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## Title Page

### Recent discovery of an early 1<sup>st</sup> century sewn boat in Istria (Croatia): the Poreč 1 wreck from the harbour of *Parentium*

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#### Abstract

The remains of the sewn boat known as Poreč 1, dating to the beginning of the 1st century BC, which was discovered, documented *in situ* and recovered in 2020, and then re-examined in 2021 prior to conservation treatment, adds new information to the already rich archaeological corpus of sewn boats from the northern Adriatic, providing valuable new data for defining local shipbuilding traditions. This article presents the results of the recent archaeological research, interdisciplinary study and preliminary reconstruction.

## Keywords

Adriatic, Croatia, Istria, Poreč, sewn boat, wreck

## Main text

### Introduction

In early 2020, the municipality of Poreč, Croatia, began renovating the southern waterfront of the town, and archaeologists from the Museum of Poreč territory were tasked with archaeological supervision and excavation (Figures 1 and 2) (Bartolić Sirotić & Benčić, 2021).

The remains of a sewn boat were discovered at the intersection of Obala Maršala Tita and Cardo Maximus Streets, near the Porta da Mar (Sea Gate), at a depth of 1.55 m below current mean sea level (Figures 3 and 4). It was buried under irregularly-shaped stones of various sizes, at the foot of a quay built of large local limestone blocks. Several fragments of ceramics and amphorae testified to the fact that the port was operational from the Flavian Period until Late Antiquity. Thereafter, other structures, including a medieval tower, whose remains were uncovered during excavations, were built over the quay (Figure 5).

During April 2020, excavation, complete documentation by photogrammetry, and *in situ* study of the wreck, as well as its salvage, were carried out in collaboration between the Museum of Poreč territory, the Archaeological Museum of Istria, the Conservation Department in Pula of the Ministry of Culture and Media in Croatia, and the Centre Camille Jullian UMR 7299 (Aix-en-Provence, France). The companies Macuka Ltd., Kapitel Ltd. and In Situ Ltd. provided technical and logistical support for the whole operation. The remains of the sewn boat, Poreč 1, were dismantled and, after a year of desalination in a fresh-water tank in a depot of Poreč town, were sent to the Arc-Nucléart laboratory in Grenoble for conservation. At the end of November and into December 2021, the remains were cleaned, documented and prepared for PEG impregnation, and wood analyses (identification of species and dendrochronology) were carried out in Aix-en-Provence at the Mediterranean Institute for Marine and Terrestrial Biodiversity and Ecology (IMBE). Nine samples for AMS dating were prepared by the Centre de Datation par le Radiocarbone (UMR 5138 Archéométrie et Archéologie) at Lyon and the measurements of  $^{14}\text{C}$  was carried out using the accelerator ARTEMIS, UMS 2572, Laboratoire de Mesure du Carbone 14 (LMC14) at Saclay, Paris.

In this article we will describe the wreck, present the wood identification results and dating, and provide some useful data regarding the interpretation of the presence of this boat in the ancient port of Poreč [1].

### **Preservation, date and interpretation**

The remains of the Poreč 1 sewn boat, roughly oriented east to west parallel to the Roman quay, were particularly distorted and fragmented due to the weight of the stone filling of the harbour basin. The wreck also showed clear evidence of damage from wood borers (*Teredo navalis* or similar). The boat rested on a slight slope of 6.5 degrees running east to west. The western end, protected by the construction of later structures, appeared to be in better condition than the eastern end. Similarly, the north side, adjacent to the quay, was the best preserved (Figures 5 and 6).

Twenty-two samples providing tree-ring series from the Poreč 1 strakes, all made of beech wood (*Fagus sylvatica* L.), were analysed. Eleven series belonging to eight strakes made it possible to build up a mean chronology of 182 years (PorecM6.mn). Attempts to cross-date these with master chronologies in order to date the ship failed; therefore PorecM6.mn remains 'floating' in dendrochronology terms (Kaennel & Schweingruber, 1995, p. 146).

In order to better assess the felling date of the timber used for the construction of the planking of Poreč 1, nine samples, each containing three rings, were collected for AMS dating from seven strakes, whose ring-width series were included in the mean chronology PorecM6.mn. The results have been cross-correlated to the <sup>14</sup>C calibration curve using the wiggle-matching method (Pearson, 1986), giving the felling date for the trees as 94–72 BC. This date has important implications for the interpretation of the discovery.

It is possible that Poreč 1 had been built a few years after the timber was felled in 94–72 BC, as the boat could have been in use for at least 50 years, or even a few decades longer. If this hypothesis is correct, the boat would have been abandoned around 44–32 BC, perhaps around 25 BC. A long lifespan does not seem all that unusual in consideration of the economic and labour efforts that would have been required to build a new boat in the context of a small shipyard with limited financial resources. For example, the Roman small sailing ship Napoli A, abandoned in the ancient harbour of *Neapolis* at the end of the 1<sup>st</sup> century AD, was repaired several times and its lifespan was estimated at 50 to 100 years (Boetto & Poveda, 2018, p. 26–27).

But why was Poreč 1 found embedded in layers formed in the Flavian Period, in the last quarter of the 1<sup>st</sup> century AD? Two hypotheses can be put forward. In the Flavian Period, the

boat, which was lying abandoned in an unlocated boat cemetery near the Poreč Peninsula, was blown against the quay by a storm. Alternatively, it could have been reused and scuttled by filling it with stones. It seems significant that a row of piles, parallel to the boat, was uncovered to the south-west of the excavation trench. It is tempting to say that they were used to contain the stones accumulated in the boat that formed the foundations of a new waterfront, built just out from the quay in order to reclaim an area from the sea. However, the recycling of the Poreč 1 sewn boat is only a hypothesis that cannot be verified, even if the reuse of ships in the foundations of harbour structures is particularly well documented in Dalmatia, at the sites of Caska and Kaštel Sućurac (Radić Rossi & Boetto, 2020; Boetto & Radić Rossi, 2021; Radić Rossi & Ruff, 2020; Ruff et al., 2021).

In conclusion, Poreč 1 testifies that the sewing technique was in use by the local community before the foundation of the colony of *Parentium* that traditionally is dated to the Caesarean Period as the colony of *Pietas Iulia Pola* (nowadays Pula) (Matijašić, 2018 with references).

### **Description of the boat remains**

The Poreč 1 wreck is preserved over 5.7 m in length and 1.4 m in width. The longitudinal profile is flat, and the transverse section at the main frame is flat with a round turn of the bilge. The remains consist of the keel, five strakes on the northern side and seven on the southern side, eight frames, a mast step timber, and two stringers. Traces of a ninth frame were identified on the planking at the stern, and part of a probable V-shaped floor timber was found detached from the wreck near the stern. Based on the position and form of the mast recess, it is possible to establish that the bow of the Poreč 1 was on the eastern side (Figures 6–8).

#### *The keel and transitional timbers*

The axial element was broken into two pieces separated by a gap of about 30 cm. The main piece is about 4.6 m long and consists of a section of the keel (K) and the timber (K2) allowing transition with the sternpost (not preserved). The preserved part of the keel is about 2.6 m long and 6.2–7.0 cm moulded (Figure 9). The cross-section has no chamfer and is irregularly shaped, larger on the inside of the hull (5–6 cm) than at its base (4 cm). In some places, the cross-section is roughly triangular. A treenail penetrating the keel was observed. As it does not connect any parts of the structure, its function is unclear, but it could be related to a repair or to the recycling of a timber belonging to another vessel, as is the case of the transitional timber K2 (see below). A simple hook scarf, positioned midway in the space

between frames F15 and F16 and measuring 12 cm in length, connects the keel to the transitional timber K2. The scarf is secured by a horizontal key (13 x 8 mm), a treenail (internal diam. 15 mm, external diam. 8 mm) and a nail, both driven in perpendicular to the scarf from the inside of the hull. The nail does not penetrate the thickness of the scarf, whereas the treenail does (Figure 9).

The transitional timber K2 is broken aft and is 1.86 m long, 6 cm sided. It has a roughly rectangular cross-section with no chamfer near the scarf (6.8 cm moulded). Its height increases towards the stern (9.5 cm moulded). This increase is due to the need to cut side rabbets to hold the ends of the garboards and strakes in place. The rabbets are triangular, 4.2 cm high and 1.4 cm deep (Figure 10). The western-most end of K2 shows the traces of three mortise-and-tenon assemblies (7–7.5 cm wide, 6–7 mm thick, 15 cm apart) on its port side (Figure 10). This proves that K2 was obtained by reworking a piece from a mortise-and-tenon built boat, perhaps a keel or a wale due to the cross dimensions of the piece.

The smaller piece of the axial element is about 70 cm long (Figure 11) and was found separated from the main piece to the east. It consists of a section of the keel (K) and the timber (K1) allowing transition with the stempost (not preserved). The section of the keel is 40 cm long and the stem transitional timber is 30 cm long. The slight curvature of the stem is noticeable at the scarf, where the rabbets also begin. The scarf is secured by a horizontal key (12 x 6 mm) and two treenails (internal Diam. 16 mm), driven perpendicularly into the scarf from the inside of the hull. The treenails penetrate the thickness of the scarf.

### *The planking*

Five strakes are preserved on the port side and seven on the starboard side (Figure 12). They are particularly damaged and fragmented, with some parts missing. The garboards PN1 and PS1 consist in a single plank, respectively 15 cm and 12 cm wide. They are up to 16 mm thick at the keel, to which they are attached with stitching. The other boat planks have an average thickness of 9 mm (ranging from 7 mm to 12 mm) and an average width of around 12 cm (ranging from 7 cm to 14 cm). On the port side, the second strake is composed of three planks: PN2, and PN3 joined to PN4 by an oblique scarf. PN2 and PN3 form a stealer towards the stern. Analysis of the planking arrangement shows that stealers to reduce the width of the strakes aft are firmly attested on the starboard side (second strake PS2 and third strake PS3). It is possible that the fifth and sixth strakes (PS5 and PS6) on the starboard side also ended in a stealer at the stern. Similarly, we can advance the hypothesis that on the port side the third

strake (PN5) ended with a stealer at the stern. The final reconstruction of the boat shape and structure will certainly help in the study of the planking outline.

Planks are fastened by stitching. The presence of pre-assembly dowels, driven into the edges of planks to aid assembly, was not noted even though the boat was partially dismantled. The sewing is regular and made of simple overedge vegetal stitches (/// pattern) through oblique channels (in section) set perpendicular to the plank edges (Figure 13). A flat braid of three strands of twisted vegetal fibres (width 5 mm) was used for the stitching [2]. The stitches pass over a wadding pad of vegetal fibres placed over the seams.

Small, tapered pegs (max. internal diam. 6–7 mm; external diam. 4–5 mm), spaced on average 2.6 cm centre-to-centre, lock the stitches in the channels. The channels end at the corner of the plank edges in rectangular recesses, 5 mm wide and 3–5 mm high. Vertical channels were also recorded. They have a random location does not seem to be linked to any particular reason. In this case, the internal-edge recesses protecting the seams are very small, and a little groove was carved to lodge the stitch on the outer face of the plank.

Three strakes were repaired using the same system of stitching already described (Figure 12). A repair is located in the middle of the strake PS2 on the starboard side between floor timbers F15 and F16. Two other repairs are visible on the port side: on the strake PN4 between floor timbers F13 and F10, and on the strake PN5 between F15 and F12. The first repair is 1.14 m long, the second is 1.52 m long. These two long repairs run under the floor timbers, but there is any evidence of new notches to facilitate the repairs, cut into the floor timbers.

### *The frames*

Eight frames were found in their original position still attached to the planking (from F9 to F16) (Figure 7). A ninth frame (not preserved) was attached by treenails to the planking near the western end. Its position is evident by the row of treenails visible on the planking. Part of a probable V-shaped floor timber (W1) was also found detached from the boat. East of frame F9, no other frame attachments or imprints left by the passage of a frame were observed on the planking.

The general frame pattern is a sequence of floor timbers (Figures 7, 8 and 14), although frame F9 is unidentified because of its poor state of conservation. Only one futtock has been observed (F15N). It was found adjacent to the end of floor timber F15 on the port side (Figures 14 and 15). A quadrangular wedge was observed underneath floor timber F15 above the port garboard PN1 (Figure 16), and a similar wedge was also found underneath F13. These wedges were probably used to adjust the height of the floor timbers during construction

of the boat. The frames from F9 to F15 are rectangular in section (5 cm sided, 7 cm moulded) and are spaced on average 39 cm (between sides) and 44 cm (between centres). The room-and-space between the two frames at the stern (from F15 to F17) is twice the average space of the rest of the frames and measures 80 cm (between sides) and 83 cm (between centres). It is possible that the space between frame F9 and a frame no longer preserved towards the bow was also twice the average space measured on the boat.

The frames are fastened to the planking with tapered treenails driven from outboard (diam. 7–11 mm). Floor timbers are not attached to the keel. Throughout the boat, the lower face of the frame is notched to avoid crushing the wadding pad placed over the seams. The recesses are oversized so as to function as limber holes.

In the majority of the frames (F9, F11, F13, F15-F15N, F16 and the V-shaped floor timber W1), the recesses are quadrangular in shape and are chamfered along their edges (Figures 15 and 17). This characteristic was observed in the frames of other sewn boats, such as Caska 1, Pula 2 and Zaton 2 (see below) and could be considered a distinctive feature to identify the frames belonging to the original construction. In contrast, only three floor timbers (F10, F12 and F14) have triangular or slightly rounded recesses without chamfers (Figure 18). The difference in shape and treatment of the adjoining right-angled faces (with or without chamfers) could be related to distinctive stages of construction and successive refitting, with substitution of some frames. It is also possible to imagine the presence of at least two shipwrights, each with their own touch, working at the same time on the construction of the boat. Although this hypothesis is speculative, it seems simpler to consider that the frames with triangular or slightly rounded notches come from successive repairs that would have affected the frame and not only the planking, as we have already pointed out above.

#### *The mast step and stringers*

The mast step timber (MS), 1.3 m long and 5 cm thick, is installed above the floor timbers F10 and F13 (Figures 7, 19 and 20). This element is 11 cm wide at its widest and has two narrower arms towards the ends of the boat (width 5.3 cm). Two recesses were cut into its lower surface to fit precisely upon the upper surface of floor timbers F11 and F12. Only the recess above F12 is preserved and measures 3 cm in depth, while the second one has broken off, resulting in the loss of the part of the wood that was situated above floor timber F11.

The mast recess is rectangular, 8 cm long, 4 cm wide and 3.9 cm deep. The forward edge was cut slightly obliquely (85 degrees) to facilitate raising and lowering the mast (Figures 20 and 21). Due to the small size of the sailing gear, the mast step is not flanked by recesses to house



vertical planks supporting the mast, as in the case of the sewn boat Zaton 3 (Romanović, 2021, pp. 71–72, figs 96–97).

Two pairs of parallel curved grooves inscribed with a compass mark the passage between the arms and the widest part of the mast step (Figures 21 and 22). One can imagine that they had a decorative function, but it seems that their position is also significant. The grooves seem to be references for the shaping of the mast step timber. It is worth noting that the recess for the mast foot is positioned at one third of the total distance between the grooves, corresponding more or less to two Roman *pedes* (58 cm).

A small part of a starboard stringer (SS1), 20 cm long, 4.7 cm wide and 16 mm thick, was found not in its initial position, but located above the planking in the space between floor timbers F10 and F11. In contrast, the port stringer (SN1), 1.41 m long, 6.5 cm wide and 23 mm thick, was found still attached by an iron nail to floor timber F12. Traces of another iron nail on floor timber F11 suggest that this stringer SN1 continued forward.

### The wood

The keel (K) is made of elm (*Ulmus* sp.), while the two transitional timbers are made of oak (*Quercus* sp.). The planking is all made of beech (*Fagus sylvatica* L.). Six frames are of oak (F9 to F11, F15, F15N, F16 and W1), two (F12 and F14) are of ash (*Fraxinus* sp.) and one (F13) of holm oak (*Quercus ilex* L.). The mast step is made of ash, and the two stringers are made of beech and holm oak (Figure 23).

The two horizontal keys locking the hook scarfs of the keel were cut from elm, the same species used for the keel. The three treenails securing the scarfs are made of an unidentified rosaceous species (*Rosaceae maloïdeae*). The 34 small pegs locking the stitching in the channels that were analysed are mostly made of fir (*Abies* sp.), only one was found cut from an unidentified rosaceous species. These two wood taxa were also used for the treenails, of which only nine were analysed. In contrast to the pegs, the unidentified rosaceous species predominates (eight pegs) compared to the fir (one peg) (Figure 23).

Except for beech and fir, all the other species were probably widely distributed around the Adriatic coast. It is possible that beech and fir were imported from the Učka or Čićarija mountains, where these trees are still nowadays abundant. Mountain forests could easily have supplied the shipyard where Poreč 1 was built (see below).

The examination of the morphology of the remains and measurements of the tree ring-widths have led to some considerations about the wood technology. In general, the planking and the

two stringers have narrow rings, indicating slow-growing trees. In contrast, the frames, the keel, and the mast step have wide ring, indicating fast-growing trees.

The keel and transitional timbers were made from squared trunks, resulting from quartering, close to the pith. No traces of bark or cortical tissue were noted, as the pieces were carefully shaped on all sides. The sapwood is only present on the stern transitional timber (K2). This indicates that the log had a maximum diameter of at least 12–14 cm and that it came from a small branch, or a stem obtained by coppicing.

The frames were cut in half-trunk and quarter-trunk. Sapwood was identified on three pieces (F10, F11, F12), and only one frame (F10) revealed remains of cortical tissue. These characteristics allow us to consider the use of small-diameter logs (between 5 cm and 13 cm), probably from branches or stems from coppicing.

The mast step was made from a squared trunk, with the pith present in the centre of its cross-section. The log had a minimum diameter of 9.5 cm. The two preserved stringers show cuttings from a half quarter. None of the pieces have retained any sapwood rings or bark remains. The minimum diameter of the logs used can be estimated as between 8 cm and 14 cm.

The planking strakes are systematically rectangular in cross-section, resulting from radial cutting. None of the pieces showed the presence of pith or sapwood, which is in any case difficult to distinguish in beech, nor of bark remains that might indicate the proximity of the trunk periphery. The minimum diameter of the logs used for planking can be estimated as between 10 cm and 30 cm.

It should be noted that the majority of the strakes (eight) are oriented so that the peripheral rings are placed towards the keel (Figure 24). On the contrary, the third and fifth strakes on the port side (PN5 and PN7) and the sixth and seventh strakes on the starboard side (PS6 and PS7) are oriented differently, with the pith towards the keel. In the second port strake, planks PN2 and PN3 present peripheral rings towards the keel, while PN4 presents the pith towards the keel. It is debatable whether the plank placement is the result of a deliberate choice or whether it is unintentional. With this knowledge, however, we can put forward the hypothesis that the homogeneous position of most of the strakes (with bark towards the keel) could be intended to lend the planking more flexibility. In this way, the rings near the bark of the trunk are flanked by the rings near the pith of the trunk, thus reducing the possibility of strain on the joints between the planks.

As to the elements of assembly, the key securing the hook scarf between the keel (K) and the stern transitional timber (K2), the perpendicular treenails locking the scarfs, and the treenails

attaching the frames to the planking were made systematically from small branches. Pith is present in all the pieces. The deliberate and systematic selection of small branches reflects a specific supply and the desire to ensure a certain rigidity to the assemblies, but also an optimization of the available wood material and work time, insofar as the carpenter would have taken advantage of the naturally rounded shape of the branches. In contrast, the use of small branches for the production of the pegs for stitching can be ruled out as no pith was observed.

In general, no tool marks (saw, axe or adze) were observed on the surface of the pieces, except for the mast step. Two parallel circular grooves, inscribed with a compass, were found on its upper surface (see above), and marks of a chisel, possibly fitted with a round blade, were found in the mast recess. Possible traces of a small chisel were also observed on one face of the key securing the scarf joining the keel K to the transitional timber K2.

Since the planks have been cut radially, it is likely that they were split using wedges and a sledgehammer, and then finished with a squared axe or adze. It is also possible that the stringers were split in the same way.

### **The pitch and red pigment**

A thick layer of pitch was applied to the inside and outside of the hull to protect and seal the hull. Pitch covered the planking and the frames.

Small traces of red pigment were observed on the outer surface of the starboard plank PS2. A sample of this red pigment was analysed by scanning microscope coupled with energy dispersive X-ray spectroscopy (SEM-EDS) in the ARC-Nucléart laboratory, and was clearly identified as cinnabar (mercury sulphide, HgS). Cinnabar, named κιννάβαρι by the Greeks and *minium* by the Romans, was a rare and precious mineral pigment, mostly used in wall paintings. This substance was not readily available in Istria and it is likely to have been procured through long-distance exchange networks. According to Vitruvius (*De Arch.*, VII, 9, 4), Pliny (*NH*, XXXIII, 7) and Cicero (*Phil.*, II, 48), most of the cinnabar came from Spanish mines. Idrija in Slovenia has an important deposit of cinnabar, but underground mining of this mineral only started at the end of the 16<sup>th</sup> century AD (Trinquier, 2013).

### **Discussion**

Following the notion of architectural types and the concept of principles and methods of construction (Pomey, 2004; Pomey & Rieth, 2005, pp. 29–33; Pomey et al., 2012; 2013), the construction principle of Poreč 1 is based on a shell-first concept for the hull structure, and on

a longitudinal strake-oriented concept for its shape, while the building process is shell-first. Indeed, this construction process is only compatible with a longitudinally-sewn boat like Poreč 1.

Based on the remains, a number of similar features in the structural and assembly systems place Poreč 1 in close relationship with four other sewn boats found at Pula (Pula 2, [Boetto et al., 2017](#)) and Caska (Caska 1, 3 and 4, [Boetto & Radić Rossi, 2017](#); [Radić Rossi & Boetto, 2020](#))[3]. However, it has to be said that Caska 3 is poorly preserved (seven strakes of beech) and Caska 4 has some structural differences from this ensemble, which may be related to a different way of building the same type of boat. In Caska 4, the frames consist of crenelated floor timbers connected to the futtocks by hook scarfs. These scarfs are secured by two or three treenails. The frames are lashed to the planking and not treenailed as in the other sewn boats. The space between frames is 89 cm on average, twice that of the other sewn boats. Additionally, in some seams, pieces of textile were added to the pads made of fibres.

The Poreč 1 wreck also has some similarities with the sewn boats of Zaton (Zaton 1, 2 and 3, [Brusić, 1968](#); [Brusić & Domjan, 1985](#); [Gluščević, 2004](#); [2011](#); [Liphschitz & Gluščević, 2015](#); [Romanović, 2021](#))[4].

The relationship between Poreč 1 and the above-mentioned wrecks of Caska and Pula is confirmed by the results of wood identification and study of the morphology of the structural pieces ([Ferreira Domínguez et al., 2021, pp. 255–256](#); [Ferreira Domínguez, 2021, p. 208](#)). The most striking similarity concerns the planking. All these sewn boats have a very homogeneous planking made exclusively of beech, a deciduous species not much used in shipbuilding in antiquity, and in particular for shaping planks. If the exclusive use of beech in the planking is one of the most notable characteristics of their construction, the radial splitting of the strakes is another equally original feature never before observed in the Mediterranean ([Ferreira Domínguez, 2021, pp. 214–224](#))[5]. This type of woodworking of the beech logs added longitudinal flexibility and strength to the hull and testifies to specific technological choices, probably well adapted to the construction of a regional type of boat. The orientation of most of the preserved strakes of Poreč 1, with their peripheral rings oriented towards the keel of the boat, is another notable characteristic, which could also be related to a specific way of building this particular type of sewn boat. Although no definite explanation can be found at this stage of the research, it would certainly be interesting to reproduce this kind of observation in the other sewn boats.

Given the presence of a mast step, Poreč 1 was certainly a sailing boat. In Pula 2, the caprail was pierced by rectangular mortises to insert tholepins for rowing ([Boetto et al., 2017, p. 196](#))

in a similar way to what has been observed in two small service boats, Toulon 1 and 2 (end of the 1st century AD, Boetto, 2022, pp. 313, 327, figs 48–49). Given the fact that Poreč 1 and Pula 2 belong to the same type of sewn boat, a mixed propulsion system for both vessels can be proposed. A mixed propulsion system has been also proposed for the sewn boats of Caska although no traces of the propulsion system or steering devices were discovered (Boetto & Radić Rossi, 2017, p. 286; Radić Rossi & Boetto, 2020, p. 287). In contrast, in Zaton 3, the keelson/mast step was particularly well preserved (Romanović, 2021, pp. 71–72, fig. 104–105).

The preliminary reconstruction of the hull shape of Poreč 1 confirms that this boat was small in size, the main dimensions being about 7.6 m long, 2 m wide and 1.2 m high. The hull lines show a flat-bottomed boat and rather symmetrical cross-sections at the ends (Figure 25). In contrast, the longitudinal profile is much more elongated at the stern, with a flat keel in the middle (Nees, 2022, pp. 48–57, fig. 24).

According to P. Pomey and G. Boetto (2019, pp. 8–12), the Roman-period wrecks found in Pula, Caska and Zaton belong to a regional tradition of sewn boat construction that they define as north-eastern Adriatic in contrast to a northern and north-western Adriatic tradition of sewn ships identified in an area from the Gulf of Aquileia to Ravenna through the Po River Delta, in the coastal, lagoon, and inland waters (Pomey & Boetto, 2019, pp. 12–17; see also Boršić et al., 2021). The origin of the north-eastern Adriatic tradition is to be found in Liburnia and Istria and could date back to protohistory as evidenced by the discovery of an extended sewn boat in Zambratija Cove, Istria (1120–930 BC, Boetto et al., 2017; Koncani Uhač et al., 2019). Poreč 1 is the oldest example of a multi-purpose type of sailing and rowing sea-going sewn boat well attested in Istria and Dalmatia. Given its dating to beginning of the 1<sup>st</sup> century BC, Poreč 1 was probably built by a local community of *Histri* before the foundation of the Roman colony of *Parentium*.

The species of wood used in the construction of this type of mixed propulsion sewn boats belonging to the north-eastern Adriatic tradition point towards regional construction since most of them are widely distributed along the Adriatic, near the coast or in riparian forests that could be located not far from the shipyards. A regional supply of species growing in temperate ecosystems, such as the beech and fir found in Poreč 1 and also in the other sewn boats from Caska and Pula, could be proposed because the forests of Istria and northern

Dalmatia (Učka, Ćićarija and Velebit Mountains) are not far from the coast and could easily have supplied regional shipyards (Ferreira Domínguez et al., 2021, pp. 255–256; Ferreira Domínguez, 2021, pp. 224–234).

It is worth noting the recycling of a piece from a mortise-and-tenon built boat into the axial carpentry of Poreč 1. The presence of repairs in the planking and the possible substitution of some frames, indicated by the different shape of the recesses for the wadding pads, confirm that Poreč 1 was in use for quite a long time before its abandonment or reuse in the harbour. If one accepts the assumption of a long life for the boat, the fact that a piece from a mortise-and-tenon-built boat was reused in the axial carpentry becomes particularly interesting. This could be an indication of a self-sustaining economic system where a small shipyard might have problems sourcing wood because the resource was too expensive, difficult to access, or scarce. On the other hand, this recycled piece in the keel confirms the contemporary use of mortise-and-tenon ships and sewn boats in the same geographical area and in the same period, as already noted in Caska where a mortise-and-tenon built sailing vessel, Caska 2, was also scuttled and reused to build harbour structures (Radić Rossi & Boetto, 2020, p. 287; Boetto & Radić Rossi, 2021)[6].

## Conclusion

The recently discovered sewn boat from the town of Poreč in Istria has added new information to the already rich archaeological corpus of sewn boats from the northern Adriatic. In particular, the Poreč 1 wreck offers valuable new data for defining the shipbuilding tradition of the north-eastern Adriatic and confirms its origin in pre-Roman Istria and Liburnia. The discoveries at Zaton, Caska and Pula clearly show that this Istro-Liburnian tradition survived after the Roman conquest, thanks to the attachment of the indigenous communities to traditional shipbuilding techniques whose ancient origins are strongly connected to a native tradition which in turn has its roots in an even earlier period, dating back at least to the end of the Bronze Age/beginning of the Iron Age, as the Zambratija sewn boat demonstrates (Pomey & Boetto, 2019; Borsić et al., 2021).

What's more, Poreč 1 offers the oldest evidence of a multi-purpose type of sailing and rowing sea-going sewn-boat, well suited to the demands of local people's daily lives for a host of different activities in terms of transport, trade and, perhaps, fishing.

The hypothesis of P. Pomey and G. Boetto (2019, pp. 18–19) on the development of different traditions of sewn ships both in the north-western and north-eastern Adriatic regions both in

maritime and inland transport zones, according to the concept of maritime cultural landscapes defined by C. Westerdahl (1992, 1995, 2001), has been recently discussed (Beltrame & Costa, 2023, pp. 114–116). We think that archaeology shows even more clearly that the Adriatic sewn-boat traditions are marked by the construction of diverse types of vessels well adapted to different maritime cultural landscapes. They are defined not only in term of their geographical environments, but also in reference to the cultural, economic and social characters and technical skills of the local communities. In-depth study of each architectural unit from the structural and technical point of view, identifying the different sewing patterns or mixed techniques (sewing and pegged tenons) and the choice of types of wood and raw materials for ship components and waterproofing, and dating precisely the construction will surely improve our knowledge of the extremely rich northern Adriatic shipbuilding traditions.

#### Notes

1. The harbour structures, fine, coarse and fire wares and amphorae, as well as sedimentological analysis of the harbour infill, will be published elsewhere.
2. The fibres have not yet been analysed.
3. The Pula 1 wreck had a massive structure and a stronger sewing pattern of overedge stitches with a clamping turn (/I/I) compared to the other sewn boats. It was a sailing vessel, estimated to be about 15 m long and intended to carry heavy cargoes, and belonged to a different type of vessel from that of Caska, Pula 2 and possibly those of Zaton (Boetto et al., 2017, pp. 195–196; Pomey & Boetto, 2019, pp. 11–12). This difference is also reflected in the wood used for the planking, which is uniformly elm and not beech (Ferreira Domínguez, 2021, p. 100).
4. Dušanka Romanović of the Archaeological Museum of Zadar has recently resumed the study of the sewn ships from Zaton in the catalogue of an exhibition held in Zadar in 2021 (Romanović, 2021). Her study of Zaton 1 and 2 is based on the examination on published data, the archives of Zdenko Brusić and the wooden remains stored in the Museum of Zadar. As for Zaton 3, a wreck that has been the subject of several excavation campaigns under the direction of Smiljan Gluščević, D. Romanović conducted new underwater research in 2019.
5. Beech is also mentioned in the sewn boats from Zaton (Romanović, 2021, pp. 35, 56 and 76). Analyses by N. Lipshitz attest that beech was the wood mainly used for the planking of the Zaton 2 boat, with only one maple (*Acer pseudoplatanus*) and three fir (*Abies alba*) planks (Lipshitz & Gluščević, 2015). Recent analyses by A. Ferreira

Domínguez confirm that beech was also mainly used for planking in Zaton 1 and 3 (D. Romanović, pers. comm.). On the other hand, A. Ferreira Domínguez also identified radial cuts in the photographs of some of the Zaton 3 planks. This observation indicates that extensive direct investigation needs to be conducted on the pieces of wood.

6. A few displaced pieces of planking and a frame belonging to mortise-and-tenon built ships were found in the port of Pula in 2013, in addition to the two sewn boats, Pula 1 and 2.

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### **Author contributions**

All authors contributed to the writing of the manuscript. KBS, GBe, AD, IKU and MU conducted the excavation and collected data on ship architecture *in situ*. GBo, VD, KN and



PP conducted new observation on the ship structure before conservation in Grenoble. FD and FG conducted ring-width dendrochronology and sub-sampling for AMS dating. CO prepared samples for AMS dating. FG and CO conducted the cross-correlation by wiggle-matching.

### Statement of Interest

The authors declare no conflict of interest.

### Permission Statement

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