HAL
open science

Sewn Ships from Istria (Croatia): the shipwrecks of Zambratija and Pula

Giulia Boetto, Ida Koncani Uhač, Marko Uhač

To cite this version:

Giulia Boetto, Ida Koncani Uhač, Marko Uhač. Sewn Ships from Istria (Croatia): the shipwrecks of Zambratija and Pula. J. Litwin. Baltic and beyond. Change and continuity in shipbuilding. Proceedings of the fourteenth international symposium on boat and ship archaeology, Gdansk 2015, National Maritime Museum, pp.189-198, 2017. halshs-01977580

HAL Id: halshs-01977580

https://shs.hal.science/halshs-01977580v1

Submitted on 10 Jan 2019

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Baltic and beyond
Change and continuity in shipbuilding

Proceedings of the Fourteenth
International Symposium
on Boat and Ship Archaeology
Gdańsk 2015

Edited by
Jerzy Litwin

National Maritime Museum
Gdańsk 2017

Giulia Boetto, Ida Koncani Uhač and Marko Uhač

26. Sewn Ships from Istria (Croatia): the shipwrecks of Zambratija and Pula

1. Introduction

Three new sewn ships were recently discovered and studied in Istria (Croatia) in the frame of a scientific collaboration between the Archaeological Museum of Istria, the Ministry of Culture of the Republic of Croatia and the Centre Camille Jullian, Aix-Marseille University-CNRS.[1] These discoveries are particularly important for the studies on ancient shipbuilding in Mediterranean as they bring the evidence of the existence and development of an original and local tradition of sewn vessels in the Eastern Adriatic region.

The first shipwreck was found in the cove of Zambratija, south of Savudrija and 2 km north of Umag. It is dated to the Bronze Age and, till now, represents the most ancient example of a sewn vessel in the Mediterranean.

The others two shipwrecks were discovered in the city centre of Pula during a rescue excavation in a wet environment. These two sewn ships (Pula 1 and Pula 2), dated to the Roman Empire, were abandoned within the harbour basin of the ancient Roman colony of Pula (Fig. 1).

Figure 1: Localisation of the sewn ship of Zambratija and Pula in Croatia (drawing V. Dumas, G. Boetto, AMU/CNRS/CCJ)

2. Zambratija

2.1 Discovery, excavation and date

In 2008, the existence of a possible ancient shipwreck in the Zambratija cove, lying in shallow waters at a depth of 2–2.5 m, as well as the presence of a large area of wooden poles, were brought to the attention of the archaeologists of the Archaeological Museum of Istria. The area with pile dwellings (*palafitte*) was situated around a hundred metres from the shipwreck towards the northwest, covering a surface of at least 6,500 m². A few small archaeological trenches revealed that it was mostly frequented in the Early Chalcolithic period (Koncani Uhač, 2009a; 2009b; Benjamin *et al.*, 2011: pp. 194–195; Koncani Uhač and Čuka, 2016).

The short investigation of 2008 indicated without any doubt that the shipwreck of Zambratija was ancient in date as its flush-laid planking was assembled by means of the sewing technique well known in the Adriatic region (Koncani Uhač, 2009b). However, the shape and structure of the assemblages of this vessel were very original and significantly different from the known Adriatic examples of the Roman period.

Thus, the shipwreck was preliminarily surveyed in 2009 in order to confirm the observations previously made and to sample for radiocarbon dating.[2] Due to the interest of the site, the following year a short operation was conducted with the purpose of ensuring a safe coverage of the site. A second sample from the planking was also collected for a new AMS radiocarbon dating.[3]

---

[1] The Ministry of Culture of the Republic of Croatia, the County of Istria, the city of Umag and the Archaeological Museum of Istria supported the research in Zambratija. The company Pula Herculanea Ltd financed the archaeological excavation in Pula. The French Ministry of Foreign Affairs, the University of Aix Marseille and the CNRS supported the fielwork and the post-excavation analyses and studies.

[2] The result of this first conventional radiocarbon date (sample Z-4195, B626), performed by the Institute Ruđer Bošković of Zagreb, indicated a calibrated date between 800–540 BC (Conventional Radiocarbon Age 2535±60 BP, Cal BC 800–540, 68% of probability). In 2013, the same laboratory, after re-calibration, obtained a second date (Conventional Radiocarbon Age 2950±60 BP, Cal BC 1264–1053, 68% of probability) matching with the AMS dates realized in Miami (2013) and Lyon (2015): see *infra*.

[3] Beta Analytics Inc. Miami, Sample Beta-296186, Conventional Radiocarbon Age 2860±30 BP, Cal BC 1120–930, 95% of probability.

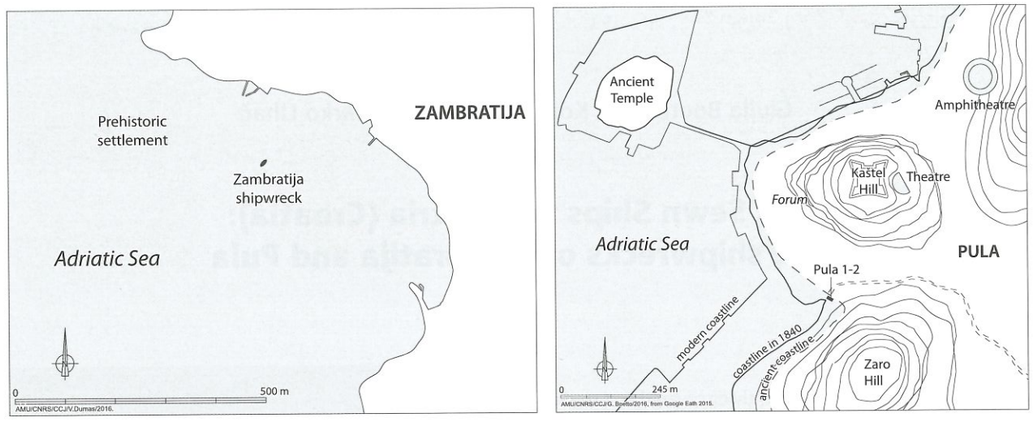

Figure 2: Location of the shipwrecks in Zambratija and Pula (drawing: V. Dumas, G. Boetto, AMU/CNRS/CCJ)

In September 2011, the first archaeological excavation campaign was conducted on the shipwreck (Koncani Uhač and Uhač, 2012; 2014) while two years later the entire remains of the vessel were uncovered (Boetto, *et al*, 2014; Koncani Uhač, *et al.*, 2015; 2017). Under a very thin layer of sand with rhizomes of *Cymodocea*, the wooden structure was exceptionally well preserved. For the protection of the site during the excavation, a metal box (7 m long, 4 m wide, 60 cm high) was expressly built and placed around the trench. Supplied with movable panels, the box could be closed after the daily work or in case of a storm.

After the excavation and the fine cleaning of the wooden structures, the shipwreck was labelled and documented by photogrammetry (with and without the frame) (Fig. 2). The three conserved floor-timbers were also retrieved and separately recorded by photogrammetry. These frames were returned and placed on the shipwreck before the final long-term covering of the site. During the 2013 campaign, the sampling of the shipwreck (wood, pitch, fibres) was also finalized.

Finally, in 2015 the xylological and dendrochronological analyses were completed.[4] A set of four AMS dates was then realised in Lyon-Saclay on the same fragment of plank.[5] The results were cross-dated on the radiocarbon calibration curve by wiggle-matching (Pearson, 1986: pp. 295–296; Ramsey, *et al.*, 2001: pp. 384–385) but, due to the plateau affecting the calibration curve for the period 1210–1140 BC, it was not possible to better define the date.

Although the six radiocarbon dates realised till now on different samples from the planking of the Zambratija vessel offer a large but homogeneous chronological span going from 1288 BC to 930 BC, it is reasonable to consider that the sample with an earlier date is much closer than the others to the felling date of the trees used in the ship construction. So, at the actual stage of the research, the date of the Zambratija vessel could be placed between the last quarter of the 12th century and the second half of the 10th century BC (Beta-296186, Miami, Cal BC 1120–930).

2.2 Description of the conserved remains

The shipwreck of Zambratija is oriented nearly north-south with the preserved extremity of the hull pointing towards the beach. The vessel, when sunk, rested on one side thus the western side is poorly preserved while the eastern side extends to the gunwale (Fig. 2).

The hull remains measure 6.7 m in length and 1.6 m in width at the main section. An axial element or logboat keel base, five strakes of planking on the eastern side and two strakes on the western side, three floor-timbers comprise the shipwreck (Fig. 3).

The position of three more frames has been identified on the planking due to the observation of some rows of plugged holes probably connected to the system of assemblage of the frame. Furthermore, some darker traces on the wood and some evident marks left by the foot of the frames on the inside layer of the pitch clearly indicate the frame stations.

A single piece of wood obtained from a trunk of elm (*Ulmus* sp.) with a diameter of more than 40 cm constitutes the axial element of the vessel. At the main frame, this piece is flat, 3 cm thick, while towards the North its thickness increases to reach 21–23 cm. The width decreases from 39 cm to 6 cm. So, the northern extremity of the log was carved in order to obtain a block with a very sharp shape. Undoubtedly, this important axial piece plays, from an architectural and structural point of view, the role of a keel.

[4] The identification of the wooden species of the three shipwrecks was undertaken by C. Cenzon-Salvayre and A. Ferreira Dominguez at the Mediterranean Institute of marine and terrestrial Biodiversity and Ecology (Aix-en-Provence, France). A. Ferreira Dominguez and F. Guibal also undertook the dendrochonological analyses and the calibration by wiggle-matching.

[5] The four samples (codes Lyon-12422/SacA43732 to Lyon-12425/SacA43735) have been prepared by the *Centre de Datation par le RadioCarbone* of Lyon and the measurements of the C^{14} contents have been realised in Saclay (particle accelerator ARTEMIS).

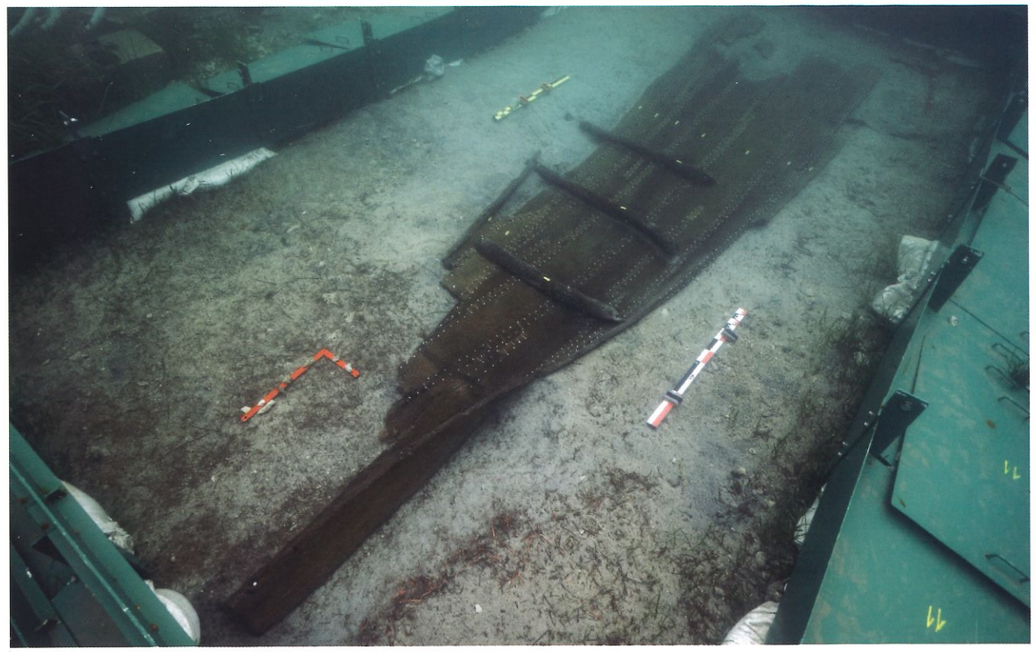

Figure 3: The Bronze Age shipwreck of Zambratija (photo: Ph. Groscaux, AMU/CNRS/CCJ).

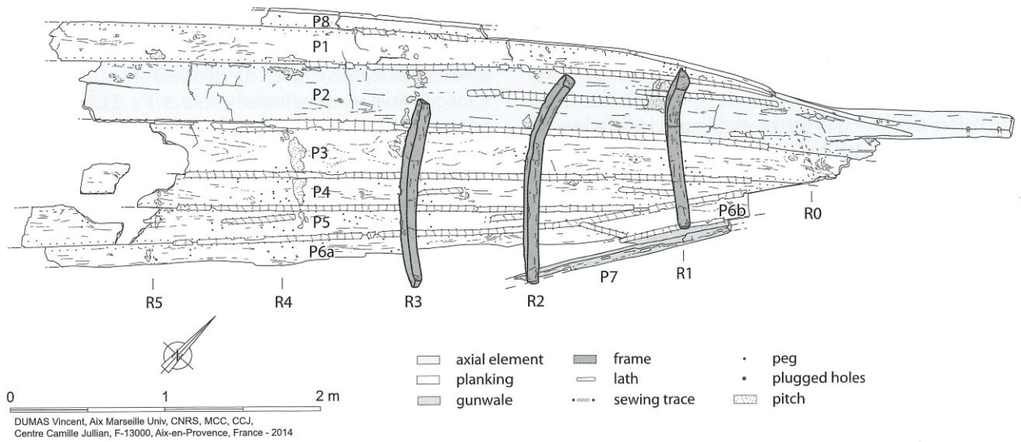

Figure 4: Plan of the shipwreck of Zambratija (drawing: V. Dumas, AMU/CNRS/CCJ).

The planking is made of elm. The strakes are 2.8 cm thick on average, with a maximum width of 32 cm. The second (P4) and the third (P5) strakes are stealers, while two planks connected with an oblique scarf form the fourth strake (P6). The fifth and upper strake (P7) is the gunwale. Its section has an L shape towards the inside of the hull (upper max width 9 cm). This piece includes two (or, possibly, three) open mortises, rectangular in shape measuring 5 and 7 cm for 1 and 1.7 cm, and spaced 20–23 cm. Their function is still uncertain but could be connected with the system of propulsion.

The strakes, which are flush-laid, are connected to each other by a longitudinal sewing system of assemblage. The sewing, made with some vegetal fibres, is not preserved. However, the traces left by the passage of the stiches are clearly visible on the laths put over the seams, before the sewing, and belonging to the water proofing system of the vessel. Two dark lines flank a lighter zone, which corresponds to the passage of the stiches (Fig. 4).

The sewing is made of simple over edge stitches (*///* pattern) going through oblique channels diagonally cut with respect to the plank edges (not perpendicular). The

Figure 5: Detail of the planking with the lath of fir covering the seams. The sewing passages are evidenced by the traces on the lath (photo: Ph. Groscaux, AMU/CNRS/CCJ).

orientation of the sewing is not regular: the stiches are more or less oblique but they are always parallel.

Small tapered and sharped pegs, spaced centre-to-centre at 6 cm on average and mostly made of alder (*Alnus sp.*) and poplar (*Populus* L.), locked the sewing. A thin lath, made of fir (*Abies* sp.), 3–4 cm wide, is put over the seams and before the sewing to set the wadding made of a layer of vegetal fibres inserted between the lath and the planking. This layer is made using some loose vegetal fibres, most of them belonging to the sea-grass plants (*Cymodocea nodosa*).[6] Some cracks in the planking, observed in the axial element and in the planking, were assembled using the same method of sewing. An inside coat of pitch ensured the hull was watertight.

Three floor-timbers obtained from alder and from wild peer tree (*Pirus communis* L.), remained *in situ*. Their eastern arms conserve the top termination, while the western arm is broken. Widely spaced (around 83 cm on average), these floor-timbers have a trapezoidal section with a narrow foot and a rounded and wider upper surface (8.4 cm sided, 11.3 cm moulded on average). The lower face is smooth and shaped to match the inner surface of the planking, while the floor-timbers R1 and R2 are carved with limber holes allowing the circulation of bilge water.

The frames are without internal assemblies (treenails, nails or lashing) and so they were originally lashed to the planking by mean of an external lashing system. This lashing, which did not survive, passed through holes driven obliquely in the planks then locked with pegs.

[6] Identifications done by S. Wicha, Archéobois Ltd. Marseilles and R. Verlaque, Aix Marseille Univ, Univ Avignon, CNRS, IRD, IMBE, France.

Concerning the principles and methods of construction (Pomey, 2004; Pomey and Rieth, 2005: pp. 29–33; Pomey, Kahanov and Rieth, 2012; 2013), there is no doubt that the principle of construction of the vessel of Zambratija is based on a shell concept for the hull structure, and on a longitudinal strake-oriented concept for its shape. The building process is shell first. Indeed this process is the only one compatible with a longitudinal sewing of the planking.

The Zambratija ship, which is the oldest example of a boat entirely sewn ever found in Mediterranean, also corresponds to an unparalleled architectural type of boat. The sewing technique employed for the assemblage of the planking and the related water proofing system, is also unparalleled.

3. The Roman Sewn Ship finds from Pula

3.1 Discovery, excavation, recovery and date

Between 2012 and 2013, the company Pula Herculanea Ltd., in charge of a multi-year project for the construction of rainwater and sewage collectors in Pula, started to work along the waterfront of the city as well as on Flacius Street. This work was supervised by the Archaeological Museum of Istria (Boetto, *et al.*, 2014; Uhač, *et al.*, 2015; Essert, *et al.*, 2016) (Figs 2 and 6).

In February 2013, during the machine-powered excavation of a trench for the collector on Flacius Street, some wooden elements were discovered at a depth of 5 meters below the street surface (-2 m below the actual mean sea level). The trench, oriented east-west parallel to Flacius Street, was 7 m wide. After cleaning, it was possible to recognise the preserved remains of a first sewn shipwreck (Pula 1).

Figure 6: The two Roman sewn ships of Pula within the excavation trench: in the forefront the shipwreck Pula 2, in the background the shipwreck Pula 1 (photo: T. Braiković, AMI)

Based on the afore mentioned archaeological discovery, the Conservation Department of the Ministry of Culture stopped all machine-powered excavation activities, while Pula Herculanea Ltd. contracted the company Kapitel Ltd. to provide technical support for the exploration, including archaeological documentation, and to carry out the lifting and temporary conservation of the ship remains. During this phase, G. Boetto of the Centre Camille Jullian was contacted in order to prepare the technical specifications for the archaeological work to be carried on the shipwreck.

Finally, the archaeological operation in Flacius Street started 1st July 2013. Because of financial and technical constraints, it was decided to continue the machine-powered excavation besides manual excavation in order to remove as quickly as possible the sediments around and over the shipwreck. During this phase, a few metres to the east of the first shipwreck, several more wooden ship elements were unearthed, pointing to the existence of a second shipwreck (Pula 2).

The sewn ships in Pula were found in the layers of a part of Roman harbour, situated southeast of the Roman town *Colonia Iulia Pola* founded in the 1st century BC (Gnirs, 1911; Degrassi, 1942–1943; 1954; Zecchini, 2014). The investigated part of the Roman harbour, because of glacio-eustatic sea level changes, hydrological features and human activities through the past, are located at a distance of around 160 m inwards from the modern coastline, within the actual urban development of the city (Fig. 2). The layers of the harbour were mostly alluvial and originate from the still-active stream, Pragrande, which flows on the southeastern edge of the old city. In Roman times, this part of the Pula port basin was probably a bay on whose southern part (Zaro hill) a large Roman theatre was built, while on the northwestern part the city's seafront was developed (Krizmanić, 2005).

After some serious problems due to the flooding of the site by rainwater and sewage, a new and more effective pumping system was implemented allowing the efficient evacuation of all the water including the salted table water that constantly penetrated the trench. A roof over the trench was built allowing the protection of the site from the rain and sun as well as a system of watering to keep the wood wet. On 19th July, the first phase was completed and the removal of the sediments in direct contact with the wooden structures as well as their fine cleaning started.

Before salvaging, when the fine cleaning was completed, the shipwrecks were prepared for different phases of documentation (labelling). On the basis of a complete geodetic survey with a Total Station (electronic theodolite), a plan and several cross-sections of the shipwrecks *in situ* were drawn. The company Vektra Ltd also undertook a 3D laser scanning and a photogrammetric micro-scanner documentation of the shipwrecks. A professional photograph documented all phases of the fieldwork, as well as details of the architectural features of the vessels. Finally, samples from all the preserved wooden structures of the ships were taken for xylotomic analysis and, several others were collected for dendrochronological studies. Organic materials (wadding pads, sewing, pitch) were also sampled.

Figure 7: Plan of the two Roman shipwrecks of Pula (drawing: V. Dumas, G. Boetto, AMU/CNRS/CCJ).

At the beginning of August, the salvage operation started on the smaller of the two vessels, Pula 2. After the recovery of the frames that were not in their original position, the outer shell, which lay flat and badly damaged on the ancient harbour bottom, was retrieved in sections in accordance with some visible breaks on the hull. The division in sections and their lifting was performed using purpose-built "blades" that were introduced, with the help of knives, underneath the hull in a parallel sequence, each 15 cm. After the "blades" were put in place, they were raised at one end, and a piece of polycarbonate, 10 mm thick, was placed underneath them. Polycarbonate was also used for wrapping, in a sort of sandwich, all lifted ship parts for temporary storage.[7]

In contrast to Pula 2, Pula 1 was retrieved in one piece. After further excavation and preparations, on 6th August the shaping of tunnels started, i.e. transverse trenches underneath Pula 1 at regular intervals of 60–70 cm. In parallel, some temporary supports were put under the hull to prevent any deformations. The frames that were not completely connected to the planks were removed and deposited in a temporary pool.

Two metal girders (made of galvanised iron) were placed parallel to the ship on either sides. These girders were used to support a close set of transverse beams placed at intervals of 40 cm under the shipwreck. This metal frame was used to maintain separate wooden moulds cut according to the outer transverse profile of the vessel. Each board was equipped with a polycarbonate strip, up to 15 cm wide, which directly supported the hull of Pula 1. A total of 17 such transverse moulds were installed.

[7] The impregnation with PEG of Pula 2 started in January 2016 in Grenoble (France) at the laboratory ARC-Nucléart and finished in 2017.

On 19th August, Pula 1 was lifted by a mobile crane and was transported, with the other separate pieces of the hull and the remains of Pula 2, in a pool located in the nearby Uljanik Ltd shipyard for long-term storage in water before the initialisation of the conservation process.

In 2015 the samples of wood were analysed for the identification of the wooden species and for the study of the ring widths (dendrochronology). Two sets of six AMS dates for each shipwreck were then realized in Lyon-Saclay.[8] The results were cross-dated on the Radiocarbon calibration curb by wiggle-matching (Pearson, 1986: pp. 295–296; Ramsey, *et al.*, 2001: pp. 384–385) but, due to the plateau affecting the calibration curve for the period, it was not possible to obtain a precise date for the ships construction. As for Zambratija, we consider that the sample including the more external rings are probably closer to the felling date of the trees used in the ship construction. Unfortunately, these results, which indicate a chronology between 28–214 AD for Pula 1[9] and between 73–226 AD for Pula 2[10], offer a large chronological span. These results match with the date obtained by stratigraphy placing the abandonment of the vessels between the 1st century AD and the first half of the 3rd century AD.[11]

Before the presentation of the main architectural features of the ships of Pula, it is important to note that the excavation trench intercepted both the shipwrecks. Therefore, only the central bottom part of Pula 1 ship was studied, as the two extremities extend beyond the trench sides. On the other hand only one extremity of Pula 2 was preserved underneath Pula 1, while the southern extremity extends beyond the trench side.

3.2 Pula 1

The remains of the sewn ship Pula 1 are 8.1 m long and 4.1 m wide. The transverse section at the main frame has a flat frame with a round turn of the bilge. The longitudinal section is flat. A keel, six strakes on each side, 14 floor-timbers and some fragments of ceiling were found *in situ*. Due to the lack of indicative elements, it was not possible to establish the position of stem and stern.

The keel, rectangular in section without chamfer, 17.5 to 21 cm sided and 17 cm moulded, was made of deciduous oak (*Quercus* sp.). Planks were 2.4 cm thick on average, with a maximum width of 40–49 cm. The garboard strakes were thicker than the other strakes near the keel (3.5 cm). Some repairs were observed too.

Figure 8: The sewing patterns of the Pula 1 sewn ship (top) and of the sewn boat Pula 2 (bottom) (photos: T. Braiković, AMI).

Planks were all made of elm (*Ulmus* sp.) and were sewn to each other. The sewing was made of overedge stitches with a clamping turn (/I/I/I pattern)[12] going through diagonal channels perpendicular with respect to the edges of the planks. The external hole of the channels ended on the edge of the plank forming a rectangular or a trapezoidal notch for the passage of the sewing. The sewing, made of strands of vegetal fibres, passed over a wadding pad (made of vegetal fibres) placed over the seam between planks. Pegs made of fir (*Abies* sp.) and spruce (*Picea*) locked the sewing in the channels at an average space centre-to-centre of 4.6 cm. A thick layer of pitch completed the watertight system. The plank joinery did not include edge inserts, or coaks, but we have to consider that the planking has not been dismantled and, as a result, the planking edges have not been systematically observed.

Concerning the frames, 14 floor-timbers survived *in situ*, and traces of an additional four were identified. The general framing-pattern was of a sequence of floor-timbers. These frames were made of deciduous oak, evergreen oak

[8] The six samples of Pula 1 have the codes Lyon-12426/SacA43736 to Lyon-12431/SacA43741 while the six samples of Pula 2 have the codes Lyon-12432/SacA43742 to Lyon-12437/SacA43747.

[9] *Centre de Datation par le Radiocarbone*, Lyon, code Lyon-12431/SacA43741, Conventional Radiocarbon Age 1900±30 BP, 95,4% of probability, Cal AD 180, 88,5% of probability.

[10] *Centre de Datation par le Radiocarbone*, Lyon, code Lyon-12437/SacA43747, Conventional Radiocarbon Age 1870±30 BP, Cal AD 73-226, 95,4% of probability.

[11] Alba Ferreira Dominguez (PhD candidate, University of Aix Marseille, Centre Camille Jullian) will try to cross-date the dendrochonological curves measured on the Pula shipwrecks with other dendrochonological curves of the region.

[12] This /I/I/I pattern, although with substantial differences in the type of the sewing cords and number of clamping turns, could be similar to the one documented in a photo of a fragment of a plank belonging to a Roman sewn ship found in 1988 in the Canale Anfora in Aquileia (Beltrame and Gaddi, 2013: pp. 297–298, fig. 5).

(*Quercus ilex*), elm and walnut (*Juglans* sp.). Rectangular in section (9.2 sided and 11.7 cm moulded on average), they were spaced on average 35 cm. The frames were connected to the planking by tapered treenails[13] driven from the outer side of the hull. Only one floor-timber (R19) was fixed to the keel by an iron bolt.

The lower face of the frames was modelled with a series of openings above the seams, in order to avoid crushing of the wadding pad. The openings at the level of the bottom were quadrangular in shape and oversized, having the additional function of limber holes. The presence of openings with irregular shapes, sometimes not centred on the seams, together with the large number of treenails on some frames could be ascribed to the reuse on Pula 1 of frames coming from another sewn ship.

Finally, the ship presented a ceiling as well as a mast-step. This mast-step, not preserved, was fitted on the top of the frame and blocked by the two rectangular recesses cut on the northern superior edge of the floor-timbers R13 and R19.

3.3 Pula 2

The remains of the sewn boat Pula 2 are 6.1 m long and 2.1 m wide. The transverse section at the main frame has a flat frame with a round turn of the bilge. The longitudinal section is flat. A keel, eight strakes on the northern side and five on the southern side were found *in situ*. Twenty loose pieces, mostly belonging to the frame but also to the wale strake, were found displaced not only inside the shipwreck, but also around it and underneath Pula 1. Due to the lack of any indicative elements, it was not possible to establish the position of the stem and the stern.

The keel, quadrangular in section with tapered sides and curved external edges, was made of oak (*Quercus* sp.). It was scarfed on the preserved extremity, in order to accommodate a knee made of evergreen oak (*Quercus ilex*). The scarf was secured by a horizontal key, and vertically locked by a treenail coupled with an iron nail.

Planks, some of them repaired, were 1.5–2 cm thick, with a maximum width of 16 cm. The wale was 6.7 cm wide on average and 5.8 cm thick. Two open mortises rectangular in shape (4.2 wide and 1.7 cm thick) and spaced 47 cm were also observed. These holes were probably connected with the system of rowing of the boat.[14]

The planking was very homogeneous and made of beech (*Fagus sylvatica* L.). Differently from Pula 1, the sewing was made of simple overedge stitches (/// pattern) going through diagonal channels perpendicular with respect to the edges of the planks. The sewing, made of strands of vegetal fibres, passed over a wadding pad (also made of vegetal fibres) placed over the seam between planks while little pegs inserted in the channels locked the sewing (average space centre-to-centre of 2.4 cm).[15] The external hole of the channels ended on the edge of the plank forming a rectangular or a trapezoidal notch. Sometimes, the hole was slightly away toward the inside and so a little groove was carved to lodge the stiches on the outer side of the plank. The channels were in this case more vertical than oblique. Only two small edge inserts, or coaks,[16] were observed in the edge of two planks. They were tapered and had a near-square section of 5 x 6 mm for a length of around 7 cm.

An inside and outside coat of pitch completed the water tightness of the hull.

On the planking, the traces of 11 frame stations spaced at a distance of 40 cm were identified. The displaced frames, mostly made of deciduous oak,[17] were composed of floor-timbers, one cant floor and some futtocks. Rectangular in section (4.8 cm sided and 7.5 cm moulded on average) and crenelated on the lower face, they were connected to the planking by tapered treenails[18] and some copper nails.

The Pula 2 shipwreck is significantly similar to the sewn shipwreck Caska 1 found in the island of Pag and dated to the second half of the 1st century AD (Čelhar 2008; Radić Rossi, 2008; 2010; 2011; Radić Rossi and Boetto, 2010; 2011; Boetto and Radić Rossi, 2014 and in this volume). The resemblances between Caska 1 and Pula 2 are very strong and concern not only the structure and shape but also the choice of the wood used in the construction. The sewing technique is also similar to the one observed on the three shipwrecks found in Zaton, the ancient harbour of Aenona (today Nin) and dated to the 1st century AD (Brusić, 1968; Brusić and Domjan, 1985; Gluščević, 2004).

Finally, the hull-structure of the two vessels from Pula was based on a shell-first concept, and its shape was based on a longitudinal strake-oriented concept. The smaller one, Pula 2, can be identified as a coastal transport boat, 9–10 m long and probably propelled using both oars and sail. On the other side, Pula 1 can be identified with a small sailing ship around 15 m long.

4. Conclusions

Since the first discoveries in the years 1950–1980 of sewn ships in Adriatic, in Italy in Cervia (Ravenna), Pomposa and Comacchio (Ferrara) (Bonino, 1968; 1971; 1985) and in Dalmatia in Zaton (Brusić, 1968; Brusić and Domjan, 1985) and since the reassessment of previous findings such as the Lipe sewn barge discovered in the 19th century in Slovenia (Salemke, 1973), new discoveries have supplemented the corpus of the Adriatic sewn ships.

This corpus is particularly rich in both the North-western and Eastern Adriatic. In North-western Adriatic, from the Po delta to Aquileia, besides the numerous scattered fragments of Roman sewn ships (Beltrame, 2000; 2002a; 2002b; Tiboni, 2009; 2017; Capulli and Pellegrini, 2010; Beltrame and Gaddi, 2013; Willis and Capulli, 2014 and in this volume), at least three well-preserved Roman and Late-Roman shipwrecks of bottom-based river sewn vessels have been studied recently (Corte Cavanella 2: Beltrame 2000; 2002a; 2002b; Stella 1: Castro and Capulli, 2016; Santa Maria in Padovetere: Beltrame and Costa, 2016 and in this volume). Equally, several new shipwrecks of coastal keeled sewn ships, of the Roman period, were discovered in Eastern Adriatic, in Caska, island of Pag (see *supra* and Boetto and Radić Rossi in this volume), and in Zaton (Gluščević, 2004).

The recent discoveries of Zambratija and Pula add new data to this rich corpus of the Adriatic sewn ships. In particular, the Zambratija shipwreck sheds new light on the Verrius Flaccus testimony (in Festus, *De Verborum significatu*, 508, 33) where he mentioned that the term *serilia* indicates the name of vessels used by the Histrians and Liburnians.

This shipwreck of Zambratija put in evidence the origin, the existence and the development of a local tradition of sewn vessels in the Eastern Adriatic region of pre-Roman origin (Boetto and Rousse, 2011; 2012; Pomey and Boetto forthcoming). This Eastern Adriatic tradition of sewn vessels is original and independent of the other known ancient shipbuilding traditions, which employed the sewing as a technique in Mediterranean (Pomey, 1985; Marlier, 2005; Pomey and Boetto, forthcoming).

[13] Made with 6 different types of woods (*Cornus* sp., *Olea europeae, Pinushalpensis/pinea/brutia, Quercus ilex/coccifera, Quercus sp., Rosaceae maloïdeae*).

[14] G. Boetto observed a similar feature on the wale the Toulon 2 boat (France, 1st c. AD). For the *horeia* type vessels of Toulon see Boetto, 2009.

[15] The pegs are in majority made of fir (*Abies* sp.), but the use of spruce (*Picea* sp.) is attested too.

[16] Wood from the family of the *Anacardiaceae* R. Br.

[17] But also with elm (*Ulmus* sp.), maple (*Acer* sp.) and beech.

[18] Made by 5 different types of woods (*Cornus* sp., *Olea europeae, Quercus ilex/coccifera, Quercus sp., Rosaceae maloïdeae*).

Bibliographical references

Beltrame, C., 2000. *Sutiles naves* of Roman Age. New Evidence and Technological Comparisons with pre-Roman Sewn Boats. In: J. Litwin (ed.), *Down the River to the Sea, Proceedings of the 8th International Symposium on Boat and Ship Archaeology, Gdańsk 1997*. National Maritime Museum, Gdańsk, pp. 91–92.

Beltrame, C., 2002a. Le *sutiles naves* romane del litorale alto-adriatico. Nuove testimonianze e considerazioni tecnologiche. *Archeologia Subacquea. Studi, ricerche, documenti* III, Poligrafico Zecca dello Stato, Rome, pp. 355–358.

Beltrame, C., 2002b. Sewn plank boats of the Roman era in the Upper Adriatic sea: new evidence. In: H. Tzalas (ed.), *Tropis VII, Proceedings of the 7th International Symposium on Ship Construction in Antiquity, Pylos 1999*. Hellenic Institute for the Preservation of Nautical Tradition, Athens, vol. 1, pp. 103–113.

Beltrame, C. and Gaddi, D., 2013. Fragments of Boats from the Canale Anfora of Aquileia, Italy, and Comparison of Sewn-Plank Ships in Roman Era. *IJNA* 42.2, pp. 296–304.

Beltrame, C. and Costa, E., 2016. A 5th-Century-AD Sewn-Plank River Barge at St Maria in Padovetere (Comacchio-FE), Italy: interim report. *IJNA* 45.2, pp. 253–266.

Benjamin, J., Bekić, L., Komšo, D., Koncani Uhač, I. and Bonsall, C., 2011. Investigating the Submerged Prehistory of the Eastern Adriatic: progress and prospects. In: J. Bejamin, C. Bonsall, C. Pickard, A. Fischer (eds), *Submerged Prehistory*. Oxbow, Oxford, pp. 193–206.

Boetto, G., 2009. New archaeological evidences of the *Horeia*-type vessels: the Roman Napoli C shipwreck from Naples (Italy) and the boats of Toulon (France) compared. In: R. Bockius (ed.), *Between the seas. Transfer and Exchange in Nautical Technology. Proceedings of the 11th International Symposium of Boat and Ship Archaeology (ISBSA 11), Mainz, 2006*. RGZM Tagungen Bd 3, Verlag des römisch-germanischen Zentralmuseums, Mainz, pp. 289–296.

Boetto, G., Koncani Uhač, I. and Uhač, M., 2014. Navires de l'âge du Bronze à l'époque romaine en Istrie. In: P. Pomey (ed.), *Ports et Navire dans l'Antiquité et à l'époque byzantine. Dossiers d'Archéologie* 364, pp. 22–25.

Boetto, G. and Radić Rossi, I., 2014. Au large de la Dalmatie. Nouvelles recherches d'archéologie navale. In: P. Pomey (ed.), *Ports et Navire dans l'Antiquité et à l'époque byzantine. Dossiers d'Archéologie* 364, pp. 52–55.

Boetto, G. and Rousse, C., 2011. Le chaland de Lipe (Ljubljana, Slovénie) et la tradition de construciton « sur sole » de l'Europe sud-orientale: quelles influences méditerranéennes? In: G. Boetto, P. Pomey and A. Tchernia (eds), *Batellerie Gallo-romaine. Pratiques régionales et influences maritimes méditerranéennes*. BiAMA 9, Errance-Centre Camille Jullian, Paris-Aix-en-Provence, pp. 179–191.

Boetto, G. and Rousse, C., 2012. Traditions régionales d'architecture navale en Adriatique à l'époque romaine. *Histria Antiqua* 21, pp. 427–441.

Bonino, M., 1968. Tecniche construttive navali insolite nei reperti di Cervia, Pomposa e Pontelagoscuro. In: *Atti del Convegno Internazionale di Studi sulle Antichita di Classe, Ravenna 1967*. A. Longo, Ravenna, pp. 209–217.

Bonino, M., 1971. Ricerche sulla nave romana di Cervia. In: *Atti del III Congresso Internazionale di Archeologia Sottomarina, Barcelona 1961*. Istituto di Studi Liguri, Bordighera, pp. 316–325.

Bonino, M., 1985. Sewn Boats in Italy: *sutiles naves* and barche cucite. In: S. McGrail and E. Kentley (eds), *Sewn Plank Boats*. BAR, Int. Series 276, B.A.R., Oxford, pp. 87–104.

Brusić, Z., 1968. Istraživanje anticke luke kod Nina. *Diadora* 4, pp. 203–210.

Brusić, Z. and Domjan, M., 1985. Liburnian Boats: their construction and form. In: S. McGrail and E. Kentley (eds), *Sewn Plank Boats*. BAR, Int. Series 276, B.A.R., Oxford, pp. 67–85.

Capulli, M. and Pellegrini, A., 2010. Tavole cucite dall'isola di San Francesco del Deserto (Venezia). In: S. Medas, M. D'Agostino, and G. Caniato (eds), *Archeologia, Storia e Etnografia navale, Atti del I Convegno Nazionale, Cesenatico, 2008*, Navis 4, Edipuglia, Bari, pp. 263–266.

Castro, F. and Capulli, M., 2016. A preliminary report of recording the Stella 1 Roman River barge, Italy. *IJNA* 45.1, pp. 29–41.

Čelhar, M., 2008. The underwater interdisciplinary project in Caska bay, Pag island. In: I. Radić Rossi, A. Gaspari and A. Pydyn (eds), *Proceedings of the 13th Annual Meeting of the European Association of Archaeologists, Session: Underwater Archaeology, Zadar 2007*. Croatian Archaeological Society, Zagreb, pp. 176–186.

Degrassi, A., 1942–1943. La data della fondazione della colonia romana di Pola. In: *Atti dell'Istituto Veneto di Scienze, Lettere ed Arti, Classe di Scienze morali e Lettere* 102, 2. Ferrari, Venezia, pp. 667–678.

Degrassi, A., 1954. I porti romani dell'Istria. *Atti e memorie della Società istriana di archeologia e storia patria* 5, pp. 24–81.

Essert, S., Koncani Uhač, I., Uhač, M. and Šoštarić, R., 2016. Plant remains and amphorae from the Roman harbour under Flacius Street in Pula (Istria, Croatia), *Archaeological and Antropological Sciences*, pp. 1–17.

Gluščević, S., 2004. Hydroarchaeological excavation and the discovery of the third "sewn" Liburnian ship – seriliae – in the roman port of Zaton near Zadar. *Archaeologia Maritima Mediterranea* 1, pp. 41–52.

Gnirs, A., 1911. Forschungen in Istrien. *Jahreshefte des Österreichischen Archäologischen Instituts* 14, pp. 188–194.

Koncani Uhač, I., 2009a. Podvodna arheološka istraživanja u uvali Zambratija / Underwater Archaeological Researches in Zambratija Cove. *Histria Antiqua* 17, pp. 263–268.

Koncani Uhač, I., 2009b. Zambratija – uvala. *Hrvatski arheološki godišnjak / Croatian Archaeological Yearbook*, 5/2008, pp. 396–398.

Koncani Uhač, I. and Čuka, M., 2016. Doprinos poznavanju podmorskog eneolitičkog nalazišta u Zambratija / The underwater Eneolithic site at the Zambratija Cove: A Contribution to Knowledge. *Histria Archeologica*, 46/2015, pp. 25–73.

Koncani Uhač, I. and Uhač, M., 2012. Prapovijesni brod iz uvale Zambratija – Prva kampanja istraživanja / Prehistoric Boat from Zambratija Cove – The First Campaign of Exploration. *Histria Antiqua* 21, pp. 533–538.

Koncani Uhač, I. and Uhač, M., 2014. La barca protostorica di Zambratija/Zambratia in Istria: risultati preliminari della prima campagna di scavo. In: A. Asta, G. Caniato, D. Gnola and S. Medas (eds), *Archeologia, Storia e Etnografia navale, Atti del II Convegno Nazionale, Cesenatico, 2010*, Navis 5, Libreria Universitaria, Padova, pp. 29–33.

Koncani Uhač, I., Uhač, M. and Boetto, G., 2015. Arheološka istraživanja prapovijesnog broda iz Zambratije. In: *Rezultati arheoloških istraživanja na prostoru šibensko-kninske županije, Šibenik 2015*. Abstracts Book, Hrvatsko Arheološko Društvo, Šibenik, pp. 17–18.

Koncani Uhač, I., Boetto, G. and Uhač, M., 2017. *Zambratija. Prapovijesni šivani brod / Prehistoric sewn boat / Una barca cucita reistorica / Un bateau cousu préhistorique*. Katalozi edukacijskog odjela, Arheološki muzej Istre, Pula.

Krizmanić, A., 2005. Prostorni razvitak austrijske Pule. In: M. Bertoša, *Pula: Tri tisućljeća mita i stvarnosti: tri tisuće godina povijesti Pule*. Biblioteka Histria Croatica, C.A.S.H., Pula, pp. 113–192.

Marlier, S., 2005. *Systèmes et techniques d'assemblage par ligatures dans la construction navale antique méditerranéenne*. PhD Thesis, Université de Provence Aix-Marseille 1, Aix-en-Provence (unpublished).

Pearson, G.W., 1986. Precise calendrical dating of known growth-period samples using a "curve fitting" technique. *Radiocarbon* 28, pp. 292–299.

Pomey, P., 1985. Mediterranean Sewn Boats in Antiquity. In: S. McGrail and E. Kentley (eds), *Sewn Plank Boats*. BAR, Int. Series 276, B.A.R., Oxford, pp. 35–47.

Pomey, P., 2004. Principles and methods of construction in ancient naval architecture. In: F. M. Hocker and C. A. Ward (eds), *The Philosophy of Shipbuilding. Conceptual approaches to the study of wooden ships*. Texas A&M University, College Station, pp. 25–36.

Pomey, P. and Boetto, G., forthcoming. Ancient Mediterranean Sewn Boats Traditions. *IJNA*.

Pomey, P. and Rieth, E., 2005. *L'archéologie navale*. Errance, Paris.

Pomey, P., Kahanov, Y. and Rieth, E., 2012. Transition from Shell to Skeleton in Ancient Mediterranean Ship-Construction: analysis, problems, and future research. *IJNA* 41.2, pp. 235–314.

Pomey, P., Kahanov, Y. and Rieth, E., 2013. On the Transition from Shell to Skeleton. *IJNA* 42. 2, pp. 434–438.

Radić Rossi, I., 2008. Caska – podmorje. *Hrvatski arheološki godišnjak / Croatian Archaeological Yearbook*, 4/2007, pp. 371–373.

Radić Rossi, I., 2010. Caska – podmorje. *Hrvatski arheološki godišnjak / Croatian Archaeological Yearbook*, 6/2009, pp. 467–469.

Radić Rossi, I. 2011. Caska – podmorje. *Hrvatski arheološki godišnjak / Croatian Archaeological Yearbook*, 7/2010, pp. 483–487.

Radić Rossi, I. and Boetto, G., 2010. Arheologija broda i plovidbe: šivani brod u uvali Caski na Pagu – Istraživačka kampanja 2009. / Archeologia navale: il relitto cucito nella baia di Caska sull'isola di Pag – Campagna di scavo 2009. *Histria Antiqua* 19, pp. 299–304.

Radić Rossi, I.and Boetto, G., 2011. Šivani brod u uvali Caska na Pagu – Istraživačka kampanja 2010. / Il relitto cucito nella baia di Caska sull'isola di Pag – Campagna di scavo 2010. *Histria Antiqua* 20, pp. 505–513.

Ramsey, C.B., van der Plicht, J. and Weninger, B., 2001. "Wiggle matching" radiocarbon dates. *Radiocarbon* 43, pp. 381–389.

Salemke, G., 1973. Die Ausgrabung eines Binnensee Transportschiffes. Schiffsarchaeologia von 1890 aus Laidbach, Osterreich (jetzt Ljubljana in Jugoslavia). *Das Logbuch* 9, 1, pp. 21–24.

Tiboni, F., 2009. Chioggia. Località di Motta di Cavanella d'Adige. Le operazioni di scavo e primo studio di un relitto del II-I secolo a.C. *Quaderni di Archeologia del Veneto* 25, pp. 82–84.

Tiboni, F., 2017. The sewn boat from Cavanella d'Adige. Excavation and first analysis. In: J. Gawronski, A. van Holk and J. Schokkenbroek (eds), *Maritime Landscapes, Proceedings of the 13th International Symposium on Boat and Ship Archaeology (ISBSA 13), Amsterdam 2012*. Eelde, pp. 290–295.

Uhač, M., Koncani Uhač, I. and Boetto, G., 2015. Nalazi rimskih šivani brodova u Puli. In: *Rezultati arheoloških istraživanja na prostoru šibensko-kninske županije, Šibenik 2015*, Abstracts Book, Hrvatsko Arheološko Društvo, Šibenik, p. 18.

Willis, S. and Capulli, M., 2014. Putting the Pieces Together. The Laced Timbers of the Venice Lido III assemblage. *INA Quarterly*, 41.4, pp. 10–13.

Zecchini, G., 2014. Pola e Cesare. In: M. Chiabà (ed.), *HOC QVOQVE LABORIS PRAEMIVM. Scritti in onore di Gino Bandelli*. Edizioni Università di Trieste, Trieste, pp. 553–564.

Alice Overmeer

27. A Missing Link in a Period of Change? Preliminary results of shipwreck U34 in Flevoland, the Netherlands

Introduction

Rumours say that when, in 1969, the tenant of an agricultural lot in the newly reclaimed area of Flevoland found some timbers during ploughing, he first tried to pull them out by hand. When that did not work, he tied the timber remains to a big tractor, but still there was no movement. He then tried to pull the timbers out with two tractors, but again he had no success. Finally he decided to call the Archaeological Department of the IJsselmeerpolders Development Authority of the area and inform them about a shipwreck at his lot. A few days later the staff of the Archaeological Department planned a survey, providing the exact location of the wreck and its surviving dimensions. It turned out to be a 30 m-long giant clinker-built vessel lying underneath the surface, tied to the farmer's two tractors.

For a lover of maritime heritage this is a horrible story. But it was good practice in the years after the reclamation of the *Zuiderzee*, an inland sea in the centre of the Netherlands. In the Late Middle Ages and the Renaissance, the Zuiderzee served as a roundabout for ships and brought the Low Countries much prosperity (De Vries and Van de Woude, 1995: pp. 221–225; Van Holk, 2010: pp. 10–14). Unfortunately, it also brought terror: the surrounding coastal areas and islands were regularly ravaged by floods. Therefore, the Zuiderzeeproject was initiated; in 1932 the Zuiderzee was closed off by a 32 km-long dam, the Afsluitdijk, and parts of the Zuiderzee were drained between 1942 and 1968. During draining and ploughing the new land, many shipwrecks were discovered. The area turned out to be the largest ship-graveyard on land in the world! Capacity for systematic archaeological research of all wrecks was missing. Instead, ships were seen as obstacles and many of them were quickly removed (Van Holk, 2014: p. 14). To this day 423 shipwrecks were found in this area, dating from the 13th to 19th centuries, and almost every year a new wreck is discovered (Van Holk, 2014: p. 13).

One of these 423 wrecks is that 30m-long clinker-built giant (Fig. 1). It was named U34, after the agricultural lot in which it was found. In September 1984, a trial excavation was undertaken. The actual excavation and recovery took two seasons in 1986 and 1987 (Oosting and Reinders, 1987; Oosting, 1989). The ship was completely clinker-built, from keel to upper side strakes, and the strakes were connected by rivets.

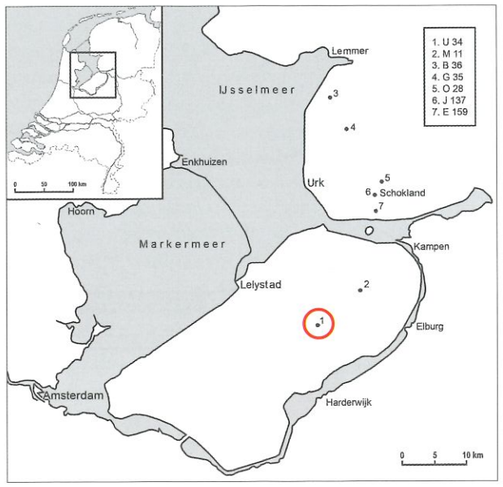

Figure 1: Map of Flevoland/the Netherlands, showing location of wreck U34 (red circle) and other clinker-built shipswrecks (S. Boersma, Groningen University)

Problem definition and research aim

Interestingly, shipwreck U34 dated between AD 1522 and 1537. This falls into a period of which little is known in terms of seagoing ships and shipbuilding. Up until AD 1400 the Hanseatic cogs and cog-like vessels sailed the Zuiderzee. From the end of the 16th century, the flute became the most important sea-going trader of the Dutch Golden Age (AD 1600–1700). In the intermediate period, roughly between AD 1400 and 1600, important changes in ship design took place, for instance enlargement of ships, extension of the rigging, introduction of cannon on board and the transition to carvel construction. However, the kind of ships that accompanied these developments are unknown. Written sources only mention that about AD 1400, the cog was replaced as most important trading vessel by a ship type called the *hulk* (Fliedner, 1969: p. 67). Historical sources about the hulk are not easy to comprehend, and up to now, the type has never been recognised in the archaeological record (Adams, 2013: p. 102). What this hulk looked like, which goods it transported, or at which ports it called, remains unclear.