of an olive jar, Tortugas shipwreck. Possible esparto matting wear scratches on the vessel's right side.

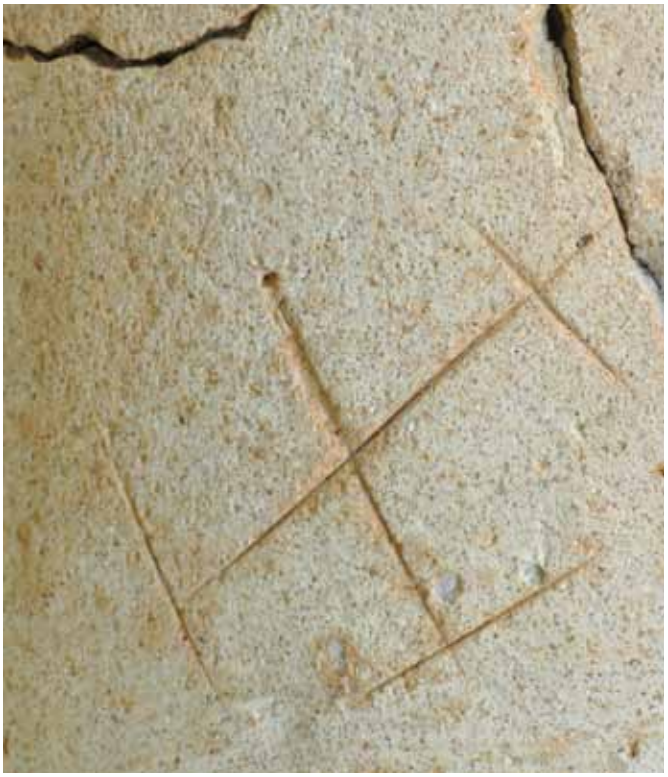

Fig. 39. A Christian cross incised post-firing onto the body of an olive jar, Tortugas shipwreck.

Jar production, however, is attested for the Moquegua Valley in southern Peru, where the wine was distilled into brandy and transported by mule pack-trains to the silver-mining regions of Potosí and towns high in the Andies (Rice, 1996: 797). Peruvian products also reached the Solomon Islands, *c*. 1595-96 AD (Kelloway *et al*., 2014). Inductively-Coupled Plasma Spectrometry (ICPS) analysis of the Tortugas shipwreck's olive jars indicates production in Cordoba for Type 1 and in Seville for Types 2 and 4 (Hughes, 2014).

Due to its volume capacity, and through comparison to references to the outward-bound manifests for the *Buen Jesús* y *Nuestra Señora del Rosario*, the Tortugas wreck's *botija* assemblage is interpreted as ship's stores. The estimated 3,724 liters of wine required for the *Buen Jesús*'s round journey represented 89% of the ship's total liquid requirements. The 332.5 liters of vinegar account for 8% of the total needs and 133 liters of olive oil for 3% by volume. The dominance of Type 1 *botijas* at 92.4% of the shipwreck's jars is suggested to correspond to volumetric consumption realities for both the crew's wine and vinegar.

These statistics must bear in mind that between 1600 and 1630 around 65% of wine was shipped in wooden containers and just 35% in *botijas*. Similarly, 91% of vinegar was transported overseas in *botijas* in the 17th century (Avery, 1997: 193, 199). This structure continues a heavy exploitation of casks and barrels in the 16th century (Skowronek, 1987: 107). Unlike the *Atocha*, however, no evidence of barrel hoops is attested on the Tortugas shipwreck, which points towards predominant, if not total, transport in ceramic jars.

The Tortugas olive jars do not comprise a single batch unified in production and metrology. In all likelihood the ship's *botijas* represent stores assembled piecemeal over a lengthy period of time and secured opportunistically, perhaps even in different geographic locations, on an as needs basis. The jar assemblage may be considered the end result of myriad transactions conducted previously by shipping agents and merchants on both land and sea. The recycled nature of the assemblage, including just one anomalous Type 1 jar glazed internally, best explains the highly mixed jar capacities. This lack of overall collection standardization was seemingly shared by the *Atocha*, whose few Type 1 jars examined ranged from 16.10-18.06 liters. Two Type 2 *botijas* from the same sister ship held 5.58 and 6.38 liters (Marken, 1994: 68-9).

The internal evidence does not sustain the view that the Tortugas ship's *botijas* sizes corresponded to the *arroba* of wine equated to 16.13 liters, the one *arroba* of olive oil at 12.53 liters or to fractions of either. There is similarly no reason to propose that the *Buen Jesús*'s jars were filled according to alternative *arroba*s sizes specified in historical sources (Pleguezuelo-Hernandez, 1993: 48):

- *Botija de arroba y media* (16.5 liters)
- *Botija de arroba y cuarta* (13.87 liters)
- *Botija de arroba also called botija perulera* (11.5 liters)
- *Botija de media arroba* (5.7 liters)
- *Botija de cuarto de arroba / botija de aguda* (2.87 liters)

The apparent unstructured nature of the Tortugas ship's *botija* metrologies is difficult to digest considering Seville's tightly controlled victualling and shipping strategy for voyages to the Americas. The lack of standardization in production is best explained by the vast jar numbers turned out in Andalusia and the colossal scale of demand across the colonies. With their diversity of merchantman stamps, the Tortugas ship's olive jars are patently an expression of intense commerce conducted prior to the loading of the vessel in Sevillle in 1622. The idea that a *laissez faire* attitude dictated olive jar capacities is improbable, primarily because lading stores of undefined size would have affected ship buoyancy. This raises the likelihood that the key factor in determining the volume of Tortugas *botijas* shipped was weight, and that jar and content were weighed collectively using a steelyard prior to storage below decks. The manufacture of such devices from iron, as at the 16th-

century Berry site, North Carolina (Rodning *et al*., 2011: 19-11), rather than bronze as in the Roman and Byzantine periods, perhaps explains their absence on Spanish wrecks.

In the final analysis, in pouring a precise unit of liquid into a *botija* for long-distance shipment the primary factor would seem to have been the jar's basic ability to contain a minimum liquid volume irrespective of jar magnitude. Whether this understanding originated one hundred years earlier, when jar capacities more closely fitted fractions of the *arroba*, remains undetermined. In the case of the Tortugas wreck it is tempting to envisage the *botija* assemblage as reflecting a fast-paced environment where demand had outstripped supply. In a world where jars could be sold in St. Augustine, Florida, in 1572 at over four times their cost in Seville (McEwan, 1992: 105), it is perhaps explicable why potters and merchants alike developed time-cutting strategies.

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For their dedication in so carefully recording and recovering the Tortugas olive jars, this project owes a debt of gratitude to the fieldwork direction of David Moore and his assistant Heather Gibbs, operating under the Offshore Project Manager, John Astley.

The data related to the Tortugas Type 1-3 jar rim typology and cork stopper sizes leans directly on the former work of George Avery (1997), who examined the collection for his doctoral thesis. The authors are sincerely grateful for various feedback provided by Dr. Beverly Straube, Senior Archaeological Curator, Jamestown Rediscovery; Russell Skowronek, Professor of History and Anthropology, University of Texas-Pan American, especially for sharing literature on the *arroba*s and its modern equivalent; Dr. George Avery, Director, Archaeology Lab, Department of Social and Cultural Analysis, Stephen F. Austin State University; and Dr. Mitch Marken, EnviroPro Consulting. All errors are our own.

Notes

1. This study replaces the preliminary data presented in Kingsley *et al*., 2012. The statistics are based on the collection of 81 intact jars recorded in the 1990s (Flow, 1999: 38-39), plus 90 rims in the collection of Odyssey Marine Exploration, Tampa. A sample of 54 intact and near-intact olive jars, 90 rims and 100 body sherds are preserved in Odyssey's laboratories today.
2. See, Awe, J., *The Sword and the Olive Jar: Material Evidence of Seventeenth-Century Maya – Spanish Interaction in Central Belize*: https://www.academia.edu/5142009/The_Sword_and_the_Olive_Jar_Material_Evidence_of_Seventeenth-Century_Maya_-_Spanish_Interaction_in_Central_Belize.
3. See also, Arroya Abad, L., Davies, E.A.R. and Luiten van Zanden, J., *Prices and Wages in Argentina, Bolivia, Chile, Colombia, Mexico and Peru*, Table A.3: http://www.iisg.nl/hpw/prices-wages-argentina-bolivia.pdf.
4. The precise date of the 1622 fleet's arrival in Havana is not specified in Chaunu and Chaunu, (1956: 26), but has been obtained through reference to AGI *Indiferente* 754, Consultas de Indiferente General, 1621-1624.

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Appendix 1

Jars Type 1: Vessel Dimensions (Cm)			
Inv. No.	**Height**	**Diameter**	**Circumference**
TOR-90-00018-CS	43.5	31.2	99.6
TOR-90-00102-CS	50	27.9	87.8
TOR-90-00103-CS	51.5	28.4	89.2
TOR-90-00104-CS	53.5	29.2	91.6
TOR-90-00105-CS	52	28.6	90
TOR-90-00106-CS	54.5	29.2	91.3
TOR-90-00107-CS	52	29.8	93.5
TOR-90-00108-CS	48.5	30.5	95.7
TOR-90-00109-CS	52	29.8	93.5
TOR-90-00110-CS	50.5	29.9	94
TOR-90-00111-CS	51	27.2	85.5
TOR-90-00112-CS	51	29.5	92.6
TOR-90-00113-CS	51	29.2	91.6
TOR-90-00114-CS	52	28.4	89.2
TOR-90-00115-CS	50.8	28.7	90
TOR-90-00116-CS	52	28.3	88.9
TOR-90-00117-CS	51.5	27.9	87.7
TOR-90-00119-CS	51	27.8	87.4
TOR-90-00120-CS	53.5	29.6	93.1
TOR-90-00121-CS	50.5	28.9	90.9
TOR-90-00122-CS	52.5	29.6	93
TOR-90-00123-CS	55	30.2	94.8
TOR-90-00124-CS	51.8	29.9	94.1
TOR-90-00125-CS	50.5	29.9	93.8
TOR-90-00126-CS	53	28.6	89.7
TOR-90-00127-CS	54	29.5	92.7
TOR-90-00128-CS	55	29	91
TOR-90-00129-CS	51.1	30	91.5
TOR-90-00131-CS	54	31	95.5
TOR-90-00133-CS	51	30.8	96.6
TOR-90-00134-CS	52	28.9	90.6
TOR-90-00135-CS	54.5	29.6	92.8
TOR-90-00136-CS	52.5	29	91
TOR-90-00137-CS	51.5	29.2	91.8
TOR-90-00138-CS	51.5	28.9	90.8
TOR-90-00139-CS	51	28.8	90.3
TOR-90-00140-CS	54.5	29.4	92.2
TOR-90-00141-CS	51	30	90.7
TOR-90-00142-CS	49	29.5	91

Table 21. Tortugas Type 1 olive jar dimensions (height, diameter, circumference).

Jars Type 1: Vessel Dimensions (Cm)			
Inv. No.	**Height**	**Diameter**	**Circumference**
TOR-90-01227-CS	56.5	30.1	94.5
TOR-90-01228-CS	53	28.6	90
TOR-90-01229-CS	49.5	30.4	95.5
TOR-90-01230-CS	53	30.7	96.5
TOR-90-01231-CS	52	28.1	88.4
TOR-90-01232-CS	50.7	30.1	94.5
TOR-90-01233-CS	53.8	29.8	93.8
TOR-90-01234-CS	55	29.3	92
TOR-90-01235-CS	51.5	29.9	94
TOR-90-01236-CS	52.5	29.7	93.3
TOR-90-01237-CS	54	29.6	93
TOR-90-01238-CS	51	30.6	96
TOR-90-01239-CS	53.5	28.8	90.5
TOR-90-01240-CS	53.5	27.8	87.4
TOR-90-01241-CS	52	29.6	93
TOR-90-01242-CS	54	29.5	92.8
TOR-90-01243-CS	50.8	27.7	87
TOR-90-01244-CS	53.7	29.5	92.7
TOR-90-01245-CS	50.8	17.9	87.8
TOR-90-01246-CS	53	31	97.3
TOR-90-01247-CS	52.8	28.7	90.1
TOR-90-01248-CS	47.7	31.3	98.8
TOR-90-01249-CS	50.5	28.8	90.3
TOR-90-01250-CS	52.5	29.6	93
TOR-90-01251-CS	51.2	29.3	92.1
TOR-90-01252-CS	52.5	29.2	91.7
TOR-90-01253-CS	51	29.9	95.3
TOR-90-01254-CS	53	30.5	95.9
TOR-90-01255-CS	53.5	29.6	92.8
TOR-90-01256-CS	53.5	29.8	93.7
TOR-90-01257-CS	52.5	28.7	90
TOR-90-01258-CS	49	29.7	93.1
TOR-90-01259-CS	55	31.1	97.6
TOR-90-01260-CS	52.5	30.7	96.4
TOR-90-01261-CS	52.5	34.1	107
TOR-90-01262-CS	47	29	89
TOR-90-01263-CS	55.5	28	90.5
TOR-90-01264-CS	51	31	94
TOR-90-01265-CS	53.2	32.5	97
TOR-90-01266-CS	51	33	92.5
TOR-90-01273-CS	49	29.3	92
TOR-90-01274-CS	52.2	31	93

Table 22. Tortugas Type 1 olive jar dimensions (height, diameter and circumference).

Jars Type 1: Rim Dimensions (Cm)				
Inv. No.	**Rim Height**	**Rim Ext. Diam.**	**Rim Int. Diam.**	**Rim Circum.**
TOR-90-00018-CS	2.1	11.9	8.8	37.5
TOR-90-00102-CS	3.3	9.5	4.7	30.2
TOR-90-00103-CS	3.9	9.6	4.8	30.5
TOR-90-00104-CS	4	9.5	5.1	30
TOR-90-00105-CS	3.4	9.1	4.9	28.5
TOR-90-00106-CS	4	9.8	5.7	31.2
TOR-90-00107-CS	3.7	9.4	5.2	30.2
TOR-90-00108-CS	3.2	11	5.4	34.8
TOR-90-00109-CS	3.5	9.7	6.3	31.3
TOR-90-00110-CS	3.2	9.2	6.2	29.5
TOR-90-00111-CS	3.4	8.9	5.2	28.2
TOR-90-00112-CS	---	---	---	---
TOR-90-00113-CS	3.7	9.5	5.8	30
TOR-90-00114-CS	3.4	9.2	5.5	29
TOR-90-00115-CS	3.2	9.1	4.5	29
TOR-90-00116-CS	3.5	8.9	4.4	28.4
TOR-90-00117-CS	3.2	9.6	5	30.4
TOR-90-00119-CS	3.1	9.5	5.1	30.3
TOR-90-00120-CS	3.1	9.3	5.4	---
TOR-90-00121-CS	2.5	9.9	5	31.2
TOR-90-00122-CS	3.2	9	4.5	28.4
TOR-90-00123-CS	4.1	10	5.4	31.4
TOR-90-00124-CS	3.9	10.3	5.7	32
TOR-90-00125-CS	---	---	5	---
TOR-90-00126-CS	4.5	9.7	5.2	30.5
TOR-90-00127-CS	4.2	9	4.8	28.3
TOR-90-00128-CS	4.1	9.4	5.2	29.4
TOR-90-00129-CS	3.8	9	4.5	29
TOR-90-00131-CS	3.5	9.5	4.6	30.5
TOR-90-00133-CS	5	4	31.7	19.7
TOR-90-00134-CS	3.8	9.8	5.5	30.6
TOR-90-00135-CS	4.5	9.9	5.2	31.2
TOR-90-00136-CS	4	9.8	5.4	30.8
TOR-90-00137-CS	3.8	9.9	5.4	31
TOR-90-00138-CS	4.3	8.9	4.8	28.2
TOR-90-00139-CS	3.7	9.5	5.1	29.8
TOR-90-00140-CS	4.1	9.8	5.2	30.9
TOR-90-00141-CS	2.7	9.5	4.5	29.5
TOR-90-00142-CS	3.5	9.7	4.6	30.8
TOR-90-01227-CS	3	9.4	4.4	29.9
TOR-90-01228-CS	4.5	9.7	4.8	31
TOR-90-01229-CS	3.4	9.8	5.7	31.6

Table 23. Tortugas Type 1 olive jar rim dimensions.

Jars Type 1: Rim Dimensions (Cm)				
Inv. No.	**Rim Height**	**Rim Ext. Diam.**	**Rim Int. Diam.**	**Rim Circum.**
TOR-90-01230-CS	3.7	9.7	5.7	30.7
TOR-90-01231-CS	3.5	9.5	5.6	30.1
TOR-90-01232-CS	---	---	---	---
TOR-90-01233-CS	3.5	9.2	5.2	29.4
TOR-90-01234-CS	3.5	9.5	5.7	30.2
TOR-90-01235-CS	3.7	9.7	6.1	---
TOR-90-01236-CS	3.7	9.2	5.6	29.8
TOR-90-01237-CS	4.2	9.4	4.4	30
TOR-90-01238-CS	3	9.5	4.5	30.1
TOR-90-01239-CS	3.6	9.6	5.5	30.2
TOR-90-01240-CS	3	9.6	4.7	30.2
TOR-90-01241-CS	3.2	9.5	5.7	30
TOR-90-01242-CS	3.4	9.2	4.9	29.3
TOR-90-01243-CS	3.5	9.8	4.7	---
TOR-90-01244-CS	4.5	9.5	4.8	29.9
TOR-90-01245-CS	4	9.5	4.8	30
TOR-90-01246-CS	4.3	9.3	5.3	29.3
TOR-90-01247-CS	4.3	9.9	4.9	31.1
TOR-90-01248-CS	4	10.6	5	33.3
TOR-90-01249-CS	3.5	9.5	5.8	29.7
TOR-90-01250-CS	3.5	9.6	5.1	30
TOR-90-01251-CS	3.5	9.2	4.9	29
TOR-90-01252-CS	4.5	9.6	5.1	30.3
TOR-90-01253-CS	4.5	9.6	5	30.2
TOR-90-01254-CS	4.2	9.8	4.8	30.7
TOR-90-01255-CS	4.2	8.9	4.6	28
TOR-90-01256-CS	3.6	9.5	5.3	29.7
TOR-90-01273-CS	3.8	9.5	4.8	29.7
TOR-90-01257-CS	4.4	9.4	4.7	29.4
TOR-90-01258-CS	3.8	9.5	4.7	29.7
TOR-90-01259-CS	5.1	4	32.2	21.6
TOR-90-01260-CS	4.2	9.6	5.5	30.2
TOR-90-01261-CS	5.2	3.8	32.3	26.9
TOR-90-01262-CS	---	---	---	---
TOR-90-01263-CS	3.5	9.5	5	29.5
TOR-90-01264-CS	---	---	---	---
TOR-90-01274-CS	3.5	9.8	4.2	30.5
TOR-90-01265-CS	3.9	9.8	4.2	31
TOR-90-01266-CS	3.3	8.5	3.6	27.5

Table 24. Tortugas Type 1 olive jar rim dimensions.

Jars Type 1: Volume (Liters), Weight (Kg) & Color *(Munsell)*			
Inv. No.	**Volume**	**Weight**	**Color**
TOR-90-00018-CS	20.8	6.4	----------
TOR-90-00102-CS	15.1	7.3	2.5YR 6/6
TOR-90-00103-CS	15.6	6.4	2.5YR 7/3
TOR-90-00104-CS	17.5	7.4	2.5Y 8/3
TOR-90-00105-CS	16.8	7.3	5Y 7/4
TOR-90-00106-CS	19.8	8.2	10YR 7/4
TOR-90-00107-CS	20.5	7.1	2YR 7/3
TOR-90-00108-CS	17	7.2	7.5YR 6/6
TOR-90-00109-CS	16.1	6.7	7.5YR 6/6
TOR-90-00110-CS	16.1	7.2	2.5YR 8/3
TOR-90-00111-CS	14.2	5.9	5YR 6/4
TOR-90-00112-CS	16.1	---	5YR 6/6
TOR-90-00113-CS	17	6.8	5YR 6/6
TOR-90-00114-CS	16.1	7.8	----------
TOR-90-00115-CS	15.1	7.1	7.5YR 6/6
TOR-90-00116-CS	15.7	7.8	7.5YR 6/6
TOR-90-00117-CS	15.1	7.5	7.5YR 7/4
TOR-90-00119-CS	15.1	6.7	5YR 6/6
TOR-90-00120-CS	19.4	7.3	5YR 6/6
TOR-90-00121-CS	17	7.8	2.5YR 8/2
TOR-90-00122-CS	18	7.8	7.5YR 6/6
TOR-90-00123-CS	21.4	7.8	10YR 7/4
TOR-90-00124-CS	21.2	7	10YR 8/2
TOR-90-00125-CS	21.5	---	2.5YR 7/2
TOR-90-00126-CS	19.5	6.5	10YR 7/2
TOR-90-00127-CS	21.5	6.7	7.5YR 7/4
TOR-90-00128-CS	21	6.5	2.5YR 7/2
TOR-90-00129-CS	19	6.9	7.5YR 7/4
TOR-90-00131-CS	21.4	7.8	2.5Y 7/2
TOR-90-00133-CS	19.7	7.3	5YR 6/6
TOR-90-00134-CS	18.5	7.7	----------
TOR-90-00135-CS	---	7.3	5YR 7/3
TOR-90-00136-CS	---	---	2.5Y 7/4
TOR-90-00137-CS	18.9	6.4	5YR 7/3
TOR-90-00138-CS	---	7.6	----------
TOR-90-00139-CS	17.7	6.5	7.5YR 7/6
TOR-90-00140-CS	19	8.3	2.5Y 7/2
TOR-90-00141-CS	18.5	6.6	2.5Y 7/4
TOR-90-00142-CS	---	6.4	2.5Y 7/3

Table 25. Tortugas Type 1 olive jar volumes, weights and colors.

Jars Type 1: Volume (Liters), Weight (Kg) & Color (Munsell)			
Inv. No.	**Volume**	**Weight**	**Color**
TOR-90-01227-CS	19.8	7.9	2.5Y 7/3
TOR-90-01228-CS	17.5	6.8	5YR 6/6
TOR-90-01229-CS	18	7.4	2.5YR 8/3
TOR-90-01230-CS	19.9	7.6	5YR 7/4
TOR-90-01231-CS	16.6	7.3	5YR 5/6
TOR-90-01232-CS	22.5	---	10YR 7/3
TOR-90-01233-CS	20.8	6.6	7YR 6/4
TOR-90-01234-CS	16.1	7.2	2.5YR 7/3
TOR-90-01235-CS	16.1	---	----------
TOR-90-01236-CS	16.1	7.3	10YR 8/4
TOR-90-01237-CS	18	7.1	7.5YR 7/6
TOR-90-01238-CS	19	7.4	7.5YR 6/8
TOR-90-01239-CS	17.8	7.1	7.5YR 6/8
TOR-90-01240-CS	16.5	6.9	7.5YR 6/8
TOR-90-01241-CS	18	7.1	7.5YR 6/8
TOR-90-01242-CS	17.1	8.1	7.5YR 6/8
TOR-90-01243-CS	14.2	7.3	----------
TOR-90-01244-CS	20	7.3	7YR 7/4
TOR-90-01245-CS	15.7	7.4	7.5YR 6/6
TOR-90-01246-CS	21.6	8	7.5YR 7/4
TOR-90-01247-CS	18.8	6.7	10YR 8/2
TOR-90-01248-CS	21	8.4	2.5YR 7/4
TOR-90-01249-CS	18.3	9.9	10YR 7/4
TOR-90-01250-CS	---	---	7.5YR 6/6
TOR-90-01251-CS	19.4	6.2	7.5YR 6/6
TOR-90-01252-CS	19	7.9	5YR 7/4
TOR-90-01253-CS	20.1	7.9	7.5YR 7/4
TOR-90-01254-CS	21.7	7.8	5YR 6/6
TOR-90-01255-CS	20.3	7.5	5YR 7/3
TOR-90-01256-CS	19.4	6.7	5YR 6/6
TOR-90-01273-CS	17.7	6.3	2.5YR 7/2
TOR-90-01257-CS	---	---	7.5YR 7/4
TOR-90-01258-CS	18	7.3	7.5YR 6/6
TOR-90-01259-CS	21.6	9.4	5YR 7/4
TOR-90-01260-CS	21.3	7.7	7.5YR 7/6
TOR-90-01261-CS	26.9	8.2	7.5YR 7/6
TOR-90-01262-CS	---	---	10YR 7/3
TOR-90-01263-CS	20	6.8	5YR 7/4
TOR-90-01264-CS	---	---	2.5Y 7/4
TOR-90-01274-CS	19.7	6.9	2.5Y 7/2
TOR-90-01265-CS	22.5	7.5	7.5YR 7/4
TOR-90-01266-CS	18.8	6.7	7.5YR 7/4

Table 26. Tortugas Type 1 olive jar volumes, weights and colors.

Jars Type 2: Vessel Dimensions (Cm)			
Inv. No.	**Height**	**Diameter**	**Circumference**
TOR-90-00011-CS	27.5	24.5	76.9
TOR-90-00130-CS	31	25	78.5
TOR-90-00132-CS	31	25.8	81
TOR-90-01267-CS	34	19.5	59.7
TOR-90-01268-CS	28	23.7	74.5
TOR-90-01269-CS	30.5	24	75.4
TOR-90-01270-CS	33	15.9	49.8
TOR-90-01271-CS	27	24.6	77.2
TOR-90-01272-CS	28	24.5	77

Jars Type 2: Rim Dimensions (Cm)				
Inv. No.	**Rim Height**	**Rim Ext. Diam.**	**Rim Int. Diam.**	**Rim Circum.**
TOR-90-00011-CS	3	8.3	4.6	26.2
TOR-90-00130-CS	3.5	8.5	4.7	26.7
TOR-90-00132-CS	3.6	8	4.3	25.1
TOR-90-01267-CS	2.7	9.2	5	29
TOR-90-01268-CS	2.5	8.3	6.2	---
TOR-90-01269-CS	2.9	8.9	4.6	28.5
TOR-90-01270-CS	2.1	8.5	4.5	---
TOR-90-01271-CS	3.2	9	4.8	28.3
TOR-90-01272-CS	4	9.3	5.6	29.3

Olive Jars Type 2: Volume (Liters), Weight (Kg) & Color (Munsell)			
Inv. No.	**Volume**	**Weight**	**Color**
TOR-90-00011-CS	6.3	2.6	5YR 6/6
TOR-90-00130-CS	7.2	3.6	7.5YR 6/6
TOR-90-00132-CS	8.1	3.3	5YR 6/6
TOR-90-01267-CS	3.7	2.2	7.5YR 8/4
TOR-90-01268-CS	5.7	1.9	5YR 5/8
TOR-90-01269-CS	6.6	3	2.5YR 5/5
TOR-90-01270-CS	2.8	1.8	7YR 5/8
TOR-90-01271-CS	5.9	2.8	10YR 7/3
TOR-90-01272-CS	6.3	2.7	----------

Tables 27-29. Tortugas Type 2 olive jar dimensions, volumes, weights and colors.