The 1st International Symposium of Conservation for Underwater Archaeology

IBEAM
Institut Balear d'Estudis en Arqueologia Marítima
Andrea Sanz, Enrique Aragón, Javier Rodríguez

#ISCUA2019
PROCEEDINGS

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One Vision, One Mission

IBEAM and the Conservation of Maritime Cultural Heritage

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In the development of underwater archaeology, responsibility has traditionally been given to archaeologists, while conservators-restorers have seldom formed a part of the team or been assigned roles in the management or co-management of projects. Although, fortunately, there are now projects in which the situation is different and a better balance of responsibilities between archaeologists and restorers is starting to appear, the general lack of communication between these two professions remains a concern. This raises a question: how could marine archaeological research progress without a clear and necessary involvement of conservation professionals as an inherent part of it?

Following the publication of the Manual for Activities directed at Underwater Cultural Heritage with the Annex of the UNESCO 2001 Convention, which revealed the importance of "in situ conservation", a term which archaeologists seemed to immediately adopt and appropriate, the expectation was that the role of restorers was about to gain relevance and presence in all stages of underwater archaeology projects. The reality, however, continues to be quite different. In spite of the imperative necessity to preserve archaeological objects and remains at the time of their excavation, and with the knowledge, moreover, that failure to apply the appropriate preventive measures poses a risk for their long-term conservation, multidisciplinary and equitable teams are still scarce. This is possibly due to work customs anchored in behaviours of the past governed by criteria of outdated professional elitism and, in most cases, with a clear gender difference.

Despite this situation, we must not forget the numerous good examples of professionals, many of whom are the authors of the articles that make up this publication. Through their vocation, passion and experience, they have not only opened a better path to go forward, but have also become a source of inspiration for the new generations of restorers and conservators of underwater archaeological heritage. Since the creation of IBEAM, the restoration and conservation of underwater cultural heritage has been and continues to be fundamental in all of their archaeological projects, as the objectives of both disciplines have combined perfectly in order to ensure a joint, sound and efficient execution and management, by means of coordinated guidelines. In other words, we have re-

formed the conventional methods, we have adapted, we have learned from our mistakes and, together, we turned a common work vision into a single mission for the future.

The apparent need and demand, on the part of restorers and conservators, for specialised training which would go beyond the theoretical concepts presented in the UNESCO's Manual and would delve into the real difficulties of in situ conservation, stabilisation, extraction, protection and restoration of any underwater material, prompted the IBEAM to organise a series of courses aimed at students and professionals interested in the underwater world with no or little experience in the water, through workshops on actual sites under the supervision and guidance of experts on the subject.

We soon realised that restoration and conservation professionals in underwater archaeology were in need of a single platform where they would be able to exchange ideas and experiences in relation to the preservation of the underwater cultural heritage. This is how the 1er Simposio Internacional de Conservación en Arqueología Subacuática (ISCUA) (1st International Symposium on Conservation in Underwater Archaeology), which took place in September 2019 on the idyllic island of Formentera, came to be. This symposium brought together more than 40 world-class professionals, experts in conservation and restoration of the UCH. Throughout the different sessions, it became clear that the two disciplines (archaeology and conservation) are very much interconnected despite their current separation. This connection let us fantasise about applying the latest technological advances to safeguard the underwater archaeological heritage. It is important to highlight all the technological innovations in research projects which are presented in this publication and which will be an inspiration for current and future generations of restoration-conservation professionals, as well as for other, direct or indirect, roles involved in archaeology.

The creation of this communication platform for researchers and institutions involved in the preservation of the UCH was one of the main objectives in the organisation of the ISCUA. The symposium was the ideal context for specialised, up-to-date and quality training, and made it possible to transform the real, tangible, physical distance between all the researchers into a more intimate and collaborative environment, creating solid personal and professional relations stimulated by a common preoccupation, i.e. the conservation of the underwater cultural heritage. This and many more aspects will appear in this publication, which is the first step towards the materialisation of an idea that was shaped by the vision of teamwork, a more realistic, evolved, complete archaeology, an archaeology of the future.

1

The in-situ preservation:
Conservation, Management and Protection Strategies of Underwater Archaeological Sites

Conservation and Protection actions in situ in the “Ses Llumetes” wreck of Porto Cristo (Manacor, Mallorca)

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Abstract

This paper aims to present the results of the intervention carried out to protect the remains of the so-called “Ses Llumetes” shipwreck at Porto Cristo (Mallorca, Spain). Although the site was highly accessible (near the shore) and the remains were significantly exposed during long periods of time, an important part of the hull, estimated to belong to a 1st century A.D. Roman ship, showed an exceptional level of preservation.

Since the beginning of the archaeological project in 2014, promoted by the IBEAM (Institut Balear d’Estudis en Arqueologia Marítima), the in situ preservation of the wooden structure has been a priority. In this sense, the entire intervention aimed to ensure the integrity of the archaeological remains and their correct preservation with totally innocuous and reversible means.

The different operations were managed by an interdisciplinary team specialised in underwater archaeology and conservation. This paper explains the results of the method applied during the excavation process. The selected technical solution during the process was the use of PVC cannulas to “stitch” together the different parts of the shipwreck. This proved to be effective in providing greater support and allowing a customised application.

In conclusion, this intervention had an immediate positive effect in that it enhanced the reinforcement and support of the naval structure in situ with a new material for consolidation, which could also be used as an indicator to evaluate the presence of humidity once the site would be covered.

Keywords

In situ

Conservation

Wood

Protection

Underwater Cultural Heritage

Maritime Archeology

Shipwreck

1. Introduction

The Ses Llumetes wreck is one of the most famous underwater sites in Majorcan historiography (Aragón et al., 2016). It is barely three metres deep and thirty metres away from the beach in the bay of Porto Cristo, Mallorca. It

is a Roman boat from the 1st century A.D. discovered in the middle of the last century, which first appeared as a reference in an article published by Baltasar Pinya on September 18, 1954.

Due to its location, its shallow depth and its accessibility, it became a perfect site for the study and application of new, different methods and products for in situ conservation of the wreck, as well as for the enhancement of the underwater cultural heritage of Porto Cristo.

In contrast, while the location so close to the coast is an advantage, it is also a disadvantage from a conservation point of view due to the action of currents and waves, direct exposure to sunlight and recklessness and curiosity of the bathers.

Currently, a total of 36 square metres have been excavated, in which parts of the original structure of the shipwreck continue to appear (Fig. 1). It could be said that more than 90% of the remains found are of an organic nature in an exceptional state of preservation, but there are also very specific inorganic and mixed-nature objects attached to the surface of the hull. Each year, the wreck is excavated and re-buried under a textile mesh and sand bags that serve as ballast, for the reasons described above and to protect it from possible unauthorised incursions. Thereby, it is possible to prevent or reduce accidental movements and to create a homogeneous level of protection while allowing the wreck to be covered by sand through the natural movement of the sea (Castillo 2009).

Figure 1. *Image of the last part discovered during the excavation interventions at the Porto Cristo Project 2019. Detail of the bow of the Ses Llumetes wreck (Porto Cristo, 2019).* ***Author****: Javier Rodríguez Pandozi*

2. Objectives

The work presented here follows the general policies and criteria ratified in the UNESCO Convention on the Protection of the Underwater Cultural Heritage (UNESCO 2001), based on in situ conservation as the highest priority. Admittedly, there are sometimes other factors that make it impossible to conserve in situ certain objects found and attached to the surface of the wreck. In this case, due to their fragile state of preservation, it is advisable to recover and protect them until they are deposited in the appropriate museum.

Therefore, this article details the in situ conservation work carried out on the Porto Cristo Project (Ses Llumetes wreck) from its start in 2016 to the present day, including the results of the search for new techniques with which to maintain, consolidate or fix in situ those remains recently discovered through the excavation work during the campaigns, as well as the results obtained with the combination of the different techniques of in situ protection.

Given the fragility of the remains found underwater and due to the risk of loss, attributable to natural and/or human causes, it is vitally important to find simple techniques that can be handled by a single technician, in addition to being easily accessible in the islands, of low economic cost and of course, that respect the criteria of maximum respect for the original, easy discernibility and reversibility of the materials used (ECCO professional guidelines 2003).

3. Environmental aspects

After years of study and data collection, the resulting documentation has allowed us to identify several factors of deterioration that are fundamental to understanding the state of conservation of the wreck and, therefore, to finding practical and effective solutions:

- Physical factors: The proximity of the wreck to the coast has generated continuous wear due to the waves and strong currents occurring within the natural port of Porto Cristo. On the other hand, this constant movement and the covering of the wreck by sand created an anaerobic environment capable of preserving the remains on the site to this day.
- Chemical factors: Due to the shallow depth (-3 metres), the fine grain size of the sand and the constant deposition of dead algae that are washed ashore, the conservation of the documented remains has been favoured by the covering of this natural mantle (Fig. 2), creating a totally anaerobic environment. The intervention regarding in situ protection is aimed at ensuring that the zero redox potential level is located above any of the archaeological remains, reducing the risk of their deterioration.

Figure 2.
Detail of the natural layer that covers the Ses Llumetes wreck, during its excavation.
***Author**: Guillermo González Lázaro*

- Biological factors: It has been verified that there was a minimal presence of fouling, prior to the protection of the remains in the area closest to the coast, due to the presence of calcareous cavities, unmistakably produced by shipworms (Teredo Navalis) [1] that seem to have ceased to be active (Fig. 3).

Figure 3. *Detail of the end of a frame affected by the Teredo Navalis.* ***Author****: Guillermo González Lázaro*

4. In situ conservation and protection methodologies

As in any archaeological intervention in the underwater environment, prior planning is essential to avoid any unforeseen event. In this case, the depth of three metres greatly favours continuous communication with the surface and rapid problem solving.

The techniques used are based on the principle of in situ preservation with totally innocuous materials for the original remains, since no alterations produced by them have been detected at any point. For this purpose, the material used consists of polyester resins applied by means of a gun, bi-component epoxy resin, PVC cannulas and hypodermic needles.

These systems have allowed greater protection of the remains against the currents and strong tides of the northeast component that directly affect them, given the high risk of destruction and loss that this implies (Munar et al., 2016). Therefore, the consolidation techniques used are intended to minimize the movements of the different parts of the structure and slow down the impact of the alteration factors, both environmental and human, that affect the exposed remains during the archaeological investigation.

The in-situ consolidation techniques used in this project (Fig. 4) have progressively evolved based on the results obtained year after year, and as a result of the appearance of naval architecture in an excellent state of preservation, made up of various structural elements of the ship like the strakes, the frames, the boards of the hull and the keel. For its preservation, different structural consolidation systems were created, namely (4.1.) polyester resin strips, (4.2.) sacks filled with sand for the purpose of immobilisation and (4.3.) “structural

stitching" by means of PVC cannulas grafted onto the wood with stainless steel hypodermic needles.

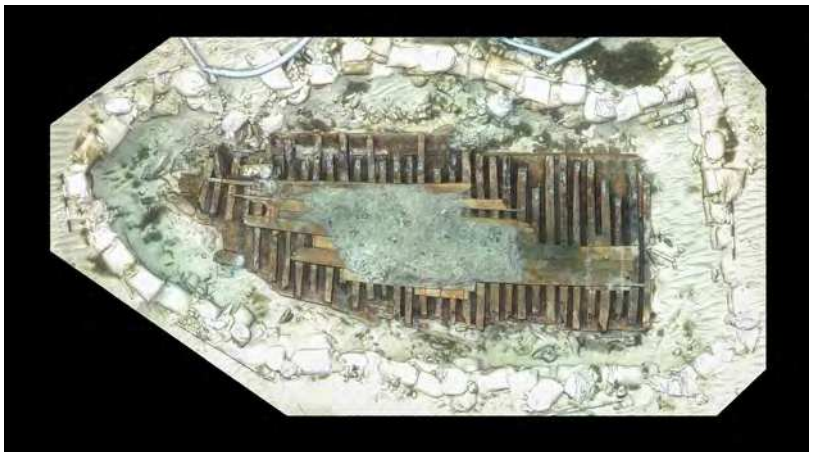


Figure 4. *Photogrammetry of the Ses Llumetes wreck showing the consolidation and in situ protection methodologies.* ***Author****: Kotaro Yamafune*

Regarding the (4.4.) protection technique used in this project, it has been the same from the beginning due to the fantastic results obtained, a combination capable of slowing down deterioration attributable to natural causes (Holden et al., 2006), preventing degradation processes from acting quickly on objects (Ortmann 2001) and guaranteeing their preservation for future generations as a priority.

4.1. Polyester resin strips

In the first Porto Cristo underwater archaeological excavation campaign, in situ consolidation was applied directly on the boat without any reinforcement or support on the original remains. (Fig. 5). An aesthetic and visual improvement was sought which would not interfere with the archaeological study, so we proceeded to carry out tests with the application of polyester resin into PVC strips segments and, before the hardening, these were pierced with plastic bolts to fix them to the wood. (Fig. 6). This system was used to immobilize fragile and mobile parts, susceptible to loss.

Figure 5. *Photograph of initial resin consolidation without PVC cannulas.* ***Author****: Javier R. Pandozi*

Figure 6. *Photograph of consolidation with polyester resin strips.*
***Author**: Andrea Sanz Catalá*

4.2. Sand bags

Depending on the area to be consolidated, a fairly simple clamping technique was also used, namely bags filled with sand placed on mobile surfaces susceptible to loss (Fig. 7) or positioned to exert minimal pressure in fragile areas (Fig. 8). This system allowed us to constantly reuse the bags whenever necessary for immobilisation.

Figure 7. *Use of sand bags for the consolidation system.*
***Author**: Andrea Sanz Catalá*

Figure 8. *Use of sand bags for the immobilisation of structural parts.*
***Author**: Guillermo González Lázaro*

4.3. Stitching

The use of this technique was prompted by the need to consolidate structural parts with a stronger system than the polyester resin strips system, previously explained (4.1. Polyester resin strips). For example, as can be seen on Fig. 8, there is a frame completely split in half for the immobilisation of which the polyester resin strips consolidation system was not sufficient. For this, we used a methodology already used in other underwater archaeological interventions, i.e. cannulas fastened with hypodermic needles (Negueruela et al., 2004). Once the intervention had been completed, the system was found to be stable enough to remove the sand bags (Fig. 9). This technique turned out to be effective for the consolidation and immobilisation of the storage tables (Fig. 10).

Figure 9. *Illustration of the stitching technique for the structural consolidation of the C110 frame.* ***Author****: Andrea Sanz Catalá*

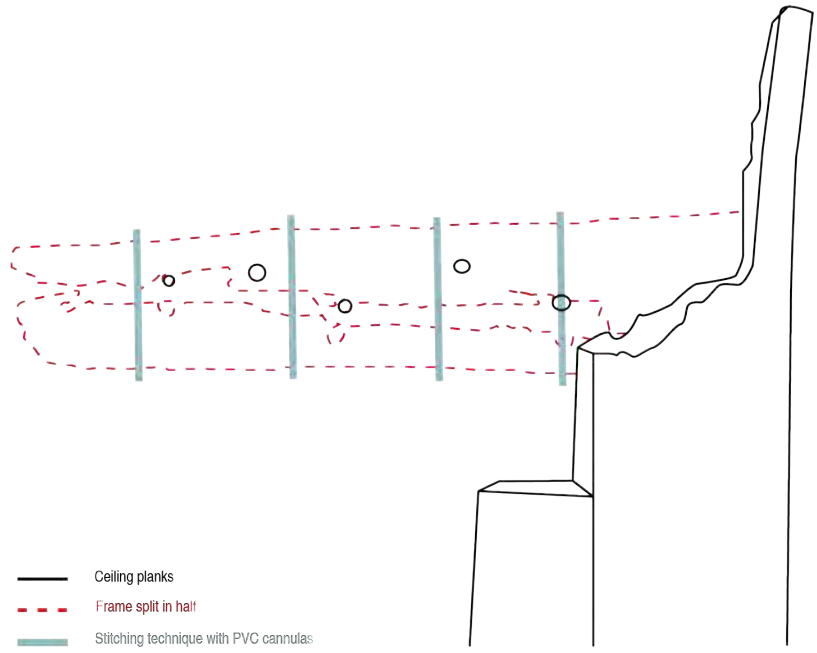
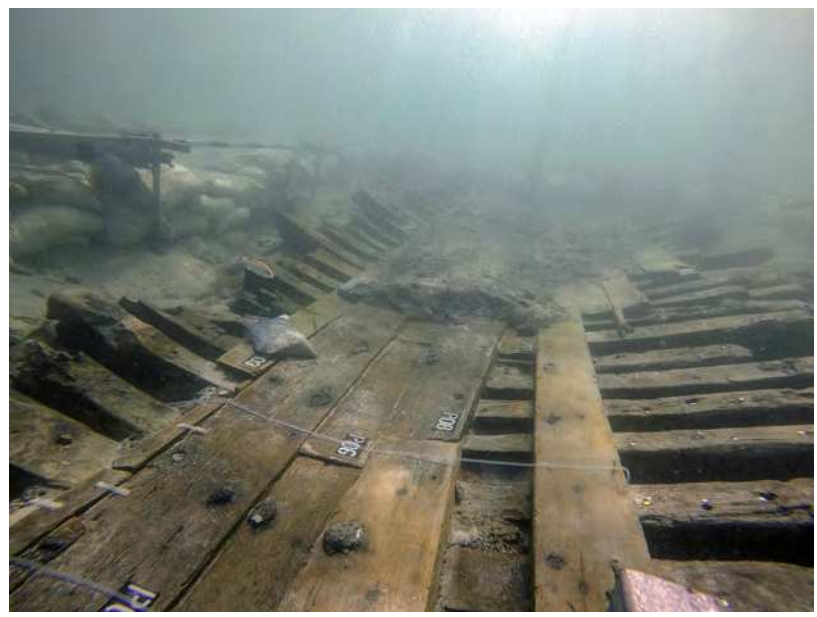


Figure 10. *General view of the Ses Llumetes wreck with various consolidation techniques in its structure.* ***Author****: Andrea Sanz Catalá*



4.4. In situ protection

The in situ protection technique combines various physical protection systems [2] in order to create an anaerobic protective environment by re-burying the

wreck with layers of sand, covering it with a textile mesh and placing sand-filled bags on it for permanent fixation (Davidde 2004). In addition, year after year, it is observed that a thick layer of dead posidonia is generated on the protection, which helps to improve the anaerobic environment and, therefore, to ensure the preservation of the remains (Fig. 11).

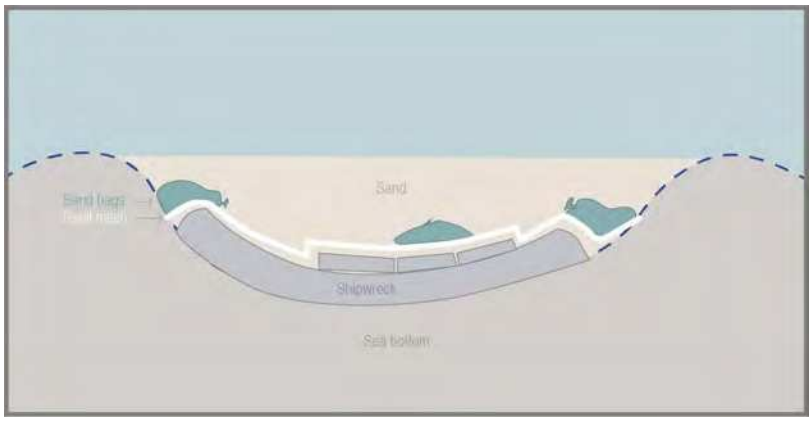


Figure 11. *In situ protection process with the placement of the textile mesh and sand bags.*
***Author**: Andrea Sanz Catalá*

The sandbags placed on the remains are reused during the excavation works as a physical barrier preventing the intrusion of sand and dead posidonia (Fig. 12) and thus improving photographic vision and documentation.

Figure 12. *Retaining wall with sand bags reused for physical protection in situ, where the effectiveness in stopping the entry of dead posidonia is observed*
***Author**: Andrea Sanz Catalá*

An urgent action regarding in situ protection was prompted by the discovery of a piece of braided rope about 1.20 m long in a bad state of preservation; this went through the scuppers numbered C119, C122, C124 and C126. Scuppers are semi-circular openings allowing water to flow out, measuring 6 cm in height by 8.5 cm in width. This discovery was made while excavating the sediment in the space separating the floor timbers. The rope formed part of a manual system that was used to clean the dirt that gradually accumulated in the bilges and blocked the flow of water towards the bilge pump .

Due to their delicate state of preservation, the IBEAM technical team decided to proceed with the in situ protection of the remains using PVC tube segments as a barrier (©Wreck Protect, 2011) with polyester resins (Figs 13-14).

Figure 13. *Attachment of half a PVC pipe on the remains of a braided rope conserved through the scuppers between frames C120-C122.*
***Author**: Javier Rodríguez Pandozi*

Figure 14.
Polyester resin application on PVC pipes and wood.
***Author**: Javier Rodríguez Pandozi*

5. Conclusion

The objectives described are considered to be effectively met. The new consolidation techniques applied in situ for loose elements reduce the risk of loss during excavation periods and are able to resist waves and tides. In addition, another objective was accomplished since the systems used so far are cheap, simple and quick to apply by a single technician. It must be taken into account that they need constant control and modifications in order to maintain the structural consolidation in optimal conditions, as they may be affected during the research work.

Throughout the 5 years of the project, the various materials, consolidation methodologies and on-site protection systems have been truly satisfactory but we are always seeking to improve application systems and reduce any impact.

From the beginning, the sand covering the site has been removed by areas for archaeological study. During each campaign, it has been observed that the tables of the storeroom, in addition to being covered by sand, are also covered by a concreted layer of sediments of pozzolana, and that most of the inorganic objects such as the bronze key - ring, oil lamps, etc. appear to be in an ac-

ceptable state of conservation. This pozzolana layer is of a plastic and clayey nature and, as a result, the environment generated is anaerobic, devoid of oxygen. This ensures the durability of objects with a good state of conservation and, therefore, is an important element for the preservation of the organic remains of the wreck, in this case, promoting the good conservation of underwater archaeological wood, slowing down its deterioration and facilitating its protection (Holden 2006).

Our main priority is to protect the wreck and prevent further degradation by combining various methods of in situ protection. This system continues to be used year after year due to the good results obtained, visible on each periodic visit, and it appears that this type of protection manages to deter vandalism, but is at the mercy of the strong actions of tides and currents.

According to Pesic (2011: 79), the main problem in the covering and protection of remains is to ensure compaction and stability of the sand that covers the wreck, as this can be easily removed by currents and tides. In addition, the shallow depth is an area of deposition for sediment, which can sometimes be removed under the effect of strong undertows. In this case, the movements of the sand act in our favour, since the accumulation of sediments in the wreck area helps to maintain control of the protection system. The protective sacks also create a volume visible from the sea surface that is most evident in the area closest to the coast. This is because the wreck is not parallel to the seabed and, in that area, there is less sedimentation. It has also been observed that the currents generate a small hole in the sand surface, which makes the sacks used as a protection method easily visible in the sea by creating volumes on the seabed and favours unearthing from adjacent areas.

Every year, the state of conservation of the remains is assessed, and it was verified that the storms that occurred there during the excavation work initially affected the site and resulted in the loss of loose elements from the naval structure. Besides these punctual damages produced before the final protection was put in place, it has been shown that this system, once applied, is totally effective.

The protection works during all the campaigns has followed the same methods of covering as before, since after four years of use, their functionality is demonstrated in that they minimise the deterioration and increase the stability of the wreck against natural and anthropogenic impacts (Gregory, 2015). The combination of methods to create a physical barrier keeps the wreck in good condition.

The in situ consolidation technique using polyester resin strips is very efficient due to its simplicity, speed and material availability. It has allowed us to ensure the conservation in situ of different moving boards, to consolidate a small board which was totally fragmented and to fix a longitudinal fragment of one of the frames.

When it was decided to introduce the PVC cannulas to facilitate their manageability, the intention was also to improve the aesthetic result, creating uniform and homogeneous lines. It has been verified that the main factor influencing the effectiveness of the polyester resin stripts is the amount of resin used, rather than the use of the strips. It cannot be denied that the use of this technique

has some drawbacks that can subjectively seem to be of a greater or lesser importance. Visually, the polyester resin strips and the stitching method have a perceptible impact, which is considered an advantage as it makes them totally recognizable and discernible from the original remains, without interfering in the interpretation and study of naval architecture.

Thereby, this project required the search for new materials or methodologies to consolidate the structural parts for daily work. We have been constantly pursuing improvement and it was demonstrated that the polyester resin strips are not sufficient in cases that require a strong hold against thrusts and pressures, such as those which can be produced by the weight of the sand and the bags during the work. In such cases, it is better to use the method of "stitching" with PVC cannulas, which provide greater support and allow a custom application.

As an experiment, two-component ultra-fast-hardening epoxy putties of bronze colour have been used [3], among others, to help obtain an appearance mimicking that of the original remains, these being compatible with water once both components have been mixed on the surface. It turned out to be an improvement in terms of aesthetics with minimal impact, which was an objective from previous years that had yet to be accomplished.

It has also been possible to observe the evolution of these interventions and, as things stand, we can say that the anchors with strips made of bronze colour ultra-fast-hardening epoxy putties have had an optimal result, since they keep the wooden slats in place and in their original location.

Acknowledgements

The author would like to thank the other members of the IBEAM team (Dr. Enrique Aragón, Javier Rodríguez, Nicolás de Montis and Jaime Ros) for offering complete freedom of action and confidence in the conservation and protection interventions carried out on the Ses Llumetes wreck, as well as my predecessor Guillermo González for facilitating this journey with his incredible ingenuity and dedication. The IBEAM team would like to express their gratitude for the sponsorship of Jaume Nicolau from the Skualo Porto Cristo Diving Center (Mallorca), Ports de les illes Balears, Cressi (Spain) and Coves del Drack (Mallorca).

Endnotes

[1] The shipworms are marine bivalve molluscs of the *Teredinidae* family: a group of saltwater clams with long, soft, naked bodies. They are notorious for boring into (and commonly eventually destroying) wood that is immersed in sea water, including such structures as wooden piers, docks and ships; they drill passages by means of a pair of very small shells borne at one end, with which they rasp their way through. Sometimes called "termites of the sea", they also are known as "Teredo worms'' or simply "Teredo". Nair, N. B. and M. Saraswathy, 1971: 'The biology of wood-boring teredinid molluscs.' Advances in marine biology 9: 335-509.

[2] Suggested reading: ©WRECK PROTECT, 2011, Guidelines for Protection of Submerged Wooden Cultural Heritage 2011, Manders M.R., Protecting Common Maritime Heritage. The Netherlands involved in two EU-projects: MoSS and

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[3] Epoxy putty has been a key component in determining the tightness of the protection used and therefore its effectiveness, since it contains bronze particles making it susceptible to oxidation. It has been found that no oxidation occurred which demonstrates that the protection system used is effective as it creates a totally anaerobic environment.

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