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A Report on the late 1st–2nd-century-AD Venice Lido III Sewn Timber Assemblage

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In 2012, fragments of hull planking bearing the signs of a Roman-era sewn vessel, with holes drilled along the plank edges, washed ashore on Venice Lido, the barrier island separating the Venice Lagoon from the Adriatic Sea. This paper describes the construction features of this timber assemblage and places it within the context of other excavated sewn boats of the Upper Adriatic. The assemblage presented here best fits into the north-western Adriatic sewn tradition and likely represents either a fluvial-maritime or maritime watercraft.

Key words: Sutiles Project, sewn boat, ship construction, Venice, Adriatic, Roman-era.

After a storm in the autumn of 2012, a set of ten detached timbers, with diagonal holes along their edges, washed ashore along the beach near Ospedale al Mare, on the seaward side of Venice Lido, the barrier island separating the Venice Lagoon from the Adriatic Sea. These timbers were collected by Marcello Rossani along with the Superintendent Archaeologist of Friuli Venezia Giulia, Luigi Fozzati. The timbers were identified as culturally significant, belonging to a sewn tradition of hull construction previously recognized in the upper Adriatic Sea. They were placed in the care of Alessandro Asta of the Superintendence for the Archaeological Heritage of Veneto, who granted the authors access to study them (Capulli *et al.*, 2014: 215–218).

The 2012 timbers represent the third assemblage of sewn boat timbers discovered along the shores of Venice Lido (Fig. 1). The hull remains that comprise Venice Lido I were found at Alberoni beach from 1993 to 1997 (Beltrame, 1996; 2000; 2002: 355–358); and 2003 (Beltrame and Gaddi, 2013: 302). According to Beltrame (2002: 358), this first assemblage includes two articulated, if highly fragmented, hull planks sewn together to form the remains of a flat-bottomed hull radiocarbon dated to the 1st or 2nd century AD. The second assemblage consists of two fragments of sewn hull planking (Venice Lido II) recovered near the Ospedale al Mare beach in 1997 and 2000, about 9km away from the first group; these hull remains are not precisely dated (Beltrame, 2002: 368–369). It was on this same beach at Ospedale al Mare that the third assemblage of ten sewn timbers (Venice Lido III) was collected after the storm.

None of the plank fragments within this third assemblage were found sewn or otherwise joined together, nor did the sewing holes along their edges align. The sewing holes of eight plank fragments had both pegs and cordage preserved within them. Only three plank fragments had intact treenails, but a fourth did have a likely treenail hole preserved along one of its broken ends. Since the planks were not joined together, and thus there were no original seams intact, there was no seam wadding—the fibrous material found along the interior seam of sewn boats—recovered from this assemblage.

It is important to note that the 'Venice Lido III' denotes the assemblage, here a group of timbers studied together (Willis and Capulli, 2014: 10–15; 2017: 147–150); however, this designation is not indicative of a third wreck-site, or a third hull, as these timbers were not found *in situ*. As the timbers from the Venice Lido II and III assemblages were recovered in the same general area, it is possible that they originated from the same hull; however, as the Venice Lido II timbers were not available to the authors for physical examination, the designation used here also allows for the possibility that

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Figure 1. Detailed map of Venice Lido showing the find spots of each of the three timber assemblages (created in Harvard World Map© by S. Willis; background map ESRI World Imagery).

they are from another wreck, as will be explored below. Survey of the coast of the barrier island to identify the hull(s) or structure(s) from which these timbers came could help clarify this situation. [M.C.]

Methodology

After their discovery, the Venice Lido III timber assemblage was moved to a storage facility of the Superintendence of Cultural Heritage of Veneto on the island of Lido. In the summer of 2013, the authors visited the facility and briefly assessed the timbers. Two timbers had distinct construction features that warranted further investigation and called for fully recording and analysing the assemblage.

In June 2014, the Venice Lido III timbers were recorded (Willis and Capulli, 2014). In total, 27 wood samples were collected and sent to Nili Liphschitz of the Botanical Laboratories of the Institute of Archaeology at Tel Aviv University for identification. Eleven samples of cordage were collected and identified by one of the authors (Willis) using the reference collection of Texas A&M University's Paleoethnobotany Laboratory. This assemblage was then returned to the outdoor storage facility. The timbers currently reside in a permanent warehouse of the Superintendence of Cultural Heritage of Veneto in Padua.

During the 2014 research season, it was noted that one of the timbers (F5) had suffered distortion and shrinkage over the course of the preceding year (Fig. 2). The warping of this fragment highlights the importance of expedient and efficient examination of archaeological materials. General measurements were made of this timber during our brief visit to the storage facility in 2013; it is the 2013 measurements presented in Table 1.

Figure 2. Comparison of F5 from the 2013 (top) to 2014 (bottom) field seasons (photo by S. Willis and M. Cusin with permission from the Soprintendenza per i Beni Archeologici del Veneto).

These ten hull planking fragments were found alongside a number of other debris, including a section of a frame. In 2013, this frame was measured and photographed and labelled as Fragment 6. However, since there were no notches cut on the underside of the frame to facilitate the seam wadding of a sewn boat, it cannot be definitively tied to a sewn boat or this sewn plank timber assemblage. It was therefore not included in the analysis presented here, which will include fragments 1–5 and 7–11. [M.C.]

Table 1. *General dimensions of the Venice Lido III timber assemblage. An asterisk (*) indicates the timbers that have two lines of sewing holes*

	General Preserved Dimensions		
	Length (m)	Width (m)	Thickness (mm)
Fragment 1*	0.910	0.222	75/48
Fragment 2	0.391	0.182	48
Fragment 3	0.237	0.137	29
Fragment 4	0.510	0.140	35
Fragment 5*	0.758	0.102	34
Fragment 7*	0.224	0.361	34
Fragment 8*	2.000	0.227	61
Fragment 9	0.288	0.154	37
Fragment 10	0.274	0.216	46
Fragment 11	0.373	0.059	30

Venice Lido III timber assemblage

All timbers in this assemblage, ten in total, are from the hull planking of one or more sewn vessels (Fig. 3). The ends and edges of these planks are broken and eroded; for this reason, the timbers are referred to as fragments (F1 to F11). They range in preserved length from *c.* 0.24m to 2m; however, deterioration of the plank ends makes it difficult to determine how accurately these measurements correspond to original length. The timbers range in preserved width from *c.* 0.06–0.36m. Four of the timber fragments (F1, F5, F7, and F8) have intact sewing holes along both plank edges, which indicates they may be close to the original width of the plank. Again, degradation of the plank edges does not permit exact measurement of original dimensions. Finally, the timbers range in thickness from *c.* 30–75mm (Table 1). [S.W.]

Preservation and resource procurement

This timber assemblage has extensive evidence of exposure to a marine environment, including the presence of teredo worm damage, imprints of seashells, and embedded marine life. Despite the substantial damage wrought by the depositional environment on these timbers, some tool marks were noted. Bow-drill marks were detected in the sewing holes of F8 and F11, and gouge marks were noted in the sewing holes of F1. Chisel marks were also observed along the edge cavities of several of the Venice Lido III timbers, F1 in particular.

Since the Venice Lido III timber assemblage is a disarticulated set of hull-planking fragments, it is difficult to ascertain which portion of a sewn hull is represented by these remains. However, two timbers (F1 and F5) have distinctive features that allow for interpretations of their position within the hull of the vessel. F1 tapers across its width, with distinctive differences in thickness between each edge of the plank: approximately 75mm thick along one edge and 48mm thick along the other (Fig 3). This intentional tapering of the plank indicates that it may have been a garboard strake, serving as a transitional strake between a thicker keel plank—or perhaps a true keel— and the bottom planking. F5 is an unusual shape, being long and narrow with a distinct tapering of the end (Fig. 2). This timber could represent a hood end, a stealer plank, or a repair; any of which could have necessitated its particular form.

Eight of the ten hull-planking fragments were made of elm (*Ulmus campestris*; Table 2). The other two timbers (F5 and F11) were of oak (*Quercus robur*). The sampled treenails, used to affix the frames to the hull planking, were shaped from dogwood (*Cornus sanguinea*) in F5 and F8 and from lime wood (*Tilia cordata*/*T. platyphyllos*) in F1. The pegs used to block the sewing holes and secure the cordage, were fashioned of dogwood, fir (*Abies alba*), and spruce (*Picea abies*). Multiple pegs were sampled for F1 (3 pegs) and F8 (2 pegs); the same material, dogwood, was used for all pegs sampled from both of these timbers. The cordage was manufactured from esparto grass (*Stipa tenaccissima*), a material that grows in Spain and North Africa. A pollen analysis of this material suggests that, in most instances, it was likely manufactured in Spain and then shipped to Italy (Willis, 2017). [S.W.]

Edge joinery

The distinctive feature of this timber assemblage is the edge-joinery system, which indicates sewn hull construction (Fig. 4). Diagonal holes are spaced along at least one edge of each timber, with pegs and cordage preserved in many of these channels. The interior face of the plank can be identified as the sewing holes are intact and set back from the plank edge; the exterior face shows the holes at the plank edge. Most of the timbers in this assemblage had sewing holes measuring about 20mm in width, with wear that caused their entrance along the interior surface of the plank to appear oval (Fig. 5). F1 and F8 are exceptions: the sewing holes of F1, while appearing oval in shape along the interior surface, are noticeably larger in dimension, about 25mm in width, than the other timbers of this assemblage. In contrast, the sewing holes of F8 are similar in width to the other timbers in this assemblage, but do not show similar signs of wear, with entrances along the interior surface appearing distinctly round in shape.

The holes of this assemblage were spaced on average about 60–70mm apart, with a total range of 44–95mm (Table 3). While the spacing of the sewing holes within the whole assemblage ranges more than 50mm, within each fragment the range of spacing generally spans only about 30mm. Again, F8 is an exception to this trend within the assemblage; the sewing holes of this timber are spaced further apart at about 80mm between holes.

The sewing holes, which start along the interior face of the plank, exit along the exterior edge where the ancient builders expanded the opening to form cavities

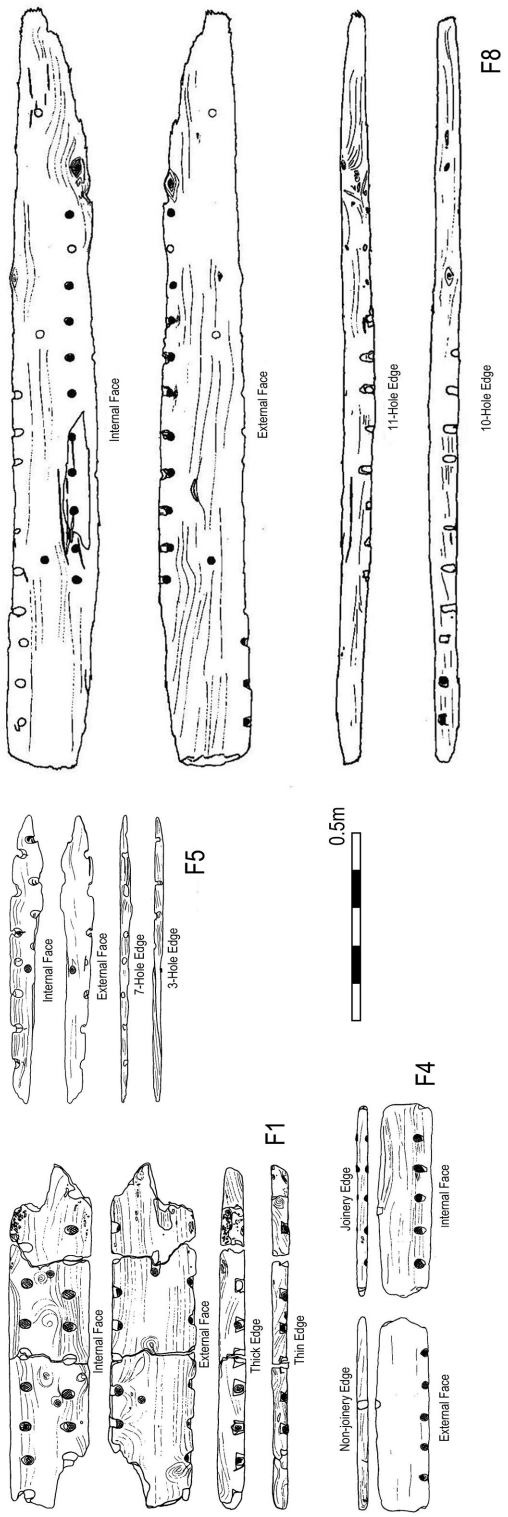

Figure 3. Construction drawings of F1–F11 (drawings by S. Willis, L. White).

Table 2. *Species identification of materials used in the Venice Lido III timber assemblage*

	Wood Type			
	Hull Planking	Treenails	Pegs	Cordage
Fragment 1	*Ulmus campestris*	*Tilia cordata*/ *T.platyphyllos*	*Cornus sanguinea* (all three sampled pegs and chock)	*Stipa tenaccissima*
Fragment 2	*Ulmus campestris*	–	*Abies alba*	*Stipa tenaccissima*
Fragment 3	*Ulmus campestris*	–	*Abies alba*	*Stipa tenaccissima*
Fragment 4	*Ulmus campestris*	–	*Abies alba*	*Stipa tenaccissima*
Fragment 5	*Quercus robur*	*Cornus sanguinea*	*Cornus sanguinea*	–
Fragment 7	*Ulmus campestris*	–	*Picea abies*	*Stipa tenaccissima*
Fragment 8	*Ulmus campestris*	*Cornus sanguinea*	*Cornus sanguinea* (both pegs)	*Stipa tenaccissima*
Fragment 9	*Ulmus campestris*	–	–	–
Fragment 10	*Ulmus campestris*	–	*Abies alba*	*Stipa tenaccissima*
Fragment 11	*Quercus robur*	–	–	–

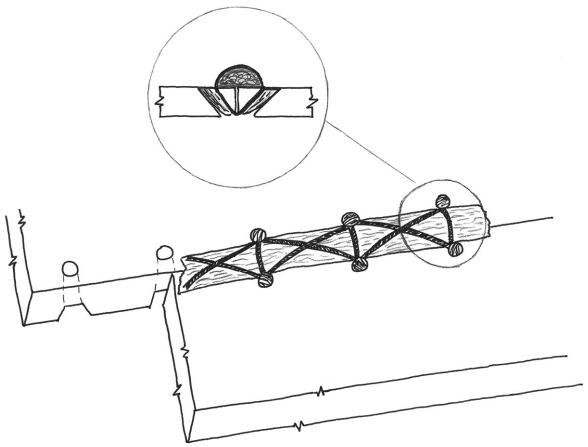

Figure 4. Schematic drawing of the sewing system used in the north-western Adriatic sewn tradition of boatbuilding (drawing by S. Willis)

(see Fig. 6, Table 4). Deterioration of the edges may have reduced the preserved dimensions on all timbers except F1. The edge cavities may have facilitated the sewing process as they permitted a larger margin of error when aligning the planks. The edge cavities are generally trapezoidal in shape and range widely in overall dimensions, generally correlated to the thickness of the timber. This is particularly seen in F1, which had the largest and best-preserved edge cavities of this assemblage (Fig. 3); its edge cavities vary considerably between the two edges of the plank.

The samples of cordage collected from the Venice Lido III timber assemblage (three samples from F1, two from F8, and one each from F2, F3, F4, F5, F7, and F10) are all two-strand, S-twist cordage 4–6mm in diameter (Fig. 7). F1 had up to 12 strands of cordage preserved within a single sewing hole, while hull planking F2, F3, and F10 had only three strands of cordage preserved. If these planks were all originally part of a single vessel, then the builders appear to have secured certain areas of the hull with more passes of cordage than other sections. If F1 was a garboard strake, then its function in providing central longitudinal support may explain the additional sewing. However, the number of strands preserved per sewing hole does not necessarily reflect the number of passes made during original construction or repair. Three sewing holes of F1 were sampled – the first sampled hole yielded 12 strands of cordage, the second at least five strands, and the last at least seven. A similar situation was noted for F8, where the first sewing holes sampled yielded seven strands of cordage and the second yielded only three. This variation likely indicates an issue of preservation. Unfortunately, while cordage was preserved, trapped by the pegs within the sewing holes, there was no evidence to determine the original pattern of the sewing.

Figure 5. Photograph of the interior face of F1; note the oval shape of the sewing holes (photo by M. Cusin with permission from the Soprintendenza per i Beni Archeologici del Veneto).

Table 3. *Dimensions of the sewing holes of the Venice Lido III timber assemblage*

	Sewing Holes				
	Width		Spacing		
	Range (mm)	Avg. (mm)	Range (mm)	Avg. (mm)	Orientation (degrees)
Fragment 1	23–27	25	53–83	71 (thick edge)/ 62 (thin edge)	50–55 (thick edge)/ 40 (thin edge)
Fragment 2	20–22	21	44–74	57	50
Fragment 3	–	20	52–59	56	45–48
Fragment 4	19–21	20	55–66	62	45
Fragment 5	18–20	19	56–85	71	38–40
Fragment 7	–	23	–	61	47
Fragment 8	13–21	20	62–95	79	40–50
Fragment 9	–	22	67–73	70	40
Fragment 10	–	20	56–62	59	50
Fragment 11	–	20	59–80	66	35–40

Table 4. *Dimensions of the edge cavities of the Venice Lido III timber assemblage*

	Edge Cavities			
	Length (Bottom x Top of Trapezoid)		Height	
	Range (mm)	Avg (mm)	Range (mm)	Avg (mm)
Fragment 1	37–55 × 27–36 (thick)/ 22–36 × 22–27 (thin)	44 × 31 (thick edge)/ 27 × 23 (thin edge)	19–30 (thick edge)/ 13–15 (thin edge)	23 (thick edge)/ 13 (thin edge)
Fragment 2	14–21 × 11–16	19 × 13	6.5–13	11
Fragment 3	–	12 × 9	–	7
Fragment 4	11–15 × 5–7	10 × 6	2–6	4
Fragment 5	–	–	–	–
Fragment 7	–	14 × 8	7–9	8
Fragment 8	–	27 × 22	10–22	16
Fragment 9	–	–	–	–
Fragment 10	–	21 × 12	17–19	18
Fragment 11	–	–	–	–

Figure 6. Edge cavities of F1 (photo by S. Willis with permission from the Soprintendenza per i Beni Archeologici del Veneto).

The pegs are roughly cylindrical and taper toward the exterior edge, indicating that they were hammered into position from the interior of the vessel once the cordage was secured. Pegs range in preserved length 37–75mm and in preserved diameter 12–23mm, with the larger pegs corresponding to greater plank thickness and sewing hole dimensions within the assemblage. Some of the pegs of F1 exhibit the use of chocks, here angular wedges (Fig. 8), made of the same material as the pegs themselves—dogwood. They were used to tighten the join and are most often observed in use with treenails. This is the first known instance of chocks used with pegs in a sewn construction. [S.W.]

Framing

While no frames were found directly associated with the Venice Lido III timber assemblage, four fragments have traces of the framing system in the form of preserved treenails, which would have been used to attach the frames to the hull (F1, F2, F5 and F8) (Fig. 3). Recovered treenails averaged 17mm in diameter. Two of the hull-planking fragments of this assemblage provide evidence for frame spacing, which can be determined when multiple treenails or treenail holes are preserved along a length of timber. F8 has treenails spaced

Figure 7. Peg and pieces of cordage from F1 of the Venice Lido III timber assemblage (photo by M. Capulli with permission from the Soprintendenza per i Beni Archeologici del Veneto).

Figure 8. Chock in one of the pegs of F1 (photo by Mirco Cusin with permission from the Soprintendenza per i Beni Archeologici del Veneto).

*c.*0.57m apart, measured from the centre to centre. In contrast, the treenails of F1 are spaced *c.*032m apart.

Three of the four hull-planking fragments (F1, F2, and F5) that have both treenails and pegs preserved present an intriguing feature. They have pegs for securing the stitching (18–23mm) that are larger than the preserved treenails that likely attached the frames (11–18mm). The greatest disparity is in F2, where the pegs are 20mm in diameter and the treenail is 11mm. These measurements highlight the robust nature of the sewing system and the relative small size of the frame attachments peculiar to this timber assemblage. [S.W.]

Repair

F8 of the Venice Lido III timbers shows signs of repair. Although the edges of this fragment are highly damaged, there are areas on either side of the sewing holes along one edge that could accommodate more holes but do not; the sewing system simply stops mid plank (Fig. 3). Furthermore, there appear to be two boring or gouging directions for the present sewing holes along this edge (Fig. 9), fashioned in opposite directions—one angled down from the lengthwise centre of the plank and one angled down from the edge of the plank. These peculiar features of construction likely indicate an ancient repair to this plank during the life of the vessel. The original plank would have been considerably wider than its current preserved width of 0.23m. At some point in its life, the middle section of the plank was damaged and a repair was necessary. Eleven holes were drilled to attach a repair plank in the centre section of what remained of the plank. These holes would have been drilled to the bottom of the plank, angled down from the lengthwise midline of the plank. Since this plank was still attached to the hull, normal edge cavities could not be carved, so instead a gouge was used to punch out holes to open up an edge cavity or secondary hole due to limited access to the plank edge. In this manner, the holes running in opposing directions were fashioned and a repair section of planking was added (Fig. 10). During deposition or post deposition, the plank broke lengthwise along the repair; the area that lacks sewing holes at each end of the preserved fragment represents the portion of the plank that was still intact at a larger width in the hull of the vessel. [S.W.]

Dating

Since this timber assemblage was not discovered within its original archaeological context, scientific dating methods were the only means to establish its chronology. Unfortunately, dendrochronology was not possible as too few rings are present in any single hull-planking fragment. Therefore, we had to rely on radiocarbon dating. There are notable limitations to this method, in particular the wide date ranges that are often returned, but it does provide a general age of harvesting for the materials, providing a *terminus post quem* for construction.

Samples were collected for radiocarbon dating from the outermost preserved ring and sent to two laboratories for analysis.[1] Cordage samples were also radiocarbon dated for F1 and F8. Since neither cambium nor bark—both indicators of the newest growth and therefore the closest approximation of the

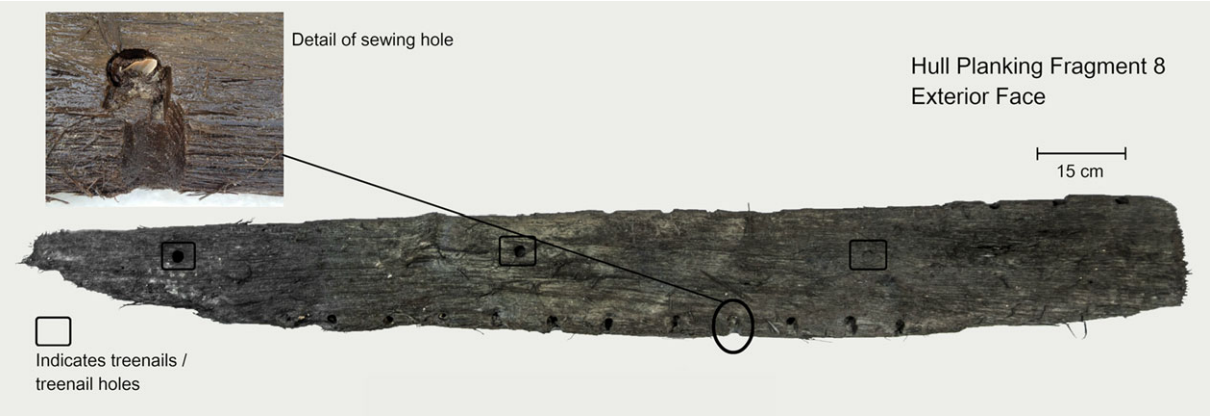

Figure 9. The external face of F8 of the Venice Lido III timber assemblage showing construction details (photo by Mirco Cusin, inset photo by S. Willis, with permission from the Soprintendenza per i Beni Archeologici del Veneto).

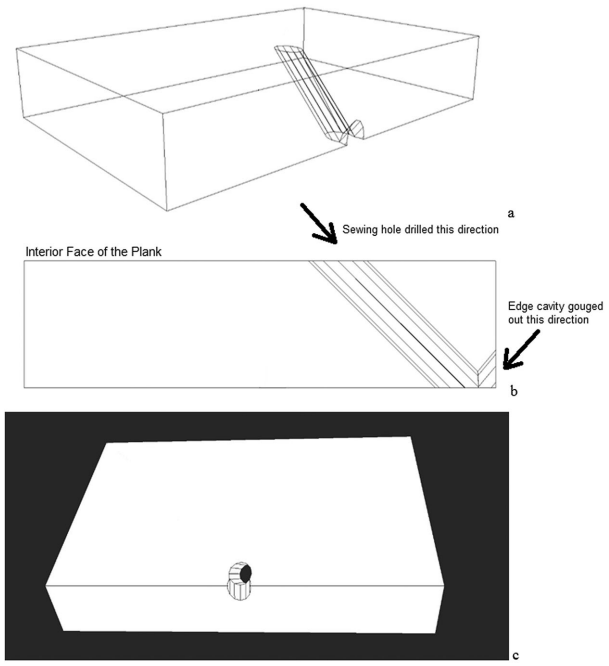

Figure 10. Schematic drawings of the two opposing holes along the repaired edge of Venice Lido III F 8. Three views: *a)* perspective view with the internal face of the plank at the top; *b)* side view with the internal face at the top; and *c)* top view with external face of the plank at the top, mirroring the inset image in Fig. 9 (drawing by Seth Willis).

felling date of the tree—were observed for any of the hull-planking fragments, harvesting of the grass for the cordage may present a more reliable date for the manufacture of the vessel.

Complicating this approach is the likelihood that cordage may have been periodically replaced, as is evidenced in the ethnographic record of modern sewn vessels (Prins, 1986: 72, 107; Kentley, 2003: 135). However, the fact that the frames were treenailed to the hull would have made repairs more difficult as it would have required the frames to be cut from the hull. In the Stella 1 sewn barge, a Roman-era sewn boat from northern Italy, a section of one frame was removed in the middle of the vessel, likely to access a crack in the hull planking that subsequently was re-sewn or repaired (Castro and Capulli, 2016: 33–4; 2017: 425–430). If the frame was not entirely removed in order to repair the cracked planking, then it is possible, and perhaps likely, that frames were not frequently removed for periodic replacement of the cordage throughout the life of the vessel. Thus, the boats within this sewn tradition may not have undergone this type of routine maintenance as frequently as is observed with modern sewn boats where either the frames are lashed in place (for example sewn boats of Kerala, south-west India) or crossbeams are used instead of frames (for example the *masula* sewn boat of south-east India), which make them easier to disassemble and reassemble (Kentley, 2003; Pomey, 2012).

Limitations to the available material and plateaux in the ^{14}C calibration curves result in fairly wide date ranges. Despite this lack of precision, radiocarbon analysis provides the only chronology currently available for this assemblage, and thus, we depend on it as far as we can for our tentative interpretation.

The calibrated radiocarbon dates for this assemblage range from the 1st century BC to the 4th century AD (Table 5). While the wide date ranges for most of the timbers overlap with each other in the 1st century AD, supporting the hypothesis that these timbers could have been incorporated into the same vessel with an earliest possible construction date to the late 1st century AD, F5, dated to cal 170–400 AD, falls outside the ranges of several timbers. It is possible that this timber was part of a separate vessel or represents a later addition (such as a repair plank) to the vessel. If this timber assemblage represents a single vessel, then it is possible, based on the results presented here, that the vessel was

Table 5. *Calibrated radiocarbon dates of the Venice Lido III timber assemblage*

	Hull Component	Radiocarbon Years BP	Calendar Year, calibrated 2σ	Laboratory	Sample Number
F1	plank	1901 +/- 31	Cal 27–40 AD, 48–180 AD, and 185–214 AD	Arizona	AA106151 / X28954
	cordage	1960 +/- 29	Cal 40 BC–87 AD and 105–120 AD	Arizona	AA106152 / X28955
F2	plank	1950 +/- 40	Cal 40 BC to 130 AD	ICA	15W/0470
F3	plank	1800 +/- 40	Cal 90–340 AD	ICA	15W/0471
F4	plank	1979 +/- 25	Cal 41 BC–71 AD	Arizona	AA106629 / X29244
F5	plank	1740 +/- 40	Cal 170–400 AD	ICA	15W/0473
F7	plank	1990 +/- 40	Cal 100 BC to 120 AD	ICA	15W/0474
F8	plank	1994 +/- 31	Cal 54 BC to 75 AD	Arizona	AA106153 / X28956
	cordage	1942 +/- 29	Cal 19–14 BC and 1 to 129 AD	Arzona	AA106154 / X28957
F9	plank	1874 +/- 28	Cal 71–223 AD	Arizona	AA106627 / X29241
F10	plank	1830 +/- 30	Cal 80–310 AD	ICA	15W/0476
F11	plank	1882 +/- 27	Cal 66–217 AD	Arizona	AA106628 / X29242

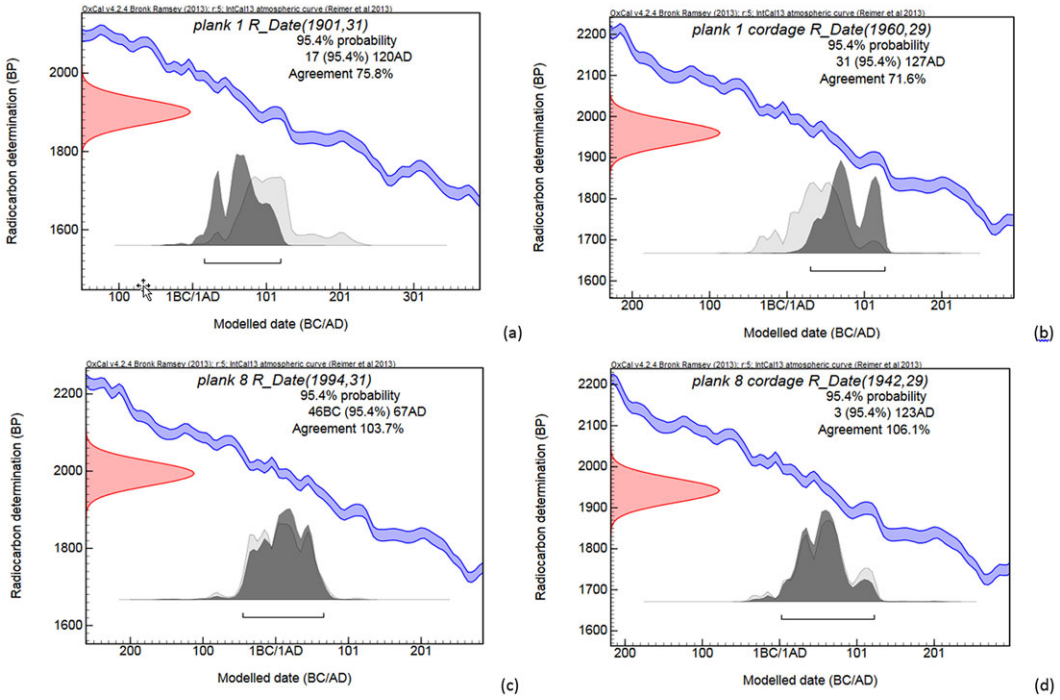

Figure 11. Calibrated radiocarbon ages of *a)* hull plank F1; *b)* F1 cordage; *c)* hull plank F8; and *d)* F8 cordage, based on a simple Bayesian model. Dark grey (modelled) and light grey (un-modelled). (Graphs produced in OxCal v.4.2.4 by G. Hodgins).

originally constructed in the late 1st or 2nd century AD, and repaired in the late 2nd century AD. This remains a problematic timeline as it suggests that the vessel was in use for a half a century or more. It may be more likely that more than one hull is represented by this timber assemblage.

In order to try to refine the dates, a Bayesian analysis of the calibrated radiocarbon dates of cordage and hull plank samples from F1 and F8 was conducted by Greg Hodgins of the University of Arizona AMS Laboratory. Bayesian analysis of radiocarbon dates has been increasingly incorporated into archaeological practice (Bayliss, 2015: 678–679). When applied to archaeological contexts, it is a statistical method for building chronological models based on additional available data, such as stratigraphy (Ramsey, 2009). The model employed here is based on the assumption that the grass cordage is younger in date than the wood of the hull planking, sampled from the outermost ring, but with no sapwood or bark present. This model refines the calibrated dates of samples from F1 to 16–120 AD (plank) and 21–127 AD (cordage) and of samples from

F8 to 46 BC–66 AD (plank) and 4–123 AD (cordage) (Fig. 11). [S.W.]

Discussion

Upper Adriatic sewn boat traditions

In order to categorize the Venice Lido III timber assemblage, a brief examination of the sewn boatbuilding traditions in the upper Adriatic is necessary. Sewn boatbuilding traditions have been discovered and documented around the world and from many different time periods, even to the present day (see Prins, 1986), but there are two traditions of sewn vessels from the upper Adriatic Sea, here delineated as the eastern Adriatic and the north-western Adriatic. Boetto and Rousse (2011: 186–188) propose the names Romano-Illyrian and Romano-Po for the eastern Adriatic and north-western Adriatic traditions respectively. We are reluctant to adopt this terminology. While the authors use the 'Romano' label as a marker of chronology, it nonetheless suggests Roman involvement or influence on what are more likely local traditions of the indigenous inhabitants of the region. While the current archaeological material predominantly dates to the Roman period, the recently discovered Bronze Age sewn boat at Zambratija supports the hypothesis that sewn boatbuilding predates Roman influence in the region (Boetto and Rousse, 2011: 188; Boetto *et al.* 2017). For this reason, we prefer simple geographic designations. However, we agree with Boetto and Rousse that the substantial differences in materials and techniques between the north-western and eastern halves of this small sea warrant this separation into two distinct traditions (Boetto and Rousse, 2011: 186–188).

Boetto and Rousse (2011: 188, fig. 9) propose that the key construction element that distinguishes the eastern Adriatic tradition (Romano-Illyrian in their terminology) from the north-western Adriatic (Romano-Po) is the sewing pattern. While the north-western Adriatic sewn tradition employs the cross-stitched 'X', or banded-X, sewing pattern, the eastern Adriatic tradition uses a simple loop sewing pattern. Furthermore, Boetto has emphasized the disparity in general hull form: most eastern Adriatic sewn vessels are small coastal boats with relatively moderate-sized keels and rounded hulls, while most north-western Adriatic sewn vessels have either completely flat hull bottoms or at most a thickened keel plank (Boetto *et al.,* 2017).

We argue here that in addition to these features, the specific details of the sewing system are also useful in differentiating between vessels of each sewn tradition of the upper Adriatic. While there is less recognizable consistency in the construction details between the vessels of the eastern Adriatic tradition based on currently published dimensions of these hull remains, the trend seems to be toward small sewing holes (less than 10mm in diameter) spaced very close together (about 20mm apart). By comparison, the sewing holes of the north-western Adriatic tradition are larger in diameter (from 10–25mm on average) and spaced further apart (about 60–100mm on average) than the holes of the eastern Adriatic sewn tradition.

It is possible that another distinguishing feature between these traditions are the materials used in hull construction. Trends in resource procurement for the north-western Adriatic traditions have been previously noted, with noticeable preferences of elm (*Ulmus* sp.) for hull planking and oak (*Quercus* sp.) for frames (Beltrame, 2002: 375; Beltrame and Gaddi, 2013: 301). Furthermore, esparto grass (*Stipa tenacissma*) is, thus far, the only material identified for the cordage of north-western Adriatic hulls, while lime bast (*Tilia* sp.) and willow or flax have been identified for cordage of eastern Adriatic hulls (Brusić and Domjan, 1985: 77; Castelletti *et al.*, 1990: 146–148; Vitri *et al.*, 2003: fig. 3; Radić Rossi and Boetto, 2011: 510). The small sample size of identified cordage means that, at this stage, this trend is merely suggestive. General trends in resource procurement for the eastern Adriatic tradition are not established as fewer hull remains have undergone materials analyses. While the Zambratija hull had planking of elm (*Ulmus* L.), its frames were of alder (*Alnus* sp.) (Koncani Uhač and Uhač, 2012: 535, 537; Boetto *et al.*, 2017; Koncani Uhač *et al.,* 2017). One of the Caska Bay wrecks, on the other hand, had planking of beech (*Fagus sylvatica* L.) and frames of oak (*Quercus* sp.) (Radić Rossi and Boetto, 2011: 509–510). As more hulls from the eastern Adriatic tradition are studied, a separate trend in preference for hull planking and frames may emerge.

Currently, there are at least eight vessels attributed to the eastern Adriatic tradition, which have been recovered along the coast of modern day Croatia.[2] The recent discovery of a fully sewn boat at Zambratija, radiocarbon dated between the last quarter of the 12th century and the last quarter of the 10th century BC, is the earliest-known fully sewn boat in the Mediterranean and belongs to the eastern Adriatic tradition (Boetto *et al.,* 2017; Koncani Uhač *et al.,* 2017). Most of the finds from this tradition, however, come from the Roman Imperial period, dating between the 1st century BC and the 3rd century AD. It is impossible to say at this stage in research whether this tradition of sewn construction was in continual use in the region of the eastern Adriatic throughout the period, or if it fell out of usage and was revived at some point between the Bronze Age and the Roman Period. [M.C.]

Based on the details of the sewing system, there is a possible ninth example that may be associated with the eastern Adriatic tradition—the hull planks excavated from a canal structure on the island of San Francesco del Deserto in the Venice lagoon (Capulli and Pellegrini, 2010: 263–266; Capulli, 2015: 46–51). The canal structure, and thus the reuse of these planks, dates between the 2nd and 4th centuries AD. These

two planks from a sewn vessel are typically classified with the north-western Adriatic sewn boats. However, the sewing holes are less than 10mm in diameter (7mm and 9mm) and are spaced approximately 20–30mm apart, features that more closely align with the eastern Adriatic tradition. The sewing pattern is no longer preserved—in fact, no cordage was found to survive—so it is not possible to verify if they were joined with a simple loop, but the size and spacing of the sewing holes may indicate these hull remains were from an eastern Adriatic sewn boat. While an eastern Adriatic provenience for these planks cannot be definitively determined at this stage, this interpretation is plausible. As eastern Adriatic sewn vessels were sailing vessels with keels, perhaps it should not be surprising that an eastern Adriatic sewn boat could be found within the Venetian lagoon. It is possible that such a craft could have been wrecked during a journey to western Adriatic ports and the hull planking salvaged and then incorporated into structures in the lagoon. [M.C. & S.W.]

In comparison with the eastern Adriatic tradition, the north-western Adriatic tradition has more archaeological remains, with 18 attributed finds.[3] All known vessels are flat-bottomed boats, lacking a true keel, though they range considerably in overall size and can be classified within two general hull types (Boetto and Rousse, 2011: 187). Hull remains of this tradition have been recovered as far south as Cervia, as far inland as Padua, and as far east as Aquileia, with definitive dates that range from the 2nd century BC to at least the 6th or 7th century AD, and possibly to the Early Medieval period (Beltrame and Gaddi, 2013). The earliest date attributed to the remains of this tradition (Barena del Vigno timber) is the 6th or 5th century BC (590–470 BC) and the latest date is the 11th century AD (Pomposa Borgo-Caprile hull remains). While Beltrame (2000: 92–93, 2009: 415; Beltrame and Costa, 2016: 263) has called into question the reliability of the assigned date of the Pomposa Borgo-Caprile hull remains, which were dated based on tentatively associated pottery, we contend that both ends of this date range should be critically re-examined as the wooden fragment radiocarbon dated to the 6th or 5th century BC from Berena del Vigno cannot be definitively linked to a sewn boat. [M.C.]

North-western Adriatic sewn planks

Based on the details of construction presented above, the Venice Lido III timber assemblage is best categorized within the north-western Adriatic sewn tradition of boatbuilding. While neither the sewing pattern nor the general form of the hull can be definitively recreated based on the preserved remains of this timber assemblage, other features clearly align with the north-western Adriatic tradition. The sewing holes are larger than 10mm and spaced more than 50mm apart on average. Across the north-western Adriatic tradition, edge cavities are trapezoidal or sometimes rectangular in shape as seen in this assemblage (Beltrame, 2002: 372; Beltrame and Gaddi, 2013: 301). Furthermore, peg morphology of the Venice Lido III assemblage is consistent with other pegs of the north-western Adriatic tradition (Beltrame, 2002: fig. 7; Beltrame and Gaddi, 2013: fig. 9; Castro and Capulli, 2016: 34, fig. 6d). Intriguingly, based on published construction drawings, the Venice Lido I assemblage may have a similar disparity between its pegs and treenails noted above in the Venice Lido III assemblage, but the dimensions of the treenails of the former have not been reported.

The use of materials in this assemblage, particularly the preference for elm for hull planking and perhaps the use of esparto grass cordage, is consistent with materials usage within the north-western Adriatic tradition previously noted (Beltrame, 2002: 375; Beltrame and Gaddi, 2013: 301). The Venice Lido III timber assemblage is the first documented example of the use of spruce for pegs within this tradition. Although lime wood has been used to manufacture pegs of other sewn vessels of this tradition, including Venice Lido I and II, this is the first instance of its use for treenails (Castelletti *et al.*, 1990: 148; Beltrame, 2002: 357, 368).

Frame spacing is quite variable across the north-western Adriatic tradition of sewn boatbuilding, but the Venice Lido III timber assemblage falls within observed ranges. The frame spacing was not always reported for each vessel of this tradition; in these cases (Corte Cavanella I and II, Marcon, and Padova), the spacing reported here is based on measurements taken from published and unpublished drawings and photographs. Some fairly complete hull remains have frames that are spaced as close together as 0.25–0.30m, as in the Stella 1 barge and the Marcon boat, and as far apart as 0.60–1.00m, as in the Corte Cavanella I and II hull remains (Beltrame, 2002: fig. 13). The Venice Lido I timber assemblage has treenails spaced in the range 0.29–0.74m apart (Beltrame, 1996).

The frame spacing noted within the hull remains of this tradition as preserved within the archaeological record appears to tend toward the larger range. Six of the 13 examples of this tradition with evidence for frame spacing have frames spaced more than 0.5m apart: hull remains of Canale Anfora I, Corte Cavanella I and II, Padova, Venice Lido I, and Venice Lido III F8 (Beltrame, 1996; Beltrame, 2002: fig.13, fig. 17; Beltrame and Gaddi, 2013: 298). Three finds have frames spaced about 0.40–0.45m apart: hull remains of Cavanella D'Adige, Comacchio, and Pomposa Borgo Caprile (Bonino, 1978: 53–54; Berti, 1990: 29; Tiboni, 2009: 83; 2017: 290–295). And four examples have evidence of frame spacing less than 0.35m: hull remains of Marcon, Cervia, Stella 1, and Venice Lido III F1 (Bonino, 1971: 322).

Drawing conclusions based on incomplete remains, however, is risky. In the Comacchio hull, the spacing of the frames varied based on their position in the hull, with frames toward the extremities spaced

closer together than the frames in the centre, which were spaced as far apart as 0.60m amidships (Berti, 1990: 29). The Comacchio ship, therefore, helps to contextualize other incomplete examples of the north-western Adriatic tradition, such as the Venice Lido III timber assemblage. The frame spacing preserved in the Venice Lido III hull fragments likely does not represent the average frame spacing of the vessel from which they came. However, using the Comacchio hull as a guide, if F1 and F8 are from the same vessel then F1 may be part of the bow or stern and F8 may have come from amidships. As more complete vessels are excavated, a clear pattern may emerge that permits a more accurate identification of hull-planking fragments to distinct parts of a hull. [M.C. & S.W.]

A fluvio-maritime or maritime vessel

Within the north-western Adriatic laced tradition, two disparate types of hulls can be distinguished, which Boetto and Rousse (2011: 187) classify as fluvial and fluvio-maritime vessels. The fluvial type, such as the Stella 1 barge, has a flat-bottomed hull with a hard chine connecting the bottom planking to the side planking, and was used almost exclusively on inland waterways (Boetto and Rousse, 2011: 187; Castro and Capulli, 2016). The fluvio-maritime type is also flat-bottomed, but has a smooth, rounded turn of the bilge and a thickened central plank or keel plank; such a hull is well-suited for both inland waterways and coastal travel (Boetto and Rousse, 2011: 187). The Comacchio ship is perhaps the best known fluvio-maritime type within this tradition (Berti, 1990).

The Venice Lido III timber assemblage show clear signs of being from a seagoing vessel, placing it within the fluvio-maritime type of Boetto and Rousse. The deposition of this assemblage of timbers in the Adriatic Sea suggests that the vessel (or vessels) they represent once sailed on these waters. While teredo worm damage and marine encrustation may also provide evidence of sea voyages, their presence could merely be a product of post depositional processes; however, the features of construction are perhaps the most compelling evidence that these timbers came from a more robust vessel built for the sea. The Comacchio ship, a seagoing ship of the fluvio-maritime type, has a reported hull-planking thickness of 50mm (Berti, 1990: 29). By comparison, fluvial-type hulls have planking around 20–30mm thick (Tiboni, 2009: 83; Beltrame and Gaddi, 2013: 299; Castro and Capulli, 2016: 32). The thickest planks from the north-western Adriatic sewn tradition are from the Venice Lido I and III hull remains. Venice Lido I had a 100mm-deep keel plank (Beltrame, 2002: 357). If F1 was a garboard strake, then the Venice Lido III assemblage represents a hull with a keel plank (or perhaps a true keel) that was at least 75mm thick. The more substantial longitudinal timber would have made these vessels better sailors on the open sea than their river-barge counterparts, while still permitting them to travel inland. If F1 was attached to a true keel, then this assemblage may represent, arguably, a third type of maritime, or primarily seagoing, vessel within this tradition. However, further research is needed to substantiate this possibility. [M.C. & S.W.]

Conclusions

The Venice Lido III timber assemblage represents one or more north-western Adriatic sewn seagoing ships that likely wrecked while either entering or leaving the lagoon in antiquity. While clearly a part of the north-western Adriatic tradition of sewn boatbuilding, this assemblage shows some features unique to the tradition. These include the use of chocks within the pegs of the sewing system and the larger dimensions of the sewing system in comparison to the framing system. [M.C. & S.W.]

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Notes

1. The use of multiple laboratories for radiocarbon dating of samples in this study was largely a product of budgetary constraints. The processing and analytical tools of each lab is summarized here: University of Arizona AMS Facility (Arizona) - ABA sample pretreatment; radiocarbon ages calibrated using the IntCal13 data set, and OxCal 4.2.4 software to 2 sigma measurement uncertainties (95.4% confidence interval); simple Bayesian statistics were applied to the related samples (plank and cordage samples from the same timber fragment) using models available in the OxCal software. International Chemical Analysis Inc. (ICA) - AAA sample pretreatment; radiocarbon ages calibrated to BC/AD calendar years using the IntCal 13 data set to 2 sigma calibration (95% probability).
2. Listed here in alphabetical order: Caska Bay (1 and 3, Radić Rossi and Boetto, 2011; Boetto and Radić Rossi, 2017), Pula (1 and 2; Boetto *et al.*, 2017), Zambratija (Boetto *et al.* 2017; Koncani Uhač *et al.* 2017), and Zaton, previously called Nin, (1, 2, and 3; Brusić and Domjan, 1985; Gluščević, 2004; Brusić, 2006) shipwrecks. Boetto and Rousse (2011) persuasively argued

that the Llubjlana boat, a sewn river barge in modern day Slovenia, should be categorized with the bottom-based tradition of central Europe. It is therefore not included here as part of the eastern Adriatic sewn tradition.

3. Listed here in alphabetical order: Barena del Vigno in the Venice Lagoon (Dorigo, 1983: 247), Canale Anfora I and II (Beltrame, 2002: 358–359; Beltrame and Gaddi, 2013; Capulli 2013), Cavanella D'Adige (Tiboni, 2017: 290–295), Cervia (Bonino, 1968, 1971, 1985; Beltrame, 2002: 359–360), Comacchio (Bonino, 1985; Berti, 1990), Concordia (currently unpublished), Corte Cavanella I and II (Beltrame, 2002: 360–364), Marcon (Cipriano, 2011: 85–86; Beltrame and Gaddi, 2013: 302), Meolo I (Beltrame, 2002: 370–371), Oderzo (Beltrame, 2002: 367–368), Padova (Beltrame, 2002: 366), Pomposa-Borgo Caprile (Bonino, 1968, 1978, 1985; Berti, 1986), Santa Maria in Padovetere (Beltrame and Costa, 2016), Stella 1 (Vitri *et al.*, 1999, 2003; Capulli and Castro, 2014; Castro and Capulli, 2016; 2017: 425–430), and Venice Lido I and II (Beltrame, 1996, 2002: 355–358, 368–369) hull remains.

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