# Recording, analysis, and interpretation of the hull remains of Santo Hieronimo (1576), a vessel from the merchant fleet of the Maritime Republic of Ragusa

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**Abstract**: Following the discovery of the remains of *Santo Hieronimo* in the early 1970s near the Island of Šipan (Croatia), the Maritime Museum of Dubrovnik carried out the rescue excavation of the wreck. The pioneering work led to the preliminary interpretation of hull remains and recovered artifacts. Ten years later, the research conducted at the National Archive of Dubrovnik resulted in the identification of the sunken ship. The archaeological study of the remains of *Santo Hieronimo* continued in 2014. This paper presents the latest research results on the hull features of *Santo Hieronimo*, aimed at understanding the shipbuilding techniques of the post-medieval vessels that sailed the Adriatic.

**Keywords:** shipwreck, *Santo Hieronimo*, Maritime Republic of Ragusa, wooden hull, lead sheathing

## 1. Introduction

The *Santo Hieronimo's* hull remains were discovered at the Bay of Suđurađ, on the Island of Šipan (Croatia), in the early 1970s. Following its discovery, the Maritime Museum of Dubrovnik carried out the rescue excavation of the wreck between 1972 and 1974, under the direction of Anica Kisić and Zdenko Brusić (Kisić 2006: 131, 143). This pioneering work led to the preliminary interpretation of hull remains. The artifacts recovered from the site dated to the second half of the 16th century and connected the wreck with the wealthy Ragusan merchant family Primi. Ten years later, the research conducted at the State Archive of Dubrovnik (DAD) resulted in the identification of the sunken ship. According to the archival documentation, the wreck of the Island of Šipan was the 'nava' *Santo Hieronimo* which sunk in 1576 and was the property of the famous merchant Hieronimo Benedicto de Primi (Jerolim Benedikt Primojević), of Ragusan origin (Vekarić 1987: 65–71; Kisić 2006: 132).[1] The archaeological study of the remains of *Santo Hieronimo* continued in a systematic form from 2014 to date, carried out as part of the Archaeology of Adriatic Shipbuilding and Seafaring Project (AdriaS).[2] This paper presents the latest results of the ongoing archaeological survey, excavation, recording, and interpretation of the hull features, dimensions, and assembly of *Santo Hieronimo*.[3]

## 2. Location of the site

The Island of Šipan is located off the Dalmatian coast of Croatia, in the Adriatic Sea, 18 km to the northwest of Dubrovnik (Ragusa), the capital of the former Maritime Republic of Ragusa. Šipan is the largest of the Elaphiti Islands and is separated from the mainland by the Koločep Channel. The island extends parallel to the coast, following a northwest-southeast orientation, with a maximum length of 9 km and a width of 2.6 km. Šipan has two ports, Šipanska Luka (Port of Šipan) located in the northwest and the port of Suđurađ (Saint George) in the southeast.

[1] Researchers of the Santo Hieronimo Project conducted archival research at the State Archive of Dubrovnik in 2016 and 2017, confirming the previous identification. However, no new archival data regarding *Santo Hieronimo* has been located yet.

[2] The aim of the project is the interdisciplinary study and interpretation of the archaeological and historical record of shipbuilding and seafaring in the Eastern Adriatic.

[3] The remains of *Santo Hieronimo* have been systematically surveyed and excavated thanks the support of the Croatian Science Foundation, Ministry of Culture and Media of the Republic of Croatia, University of Zadar, Institute of Nautical Archaeology (INA), Center for Maritime Archaeology and Conservation (CMAC) of the Texas A&M University and German Association for the Promotion of Underwater Archaeology (FUWA) from Koblenz.

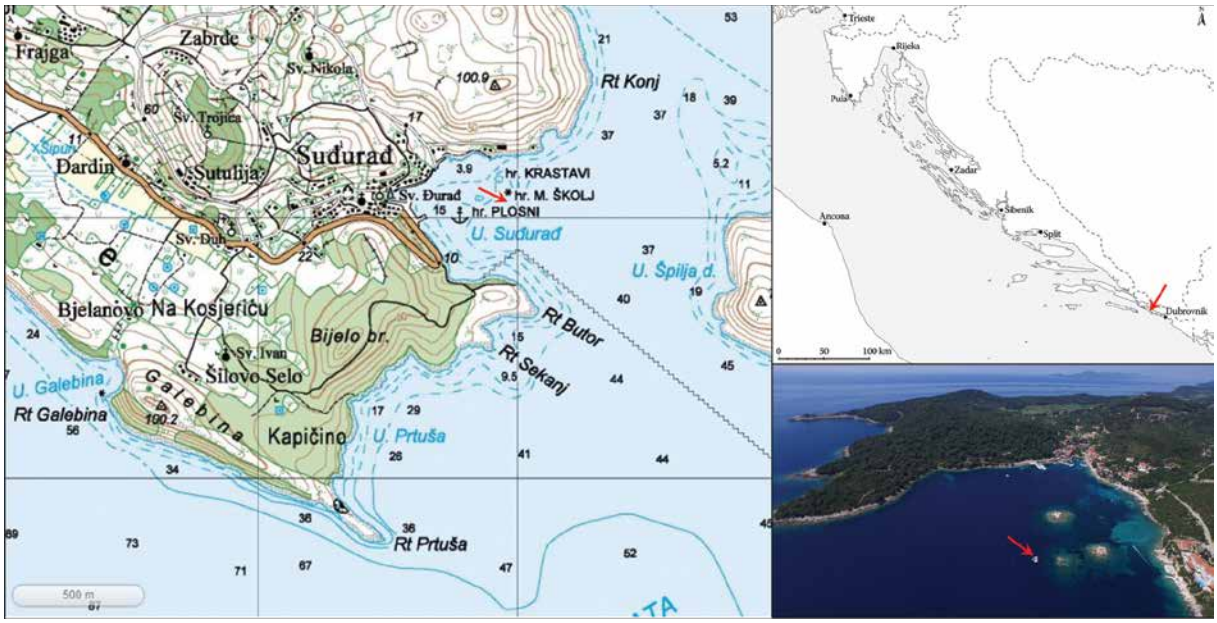


**Fig. 1** Location of the site

The village of Sudurađ is situated at the bottom of the homonymous Bay. At the Bay's entrance, a group of three rocks rises from the bottom to slightly above the surface (Fig. 1). *Santo Hieronimo's* hull remains and artifacts are located on a sandy seabed, south of the outer rock named Mali Školj, between 27 and 33 m deep, scattered over an area of approximately 543 m$^2$ (Fig. 2).

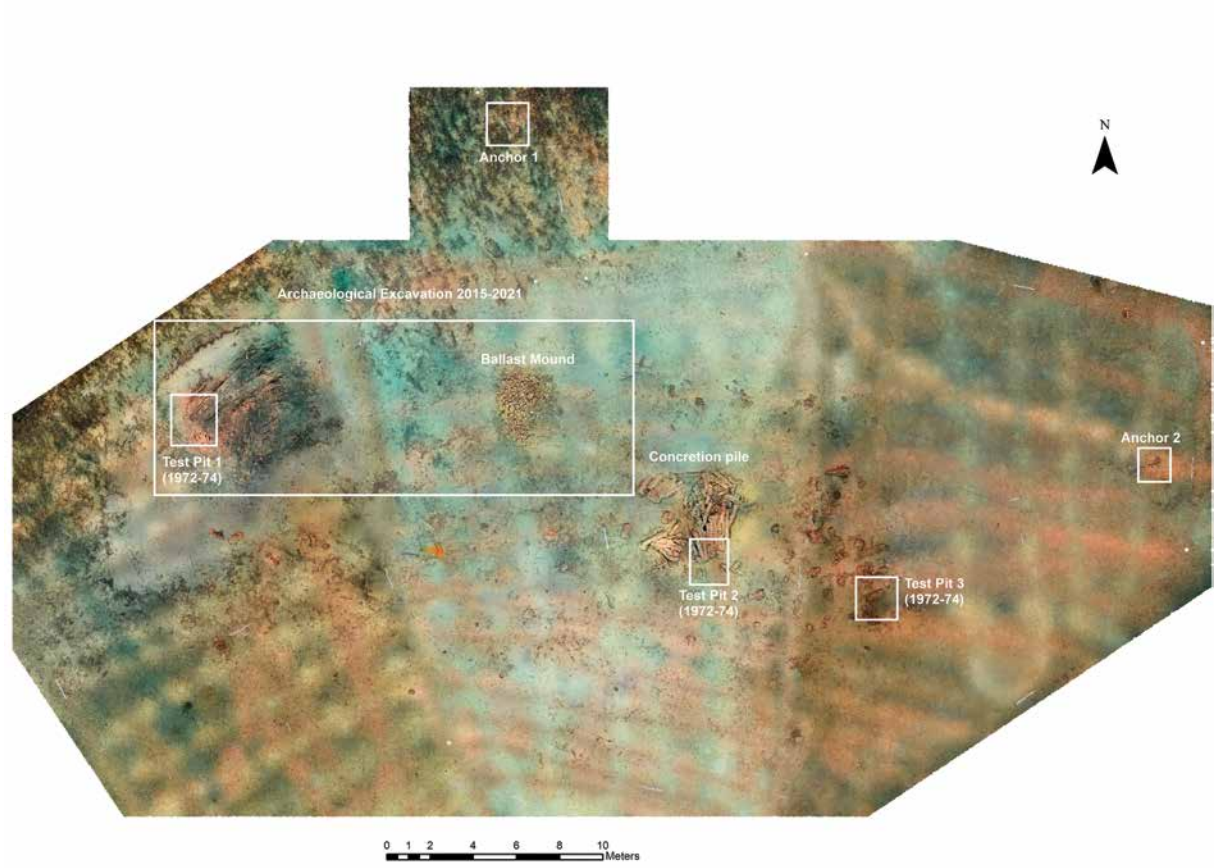


**Fig. 2** Situation in 2017 (orthomosaic: K. Yamafune; interpretation: J. L. Casabán)

## 3. Fieldwork

Between 1972 and 1974, after the wreck's discovery, the Maritime Museum of Dubrovnik organized and conducted a series of archaeological rescue campaigns due to the constant looting that the site was being subjected (Kisić 1979; 2006). In 2000, the Department for the Protection of Archaeological Heritage of the Croatian Ministry of Culture (Mihajlović, Jurišić 2010: 104–105) carried out a short-term research test campaign on the wreck, determining that continuing its research was not a priority in Croatian underwater archaeology.[4] In 2008, a joint team of the University of Zadar and the University Ca' Foscari from Venice (Italy) briefly revisited the site, concluding that it was worthy of systematic excavation based on its condition.[5] In 2014, a preliminary photogrammetric recording of the site was conducted, and in 2015 the systematic research of the site began in cooperation with the University of Zadar and the Institute of Nautical Archaeology of Texas A&M University (USA).[6]

### 3.1. Archaeological rescue excavations 1972–1974

Zdenko Brusić directed the archaeological rescue excavation, and Anica Kisić interpreted the archaeological data (Kisić 2006: 131, 143). The archaeological research included the mapping of the site and the excavation of the three test pits. The excavated area covered approximately 20-30% of the wreck (Kisić 2006: 130).

The first test pit was excavated east of the wreck's ballast mound, the second on a pile of concreted metal bars, and the third south of the pile (Fig. 2). Brusić and Kisić interpreted the wooden hull remains uncovered in test pit 1, mainly frames and fragments of lead sheathing that protected the wooden hull from marine organisms, as part of the ship's bow. Test pit 2 revealed a mix of timbers which, according to Kisić, could be part of the upper works of the ship's stern (Kisić 2006: 130). Finally, the thickness of the sediment layer in test pit 3 prevented the archaeologists from uncovering the remains of the hull timbers. This test pit was located southeast of the area, interpreted as the ship's stern (Kisić 2006: 130). The underwater survey of the site also revealed the location of two anchors, one about 19 m east of the ballast mound and the other deeply buried in the sand 13 m to the north (Kisić 2006: 131) (Fig. 2).

Two hundred artifacts were recovered during the archaeological rescue excavations, including part of the ship's defensive armament, such as a small iron gun, stone shots, lead shots, a bullet mold, a copper powder scoop, and firepots. Among the ceramic artifacts found were cups, bowls, plates, different types of food containers, and cooking pots. Finally, a series of well-preserved metal objects, including a bronze stamp, a steelyard with a copper bowl, two lead weights, and 11 bronze coaks from the ship's blocks were also recovered (Kisić 2006: 132, 136–137, 140–142). The ship had no recognizable cargo materials, with the exception of the pile of concreted metal bars whose composition and function are still unknown. This situation led Kisić to propose that the ship was carrying some organic cargo, such as cereals, salt, or wool, which would not have been preserved (Kisić 2006: 131).

### 3.2. The systematic archaeological research 2015–2021

The current systematic research of *Santo Hieronimo* began in 2015 in the test pit 1 area excavated during the 1972–1974 archaeological rescue campaigns. The project's objective was the excavation, recording, and interpretation of the vessel's hull features, dimensions, and assembly. The 2015 excavation confirmed that this wreck area corresponded to the port side of the ship's bow. Since then, except in 2020, the initial excavation area has been progressively extended towards the north, south, and east using an expandable metal grid composed of 2 × 2 m squares as a reference system. The total excavated area between 2015 and 2021 covers approximately 165 $m^2$ (Figs 2, 3). In addition, the site's surface was surveyed again to record and map the different types of metal concretions scattered on the seabed. *Santo Hieronimo's* hull remains and concretions have been documented using underwater photogrammetry and direct measurements to produce a 3D model of the wreck, orthomosaics, and 2D site plans.

[4] The research was directed by Mario Jurišić.

[5] The operation was directed by Mate Parica, Irena Radić Rossi and Carlo Beltrame, in the framework of the Educational programme in the field of nautical archaeology and maritime history; 16th and 17th century, funded by UNESCO Participation Programme 2008-2009. Parica 2009.

[6] The systematic research is directed by Irena Radić Rossi and Jose L. Casabán.

## 4. The hull of Santo Hieronimo

The excavation revealed that the best-preserved section of the vessel corresponds to its port side, with eleven strakes still assembled under the frame timbers of the bow area. In contrast, due to its collapse, most of the starboard side is composed of disassembled planking, lead sheathing fragments, and only four intact strakes extending from the bow to the stern area. The hull features identified and recorded during the 2015–2021 archaeological excavation include the keel and stem, hull planking, lead sheathing, frame timbers, keelson, mast step, ceiling, stringers, the probable remains of the pump well, and rigging components such as metal straps and chains (Fig. 3).

### 4.1. The keel and stem

The keel's upper surface of *Santo Hieronimo* is partially visible among the floor timbers, from the midships to the bow area, forming a flush seam with the upper edge of the garboards. The keel's width between the garboards is 28 cm, although this measurement does not include the with of the rabbets. The seams between the keel and the garboards, and even the keel's upper surface, are partially covered with pitch for most of their length, especially towards the hull's forward end. A fragment of the ship's stem, probably its lower timber, was also identified in the bow area of the wreck. Its upper end is broken while the lower part, including the stem-keel scarf, is hidden beneath the remains of the V-shaped frames and a layer of pitch and gravel that fills the spaces between them. The stem timber's lower surface is badly eroded, while the upper one appears preserved, including the rabbets where the diagonal hooding ends of the hull planking are still inserted. The rabbets have a depth of 6 cm and a width of 5 cm.

### 4.2. The frames

The remains of 50 frame timbers, including the master frame amidships and the V-shaped frames at the bow, were partially documented during the excavation. Thirty-three frame timbers were documented before the master frame, including the remains of V-shaped frames, or crotches, at the bow. However, the foremost V-shaped frames are badly damaged, having lost more than half of their original thickness. Sixteen frame timbers are located aft of the master frame until the eastern limit of the excavation area. On the starboard side, the floor timbers are broken just before the turn of the bilge, and only two have a fragment of the first futtock lower end still attached. On the bow port side, however, six first futtocks and five second futtocks of the V-shaped frames are partially visible. The rest of the port side floor timbers are hidden by the limber boards, and only four first futtocks lower ends are visible still attached to floor timbers aft of the mast step (Fig. 3).

The sided dimensions of the floor timbers range between 14.3 cm and 24.7 cm. However, the average width from the aftermost excavated floor timber to the 20th before the master frame is 16.7 cm, and 21.3 cm for the remaining V-shaped frames towards the bow. The increase of sided dimension of the floor timbers could be related to the location of the bow tailframe, which, together with the master frame and stern tailframe, determined the hull's shape. However, this hypothesis must be correlated with the examination of the design methods described in 16th and early 17th century Mediterranean shipbuilding treatises and archaeological parallels[7].

The floor timbers before and aft of the master frame have an almost identical average room and space, 36.1 cm and 35.7 cm, respectively. The room and space average becomes 38.8 cm from the 20th floor timber before the master frame to the bow, with a room and space ranging between 51.1 cm and 31.4 cm.

The floor timbers amidships are 21.4 cm molded on average, including the master frame. The molded dimension increases progressively up to 45 cm from the 10th to the 20th floor timber before the master frame. The molded dimension of the rest of the V-shaped frames towards the bow is not visible because the space between them is filled with a thick layer of pitch up to the keelson. In addition, the spaces between the 29th and 33rd floor frames are also filled with a type of mortar composed of gravel and pitch, although only the lower surface of the frames is preserved.

The first futtocks in the bow area are 18.4 and 15.2 cm sided, and 19.3–16.1 cm molded. The second futtocks are 15–19.2 cm sided. The stringers hide the types of scarfs between the floor timbers and first futtocks, and the first and second futtocks, so they cannot be identified yet. However, it is expected that these scarfs will be documented as the excavation progresses.

[7] Historical sources, e.g. Lane 1934; Nicolardi 2014; Bondioli *et al.* 2020. Archaeological sources, e.g.: Guérout *et al.* 1989; Villié 1994; Beltrame *et al.* 2014; Cazenave de la Roche 2020.


**Fig. 3** Hull remains uncovered until 2021 (orthomosaic: J. L. Casabán)

The double-floor timber situated amidships beneath the forward end of the mast step was identified in 2021 as the ship's master frame. As with the rest of the floor timbers, its starboard side is broken just before the turn of the bilge, while its port side appears to continue underneath the limber boards of the ship's ceiling (Fig. 4). The floor timbers of the master frame are 17.4 cm and 16.7 cm sided, and 21 cm molded, with a combined width of 34.1 cm and a room and space between the first floor timbers before and aft of the master frame of 51.9 cm and 52.2 cm respectively.


**Fig. 4** Mast step, master frame, and presumed pump well (orthomosaic: J. L. Casabán)

### 4.3. The planks

The average planking thickness is 6.5 cm, and the width is 20–31 cm. The maximum preserved plank length is 6.37 m, although this length might increase since several planks have not been fully exposed yet. The hull planks were fastened to the frames with iron nails that have not survived, apart from small dark ferrous deposits left in the planks. The iron-nail holes on the planks have a circular section with a diameter of 1.5 cm. Two iron nails were nailed at each plank-to-frame joint following a diagonal orientation, while at the butt joints of the planks, the orientation was vertical. There is no evidence of treenails being used to fasten the planks to the frames.

### 4.4. Lead sheathing

Exceptionally large sheets of lead sheathing appear underneath *Santo Hieronimo's* lower hull, especially on the port side of the bow area, where the strakes' forward ends have disappeared. The overlapping lead sheets have a width of 50 cm and a maximum length of 229 cm. Comparing the dimensions of these sheets with other published finds, the lead sheets from *Santo Hieronimo* are by far the largest. The only ones that are somewhat comparable are those from Lomellina, which measure 40 × 120 cm (Veyrat 2016: 390).

The lead sheathing is 0.1–0.2 cm thick, and some fragments present layers of pitch that may increase its thickness up to 1.3 cm. The holes and impressions on the lead sheets' surface indicate that they were fastened to the outer hull planking with tacks whose round heads had a diameter of 0.7–2.8 cm.[8]

[8] Given the limitations of the length of the text, more will be said about the lead sheathing in a comprehensive publication of the research results.

### 4.5. The keelson and the mast step

The *Santo Hieronimo's* keelson appears to be composed of a single timber, with an expanded central area that forms the mast step. However, only the forward section of the keelson and the mast step are still preserved (Fig. 3). A fragment of the keelson, 6.48 m long, extends from the 10th to 28th frame before the master frame. It has a section that is 28 cm sided and 22–19.5 cm molded, and its lower surface is notched with mortises to fit the upper surface of the floor timbers. The forward end of the keelson appears to be joined to the aft end of the stemson with a horizontal flat scarf with an approximate visible length of 88 cm. The stemson fragment is 1.16 m long, with the upper surface badly eroded, and was fastened to the keelson with two iron bolts of 3.5 cm in diameter. The keelson upper surface presents three quadrangular notches, which probably served to insert the heel of the stanchions that supported the lower deck. The average dimensions of the notches are 15 × 15 cm, 4 cm deep, and have an average center-to-center spacing of 1.6 m.

The mast step extends over nine floor timbers, from the first floor timber before the master frame to the seventh aft (Fig. 4). It measures 3.21 m in length, 63 cm in width, and has a preserved height of 21 cm, with its center just after the master frame. On its upper surface, it has a rectangular mortise for the heel of the mainmast located between the first and fourth floor timbers aft of the master frame. The mortise is 73.2 cm long, 23 cm wide, and 15 cm deep. The upper surface of the mast step surface is damaged, especially from the mortise to the aft end, and a portion of its port side is also missing. The damage was probably caused by the weight of the ballast mound that was visible on the site's surface and located directly above the mast step.

The starboard side of the mast step presents four notches cut on its upper edge to insert the buttresses that laterally reinforce the mast step, although only three are completely visible (Fig. 4). The preserved edges of the notches are 17.5 cm long, 4 cm wide, and have an approximate depth of 5 cm, with a 44–50 cm center-to-center spacing. The traces of two more notches, and two preserved buttresses, 15 cm sided and a visible length of 81 cm, have been identified aft of the master frame, directly opposite the notches documented on the starboard side of the mast step.

Finally, the remains of a wooden structure, currently under excavation, situated amidships south of the mast step, have been tentatively interpreted as the western side of the ship's pump well (Figs 3, 4). A horizontal wooden plank 2 cm thick and 30 cm wide would form the partially visible side of the western wall of the pump well. The inner side of the plank is attached to a vertical, although slightly tilted outwards, post with a 20 × 13 cm section situated aft of the master frame floor timber. The pump well is not preserved north of the vertical post, and, at this stage of the excavation, it is unclear if the southern and eastern walls survived since the weight of the ballast mound severely damaged this hull area.

### 4.6. The ceiling, stringers, and shelf clamp

A large section of the partially excavated limber boards appears on the keelson's port side, from the bow to the presumed wall of the pump well and towards the stern of the ship, near the eastern limit of the excavation area.

The twenty-five limber boards, 47–30 cm wide and 2.5 cm thick, that form the ceiling before the master frame lie almost perpendicular to the keelson, from the scarf between the stemson and the keelson to the western wall of the structure tentatively interpreted as the pump well. However, only the edges of five limber boards are preserved up to the keelson. These edges rest on a narrow plank 10 cm wide and 2.5 cm thick situated along the port edge of the keelson, and the other edge is butted against the stringer forming an almost horizontal platform (Fig. 5). A series of transversal and longitudinal timbers situated on top of the floor timbers supports the limber boards between the keelson and the stringer. The transversal timbers, 13 cm sided and 12 cm molded, are butted against the keelson and nailed to the top of the floor timbers with two iron nails. The longitudinal timbers, 14.5 cm sided and 10.5 cm molded, are placed between the keelson and the stringer and appear to be nailed to the transversal ones. There is only one longitudinal timber near the bow whose outer side end overlaps with the forward inner side of a second timber that continues up to the floor timbers of the master frame. However, a row of slightly concave notches on the transversal timbers would indicate the presence of another longitudinal timber between this longitudinal timber and the keelson, although only the outer one survived.

The port side first stringer is visible near the ship's bow and has a preserved 8–9 cm thickness and 28 cm width. It is situated on top of the scarf joints, between the floor timbers of the V-shaped frames and their first futtocks. It also presents a notch to insert a sill that protects the space between two first futtocks. Another stringer also appears on top of the scarf joints between the floor timber and first futtocks of the frames aft of the master frame. Although this area of

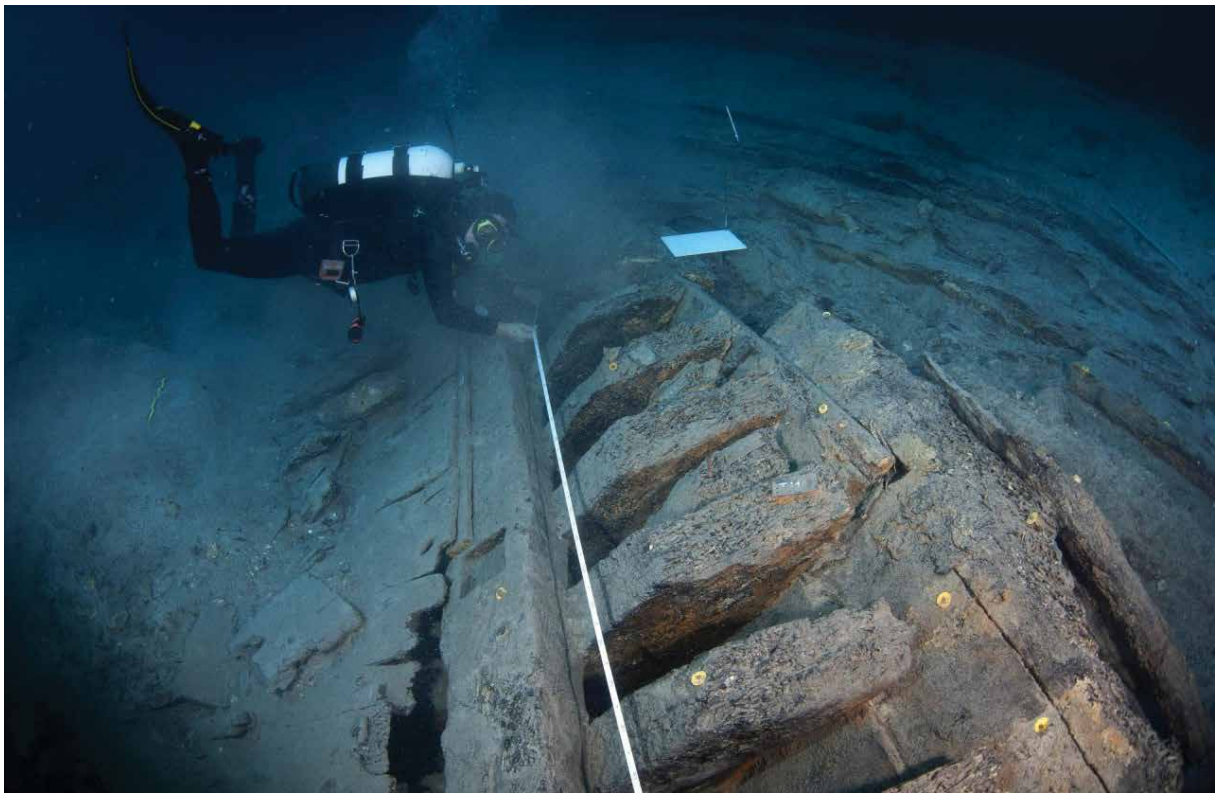

**Fig. 5** Keelson and limber boards, detail (photo: B. Vukičević)


**Fig. 6** Shelf clamp and second stringer on the port side of the bow (orthomosaic: J. L. Casabán)

the hull is still under excavation, the stringer presents a thickness of 10.8 cm and a width of 28 cm. A series of poorly preserved planks are situated immediately to the south of this stringer, although it has not been possible to determine yet if they correspond to the limber boards of the ship's ceiling. A second stringer is also visible on the port area of the bow, located on top of the joint scarf of the first and second futtocks (Fig. 6). This stringer is 27.2 cm sided and 10 cm molded, and its forward end is not preserved.

Finally, a timber situated above the second stringer at the bow was interpreted as a shelf clamp supporting the lower deck's beams (Fig. 6). The clamp is 27 cm sided and has a minimum molded dimension of 9.5 cm. Its upper edge presents a series of dovetail mortises where the 13 cm molded head of the beams are still inserted, with a center-to-center spacing of 39 cm.

## 5. Conclusion

*Santo Hieronimo's* hull features, location of the wreck off the Dalmatian coast in the Adriatic Sea, and the fact that the ship belonged to a merchantman of Ragusan origin could suggest that it was built in a Mediterranean shipyard. However, *Santo Hieronimo's* expanded mast step would indicate the influence of Ibero-Atlantic constructional characteristics in 16th-century Mediterranean-built vessels to be confirmed through the comparative analysis of contemporary hull remains.

It is expected that dendrochronological analysis of several wooden samples from the ship's hull taken in 2021 and the current research at the National Archive of Dubrovnik will also help to confirm the geographical location for the construction of *San Hieronimo*. In addition, and following an experimental methodology proposed by Mauro Bondioli and presented at the ISBSA 16 conference in Zadar (Croatia), a theoretical model of *Santo Hironimo* is currently being developed based on 16th-century historical sources on Mediterranean shipbuilding.[9] This model will be adapted based on the archaeological data recorded during the ongoing excavation of the wreck to provide an accurate representation of the original design and construction of *Santo Hieronimo*.

[9] See the text by M. Bondioli, M. Nicolardi and I. Radić Rossi, published in this book.

## References

Beltrame, C., Gelichi, S., Miholjek, I. (eds) 2014. *Sveti Pavao Shipwreck: A 16th century Venetian merchantman from Mljet, Croatia*. Oxford, Oxbow Books.

Bondioli, M., Salopek, D., Ćosić, S., Radić Rossi, I. 2020. *Kartoznanac Nikole Sagrija, dubrovačkog pomorca / Il Chartigatore di Nicholò Sagri marinaro raguseo* (Let. 2, str. 460). Zadar, Sveučilište u Zadru.

Cazenave de la Roche, A. 2020. *The mortella iii wreck: a spotlight on mediterranean shipbuilding of the 16th century*, [BAR S2976]. Oxford, BAR Publishing.

Crescenzio, B. 1607. *Navtica mediterranea di Bartolomeo Crescentio Romano.* Roma, Appresso Bartolomeo Bonfadino.

Guérout, M., Rieth, E., Gassend, J.-M. 1989. *Le navire génois de villefranche: un naufrage de 1516?*, [*Archaeonautica* 9]. Paris, Centre National de la Recherche Scientifique.

Kisić, A. 1979. Ostaci potonuloga dubrovačkog broda iz 16. stoljeća kraj otoka Šipana. *Anali Zavoda za povijesne znanosti Istraživačkog centra Jugoslavenske akademije znanosti i umjetnosti u Dubrovniku* 17: 73–98.

Kisić, A. 2006. La nave ragusea del XVI secolo sul fondale marino della baia di Suđurađ sull'isola di Šipan. In I. Radić Rossi (ed.), *Archeologia subacquea in Croazia, Studi e ricerche*. Venezia, Marsilio: 127–145.

Mihajlović, I., Jurišić, M. 2010. Pregled podmorskih arheoloških istraživanja na dubrovačkom području od 1997. do 2005. godine. *Izdanja Hrvatskog arheološkog društva* 24. Zagreb, Hrvatsko arheološko društvo: 103–111.

Nicolardi, M. 2014. Misure de navilii, Un nuovo documento di costruzione navale veneziana della seconda metà del XVI secolo. In A. Asta, G. Caniato, D. Gnola, S. Medas (eds), *Navis, Atti del II Convegno Nazionale di Archeologia, Storia, Etnologia Navale, Cesenatico 13–14 aprile 2012*. Padova, Libreria Universitaria: 239–244.

Parica, M. 2009. Stručni očevid na podmorskim arheološkim nalazištima dubrovačkog podmorja. *Obavijesti Hrvatskog arheološkog društva* 40/3: 72–81.

Vekarić, S. 1987. Dva primjera spašavanja broda u XVII i XVIII stoljeću u Dubrovniku. *Adrias: zbornik Zavoda za znanstveni i umjetnički rad Jugoslavenske akademije znanosti i umjetnosti u Splitu* 1: 65–71.

Veyrat, M. 2016. *Le mobilier en plomb dans la marine en bois (XVIe - XIXe siècles): Le cas du littoral français*, PhD Dissertation. Nantes, Université de Nantes.

Villié, P. 1994. *Calvi I.* Genève, De Boccard.