

Interreg



Co-funded by
the European Union

*CATCHING THE WAVES
OF COOPERATION*

Italy – Croatia



Report

Deliverable 2.1.1

Project Acronym: TOFOLA
Project number: ITHR0200352





Title: **COMMON GUIDELINES FOR THE RECONSTRUCTION
OF WOODEN BOATS**

WP n°	2
Task n°	D. 2.1.1
Author(s)	Centro Consorzi
Contributors	All partners
Type	Report, Document
Dissemination Level	Public
Revision	Final version
Due Date	28/02/2026
Date of submission	



Italy – Croatia



Table of contents

Document Overview.....4

1. Introduction5

2. General conservation principles6

 2.1. Authenticity: Materials and Techniques6

 2.2 Use, Context, and Territorial Authenticity6

 2.3 Documentation and Transparency.....6

 2.4 Assessment of Significance and Conservation Strategy7

 2.5 Minimum Intervention, Reversibility, and Compatibility7

3. Examination and methodology8

 3.1 Documentation Standards (HAER/HABS)8

 3.2 Accuracy and Reliability8

 3.3 Levels of Accuracy9

 3.4 Operational Survey Workflow.....10

 3.5 Photographic and Graphic Standards10

4. Construction features and materials12

5. Technical details and drawings13

 5.1 Required drawing set13

 5.2 Graphic conventions14

6. Accessibility and Adaptations for Persons with Disabilities and Older Adults.....15

Conclusion17

Annex A- Guidelines For Reconstruction Of Historic Boats – Italian Boat (Author: Belisama Yatch, on behalf of LP CC and PP8 LAG)

Annex B- Guidelines For Reconstruction Of Historic Boats – Croatian Boat (Author: PP5 MARSERVIS)

Annex C- Sustainable Reconstruction Methodology And Technical Approach – Croatian Boat (Author: PP6 PFRI)



Italy – Croatia



Document Overview

The guidelines presented in this document define a solid and shared methodological framework for the conservative reconstruction of traditional wooden boats within the TOFOLA project. The integration of the principles of the Venice Charter and the Barcelona Charter with the standards of National Historic Ships UK and HAER/HABS ensures interventions that are culturally authentic, technically reliable, and fully traceable.

The combination of historical research, significance assessment, and advanced digital tools: photogrammetry, 3D laser scanning, CAD modelling, and digital twins enables accurate documentation and supports informed decision-making. This approach preserves traditional geometries, construction logics, and materials, introducing modern solutions only when necessary for safety, durability, or accessibility. The principles of minimum intervention, reversibility, and recognizability ensure that reconstructed vessels remain legible as cultural assets and compatible with contemporary uses.

The integration of functional systems: deck hardware, sustainable propulsion, safety equipment, and accessibility measures—demonstrates how traditional boats can be responsibly adapted for inclusive and environmentally conscious tourism without compromising their historical identity.

The annexes accompanying the document expand and operationalize the methodological framework, offering complementary perspectives ranging from technical-scientific insights to operational shipyard procedures, as well as solutions oriented toward sustainability and accessibility. Together, they form an applied repertoire that enables the translation of general principles into effective and replicable practices.

Through this integrated structure, the TOFOLA project promotes the long-term sustainability of Adriatic maritime heritage by combining traditional craftsmanship, scientific documentation, and contemporary engineering. The guidelines support not only the reconstruction of individual vessels but also the transmission of skills, the strengthening of local value chains, and the development of responsible tourism products in the cross-border area. In doing so, they contribute to preserving the cultural identity of the territory and making it accessible, innovative, and inclusive for future generations.



1. Introduction

This document defines the shared technical and methodological framework developed by the TOFOLA partnership for Deliverable 2.1.1, Common Guidelines for the Reconstruction of Wooden Boats. It provides a unified reference for shipyards, operators, trainers, and project partners involved in the restoration, reconstruction, and sustainable use of traditional wooden vessels in the Italy–Croatia cross-border area. The guidelines integrate the principles of the Venice Charter and the Barcelona Charter with the methodological rigor of National Historic Ships UK (NHS UK) and the HAER/HABS documentation standards. This combined approach ensures interventions that respect cultural authenticity while meeting contemporary requirements for safety, accessibility, environmental sustainability, and operational use. The document outlines the fundamental principles of conservation: authenticity of materials and techniques, territorial coherence, minimum intervention, reversibility, and documentary transparency and defines the methodological workflow for surveying and recording traditional vessels. This workflow includes direct measurements, archival research, large-format photography, technical drawings, photogrammetry, laser scanning, and the creation of digital twins to support accurate and replicable reconstruction processes. Three annexes complement the guidelines, offering practical and methodological examples that cover different levels of complexity and purpose:

- **Annex A**, developed by **Belisama Yacht**, presents an advanced methodological approach integrating significance assessment, digital reverse engineering, structural verification, and design choices that are philologically consistent. It is intended for historically significant vessels or for interventions requiring alignment with international standards such as the Barcelona Charter and the NHS UK guidelines;
- **Annex B**, developed by **MARSERVIS**, provides an operational, shipyard-oriented example based on the reconstruction of an Istrian batana. It describes materials, structural components, documentation phases, and the sequence of reconstruction activities, offering a clear and replicable reference for artisans, shipyards, and training contexts;
- **Annex C**, developed by the **University of Rijeka Faculty of Maritime Studies**, introduces a case study dedicated to the sustainable reconstruction of the batana, with particular attention to responsible material selection, low-impact construction techniques, reverse engineering, digital modelling, accessibility, and eco-friendly propulsion solutions. The annex expands the methodological framework by integrating principles of environmental sustainability, circular economy, and inclusiveness.

The main document and its three annexes offer a compact overview of TOFOLA's full methodological range from traditional reconstruction to advanced conservation and digital design while ensuring usability and alignment with international standards. Together, they reinforce the project's core aims: valuing maritime heritage, promoting inclusive and sustainable tourism, and strengthening skills and knowledge transfer across the Adriatic.



2. General conservation principles

The conservation of maritime heritage is grounded in the main international documents dedicated to the protection of cultural assets, in particular the Venice Charter (1964) and the Barcelona Charter (2001). These references define the principles that guide the preservation, restoration, and functional reuse of traditional vessels, recognising them as material and immaterial testimonies of construction techniques, seafaring practices, and territorial identities. Within the TOFOLA project, these principles are integrated with the methodologies of National Historic Ships UK (NHS UK) and the HAER/HABS documentation standards, ensuring interventions that are coherent, technically sound, and fully traceable.

2.1. Authenticity: Materials and Techniques

Conservation must prioritise traditional materials, construction logics, and artisanal techniques, ensuring cultural continuity and historical legibility. The introduction of modern materials or systems is permitted only when necessary for safety or structural stability, provided that:

- it does not alter the historical appearance of the vessel;
- it is supported by technical evidence;
- it remains recognisable and distinguishable from the original.

These criteria are further detailed in Annex A, which illustrates how contemporary materials can be integrated while maintaining philological coherence.

2.2 Use, Context, and Territorial Authenticity

Traditional vessels are inseparable from the cultural landscape and the navigation environments that shaped their form and function. The Barcelona Charter recognises operational use as a conservation strategy: employing traditional boats for cultural, educational, or tourism purposes actively contributes to their safeguarding. Within the TOFOLA project, the Conservation Gateway guides the choice between static conservation and active use, favouring the latter whenever it is compatible with reversibility and historical coherence.

2.3 Documentation and Transparency

Every intervention must be documented in a complete and verifiable manner. The TOFOLA methodology combines traditional and digital tools:

- metric surveys;



Italy – Croatia

TOFOLA

- photogrammetry and 3D laser scanning;
- CAD modelling and digital twins;
- photographs and drawings compliant with HAER/HABS standards;
- verification of plans and historical sources.

This integrated approach ensures traceability and reproducibility, allowing a clear distinction between original elements and contemporary interventions. Applied examples are presented in Annex A and Annex C.

2.4 Assessment of Significance and Conservation Strategy

Before defining any intervention, it is necessary to identify the vessel's "cultural DNA" through a Statement of Significance, which analyses:

- historical and material value;
- cultural and associative ties;
- the relationship between form, function, and territory.

This assessment guides design choices, ensuring coherence with the vessel's period of greatest significance and with its historical role. The approach is described in detail in Annex A.

2.5 Minimum Intervention, Reversibility, and Compatibility

Interventions must comply with three fundamental principles:

- **Minimum intervention:** avoid unnecessary replacements and preserve as much original material as possible;
- **Reversibility:** ensure that introduced elements can be removed without damaging the historic structure;
- **Compatibility:** guarantee that modern materials and systems do not compromise structural behaviour, aesthetics, or historical legibility.

These criteria apply to structural repairs, material replacements, integration of functional systems, accessibility solutions, and safety equipment. Practical applications are documented in Annex B and Annex C.



3. Examination and methodology

The examination and documentation of traditional wooden vessels form the methodological foundation of the reconstruction process adopted by TOFOLA. In line with the Barcelona Charter, the NHS UK guidelines, and the HAER/HABS standards, surveying must ensure accuracy, transparency, and full traceability, thereby supporting well-grounded conservation decisions and the creation of reliable digital resources for future interventions.

The methodology integrates traditional surveying techniques with advanced digital tools—photogrammetry, 3D laser scanning, CAD modelling, and digital twins—to precisely record geometries, construction logics, and historical transformations. This combined approach enables reverse engineering, structural verification, and the preservation of traditional forms, including the asymmetries typical of Adriatic vessels. Applied insights are illustrated in Annex A and Annex C.

3.1 Documentation Standards (HAER/HABS)

Documentation begins with the identification of the vessel's significant elements through historical research, archival plans, photographic sources, and oral testimonies. The survey follows the HAER/HABS distinction between:

- **Photography:** materials, textures, surface conditions, construction details, and mechanical apparatus;
- **Technical drawings:** hull geometry, structure, joints, systems, and construction logics.

Representations prioritise clarity and technical legibility, documenting the vessel's actual condition unless historical evidence justifies the reconstruction of an earlier configuration.

3.2 Accuracy and Reliability

Accuracy is a central requirement of the HAER/HABS standards and is further reinforced through the use of digital tools.

Photography:

- avoid perspective distortions;
- ensure complete coverage;
- include metric scales;



Italy – Croatia



- provide clear and traceable captions.

Technical drawings:

- be based on complete survey notes and verified measurements;
- integrate photogrammetry and laser scanning;
- declare instruments, tolerances, and non-accessible areas;
- verify and cite any pre-existing plans.

Digital tools and reverse engineering

As described in Annex A, the digital workflow includes:

- 3D laser scanning;
- high-resolution photogrammetry;
- CAD modelling;
- digital twins for hydrodynamic and structural analyses;
- reverse engineering to reconstruct missing elements and verify symmetries.

3.3 Levels of Accuracy

Depending on the vessel's significance and the objectives of the intervention, documentation may be produced at three levels:

- **Level I – High accuracy:** for vessels of exceptional historical value; requires complete surveys and minimal tolerances;
- **Level II – Intermediate accuracy:** for restoration and operational use; combines direct measurements with digital surveys;
- **Level III – Basic documentation:** records general form and main characteristics, also relying on simplified surveys.

The selected level must be stated in the documentation package.



Italy – Croatia



3.4 Operational Survey Workflow

The TOFOLA survey process follows a structured sequence that integrates artisanal expertise with engineering tools:

- **Survey planning:** objectives, instruments, safety, preliminary assessment;
- **Field notes:** sketches, reference measurements, annotations on deformations and structural conditions;
- **Metric survey:** direct measurements, photogrammetry, laser scanning, detailed inspections;
- **Photographic documentation:** context, general views, details, mechanical systems, deterioration;
- **Archival research:** historical plans, photographs, technical documents, testimonies;
- **Data processing:** technical drawings, CAD models, digital twins, descriptive sheets;
- **Structural verification:** integration of modern standards (e.g., ISO 12215-5) without altering traditional construction logic;
- **Archiving and metadata:** organisation according to international standards to ensure preservation and accessibility.

Operational workflow examples are illustrated in Annex B.

3.5 Photographic and Graphic Standards

Photography

Photographic documentation must ensure quality, consistency, and long-term reusability. Images must:

- include metric scales;
- minimise distortions;
- prioritise orthogonal shots;
- be accompanied by complete metadata (progressive number, description, date, location, author, orientation).
-



Italy – Croatia



Technical drawings

Drawings must be organised into clear and standardised plates, featuring:

- graphic scales;
- significant dimensions;
- standardised symbols;
- explicit orientations;
- annotations on materials, joints, structural elements, and modern additions.

The plates must be legible, consistent, and useful both for reconstruction and for long-term conservation planning.



4. Construction features and materials

The construction of traditional Adriatic wooden boats reflects a balance of artisanal knowledge, territorial identity, and adaptation to local maritime conditions. Within TOFOLA, these features are documented, preserved, and complemented when needed by modern solutions that improve safety, durability, and operability without compromising cultural coherence.

Traditional vessels used locally sourced woods chosen for strength and resistance to saltwater: oak for keels, floors, and frames, and larch or pine for planking and secondary elements. Structural continuity and flexibility were ensured through joints such as mortise-and-tenon, scarfs, and dovetails, essential for navigating shallow and variable waters.

In line with the Barcelona Charter and Annex A, modern materials may be introduced when required for structural stability or long-term safety, provided they are technically justified, visually compatible, clearly distinguishable, and respectful of traditional construction logic. Silicon bronze (C65500) is particularly suitable for hardware and reinforcements in hypersaline environments, offering high corrosion resistance and a historically coherent appearance.

All interventions must follow principles of minimal invasiveness and reversibility: new structural or functional components must be removable without damaging the historic fabric, including planking repairs, frame replacements, backing plates, and integrations of propulsion or safety systems. Annexes B and C provide practical examples.

Protective treatments should combine traditional aesthetics with improved environmental performance. While pitch and pigmented oils historically sealed and darkened hulls, modern coatings may be used when they faithfully reproduce these finishes and maintain historical legibility.

Through this balanced approach traditional craftsmanship, carefully selected materials, and strict compatibility criteria TOFOLA ensures that reconstructed vessels remain structurally sound, safe to operate, and culturally authentic, preserving the technical and identity-based heritage of Adriatic seafaring.



5. Technical details and drawings

5.1 Required drawing set

In accordance with HAER standards, the technical documentation of a traditional vessel is not limited to a few descriptive drawings, but consists of a coherent set of plates which, when read together, allow for a full understanding of the vessel's geometry, structure, and historical development. For this reason, the documentation should include at least the following plates:

- **Lines Plan:** Represents the overall geometry of the hull through profile, plan, and body sections. It forms the basis for any hydrostatic analysis, symmetry verification, and study of deformations over time. It is the primary reference for potential reconstructions or comparisons with historical plans;
- **Construction Plan:** Illustrates the structural framework of the hull, including keel, floors, frames, stringers, and the main load-bearing elements. This plate is essential for understanding the vessel's structural behavior and for planning restoration work or the replacement of deteriorated components;
- **Deck Plan:** Shows the layout of the deck, passageways, openings, hatches, and functional elements (seating, rudder, bitts, equipment). It is crucial both for interpreting the organization of onboard spaces and for adaptations related to safety or accessibility;
- **Sections and Profiles:** Include transverse and longitudinal sections at significant points of the vessel (e.g., bow, midship section, engine area, stern). They allow the reader to understand volume distribution, thicknesses, the position of structural elements, and changes in form along the hull's length;
- **Joinery Details:** Depict details of joints, connections, planking, fastenings, bracing, and fixing systems. They are fundamental for preserving traditional construction knowledge and for guiding interventions that respect historical techniques and original structural logic;
- **Rigging Plan (where applicable):** Describes masts, sails, standing and running rigging, attachment points, and the general layout of the sail plan. It is important both for philological reconstructions and for any adaptations required by safety regulations, without compromising traditional coherence;
- **As-built drawings:** Represent the actual condition of the vessel at the time of the survey, including deformations, historical modifications, previous repairs, and modern additions. These plates do not depict the "ideal" vessel but its concrete state; they constitute a key document for the traceability of interventions and for assessing future restoration needs.



Italy – Croatia



Together, these plates provide a comprehensive understanding of the vessel from geometric, structural, and functional perspectives, enabling the integration of historical conservation requirements with operational and regulatory needs.

5.2 Graphic conventions

For technical documentation to remain truly usable over time, the drawings must follow standardized graphic conventions. This ensures that designers, restorers, authorities, and researchers can read and interpret the drawings unambiguously, even many years later.

In particular, it is recommended that:

- **thick lines** be used for the main structural elements (keel, frames, floors, load-bearing bulkheads), highlighting their role and clearly distinguishing them from secondary components;
- **thin lines** describe secondary details, fillets, fittings, and non-structural components, avoiding unnecessary visual weight on the primary scheme;
- **dashed lines** represent hidden or non-visible elements in the given view (e.g., internal structures shown in plan), facilitating a three-dimensional understanding of the hull;
- **graphic scales** be present and legible on every plate, allowing immediate verification of proportions even when reproductions or prints are not perfectly to scale;
- **symbol legends** clearly indicate all symbols used (materials, types of joints, removable elements, new parts compared to the original, etc.);
- **orientation** be explicitly stated (bow/stern, port/starboard), especially in detail drawings, to avoid ambiguity during execution;
- **primary and secondary dimensions** include overall measurements (length, beam, draft, heights) as well as key local dimensions (thicknesses, spacing, relative positions of structural elements).

The systematic adoption of these conventions is not merely a graphic requirement; it contributes to the overall quality of the documentation, facilitating communication among all actors involved in the restoration, reconstruction, and potential replication of traditional vessels.



6. Accessibility and Adaptations for Persons with Disabilities and Older Adults

The University of Padua contributed to the development of this chapter through its expertise in accessibility and inclusive design. The development of accessible and inclusive maritime experiences for persons with disabilities and older adults necessitates a comprehensive understanding of the multifaceted barriers inherent in traditional boat environments. Through various research activities, including desk research, benchmarking existing accessibility solutions, and participatory activities such as interviews and focus groups with nautical professionals and target users, a clear picture has emerged of both the challenges and opportunities involved in adapting traditional wooden rowing boats for universal accessibility.

Physical access represents perhaps the most immediately perceptible obstacle in maritime accessibility. Transitioning from land to water introduces unique challenges that extend beyond conventional architectural impediments. The dynamic nature of aquatic environments, characterized by tidal variations and inherent movement, necessitates boarding solutions capable of accommodating fluctuating height differences while maintaining stability and safety. For traditional wooden vessels, particularly those under seven meters in length, structural constraints limit the practicality of onboard lifting mechanisms; consequently, emphasis is placed on shore-based accessibility infrastructure. Wide gangways with secure handrails are essential, providing the physical framework through which individuals with limited mobility can safely embark and disembark. The choice of mooring approach, whether stern or lateral docking, bears significant implications for accessibility, with each configuration offering distinct advantages contingent upon port infrastructure and tidal conditions.

Beyond the boarding process, the interior spatial organization of accessible boats must be meticulously designed to facilitate movement, comfort, and safety during navigation. Barrier-free circulation pathways enable passengers to move with confidence and independence, while ergonomic seating provides the necessary postural support for extended water journeys. The strategic placement of handrails and support points throughout the vessel acknowledges that balance and stability are continuous concerns rather than challenges limited to the boarding process. These physical modifications should be implemented with sensitivity to the cultural and aesthetic integrity of traditional wooden boat construction, ensuring that accessibility enhancements complement rather than compromise the authentic character of these maritime vessels.

For individuals with sensory impairments, accessibility extends beyond mere physical modifications. Tactile navigation systems, such as specialized flooring and tactile maps, furnish essential orientation cues for those who cannot rely solely on visual information. Auditory feedback mechanisms offer supplementary support, establishing multisensory navigation environments that promote independence and reduce reliance on external assistance. The integration of assistive technologies emphasizes the understanding that accessibility is a multifaceted concept, necessitating tailored solutions to accommodate diverse needs.



Italy – Croatia



Material choices also have implications beyond functionality; the preference expressed by many users for traditional wooden surfaces over metal alternatives underscores the significance of tactile comfort and psychological reassurance provided by familiar, natural materials.

The human dimension remains equally critical in accessibility provision. The presence of adequately trained crew members, cognizant of the diverse needs of passengers with disabilities, transforms accessibility from mere physical accommodation to genuine inclusion and support. Maintaining a minimum of two to three crew members on boats reflects not only navigational requirements but also the practical necessity of providing meaningful assistance through dedicated human attention. This focus on trained personnel emphasizes a fundamental principle: infrastructure and technology create conditions for accessibility, but human understanding and responsiveness are essential in translating those conditions into positive, dignified user experiences.



Figure 1. Key accessibility features on board: side-boarding ramp, external handrails, ergonomic lateral bench, and tactile flooring.

The insights from nautical specialists, persons with disabilities, and senior citizens collectively highlight that accessibility issues within maritime settings are not restricted to particular user groups but constitute universal design challenges relevant to a wide range of functional profiles. Therefore, advancing accessible traditional wooden boats presents an opportunity to not only address individual differences but also foster inclusive maritime experiences.



Italy – Croatia



Conclusion

The guidelines presented in this document provide a coherent, rigorous and operational framework for the conservation-oriented reconstruction of traditional wooden boats within the TOFOLA project. By integrating the principles of the Venice Charter and the Barcelona Charter with the methodological standards of National Historic Ships UK and HAER/HABS, the document establishes a shared foundation that ensures cultural authenticity, technical reliability and full transparency throughout the reconstruction process.

The combined use of historical research, significance assessment and advanced digital tools photogrammetry, 3D laser scanning, CAD modelling and digital twins enables accurate documentation and supports informed decision-making. This approach ensures that traditional geometries, construction logics and material characteristics are preserved, while allowing the introduction of modern solutions where required for safety, durability or accessibility. The principles of minimal intervention, reversibility and recognisability guide every adaptation, ensuring that reconstructed vessels remain legible as cultural artefacts and compatible with contemporary operational needs.

The integration of functional systems deck hardware, sustainable propulsion, safety equipment and accessibility measures demonstrates how traditional vessels can be responsibly adapted for inclusive and environmentally conscious tourism. These interventions, when designed according to the criteria outlined in the guidelines, enhance usability without compromising historical identity.

Annex A and Annex B complement the methodological framework by providing concrete and replicable examples. The reconstruction of the Istrian batana illustrates practical workshop procedures, material selection and documentation workflows, while the Belisama Yacht guidelines offer an advanced model for significance assessment, digital reverse engineering and philologically consistent design choices. Together, they demonstrate how the general principles of the document can be translated into effective shipyard practice.

Through this integrated structure, the TOFOLA project promotes the long-term sustainability of maritime heritage by combining traditional craftsmanship, scientific documentation and contemporary engineering. The guidelines support not only the reconstruction of individual vessels but also the transmission of knowledge, the strengthening of local skills and the development of responsible tourism products across the cross-border Adriatic region. In doing so, they contribute to preserving the cultural identity of the territory while enabling its innovative and inclusive use for future generations.

- End of the document -





ANNEX A: GUIDELINES FOR RECONSTRUCTION OF HISTORIC BOATS –
Italian Boat
(Author: Belisama Yacht on behalf of LP CC and PP8 LAG)



Italy – Croatia



Table of contents

Document overview3

1. Introduction4

2. Methodological Framework and Significance.....5

 2.1 Significance and conservation gateway.....5

 2.2 Intervention philosophy.....5

3. Preliminary Documentation and verification.....6

 3.1 Documentation and digital reverse engineering.....6

 3.2 Structural verification and respect for traditional construction6

4. Equipment and functional systems7

 4.1 Deck hardware and mooring systems.....7

 4.2 Sustainable propulsion and mechanical systems.....7

 4.3 Safety and regulatory equipment7

5. Accessibility and inclusive tourism8

6. Aesthetics, maintenance and knowledge transfer9

 6.1 Aesthetics finishes and visual authenticity9

 6.2 Documentation and knowledge transfer.....9

Conclusion10



Document overview

This annex outlines the methodological approach adopted by Belisama Yacht for the reconstruction and adaptive reuse of traditional wooden vessels within the TOFOLA project. The guidelines establish a coherent framework that combines recognised European conservation principles with technically robust practices, ensuring that interventions respect the cultural value of historic boats while enabling their contemporary operational use.

The reconstruction process is guided by an initial assessment of the vessel's historical and functional identity its "cultural DNA" developed through a structured evaluation of significance. This assessment supports the project's strategic orientation toward active use, consistent with Article 5 of the Barcelona Charter, which states that "making use of traditional ships for some socially useful purpose always facilitates their preservation."

The document also clarifies the role of advanced technical documentation in supporting accurate reconstruction and the careful integration of modern systems. As noted in the text, interventions follow "the principles of least intervention, reversibility and recognisability," ensuring that upgrades remain compatible with the vessel's historic character.

Finally, the annex emphasises the long-term dimension of conservation, highlighting the importance of systematic documentation and knowledge transfer. These elements are treated as essential to maintaining both the technical integrity and the cultural continuity of reconstructed vessels throughout their operational life.



Italy – Croatia



1. Introduction

For the drafting of the guidelines and best practices for Deliverable 2.1.1 of the TOFOLA project, Belisama Yacht mainly referred to the Barcelona Charter and to Conserving Historic Vessels, published by National Historic Ships UK, resulting in a consolidated summary of ideal practices to be followed.

The Barcelona Charter [2], formally known as the European Charter for the Conservation and Restoration of Traditional Ships in Operation, is an informal yet broadly recognized framework that guides maintenance and restoration activities for historic watercraft that continue to operate as active sailing vessels.

“Conserving Historic Vessels” [1] is a comprehensive manual published by National Historic Ships UK that establishes standardized methodologies for the preservation and restoration of historic watercraft, balancing the protection of original fabric with the requirements of operational use.



Figure 1 Traditional Venetian boat navigating along the Grand Canal, an emblematic example of the Adriatic's historic maritime heritage.

[1] Deanna Cunliffe. Conserving Historic Vessels, volume 3 of Understanding Historic Vessels. National Historic Ships UK, 2012.

[2] European Maritime Heritage (EMH). European charter for the conservation and restoration of traditional ships in operation. <https://european-maritime-heritage.org/bc.aspx>, 2003.



2. Methodological Framework and Significance

2.1 Significance and conservation gateway

The ideal reconstruction pathway begins by establishing the vessel's "cultural DNA" through a structured process of historical and technical assessment. A formal Statement of Significance is drafted following the National Historic Ships UK methodology. This statement evaluates the vessel under three main headings: its capacity to demonstrate history through its physical fabric, its associational and cultural links, and the way in which its form contributes to its function. At this stage, a strategic decision is made through what National Historic Ships UK defines as the "Conservation Gateway", namely the choice between preserving the vessel's material fabric in perpetuity or maintaining it in operational use. For TOFOLA, the operational use pathway is prioritised. As stated in Article 5 of the Barcelona Charter, "Making use of traditional ships for some socially useful purpose always facilitates their preservation."

2.2 Intervention philosophy

In accordance with Article 5 of the Barcelona Charter, the use of traditional vessels for socially useful purposes, such as sustainable and inclusive tourism, is recognised as a fundamental mechanism for their preservation. At the same time, any modification must not significantly alter the external layout of the craft. Consistently with the NHS-UK approach, every new installation follows the principles of least intervention and reversibility, ensuring that the vessel can, if necessary, be returned to an earlier configuration without damaging the historic fabric.



3. Preliminary Documentation and verification

3.1 Documentation and digital reverse engineering

Scientific documentation constitutes the ethical and methodological foundation of the reconstruction process, as emphasised by Article 7 of the Barcelona Charter. The original vessel is first subjected to a comprehensive recording phase, that includes 3D laser scanning and high-resolution photogrammetry to capture the geometry, deformations, and construction details of the hull. From this data, a digital twin is developed in a CAD environment. This model allows also for the analysis of hydrodynamic behaviour and long-term structural deformations. For example, this process ensures that the reconstruction retains the distinctive “asymmetry” characteristic of Venetian traditional craft, such as gondolas and bragozzi, which is often lost in generic replicas.

3.2 Structural verification and respect for traditional construction

For vessels intended for commercial or touristic use, traditional construction is integrated with modern structural verification. Hull dimensions and structural elements are checked against ISO 12215-5 (Small craft — Hull construction and scantlings), ensuring that traditional materials and forms can withstand contemporary operational loads. This technical integration is carried out without compromising the vessel’s traditional proportions or the “balance of its composition,” as required by Article 11 of the Barcelona Charter. Joinery techniques prioritise continuity with historical practice using traditional scarf joints, including hooked and nibbed forms. Where historically appropriate, mild steel fastenings may be employed. However, modern materials such as silicon bronze are introduced where safety and durability require it. In all cases, new elements remain intentionally distinguishable from original construction, in accordance with Article 10 of the Charter, so that the reconstruction does not falsify historical evidence.



4. Equipment and functional systems

4.1 Deck hardware and mooring systems

All deck hardware is designed to satisfy the dual requirement of mechanical resistance for professional operation and philological consistency with Venetian maritime tradition. While traditional materials are preferred wherever possible, the controlled use of modern alloys such as silicon bronze (C65500) is considered justified under Article 8 of the Barcelona Charter. This offers superior durability in the hypersaline conditions of the Venetian Lagoon and develops a natural patina that harmonises with timber surfaces, avoiding the aesthetic dissonance associated with polished stainless steel. In accordance with Article 7 of the Barcelona Charter, the formal design of components such as bitts and fairleads derives from systematic historical research. Their geometry is developed from three-dimensional scans of original artefacts conserved at the Venetian Naval Museum, ensuring that newly manufactured hardware preserves the aesthetic DNA of the local maritime tradition. From a structural standpoint, and in line with NHS-UK technical guidance, all new fittings are through-bolted and reinforced with internal backing plates in larch or bronze.

4.2 Sustainable propulsion and mechanical systems

The transition to electric or hybrid propulsion is treated as a process of functional evolution rather than substitution. Modern propulsion systems are required to remain visually distinguishable from the original fabric, in accordance with Article 10 of the Barcelona Charter. In accordance with NHS-UK guidance on stability and performance, electric motors and battery banks are positioned as low as possible within the bilge, allowing them to function as permanent ballast. Mechanical integration follows NHS-UK technical recommendations for vibration control: elastomeric damping mounts and flexible couplings are mandatory to isolate motor vibrations from the wooden hull.

4.3 Safety and regulatory equipment

Compliance with contemporary maritime safety codes, including the Italian Nautical Code Annex V, is achieved through solutions that minimise visual and spatial intrusion. Following NHS-UK recommendations, life-saving appliances such as life rafts, personal flotation devices, and fire extinguishers are housed within custom-built wooden lockers. In accordance with Article 10 of the Barcelona Charter, safety equipment must remain immediately accessible while being visually secondary. Emergency signage is therefore integrated through laser-engraved wooden panels or etched brass plates.



5. Accessibility and inclusive tourism

The TOFOLA project applies the NHS-UK Creating Access for All standards. In line with Article 11 of the Barcelona Charter, adaptations for persons with reduced mobility are permitted provided they do not detract from the vessel's traditional setting. Boarding ramps are constructed from marine-grade aluminium structures sheathed in thin-cut larch veneers. For the safety of elderly passengers and persons with reduced mobility, removable silicon bronze stanchions equipped with hand-spliced hemp or manila ropes are installed as handrails. To allow wheelchair circulation, selected thwarts are designed to be modular or removable, maintaining full reversibility.

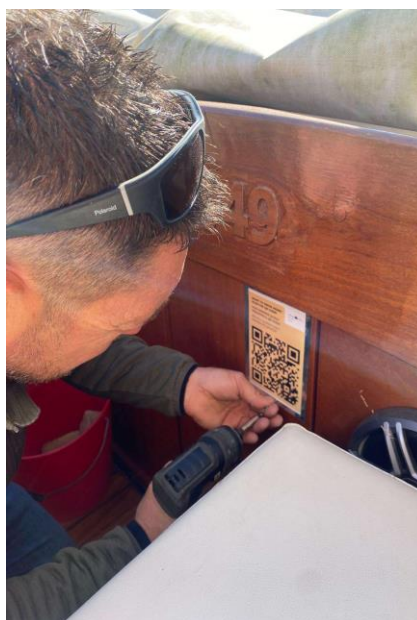


Figure 2 Installation of the access measures for boarding the vessel and of the QR code for accessing digital information.



6. Aesthetics, maintenance and knowledge transfer

6.1 Aesthetics finishes and visual authenticity

The visual identity of the Venetian working fleet is recognised as a fundamental component of its cultural significance. In accordance with Article 9 of the Barcelona Charter, restoration does not necessarily aim to reproduce the vessel's launch condition, but a period of greatest historical value. Historically, black surfaces were achieved using pitch; TOFOLA maintains this aesthetic using traditional pigmented oils or modern water-based coatings that faithfully reproduce the matte appearance. Colour schemes, particularly black and ochre, are selected to remain philologically consistent.

6.2 Documentation and knowledge transfer

In accordance with Article 12 of the Barcelona Charter, all phases of adaptation are documented through analytical reports supported by technical drawings and photographic records. This ensures future conservators can distinguish between original fabric and TOFOLA project interventions. Finally, the shipyard delivers contextualised manuals for operators, ensuring that knowledge transfer becomes an integral component of conservation, ensuring continuity of best practice throughout the vessel's operational life.



Italy – Croatia



Conclusion

The guidelines presented in this annex provide a coherent and operational framework for the reconstruction and adaptive reuse of historic wooden boats within the TOFOLA project. By integrating the principles of the Barcelona Charter with the methodological rigor of National Historic Ships UK, the document establishes a balanced approach that safeguards cultural authenticity while enabling contemporary, socially valuable use.

The reconstruction pathway outlined here demonstrates how traditional craftsmanship, scientific documentation, and modern engineering standards can coexist without compromising the vessel's historical integrity. Digital surveying, structural verification, and philologically consistent design choices ensure that each intervention remains both technically robust and culturally respectful. At the same time, the controlled introduction of modern systems—propulsion, safety equipment, accessibility solutions—shows how functional upgrades can be implemented in a reversible and visually coherent manner.

The guidelines also highlight the importance of long-term sustainability, not only in terms of materials and maintenance practices but also through knowledge transfer. Systematic documentation, operator manuals, and the preservation of traditional skills ensure that reconstructed vessels can continue to operate safely while remaining legible as cultural artefacts.

Overall, the document provides a replicable model for heritage-aligned reconstruction, demonstrating that historic boats can be effectively preserved through responsible use, informed technical choices, and a clear commitment to cultural continuity.

- End of the document -





ANNEX B: GUIDELINES FOR RECONSTRUCTION OF HISTORIC BOATS -
Croatian Boat
(Author: PP5 MARSERVIS)





Italy – Croatia



Table of contents

Document overview3

1. Introduction4

2. Materials5

3. Wooden boat structure5

4. Joints and fasteners6

5. Drawings6

6. Wooden boat reconstruction process9

7. Equipment of an old boat9

8. Minimum safety equipment to be installed10

9. Accessibility adaptations for persons with disabilities10

10. Testing and commissioning10

11. Reconstruction photos11

Conclusion16



Document overview

This document presents the practical guidelines developed by MARSERVIS for the reconstruction of a traditional wooden vessel, specifically an Istrian batana. It has been included as Annex A to Deliverable 2.1.1 in order to provide a concrete, operational example that complements the methodological and conservation principles described in the main document.

While Deliverable 2.1.1 defines the shared framework for documentation, material selection, structural assessment and reconstruction criteria applicable to all traditional Adriatic boats, the present annex illustrates how these principles can be translated into real shipyard practice. The document describes the materials used, the structural components of a wooden boat, the recommended documentation workflow, and the step-by-step reconstruction process, supported by photographic evidence.

Its purpose is to offer a replicable reference for shipyards, craftsmen and operators involved in the restoration of traditional vessels, ensuring that interventions remain consistent with historical authenticity while meeting contemporary safety and functional requirements. Although based on the example of a batana, the procedures and considerations presented here are relevant to a wide range of small wooden boats typical of the Adriatic region.



1. Introduction

The reconstruction of historical wooden boats represents an important contribution to the preservation of maritime heritage, traditional craftsmanship, and cultural identity of coastal communities. Traditional vessels such as batana were built using locally available materials and techniques developed over centuries.

This technical elaboration provides comprehensive guidelines for the reconstruction of historical wooden boats, ensuring:

- Structural safety;
- Historical authenticity;
- Durability and sustainability;
- Accessibility and modern safety compliance;
- Testing and commissioning.

The document covers materials, technical drawings, construction methods, reconstruction processes, equipment, accessibility adaptations, documentation procedures, and commissioning tests.



2. Materials

Materials used for reconstruction must comply, as much as possible, to original materials used for building

Keel	Oak, elm	High strength, moisture resistance
Frames (ribs)	Oak, acacia	Flexibility and durability
Hull planking	Pine, larch, cedar	Easy processing, water resistance
Decking	Pine, teak	Wear resistance

All wood should be properly seasoned through natural air drying (12-24 months) or controlled drying to minimize deformation.

However, it is allowed to use modern materials, provided that:

- they are necessary to ensure structural stability or navigational safety;
- their effectiveness is supported by scientific data and practical experience;
- they do not falsify the vessel's historical appearance;
- they remain clearly distinguishable from the original elements.
-

This is particularly important for vessels intended for public use, such as those employed in tourism, educational activities, or social initiatives. Safety, in fact, cannot be compromised, and functionality must be ensured without betraying the historical identity of the asset.

3. Wooden boat structure

Basic elements of a wooden boat:

- Keel – Primary longitudinal bottom structure element
- Posts – bow and stern keel ends (vertical)
- Floors – Transverse bottom structural elements
- Frames - Transverse side structural elements
- Deck beams - Transverse deck structural elements



Italy – Croatia



- Planks – Plating and decking

4. Joints and fasteners

Traditional wooden joints (preferred):

- Mortise and tenon;
- Dovetail joints;
- Wooden dowels and wedges.

Modern fasteners may be used discreetly:

- Copper nails and rivets;
- Bronze screws;
- Stainless steel bolts (where structurally necessary and hidden).

To ensure longevity, the following protective systems are recommended:

- Flaxseed oil impregnation;
- Traditional tar application for underwater hull sections;
- Natural oil-based paints and varnishes;
- Marine antifouling coatings below the waterline.

5. Drawings

It is advisable to obtain original drawings before going into reconstruction process. The reconstruction itself should also be documented with drawings and annotations of basic elements as well as connection details. Transparency is essential to ensure the traceability of interventions and to enable future research or restoration work.

Drawings should include

- Overall length (LOA)
- Beam width (B)



Italy – Croatia

TOFOLA

- Draft (T)
- Freeboard height
- Lines plan
- Basic structural elements with dimensions
- Hull transverse and longitudinal sections
- Keel and sternpost sections
- Keel to frame connections
- Plank to frame fastenings
- Deck to hull interfaces

Main drawing to be produced is the General Arrangement Plan which illustrates the overall configuration of the vessel and includes profile view, deck layout, equipment location, seating layout



Italy – Croatia

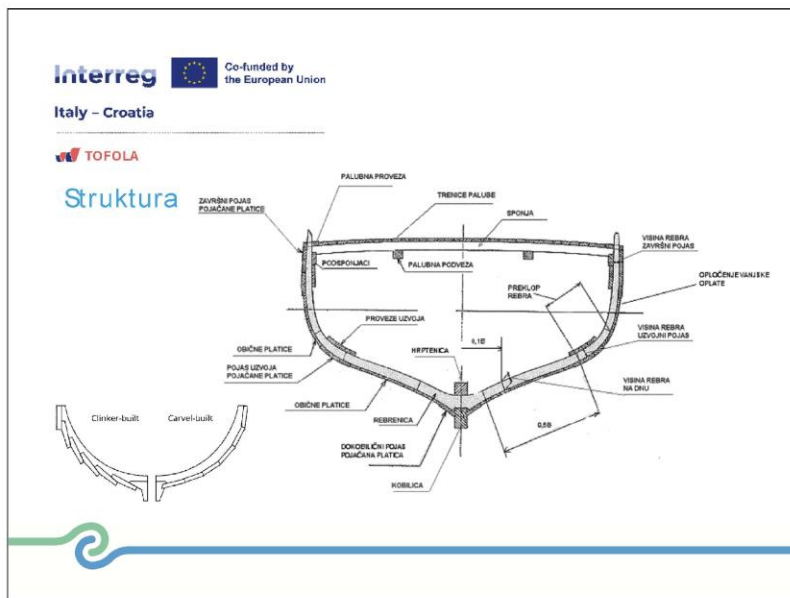


Figure 1 Overlapping connection - Butt joint.

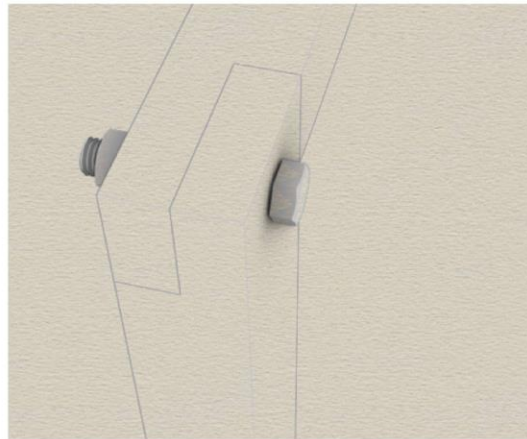


Figure 2 Notch connection - Half lap joint.



6. Wooden boat reconstruction process

First step in reconstruction of a historical boat needs to be investigation. How was the boat used, how was it build, with what tools and materials, what were the techniques used in building, carving the wood, joining different parts.

Reconstruction should be made as much as possible as was the original boat. Minimal interventions should be used to satisfy current regulations.

Reconstruction of wooden boats goes on in following steps:

- Dismantling all equipment;
- Documenting and photographing of all equipment taken off;
- Removing old paint;
- Removing rotten wood;
- Tailoring new elements and impregnating them;
- Attaching new elements to existing structure;
- Protection of all wooden structure;
- Final painting;
- Equipment installation.

7. Equipment of an old boat

- Wooden oars;
- Seating benches;
- Mooring additions;
- Mooring ropes.



8. Minimum safety equipment to be installed

- Life jackets;
- Manual bilge pump or bucket;
- Anchor.

Safety equipment depends on size of the vessel as well as purpose and local rules and regulations so be sure to advise the Authorities on minimum requirements.

9. Accessibility adaptations for persons with disabilities

To promote inclusive use while respecting historical integrity all adaptations should be reversible and minimally invasive.

Some of the construction adaptations which can be done are:

- Stable boarding platforms or ramps;
- Davits on board or on shore;
- Lowered and secured seating;
- Handrails along the sides;
- Non-slip deck surfaces.

10. Testing and commissioning

After the reconstruction it is necessary to inspect all work and full functionality of the boat. Minimum to carry out is the visual inspection of surfaces, surface finish, joints and fasteners. Additionally, all test which need to be carried out according to applicable rules are to be conducted in the presence of the authority representative. Those might include load testing, watertightness testing, stability testing and calculations, performance and manoeuvrability assessment.



11. Reconstruction photos



Figure 3 Batana before reconstruction.





Figure 4 Rotten elements taken off, new elements fitting.



Figure 5 Impregnation of new elements.



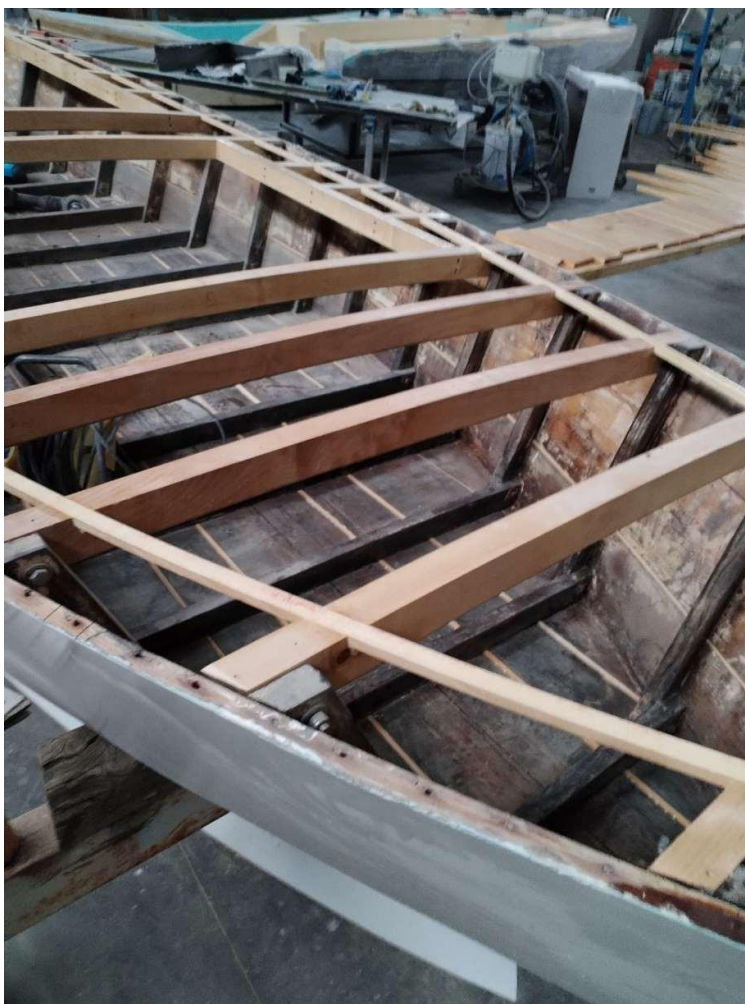


Figure 6 Installation of new elements.





Figure 7 Protection of reconstructed and mounted elements.



Italy – Croatia



Conclusion

The reconstruction of the Istrian batana presented in this annex demonstrates how traditional wooden-boat restoration can be carried out in a manner that is both respectful of historical authenticity and fully compatible with contemporary safety and functional requirements. By combining traditional craftsmanship, appropriate material selection and a transparent documentation workflow, the process illustrates a practical application of the methodological principles outlined in Deliverable 2.1.1.

Although the example refers to a specific vessel type, the operational steps, structural considerations and documentation practices described here are broadly applicable to many small wooden boats typical of the Adriatic region. As such, this annex is intended to support shipyards, craftsmen and operators in adopting a consistent, replicable and conservation-oriented approach to reconstruction activities.

Through this contribution, the TOFOLA project reinforces the transmission of traditional maritime knowledge while promoting sustainable and responsible use of historic vessels within contemporary cultural and tourism contexts.

- End of the document -





**ANNEX C: SUSTAINABLE RECONSTRUCTION METHODOLOGY AND
TECHNICAL APPROACH - Croatian Boat**
(Author: PP6 PFRI)





Italy – Croatia



Table of contents

Document Overview..... 1

1. Introduction 2

2. The Batana Boat And Its Historical Significance 4

 2.1 Sustainability and environmental considerations in reconstruction and exploitation6

 2.2 Selection and sourcing of wood for Batana construction..... 8

 2.3 Structural and functional design considerations 11

3. Reverse Engineering And Digital Modelling Approach..... 13

4. Boat Assembly Process And Construction Stages 15

5. Blending Tradition And Innovation In Batana Boat Reconstruction 17

6. Innovations For Sustainability And Inclusivity: Accessibility, Eco-Friendly Solutions, And Sustainable Propulsion 19

 6.1 Enhancements for accessibility and inclusive use..... 19

 6.2 Sustainable propulsion systems and low-impact solutions..... 20

Conclusion 22

References..... 23



Document Overview

The document “D2.1.1 Annex C: Sustainable Reconstruction Methodology and Technical Approach (Case Study: Istrian Batana)” defines the technical, methodological and sustainability framework for the reconstruction of the traditional Istrian Batana boat within the TOFOLA project. Prepared under the leadership of the University of Rijeka, Faculty of Maritime Studies, it establishes the strategic rationale for linking maritime heritage preservation with sustainable tourism development in the Northern Adriatic cross-border area. The document positions the Batana reconstruction not simply as a restoration activity, but as a structured intervention that integrates cultural revival, environmental responsibility and innovation, contributing to the broader objective of diversifying tourism flows and valorising shared historical traditions rooted in Adriatic shipbuilding.

The core of the document provides a comprehensive technical elaboration of the reconstruction process, beginning with the historical and structural characteristics of the Batana and progressing into detailed specifications for sustainable material selection, certified timber sourcing, and environmentally responsible construction techniques. It addresses wood species selection, preparation methods such as air-drying and steam bending, low-impact assembly processes, and lifecycle considerations to ensure durability and minimal ecological footprint. Structural and functional design principles are analysed in depth, including hull configuration, framing systems, fastening methods and stability requirements, while also outlining how modern reinforcements and protective treatments can be discreetly integrated without compromising historical authenticity. Reverse engineering and digital modelling techniques, including 3D scanning and CAD-based documentation, are introduced as tools to ensure geometric precision, reproducibility and long-term preservation of technical knowledge.

In its final sections, the document expands the reconstruction framework to encompass inclusivity and sustainable operation, detailing accessibility adaptations, ergonomic enhancements, and safety improvements designed to enable broader public use in eco-tourism contexts. It further explores sustainable propulsion solutions, maintaining traditional rowing and sailing modes while assessing the integration of electric systems powered by renewable energy sources. The assembly process, finishing treatments, testing procedures and environmental safeguards are systematically described, embedding circular economy principles and responsible waste management throughout the boat’s lifecycle. Overall, the document presents the Batana reconstruction as a demonstrative model of how traditional maritime craftsmanship can be revitalised through a technically rigorous, environmentally conscious and socially inclusive approach aligned with contemporary sustainability standards.

The Annex C is based on a published peer reviewed scientific paper, namely Aksentijević, S., Tijan, E., Vrhovski, D. and Jardas, M., 2025. Journal of maritime & transportation sciences, 65, pp.153–173.



1. Introduction

The TOFOLA project [1] has been designed to generate sustainable (economically, environmentally and socially) tourist products based on the historiography of shipbuilding during the Serenissima Republic of Venice, in order to diversify the current tourist services in the Northern Adriatic area and promote underexploited destinations. A main challenge the project aims to address is the diversification of touristic flows aimed at ensuring equal access to tourist destinations and cultural heritage [2].

To face this challenge, the TOFOLA project starts from the notion that the area represented by the coastal provinces of the Veneto Region, the Friuli Venezia Giulia and Istria Regions has got a strong history, characterised by the supremacy of the Serenissima Republic of Venice that determines a very culturally rich environment to be exploited for tourism purposes.

The project intends to contribute to the development of the cross-border area starting from what represent the 'intangible' and shared foundations: the historical memory and local traditions of the above-mentioned regions. These, however, are not intended as mere evidence of the past or museum material, but as a means to bring people back, in an active and aware manner, to those waterways that have given so much contribution to the area and that are now largely underused, starting from the historical forests (of the plain in Veneto region, Cansiglio in Friuli Venezia Giulia region and Montona in Istria region) and their timber, which, today as then, provides for the construction of historical and traditional boats that will be used for tourism purposes. The project intends to achieve this objective by bringing together local citizens and workers around a project that allows the recovery of the past by connecting it to the present and the future, with creativity and innovation.

The reconstruction of traditional wooden boats offers an opportunity to preserve maritime heritage while embracing sustainable practices in shipbuilding. Throughout history, wooden boats have been integral to coastal communities, serving purposes ranging from fishing and trade to transportation and cultural identity. However, the rise of industrial shipbuilding and modern materials such as fiberglass and metal have led to the decline of traditional shipbuilding techniques and a loss of craftsmanship. Today, there is a growing interest in reviving these boats, not only for their historical significance but also as part of sustainable tourism and environmentally friendly maritime practices. The TOFOLA project, an initiative dedicated to the reconstruction of traditional wooden vessels along the Adriatic coast, aims to integrate heritage conservation with innovative and eco-friendly approaches.

The paper starts with detailing the historical and cultural significance of the Batana boat, a traditional wooden fishing vessel integral to the maritime heritage of Rovinj, Croatia. It emphasizes the boat's design which is uniquely adapted to the shallow waters of the Adriatic Sea, making it vital for local fishermen.

Following this, the preservation efforts for the Batana boat are discussed, particularly through the Batana Eco-Museum, which is recognized by UNESCO. This museum promotes the continuity of traditional boat-



Italy – Croatia



building techniques and organizes community-centric sailing events, ensuring that the Batana's legacy is sustained for future generations

The third paragraph then shifts to specific sustainable practices in the reconstruction and use of the Batana boat. It explains how sustainable boatbuilding is implemented by selecting environmentally friendly materials and employing low-impact construction techniques. The use of certified wood, natural sealants, and recycled materials emphasizes the project's commitment to minimizing environmental impacts.

Next, the text delves into the sourcing and selection of wood for constructing the Batana, maintaining historical accuracy while integrating modern sustainability standards. The selection of appropriate timber plays a crucial role in balancing historical accuracy with ecological responsibility. This section discusses efforts to source wood from sustainably managed forests, including the use of FSC (Forest Stewardship Council) [3] and PEFC (Programme for the Endorsement of Forest Certification) [4] certified timber, as well as the potential of reclaimed or repurposed wood to reduce environmental impact.

Further, the discussion in the next paragraph extends to the structural and functional design considerations in the Batana's reconstruction. It covers the detailed engineering aspects that ensure the boat is suited for shallow waters while incorporating modern enhancements for durability and functionality.

The paper concludes with a broader look at the reverse engineering and digital modelling techniques used in the Batana's reconstruction. This process involves detailed analysis and 3D documentation of existing Batana boats to preserve their design accurately. The application of CAD and other digital tools facilitates precise reconstruction, ensuring that the Batana remains a functional and sustainable vessel honouring its rich heritage.



2. The Batana Boat And Its Historical Significance

The Batana boat is a traditional wooden fishing vessel deeply rooted in the maritime heritage of Rovinj, a historic town on the western coast of Croatia's Istrian peninsula. With its flat-bottomed design, Batana is uniquely suited for navigating the shallow waters of the Adriatic Sea, particularly in the coastal lagoons and rocky shores surrounding Rovinj. This characteristic made it indispensable for generations of local fishermen, allowing them to reach areas inaccessible to deeper-draft vessels. Figure 1. shows a typical rowing-type Batana boat.



Figure 1 Batana rowing-type boat in Rovinj [5]

Traditionally constructed using local wood from forests in Istria and Veneto, Batana reflects centuries-old craftsmanship, passed down through oral tradition and apprenticeship among shipwrights. The boat's length typically ranges from 4 to 8.5 meters, and it was originally propelled by oars, though many were later adapted for small outboard or inboard engines. The Batana boat is considered an essential part of the cultural identity of Rovinj, as it provided a means of livelihood but also played a role in social and communal traditions, such as regattas and maritime festivities. A wireframe model of Batana is shown in Figure 2.



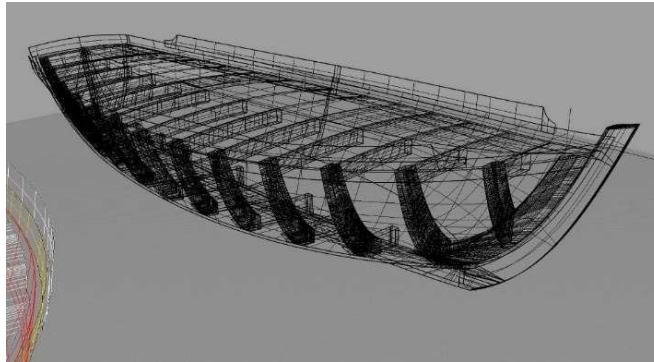


Figure 2 Batana Koštanca – schematic diagram [6]

Despite the advent of modern fishing vessels, Batana remains a symbol of Rovinj's maritime history. Today, it is actively preserved through initiatives such as the Batana Eco-Museum [7], recognised by UNESCO as an example of best practices in preserving intangible cultural heritage. This museum and its associated programs promote Batana-building workshops, community sailing events, and historical documentation, ensuring that future generations remain connected to this maritime legacy. A 3D render of Batana is shown in Figure 3.

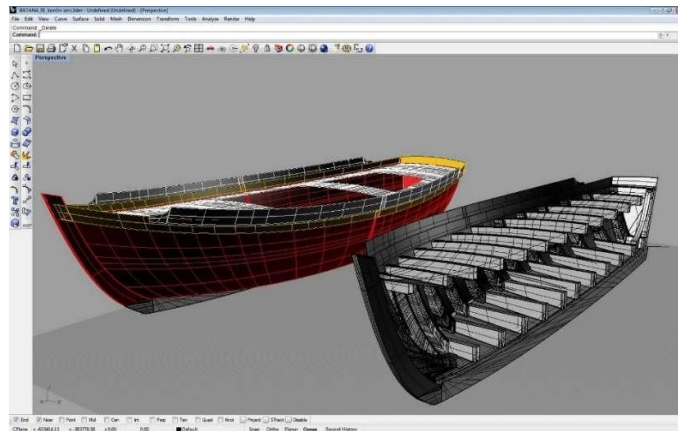


Figure 3 Batana Koštanca – 3D render [8]

The Batana reconstruction as part of the TOFOLA project is more than a technical endeavour. It is a commitment to cultural revival, sustainable tourism, and local craftsmanship. By adhering to historical building techniques while incorporating modern sustainability principles, this initiative will ensure that the Batana boat continues to be a living symbol of Rovinj's seafaring traditions. Therefore, the reconstruction of Batana presents a unique challenge: maintaining the authenticity of traditional craftsmanship while integrating modern building techniques to enhance efficiency, durability, and sustainability. The TOFOLA project aims to strike a careful balance between these two approaches, ensuring that the Batana boat



Italy – Croatia



retains its historical identity while benefiting from advancements in precision, materials, and environmental considerations.

2.1 Sustainability and environmental considerations in reconstruction and exploitation

Sustainable boatbuilding relies heavily on the careful selection of materials, ensuring that environmental impact is minimised while preserving the historical integrity of traditional wooden vessels such as Batana. Historically, these boats were built using locally sourced hardwood (inner construction) and softwood (outer planking), primarily from forests in Istria and the Veneto region. To maintain this authenticity while incorporating modern sustainability principles, the TOFOLA project prioritizes the use of certified sustainable timber, such as FSC or PEFC wood, ensuring that materials come from responsibly managed forests. Additionally, the project seeks to incorporate reclaimed or recycled wood whenever possible, reducing the need for fresh logging and promoting circular economy principles. Recognising the importance of responsible forestry management, sustainable replanting practices will be implemented to compensate for any wood used, maintaining ecological balance in forested areas. Waste minimisation strategies will also be employed, optimising cutting techniques to maximise material efficiency and repurposing wood offcuts for boat components or other applications. Furthermore, to reduce environmental contamination, the project emphasises the use of natural, biodegradable sealants and coatings rather than synthetic chemicals, which can enter into marine ecosystems and cause long-term harm.

The reconstruction of the Batana boat will adhere to low-impact construction techniques, reflecting the eco-friendly nature of traditional shipwright craftsmanship. Historically, wooden boatbuilding has relied on manual skills and simple hand tools rather than industrial-scale manufacturing. The TOFOLA project will continue this practice by prioritising handcrafted techniques over machine-intensive processes, ensuring that boat construction remains sustainable. Non-toxic, water-based adhesives and finishes will replace chemical-laden alternatives, further reducing the ecological footprint of the reconstruction process. To minimise emissions related to transportation and wood procurement, materials will be sourced as locally as possible, and boat assembly will take place in regional workshops close to their intended deployment areas.

The propulsion systems of reconstructed wooden boats are a critical factor in their overall environmental impact. Traditionally, the Batana boat was a rowing and sailing-type vessel, meaning it had zero emissions and operated in harmony with nature. As part of the TOFOLA project's adaptation for modern tourism and accessibility, it is crucial to ensure that any propulsion modifications align with sustainable marine practices. To preserve tradition while minimising emissions, human-powered propulsion, such as rowing, remains the primary propulsion mode. However, the project also explores silent, non-polluting electric propulsion options, powered by renewable sources. Hybrid solutions, which integrate sail, rowing, and electric motors, will be tested to enhance flexibility while maintaining a low environmental footprint. Furthermore, the



Italy – Croatia



establishment of solar charging stations at docking points will enable electric boat batteries to be powered using renewable energy, ensuring that reconstructed Batanas remain carbon-neutral in their operation. By promoting clean energy alternatives, the project actively contributes to preserving marine ecosystems and improving air quality in coastal regions.

Sustainability considerations extend beyond the construction and propulsion of the Batana boat, as its entire life cycle is carefully planned to ensure long-term functionality and minimal waste. Through a Life Cycle Analysis (LCA) approach, the boat will be designed with durability and repairability in mind. When a Batana reaches the end of its functional life, its materials can be disassembled and recovered through recycling, composting, or repurposing, significantly reducing landfill waste. In cases where disposal is necessary, eco-friendly methods will be prioritised, such as biodegradable wood composting or energy recovery from wood waste. By integrating these principles of circular economy, the TOFOLA project will ensure that the Batana's environmental footprint remains minimal throughout its entire lifecycle, from construction to decommissioning.

A major environmental advantage of reconstructing wooden boats like Batana is the significant reduction in marine pollution as they do not use fiberglass or plastic materials. The TOFOLA project enhances this sustainability by ensuring that the boats will not contribute to water contamination, habitat destruction caused by improper docking techniques damaging seagrass beds, or carbon emissions. The project will also focus on community education, hosting workshops, public exhibitions, and collaborations with marine conservation groups to raise awareness about sustainable maritime practices. By advocating for responsible navigation, waste management, and pollution prevention, the TOFOLA project will establish an environmentally conscious approach to maritime heritage conservation.

Beyond its ecological considerations, the TOFOLA project aims to integrate the Batana boat into sustainable tourism initiatives, leveraging its historical significance to promote eco-tourism. The reconstructed Batana will serve as a platform for low-impact tourism activities, offering tourist experiences such as guided rowing tours, cultural storytelling excursions, and noise-free boating. This will ensure that maritime heritage remains accessible to the public while promoting environmentally friendly tourism practices. Additionally, the project will actively engage local communities and artisans in the reconstruction process, ensuring that the economic benefits of heritage tourism are distributed equitably. Tourists will also be educated about maritime sustainability, gaining insights into traditional boatbuilding techniques, environmental protection measures, and coastal heritage preservation. To maintain the sustainability of these tourism activities, limits will be implemented to prevent over-tourism, ensuring that Batana's operation remains ecologically responsible. By aligning its initiatives with sustainable tourism principles, the TOFOLA project will ensure that reconstructed traditional boats are not only cultural artefacts but also functional assets contributing to environmental conservation, community development, and economic sustainability.



2.2 Selection and sourcing of wood for Batana construction

The selection and sourcing of wood for Batana construction plays a critical role in maintaining the authenticity, durability, and sustainability of the reconstructed boats. As a vessel traditionally built using locally available timber, reconstructing Batana will follow strict material selection guidelines that honour historical accuracy while integrating modern sustainability standards. Ensuring that the wood is sourced responsibly is key to balancing cultural preservation with environmental conservation. Historically, Batana boats were crafted using a combination of durable hardwoods and lightweight softwoods, chosen based on their strength, flexibility and resistance to moisture. The most commonly used species include:

- Oak (lat. *Quercus robur*, *Quercus petraea*) – Highly resistant to water and decay, traditionally used for structural elements such as keels, ribs, and frames (Figure 4).



Figure 4 Oak wood texture [9]

- Larch (lat. *Larix decidua*) – Known for its natural resin content, offering superior resistance to rot, often used for planking and outer hull surfaces (Figure 5).



Figure 5 Larch wood texture [10]

- Pine (lat. *Pinus nigra*, *Pinus sylvestris*) – A lighter wood commonly used for decking, interior structures, and non-load-bearing components due to its workability and availability (Figure 6).





Figure 6 Pine wood texture [11]

- Elm (lat. *Ulmus minor*, *Ulmus laevis*) – Historically used for elements in contact with water due to its natural resistance to splitting/moisture absorption (Figure 7).



Figure 7 English elm (hardwood) texture [12]

- Chestnut (lat. *Castanea sativa*) – Occasionally used in traditional boatbuilding, known for its resistance to pests and fungal decay (Figure 8).



Figure 8 Chestnut wood texture [13]

With modern sustainability concerns, the sourcing of wood for Batana construction will follow strict environmental guidelines to minimise deforestation and ecological impact. The TOFOLA project places a strong emphasis on using wood that meets the highest environmental standards. One of the key principles is the selection of timber that carries FSC or PEFC certification, ensuring that all materials originate from responsibly managed forests. In addition to certified wood, the project prioritises local timber harvesting,



Italy – Croatia



which significantly reduces the carbon footprint associated with long-distance transportation while also supporting regional forestry economies. Where feasible, reclaimed and repurposed wood will be incorporated into the construction process, helping to preserve historical accuracy while minimising the demand for newly cut timber, that will be used only when existing wood is damaged to the extent it is not any more usable. The project will also integrate sustainable reforestation programs, ensuring that for every tree used in Batana construction, new trees will be planted to maintain ecological balance. Furthermore, low impact harvesting techniques will be implemented to protect forest biodiversity, avoiding excessive clear-cutting and ensuring that only mature, selectively chosen trees are felled for use in the project.

Once the wood is sourced, it will undergo a meticulous preparation process to enhance its durability, resistance to marine conditions, and aesthetic appeal. Traditional methods will play a crucial role in this process, beginning with natural air-drying, or seasoning, for up to a year to reduce moisture content and prevent warping. Steam bending techniques will then be employed, allowing planks to take on the Batana's characteristic curved forms without compromising structural integrity. The application of natural oils and resins, such as linseed oil and pine tar, will further enhance the wood's resistance to water penetration and microbial decay, ensuring long-term durability. The use of synthetic chemicals will be kept to a minimum, with a preference for traditional, biodegradable sealants that maintain the boat's eco-friendly construction. These time-honoured treatments will ensure that the reconstructed Batana maintains the same longevity and seaworthiness as those built centuries ago.

Sourcing traditional boatbuilding wood has become increasingly challenging due to forest depletion, regulatory restrictions, and climate change impacts. To address modern constraints in material availability, several adaptations have been introduced. Engineered wood products such as laminated oak will be used for structural components while preserving solid wood elements for the hull and decks to maintain authenticity, if feasible. The project will also experiment with thermally modified wood, which undergoes heat treatment to improve durability without relying on chemical additives. Where necessary, alternative biodegradable composites will be explored to provide structural reinforcement while ensuring they do not jeopardise the Batana's historical look and function. By combining responsible sourcing, sustainable forestry, and innovative treatments, the TOFOLA project will ensure that the Batana boat showcases not only an authentic historical reconstruction but also a model for eco-friendly maritime craftsmanship.



Italy – Croatia



2.3 Structural and functional design considerations

The Batana boat is characterised by a simple yet effective structural design, tailored for shallow coastal waters, ease of use, and durability. Its flat-bottomed hull, moderate size, and lightweight wooden construction make it well-suited for navigation in shallow areas such as coastal lagoons, estuaries, and nearshore waters. While remaining true to its traditional form, the reconstruction process must ensure that the boat maintains structural integrity, hydrodynamic efficiency, and functionality, all while incorporating sustainable and accessible design elements.

The hull shape, while highly practical, requires careful material selection and precise craftsmanship to prevent excessive drag and ensure optimal buoyancy. The use of oak planking ensures that the hull remains resistant to rot, impacts, and deformation over time.

The structural framework of Batana consists of a robust wooden skeleton, composed of a keel, ribs, stringers, and planking. Some batana boats also have a pasma (a decorative stripe or band on the hull). The keel, although minimal in depth, provides longitudinal strength, while the ribs contribute to the overall rigidity of the vessel. Traditionally, ribs were heated into shape and fastened using wooden dowels or copper nails. Only later, techniques have developed so ribs started being steam-bent into shape and screws are being used instead of dowels.

The functional aspects of Batana's design are equally important. Originally used for fishing and transport, the boat was designed with an open deck which allowed for the easy movement of nets, equipment, and cargo. Modern adaptations will include removable seating, concealed storage compartments, and accessibility features for passengers with reduced mobility. However, these modifications must be made with care to ensure that they do not compromise the boat's weight distribution and stability.

Other important design issues to be taken into consideration are propulsion and manoeuvrability. The Batana boat has been traditionally rowed or sailed, with a gaff sail providing auxiliary wind propulsion. In contemporary reconstructions, electric propulsion systems will be employed to align with sustainability goals, offering a noise-free, non-polluting alternative. The positioning of oarlocks and rudders must be optimised to maintain traditional handling characteristics while allowing for potential improvements in control, efficiency, and accessibility.

To enhance structural longevity, modern reinforcements may be subtly introduced while preserving historical aesthetics. For example, epoxy-based adhesives and biodegradable sealants can replace traditional pitch and tar coatings, providing better protection against water ingress while maintaining an environmentally friendly approach. Similarly, hidden stainless-steel fastenings may be used in areas subject to the most stress, ensuring durability without altering the visible appearance of traditional carpentry.

As part of the functional design improvements, the reconstruction process will also explore ways to enhance Batana's adaptability for eco-tourism and cultural heritage activities. This may include customised



Italy – Croatia

TOFOLA

layouts for small, guided tours, ergonomic seating, and adjustable fittings to accommodate different operational needs. These considerations must balance tradition and innovation, ensuring that the boat remains both historically accurate and practical for modern use.

By adhering to these structural and functional design principles, the TOFOLA project will ensure that the reconstructed Batana boat will be a genuine, durable, and sustainable representation of the original vessel, capable of serving both cultural and practical purposes.



3. Reverse Engineering And Digital Modelling Approach

The reconstruction of a Batana boat requires a delicate balance between preserving its historical authenticity and incorporating modern methodologies that enhance precision and efficiency. Reverse engineering and digital modelling provide a crucial bridge between traditional craftsmanship and contemporary technology, ensuring that the boat is rebuilt with the highest degree of accuracy while maintaining the integrity of its original design.

Reverse engineering will begin with a comprehensive analysis of existing Batana boats, carefully measuring their geometries, analysing materials, and structural details. This process will involve both manual measurements and advanced 3D scanning technologies, capturing every curve, joint, and plank with precision. Traditional shipbuilding methods often relied on the experience of master craftsmen who could recreate a boat by sight and skill. While this approach remains invaluable, modern digital tools allow for the preservation of these forms in detailed digital blueprints, reducing errors and ensuring consistency in reconstruction.

The application of 3D scanning and photogrammetry will be critical in documenting the exact dimensions and surface geometry of existing Batanas. High-resolution laser scanners will create accurate three-dimensional digital replicas, enabling engineers and shipwrights to analyse the structure in ways that had been previously impossible. Such digital twins will serve as the foundation for design refinements, ensuring that every reconstructed Batana boat maintains the proportions and hydrodynamic efficiency of its historical predecessors.

Beyond capturing the boat's shape, digital modelling plays a vital role in structural analysis and material optimisation. Modern software enables simulations to test how different wood types react under stress, ensuring that the most suitable materials are selected for durability and sustainability. This approach will also allow for fine-tuning the construction techniques, balancing traditional carpentry with contemporary assembly methods to preserve its authentic aesthetics.

Another advantage of reverse engineering is its ability to standardise and replicate designs without compromising craftsmanship. Digital archives of Batana's structures will make it easier for future generations of shipbuilders to recreate the vessel with precision. In addition to supporting ongoing conservation efforts, this also facilitates knowledge transfer between traditional artisans and modern engineers, ensuring that the art of Batana construction continues to evolve while remaining rooted in its historical origins.

The integration of computer-aided design (CAD) further enhances the efficiency of the reconstruction process [14]. Detailed digital blueprints will allow for the visualisation of the boat at various stages, helping to anticipate potential challenges before construction begins. This proactive approach will minimise costly adjustments during assembly, and streamline the workflow from raw timber selection to final launch.



Italy – Croatia



One of the most transformative aspects of digital modelling is its role in accessibility and customisation. With precise virtual representations, modifications can be made to accommodate inclusive design principles, such as ergonomic seating for elderly passengers or structural reinforcements for enhanced stability. By leveraging 3D printing and CNC (Computer Numerical Control) machining, custom boat components can be produced with high accuracy, ensuring that the reconstructed Batanas meet both historical and contemporary functional needs.

Despite these technological advancements, the essence of the Batana's reconstruction remains deeply connected to the human touch of master shipwrights. While reverse engineering provides a detailed roadmap, the final execution still depends on skilled artisans who interpret digital data through hands-on craftsmanship. This synergy between technology and tradition will ensure that every Batana retains its unique character, blending old-world artistry with 21st-century precision.

By adopting reverse engineering and digital modelling, the TOFOLA project will not only preserve the legacy of Batana boats but also pioneer a model for sustainable heritage boat reconstruction. The methodologies used in this process will create a lasting digital archive, allowing future generations to engage with maritime history in a way that is both innovative and deeply respectful of tradition.



4. Boat Assembly Process And Construction Stages

The reconstruction of a Batana boat will follow a systematic, step-by-step process that ensures both historical accuracy and structural integrity. Although modern tools and precision techniques can enhance efficiency, the fundamental principles of traditional wooden boatbuilding will remain central to the process. The Batana's flat-bottomed hull, simple yet sturdy frame, and handcrafted carpentry require careful material preparation, precise assembly, and skilled craftsmanship at every stage.

The first step in the assembly process involves selecting and preparing the wood. High-quality, sustainably sourced hardwoods and softwoods such as oak, pine, and elm are chosen based on their structural and functional roles. Each plank and beam will undergo seasoning and air-drying to ensure stability and prevent warping. Traditional heat bending will be used to shape curved elements like the planks, allowing them to fit seamlessly into the hull structure. The keel, ribs, and stringers will be cut using a combination of hand tools and modern CNC machines for precision, ensuring each component aligns with the boat's historical dimensions. Pre-cut planks and frames will be numbered and prepared for dry fitting before assembly begins.

The keel serves as the Batana backbone and is the first component to be assembled. It is typically laid out on a construction jig or a flat work surface to ensure perfect alignment. Once positioned, the stem (bow post) and sternpost are attached, providing the framework for the hull's shape. The ribs (frames) are then secured at measured intervals, forming the boat's internal skeleton.

This stage is critical, as it determines the overall strength and durability of the boat. Mortise-and-tenon joints, and screws will be used to secure the structure, ensuring that the assembly remains true to historic craftsmanship. Modern reinforcements, such as hidden stainless-steel fasteners, may be discreetly integrated in high-stress areas to increase longevity without altering the traditional aesthetic.

Once the framework is complete, the next step is attaching the outer planking. Each plank will be fitted carefully along the ribs, beginning with the garboard strakes (the planks closest to the keel) and working upward. The flat-bottomed hull design simplifies this process compared to round-bottomed boats, allowing for quicker and more efficient plank installation. Planks will be screwed into place, depending on whether a fully traditional or hybrid method is used. To ensure a watertight fit, the seams between planks will be caulked with natural fibres such as hemp or oakum, soaked in pine tar or linseed oil. This technique has been used for centuries to make wooden boats resistant to water ingress and swelling. At this stage, any reinforcement elements – such as internal bulkheads or support beams – will also be installed, providing additional structural integrity.

Once the hull is complete, the focus shifts to the deck and internal fittings. The Batana boat typically features an open or partially covered deck, depending on its intended use. Traditional designs allow for easy movement and fishing activities, while modern adaptations may include removable seating, storage



Italy – Croatia



compartments, or accessibility enhancements for tourism. Oarlocks, seating benches, and gunwales will be installed, ensuring that functional elements align with historical specifications while meeting modern usability standards.

With the structure assembled, the boat will undergo final finishing and waterproofing. This will include sanding and smoothing all wooden surfaces to remove rough edges; applying natural protective coatings such as linseed oil, or eco-friendly marine varnish; painting or sealing specific areas of the boat to protect against UV exposure, saltwater corrosion, and mechanical wear. Historically, Batanas were often painted in bright colours, reflecting local traditions and helping fishermen identify their boats at sea. The reconstruction may incorporate traditional colour schemes and decorative elements, ensuring cultural authenticity.

As commented earlier, traditionally, Batana would be propelled by oars and a simple gaff sail. Within the TOFOLA project, sustainable propulsion systems such as electric motors could be installed. If designed for sailing, the mast, boom, and sail rigging will be set up and tested for balance and manoeuvrability. The rudder and tiller assembly will be attached, ensuring that the boat is responsive and easy to steer.

To prove a Batana boat seaworthy, it will undergo structural and functional testing. The boat will be placed in the sea for an initial float test, checking for any leaks or balance issues. The boat will be left in the sea to allow the wooden planks to swell and seal naturally. Once stability and buoyancy are confirmed, manoeuvrability tests will be conducted, ensuring that rowing, sailing, and motorised propulsion all perform as expected. Successful completion of these tests means the Batana boat is ready for full operational use, whether for traditional fishing, cultural exhibitions, or sustainable tourism initiatives.



5. Blending Tradition And Innovation In Batana Boat Reconstruction

For centuries, the Batana boat has been built using handcrafted wooden boatbuilding techniques, passed down through generations of skilled shipwrights. These methods, rooted in local maritime culture, involve a deep understanding of wood behaviour, manual shaping techniques, and time-honoured carpentry practices. Traditional heat bending allows the planks to take shape without causing internal stress on the wood, preserving flexibility and strength. Hand-planing and chiselling ensure that each plank and joint fits seamlessly, while natural adhesives like linseed oil provide waterproofing without synthetic chemicals.

The connection between artisans and materials is central to traditional boatbuilding. Every Batana is unique, as individual craftsmen rely on their experience and intuition rather than standardised measurements. The process is time-intensive but highly adaptable, allowing for subtle modifications based on the wood's grain, the specific needs of the end user, and the environmental conditions where the boat will be used.

Another hallmark of traditional craftsmanship is the fastening technique. Wooden boats were historically assembled using trenails (wooden pegs) and natural caulking materials, such as hemp fibres soaked in tar. These methods allowed for a flexible, watertight structure that could expand and contract with humidity changes, enhancing the boat's longevity.

While traditional craftsmanship remains at the heart of any Batana reconstruction, modern building techniques might offer additional precision, efficiency, and environmental benefits. Digital modelling and CNC machining allow for the creation of precise templates and components, reducing material waste and ensuring consistency across multiple reconstructions [15]. Techniques such as 3D scanning of existing Batanas help document historical designs in a way that prevents loss of knowledge and structural inaccuracies.

Material science has also provided improvements that enhance Batana's durability and maintenance without altering its traditional appearance. While historically, wooden boats required frequent reapplication of natural sealants and coatings, modern biodegradable marine-grade resins can offer better protection against rot and water infiltration. These coatings maintain the wood's breathability while reducing the frequency of repairs and extending the boat's lifespan.

Another key innovation is the use of hybrid fastenings. While traditional wooden pegs and copper nails can still be used for authenticity, stainless steel screws and hidden reinforcements may be incorporated in high-stress areas to improve structural integrity. This allows Batana to withstand heavier use in tourism applications while maintaining the same aesthetic and historical accuracy. One such application is shown in Figure 9.



Italy – Croatia



Figure 9 Master shipwright Michael Vlahovich working on the Batana project, combining traditional woodworking skills with contemporary tools [16]

As commented earlier, one of the most significant advantages of modern techniques is their contribution to sustainability. Traditional boatbuilding relied heavily on old-growth hardwoods, which are now scarce due to deforestation. To address this, the TOFOLA project will integrate certified sustainable timber, reclaimed wood, and engineered alternatives that mimic the properties of historically used materials while reducing environmental impact.

Additionally, modern adhesives and sealants allow for stronger, longer-lasting wooden joints, meaning that a reconstructed Batana boat would require fewer repairs and less frequent replacement of structural components. The introduction of solar-powered electric propulsion systems is another modern improvement, ensuring that the boat remains a model of sustainable heritage tourism.

The TOFOLA project's approach to the Batana's reconstruction highlights the best of both worlds – preserving the artisanal methods that give each boat its authentic character while leveraging modern tools to enhance efficiency, durability, and environmental responsibility. This combination allows for more precise documentation of traditional techniques, ensuring that future generations of boatbuilders can continue the craft with the support of digital archives, training programs, and updated methodologies. While modern techniques introduce efficiency, the Batana will remain handcrafted, ensuring that each boat carries the marks of the artisans who build it. This approach respects the legacy of traditional shipwrights while creating a more resilient, accessible, and sustainable vessel for contemporary use.



6. Innovations For Sustainability And Inclusivity: Accessibility, Eco-Friendly Solutions, And Sustainable Propulsion

The TOFOLA project emphasises inclusive design in the reconstruction of the Batana boat, ensuring that it is accessible to a wide range of users, including elderly individuals, persons with disabilities, and families with children. Traditionally, wooden boats like Batana were built for functionality and fishing, with little consideration for accessibility. However, modern adaptations should allow for improved safety, comfort, and usability without compromising the boat's historical integrity.

6.1 Enhancements for accessibility and inclusive use

A primary focus of the accessibility improvements is making the Batana boat easier to board and move around. Traditional small boats often have high gunwales and narrow interiors, which can present challenges for individuals with limited mobility. To address these issues, the reconstructed Batana accessibility features will include:

- Lowered gunwales or removable side railings to facilitate easier entry from docks or boarding platforms;
- Non-slip flooring made from textured wood or coated with an eco-friendly anti-slip finish to reduce the risk of slipping. Strategically placed handrails along the seating and entry points will provide support for passengers when boarding and navigating inside the boat;
- Adjustable seating arrangements to accommodate different physical needs, including removable benches to create additional space for wheelchair users.

While Batana remains a small vessel, these design considerations ensure that it is as accessible as possible without altering its traditional form. The Batana's flat-bottomed hull already provides greater stability compared to round-bottomed boats, making it safer for passengers with balance difficulties. However, additional modifications can further enhance security and comfort:

- Weighted ballast adjustments to maintain stability, particularly when accommodating passengers with mobility aids;
- Ergonomic seating with back support for individuals who may have difficulty sitting on traditional wooden benches for extended periods;
- Secure entry points and safety straps to assist passengers when stepping into or exiting the boat;
- Emergency flotation devices discreetly integrated into the boat's design for safety compliance.

These modifications will make the reconstructed Batana more comfortable and practical for tourists, elderly passengers, and persons with disabilities, supporting its use in eco-tourism and cultural experiences.



Italy – Croatia



To ensure the boat is accessible to individuals with hearing or vision impairments, various sensory-friendly adaptations can be implemented:

- Tactile guides and Braille labels placed on key parts of the boat for visually impaired passengers;
- Contrasting colours and markers on entry points and seating areas to improve visibility;
- Audio guides and assistive listening devices for tours conducted aboard Batana, ensuring that passengers with hearing impairments can access the information;
- Vibration-based alert systems for safety notifications, helping passengers with hearing impairment to remain informed about on-board instructions;
- These enhancements expand Batana's reach to a more diverse audience, ensuring that historical and cultural experiences remain inclusive.

Although by its size the Batana boat may be considered small, traditionally built wooden boat, adaptations can be made to improve wheelchair accessibility for passengers who require mobility aids. Some possible modifications may include docking ramps or gangways designed specifically for Batana access, ensuring a smooth transition from the pier to the boat; adjustable, removable seating that allows space for small, foldable wheelchairs and secured anchoring points for wheelchairs, ensuring stability during the journey.

While full wheelchair accessibility may be challenging in a small vessel, these efforts ensure that Batana can be as accommodating as possible while maintaining its traditional character.

The above Batana's accessibility improvements align with global sustainable tourism initiatives, ensuring that eco-tourism and cultural heritage experiences are open to everyone. The boat can be used for guided heritage tours, cultural storytelling sessions, and inclusive sailing experiences, welcoming passengers of all ages and physical abilities. By incorporating thoughtful design elements, the TOFOLA project will ensure that the Batana boat remains a vessel for the entire community, allowing tourists, locals, and historically underrepresented groups to enjoy the Adriatic's maritime heritage in an inclusive, barrier-free manner.

6.2 Sustainable propulsion systems and low-impact solutions

As discussed earlier, the Batana boat has traditionally relied on oars and simple sailing rigs for propulsion, making it an inherently sustainable vessel. Its historical design was developed for efficiency in shallow waters, where manoeuvrability and adaptability were essential for fishing and transportation. As the TOFOLA project works on reconstructing the original Batana, there is an opportunity to maintain its low environmental impact while incorporating modern propulsion solutions that align with contemporary sustainability standards.

One of the simplest and most effective ways to ensure that the reconstructed Batana remains environmentally friendly is by preserving its traditional methods of navigation. Rowing, which has been used for centuries, allows for noise-free boating with zero emissions and remains one of the most practical forms of propulsion in lagoons and coastal areas. Sailing, another method deeply rooted in Batana's history, provides an excellent alternative when wind conditions permit. By maintaining the traditional



Italy – Croatia



spritsail gaff sail, the boat can continue to operate without reliance on engines while offering a cultural and eco-friendly experience. Modern sail materials, though lighter and more durable, can be chosen to preserve historical aesthetics while improving performance and longevity.

For cases where motorised propulsion is necessary, electric systems present the best alternative. Unlike fossil fuel-powered engines, electric outboard motors provide silent operation, producing no local emissions and reducing water and noise pollution. These motors are particularly suited for heritage boats used in eco-tourism, as they allow for smooth and quiet navigation while preserving the experience of being on a traditional wooden vessel. One of the major benefits of electric propulsion is its low maintenance requirements, as these motors include fewer moving parts and do not require oil changes or fuel storage, further reducing the environmental footprint. The integration of solar energy can further enhance the sustainability of Batana. Solar panels, either onshore at docking stations or even discreetly incorporated into the boat, can provide renewable energy to recharge batteries, but they are subject to ongoing seaworthiness regulations. Solar-powered charging stations at harbours or along eco-tourism routes can enable extended use of electric propulsion without the need for fossil fuels. This approach ensures that the Batana boat remains entirely self-sufficient, drawing energy only from renewable sources and eliminating any reliance on conventional power grids.

In addition to propulsion systems, modifications to the boat's structural design can also contribute to sustainability. A well-optimised hull shape can improve efficiency by reducing drag and making propulsion, whether by rowing, sailing, or an electric motor, more effective. Lightweight yet durable materials can be used to enhance longevity without compromising authenticity. The use of eco-friendly sealants and antifouling treatments prevents damage from marine organisms without introducing harmful chemicals into the water, further minimising the boat's environmental impact. To ensure Batana operates sustainably, attention must also be given to navigation practices. Training programs for operators and eco-tourism guides can promote responsible boating habits, including limiting speeds in protected areas to avoid disturbing marine life and ensuring waste management policies prevent pollution. Using designated docking areas rather than anchoring in sensitive marine environments helps preserve seagrass beds and prevent coastal erosion. Integrating both sustainable propulsion systems and responsible boating practices will make the Batana boat an example of how heritage vessels can remain relevant in the modern world without sacrificing environmental integrity.



Italy – Croatia



Conclusion

Sustainable reconstruction of wooden boats requires a thoughtful approach that balances historical authenticity, material durability, and environmental responsibility. Efforts should focus on preserving traditional craftsmanship while adapting to modern challenges such as resource scarcity and ecological impact.

Using responsibly sourced timber is essential to maintaining sustainability. Whenever possible, wood should come from certified forests or reclaimed materials to reduce environmental strain. In cases where original species are no longer available or sustainable, suitable alternatives that closely match historical characteristics should be considered.

Traditional boatbuilding techniques should be preserved, as they carry invaluable cultural and historical significance. However, integrating modern innovations—such as improved fastenings, protective coatings, and structural reinforcements—can enhance durability without compromising authenticity. Restoration methods should prioritise reversibility to allow future adjustments without damaging original components.

Environmental impact should also be minimised through responsible waste management, including the reuse of original parts when possible. The use of eco-friendly finishes, adhesives, and antifouling treatments is encouraged to reduce harm to marine ecosystems.

Finally, proper documentation of all restoration efforts is crucial for future conservation. Detailed records, including material choices, construction methods, and any modifications made, will help ensure that future shipwrights and restorers can continue the work with respect for the boat's heritage. Sustainable reconstruction is not just about prolonging the life of a vessel - it is about safeguarding maritime history while embracing responsible stewardship of natural resources.

The TOFOLA project embraces the challenge of making the Batana boat not just a reconstructed historical vessel but a model for sustainable maritime heritage. By combining rowing and sailing with electric propulsion, utilising renewable energy sources, and implementing eco-friendly construction materials, this initiative will ensure that the boat can continue to navigate the waters of the Adriatic for future generations, serving as both a symbol of history and a beacon of sustainability.



Italy – Croatia



References

1. Interreg Italy-Croatia TOFOLA Web page, [Online] Available from: <https://www.italy-croatia.eu/web/tofola>, [Accessed on 1st February 2025.]
2. Interreg Italy-Croatia TOFOLA project application form, 2023. (not published)
3. Forest Stewardship Council Web page, [Online] Available from: <https://fsc.org/en>, [Accessed on 1st February 2025.]
4. Programme for the Endorsement of Forest Certification Web page, [Online] Available from: <https://www.pefc.org>, [Accessed on 1st February 2025.]
5. Journey Through History on batana Boat in Rovinj, [Online] Available from: <https://culturetourist.com/destinations/croatia/journey-through-history-on-batana-boat-in-rovinj/>, [Accessed on 30th November 2024.]
6. Batana Koštanca, [Online] Available from: <https://batana-kostanca-en.blogspot.com/p/boat-design.html>, [Accessed on 5th December 2024.]
7. The Batana Eco-museum Web page, [Online] Available from: <https://www.batana.org>, [Accessed on 28th January 2025.]
8. batana Koštanca: Načrtovanje, [Online] Available from: <https://batana-kostanca.blogspot.com/p/nacrtovanje.html>, [Accessed on 17th December 2024.]
9. Oak Wood Grain Texture Close Up. Photos Public Domain, 20 Nov. 2011, [Online] Available from: <https://www.photos-public-domain.com/2011/11/20/oak-wood-grain-texture-close-up/>, [Accessed on 1st January 2025.]
10. The Wood Database, [Online] Available from: <https://www.wood-database.com/european-larch/> [Accessed on 22nd February 2025.]
11. Pine Wood: Exploring Types, Properties, and Uses. BeautexWood, Jan. 2021, [Online] Available from: <https://beautexwood.com/pine-wood-types-properties-trees-and-uses-a-popular-softwood-used-for-home-floors/>, [Accessed on 10th January 2025.]
12. "English Elm: Lumber Identification (Hardwood)." The Wood Database, n.d., [Online] Available from: <https://www.wood-database.com/english-elm/>, [Accessed on 15th January 2025.]
13. GL Veneer, American Chestnut, [Online] Available from: <https://glveneer.com/species/chestnut/>, [Accessed on 18th January 2025.]
14. Bai, X. "Computer-Aided Design and Intelligent Optimization in the Inheritance of Intangible Cultural Heritage", Volume 22, S7: Applications of Reinforcement Learning in Creative Design, Computer-Aided Design Journal
15. How CNC Machines Reduce Waste in Manufacturing, [Online] Available from: <https://www.koike.com/blog/how-cnc-machines-reduce-waste-in-manufacturing/>, [Accessed on 18th January 2025.]
16. Batana, a traditional Croatian fishing skiff, nearly ready to set sail, [Online] Available from: <https://www.gigharbornow.org/news/community/batana-a-traditional-croatian-fishing-skiff-nearly-ready-to-set-sail/>, [Accessed on 28th January 2025.]

- End of the document -

