THESIS

MANAGING UNDERWATER CULTURAL HERITAGE AT MOZAMBIQUE ISLAND: *IN SITU* PRESERVATION, MITIGATION AND MONITORING STRATEGIES FOR *NOSSA SENHORA DA CONSOLAÇÃO* (IDM-003) SHIPWRECK (1608)

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2021

University of Cape Town

THESIS SUBMITTED FOR THE DEGREE OF MASTER OF PHILOSOPHY IN THE DEPARTMENT OF ARCHAEOLOGY UNIVERSITY OF CAPE TOWN

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August 2021

DECLARATION

This is to certify that the results and conclusions presented in this thesis are my own and where the work of others has been used, is appropriately referenced. This thesis has not been submitted for a degree at any other institution of high learning.

Signature: Cézar Sebastião Mahumane

Contents

DECLARATION iii
TABLES vi
FIGURES vii
ABBREVIATIONS ix
ACKNOWLEDGEMENTS x
ABSTRACT xi

CHAPTER 1 – INTRODUCTION 1
1.1. Formulating the Problem 1
1.2. Defining the research aims 4
1.3. Presentation of the dissertation 5

CHAPTER 2 – SETTING THE SCENE: UNDERWATER ARCHAEOLOGY AND TREASURE HUNTING 6
2.1. Development of underwater archaeology as a field 6
2.2. The history of treasure hunting and related debates 9
2.3. Underwater archaeology in Mozambique 14
2.3.1. Colonial Period 15
2.3.2. Post-Independence Period 18
2.3.3. The advent of treasure hunting in Mozambique 22
2.4. Assessment of fourteen years of AWW/PI operations at Mozambican UCH 27
2.5. Recent approaches to UCH at Mozambique Island 30

CHAPTER 3 – CASE STUDY OF THE *NOSSA SENHORA DA CONSOLAÇÃO* (IDM-003) SHIPWRECK: HISTORICAL BACKGROUND 36
3.1. The geographical context 36
3.2. A brief background on the identification of the shipwreck 38
3.3. Contextualizing the history of the *Nossa Senhora da Consolação* Ship 41
3.3.1. First Dutch siege of Mozambique Island 1604 43
3.3.2. Second Dutch siege of Mozambique Island 1607 44
3.3.3. Third Dutch siege of Mozambique 1608 46

CHAPTER 4 – THE ARQUEONAUTAS EXCAVATION 49
4.1. Excavation operations on the *Nossa Senhora da Consolação* (IDM-003) 49
4.2. Description of the wooden hull structure 52
4.3. Preservation of the wooden hull structure post-excavation 53
4.4. Artefact description 56
4.4.1. Boat-shaped lead ingots 56
4.4.2. Coins 59
4.4.3. Lead Seals 61
4.4.4. Hippopotamus and elephant tusks 63
4.4.5. Martaban jars 66
4.4.6. Olive Jars 69
4.4.7. Local Pottery – The Lumbo Pots 71
4.5. Assessing AWW/PI's *modus operandi* on *Nossa Senhora da Consolação* (IDM-003) 75

CHAPTER 5 – MANAGEMENT STRATEGIES FOR *NOSSA SENHORA DA CONSOLAÇÃO* (IDM-003) 80
5.1. Environmental threats to *in situ* preservation 80
5.1.1. Estimating the extent of the site to conserve 83
5.1.2. Assessing threats to the site 89
5.2.1. Physical environmental threats: 91
5.2.1.1. Tidal currents and sedimentation 91
5.2.1.2. Dissolved Oxygen, Temperature, pH and Light 94
5.2.2. Biological threats 98
5.2.2.1 Wood condition and identification 98
5.2.2.2. Shipworm – Teredo Navalis 103
5.2.2.3. Gribble - Limnoria lignorum 105
5.2.2.4. Microorganisms (Fungi and Bacteria) 107
5.2.3. Human threats 108
5.2.3.1. Fishing 108
5.2.3.2. Sport Diving 110

CHAPTER 6 – ASSESSING DIFFERENT MITIGATION AND MONITORING STRATEGIES 112
6.1. Geotextile 112
6.2. Other Possible Mitigation strategies 115
6.2.1. Sandbags 115
6.2.2. Artificial Seagrass 116
6.2.3. Debris Netting 116
6.3. Monitoring the site and implemented mitigation strategies 117
6.3.1. General Visual Inspection 117
6.3.2. Photographs and Photogrammetry 118
6.3.3. Sampling on site and sacrificial samples 119
6.3.4. Marine geophysics 120
6.3.5. Hydrodynamic environment 121

CHAPTER 7 – CONCLUSION 122
7.1. Assessing the extent of the site and its level of degradation 122
7.3. Determining the stabilization and monitoring strategies for the site 124
7.4. Additional impacts of the study 124
7.5. Way forward 126

REFERENCES 128

APPENDICES 141

TABLES

Table 1. Amount of ivory traded by Carreira da India Ships 65
Table 2. Operations used to generate the IDM-003 photogrammetry model on Agisoft PhotoScan® 86
Table 3. Sediment samples and classification.. 94
Table 4. pH readings at IDM-003 97
Table 5. Comparison of physical threats between IDM-003 and other Wrecks 98
Table 6: Rating scheme for wood degradation 99
Table 7. Wood samples condition and identification... 101
Table 8: Seawater condition for the presence of woodborers 106
Table 9. Traditional fishing methods in Mozambique Island 109

FIGURES

Figure 1. Quirino da Fonseca carrying out surveys at Mozambique Island in 1960s. Source: Da Fonseca (1964:) 16
Figure 2. Important shipwrecks areas defined by Quirino Da Fonseca. Source: Da Fonseca (1964:).. 17
Figure 3. Fieldwork carried out by Ricardo Duarte, Steve Lubkemann and David Conlin in 1999. Photo: Ricardo Duarte, 1998-1999 20
Figure 4. Partial mapping of the São Sebastião Fortress shipwreck. Source: Duarte et al., 2015 21
Figure 5. Map of the AWW/PI contract area. Compiled by Cezar Mahumane, 2019 24
Figure 6. Location of IDM-002 or São Sebastião Fortress Shipwreck and Chinese porcelain sold. Compiled by Cezar Mahumane, 2019 26
Figure 7. Condition of the sites visited by the assessment team in 2014, (a) IDM-002; (b) IDM-003 wreck. Photo: Ricardo Duarte, 2015 28
Figure 8. Institutional growth and capacity building through SWP, (a) CAIRIM facilities; (b) and (c) training local community in SCUBA diving. Photo: Ricardo Duarte, 2018 32
Figure 9. Map of Mozambique Island bay. Drawer: Cezar Mahumane, 2019 37
Figure 10. Location of Nossa Senhora da Consolação (IDM-003). Drawer: Cezar Mahumane, 2019 40
Figure 11. Hypothetical reconstruction on the capture of the nau de Trato (Barradas 2018:122). 43
Figure 12. Drawing on hypothetical Dutch attack and Portuguese defence to São Sebastião Fortress (Cardoso 2013:24) 45
Figure 13. Map of the excavated grids and exposed hull remains by AWW/PI. Source: Mirabal (2013:33) 51
Figure 14. The exposed wooden hull remain on photomosaic by AWW/PI. Source: Mirabal (2013:77) 52
Figure 15. Site condition, Jeffery 2011(a) and Duarte 2015(b). Compiled by Cezar Mahumane, 2019 55
Figure 16. Images of the boat-shaped lead ingots and a marking present on the ingots. Compiled by Cezar Mahumane, 2019 57
Figure 17. Ingots Typology according to Willies (1985) 58
Figure 18. Comparative coin collection, (a) Nossa Senhora da Consolação (IDM-003); (b) Nossa Senhora dos Mártires. Compiled by Cezar Mahumane, 2019 60
Figure 19. Cloth seals found at Nossa Senhora da Consolação (IDM-003), (a) personal and private seals; (b)Custom seals. Photo: Cezar Mahumane, 2019 62
Figure 20. De Sousa Map and the representation of the Custom seal. Source: De Sousa 2019 63
Figure 21. Elephant tusks and hippopotamus teeth left at Mozambique Island by AWW/PI. Photo: Cezar Mahumane, 2019 66
Figure 22. Comparative Martaban jars, (a) Nossa Senhora da Consolação (IDM-003); (b) Nossa Senhora dos Mártires. Compiled by Cezar Mahumane, 2019 68
Figure 23.Typology of olive jars according to Goggin 1960. 70
Figure 24. Map of the ballast pile sitting next to Nossa Senhora da Consolação (IDM-003). Drawer: Cezar Mahumane, 2019 73
Figure 25. Lumbo pottery found at Nossa Senhora da Consolação (IDM-003): Photo: Cezar Mahumane, 2019 74
Figure 26. Recording of the Nossa Senhora da Consolação (IDM-003). Photo: Ricardo Duarte, 2016 84
Figure 27. IDM-003 Site plan on Inkscape during 2016 processing data. Drawer: Cezar Mahumane, 2016 85
Figure 28. Collecting data for photogrammetry at IDM-003. Photo: Ricardo Duarte, 2016 87
Figure 29. Mapping of IDM-003 showing the differences in one year period. Drawer: Cezar Mahumane, 2019 89
Figure 30. Images of the data loggers on the site, (a) temperature and light data logger; (b) dissolved oxygen and temperature data logger. Photo: Cezar Mahumane, 2019 90
Figure 31. Wood and sand sampling. Photo: Celso Simbine, 2019 91
Figure 32. Analysing sediments from IDM-003, (a) sand sieves; (b) rinsing sand on hydrochloric acid; (c) drying and weighing the sand. Photo: Cézar Mahumane, 2019 93

Figure 33. Graphic of dissolved oxygen and temperature at Nossa Senhora da Consolação (IDM-003) 96
Figure 34. Wood sample and analyses of the process of degradation of the wood. Photo: Celso Simbine, 2019 100
Figure 35. Teredo navalis settling the wood. Source: Danilovic (2014:) 104
Figure 36. Teredo navalis in sample 4 from Nossa Senhora da Consolação (IDM-003)...... 105
Figure 37. Gribble found on wood sample 1 at Nossa Senhora da Consolação (IDM-003)...... 106
Figure 38. DWP training at Nossa Senhora da Consolação (IDM-003) for community Monitors. Photo Ricardo Duarte, 2017. 111
Figure 39. Unrolling the geotextile on Nossa Senhora da Consolação (IDM-003). Photo: Hilard Dean, 2017 113
Figure 40. Map of the areas covered with geotextile. Drawer: Cézar Mahumane, 2020 114
Figure 41. Sandbag strategy. Source: Manders (2011:) 115
Figure 42. Example of the artificial seagrass strategy. Source: Manders (2011:) 116
Figure 43. Example of the debris netting strategy. Source: Manders (2011:) 117
Figure 44. Sacrificial samples and sampling process. Source: Palma (2004:) 120
Figure 45. Community monitors initiative. Photo: Ricardo Duarte, 2016 125
Figure 46. Exhibition and seminar presentation of the study. Photo: Cezar Mahumane 2017 126

ABBREVIATIONS

3D	Three dimensional
ADCP	Acoustic Current Doppler Profiler
AUV	Autonomous Underwater Vehicle
AWW/PI	Arqueonautas World Wide/Património Internacional
CAIRIM	Centro de Arqueologia, Investigação e Recursos da Ilha de Moçambique
CMRHM	Comissão de Monumentos e Relíquias Históricas de Moçambique
CNANS	Centre of Nautical and Underwater Archaeology
DAA-EMU	Department of Archaeology and Anthropology – Eduardo Mondlane University
DSM	Direct Survey Methods
DWP	Diving With a Purpose
HD	High Definition
ICOMOS	International Council on Monuments and Sites
IDM	Ilha de Moçambique
ITCZ	Intertropical Convergence Zone
JPEG	Joint Photographic Experts Group
MAM	Missão Antropológica de Moçambique
MICOA	Ministério para a Coordenação da Acção Ambiental
MOG	Mongicual
MoSS	Monitoring, Safeguarding and Visualizing North-European Shipwreck Sites
MUCH	Maritime and Underwater Cultural Heritage
NAS	Nautical Archaeology Society
NDCH	National Directorate of Cultural Heritage
NE	North-East
PI	Património Internacional
RftD	Rising from the Depths
RMS	Royal Mail Ship
ROV	Remoted Operated Vehicle
SCUBA	Self-Contained Underwater Breathing Apparatus
SIDA-SAREC	Swedish International Development Cooperation Agency-Department for Research Cooperation
SW	South-West
SWP	Slave Wrecks Project
UCH	Underwater Cultural Heritage
UEM	University Eduardo Mondlane
UNCLOS	United Nations Convention on the Law of the Sea
UNESCO	United Nations Educational, Scientific and Cultural Organization
VOC	*Verenigde Oost-Indische Compagnie* - Dutch East India Company

ACKNOWLEDGEMENTS

I wish to thank my co-supervisor Mr Jaco Boshoff for his mentorship, fruitful ideas in the elaboration of this dissertation and support during fieldwork. And to my supervisor Professor Simon Hall for his encouragement and support in the preparation of this dissertation as well as in creating all the conditions making it possible.

I would like to express my gratitude to Mr Ricardo Teixeira Duarte for reading and commenting early draft of this dissertation. I am indebted to Mr Ricardo Teixeira Duarte who is my mentor, introducing me to Underwater Archaeology and teaching me all the basics of this science. I am also thankful to Professor Anneli Ekblom and Mr John Gribble for reading, commenting on and supporting me in language correction in the last version of this dissertation.

I give extra thanks to my colleagues at the Department of Archaeology and Anthropology at Eduardo Mondlane University, who have supported and encouraged me. A special thanks to Dr Hilário Madiquida and dra Etelvina Covane for their support in bureaucratic matters at the Department and Faculty at Eduardo Mondlane University.

Many thanks go to the Mozambique Island Community that has always supported me during fieldwork and given me joy in sad moments. To Amade Ismael, Dinho the Diver, Dinho Aptur, Sadamo, Saide, Joaquim, Faizal, Quioma, my dive and skipper team. And to all the staff from Escondidinho Hotel, I express my greatest gratitude.

To my parents, Sebastião Mahumane and Angelica Mahumane (in memory) I am deeply thankful for the motivational and emotional support and all the moments shared as a family. To my sisters, Amelia (in memory), Carla, Joana and Angela Mahumane, thank you for supporting and inspiring me all the time. To my friends, Celso Simbine and Cornelius Mushangwe, thank you for all the joy and support you have given me.

I am deeply grateful to Swedish International Development Cooperation Agency-Department for Research Cooperation (SIDA-SAREC) for funding my studies at the University of Cape Town. I am also grateful to Slave Wrecks Project (SWP) for all the support and training provided to me.

ABSTRACT

The problem of treasure hunting on underwater archaeological wrecks has been discussed since the formal development of maritime archaeology as a field and countries have been fighting against the illegal destruction of important shipwrecks and removal of scientific evidence. The underwater cultural heritage of Mozambique is no exception and is emerging from almost two decades of destructive treasure hunting that has heavily impacted this heritage, particularly around Mozambique Island and adjacent areas. In 2014, the Mozambican Government cancelled treasure hunter permits, opening up opportunities to develop proper methodologies for research on this heritage that will contribute to its management and protection. Importantly, the focus is on building capacity and developing policies and institutions concerned with underwater heritage management.

This dissertation contributes to this development. First, it explores the factors impacting the deterioration of underwater cultural heritage at Mozambique Island, with a particular emphasis on the wreck *Nossa Senhora da Consolação* (IDM-003), lost in 1608 during a Dutch siege of the island. The operations carried out by treasure hunters on this wreck are discussed and these underpin my research on the deterioration of the site and its current preservation status. Having done this, I analyse and discuss the origin of the ship and the associated material culture in order to reinterpret and contextualize its history. The consideration of the material culture additionally contributes to identifying the gaps in the collection left by the treasure hunters. Second, the dissertation assesses environmental factors affecting the site and formulates interventions and a range of *in situ* preservation, mitigation and monitoring methodologies. The results and conclusion highlight both the environmental and human factors that have, and continue to influence the rate of degradation of the site and the long term actions required to mitigate this degradation.

CHAPTER 1 – INTRODUCTION

Mozambique has a 2,700 km long coastline with rich underwater heritage which is largely unmanaged due to scarcity of resources. The present dissertation was developed in the aftermath of a treasure hunting permit given to a private company, *Arqueonautas Worldwide* (AWW) and its partner *Património Internacional* (PI) (hereafter referred to AWW/PI) in Mozambique for a period of 14 years. AWW/PI focused much of their activity on Mozambique Island, declared as UNESCO World Heritage Site in 1991. The cancelation of the AWW/PI license by the Mozambican Government in 2014 opened up opportunities to discuss issues related to the nature of underwater archaeology and treasure hunting, artefactual interpretation, preservation and the management of submerged archaeological sites that will be presented here.

Since the cancellation of the AWW/PI permit, a multidisciplinary team has been working at Mozambique Island to ensure the documentation of finds, and the protection and preservation of endangered underwater cultural heritage (UCH). There have also been efforts to build institutional capacity in Mozambican academia and locally amongst the Mozambique Island community. Through collaboration with the Slave Wrecks Project (SWP) and its support we now have more trained professional underwater archaeologists and have also seen the creation of a Centre of Archaeology and Research at Mozambique Island, devoted to the management of UCH.

The present dissertation is a combination of several efforts undertaken by the Slave Wrecks Project, funded by the Smithsonian Institute and also the Biocultural Heritage Project, funded by Swedish International Development Cooperation Agency, in building capacity in Mozambique and fostering research and heritage preservation. The dissertation explores and discusses the nature of treasure hunting and proposes strategies for the *in situ* preservation of the *Nossa Senhora da Consolação* (IDM-003) wreck at Mozambique Island. The experience generated from this wreck will be used to discuss the *modus operandi* and consequences of treasure hunting practice on UCH.

1.1.Formulating the Problem

Through the years, the development of underwater archaeology has been built on the application of multi-disciplinary knowledge and approaches, which has allowed for a range of analysis and techniques to explore submerged sites (shipwrecks) and artefacts, broadening the perspective of the potential of underwater heritage to explain the human past (Gould 2000;

Bass 2011). At the same time, treasure hunting companies have been taking advantage of these technological advances by applying the methods developed and used in archaeological science to sites and in lobbying for licensing rights (Williams 1997; Carvalho 2007; Bass 2011).

Although AWW/PI and other similar companies market themselves as companies carrying out high quality research, treasure hunting is detrimental to underwater heritage as I will show here. The aim of treasure hunting, for the most part, is to recover valuable artefacts for sale, often at the cost of the disturbance of sites and even the destruction of shipwrecks. The extraction of finds leaves behind little besides destruction, dispersed collections and, typically, poor documentation or a complete lack of documentation (see discussion in Williams 2007; Duarte *et al.,* 2015). Hence, important information for site interpretation and the reconstruction of the human past, risks being lost.

Over time, archaeologists and officials worldwide have increasingly voiced concern over the detrimental effects of treasure hunting. Many pushed for fighting treasure hunting practice through legislation and international treaties such as the United Nations Educational, Scientific and Cultural Organization (UNESCO) 2001 Convention on the Protection of Underwater Cultural Heritage. Mozambique has not ratified the UNESCO 2001 Convention yet. The process has been slow and national governments have been weak in countering the lobbying from treasure hunting companies.

Mozambique like many other countries over the world have had to deal with treasure hunting activities for a long time. The country has a long coastline and a generally understaffed heritage sector. There is also a general lack of understanding in the political arena that the basic premise of heritage management is to preserve and document, rather than to extract. In 1999, the Mozambique Government, persuaded by the lobbying of AWW/PI, granted them an exclusive exploration permit to work along 700 kilometers of the northern Mozambique coastline (Lane 2012; Duarte 2012; Duarte *at al*., 2015). This license was given against the advice of national and international academia and authority officials, as will be discussed further in Chapter 2.3.3.

For 14 years AWW/PI intervened on important shipwrecks, most of them located at Mozambique Island, a place which reflects a long history of maritime trade between Europe, India and the East African coast. In addition to *Nossa Senhora da Consolação* (IDM-003), that will be discussed here, detrimental interventions by AWW/PI were carried out on the *São Sebastião Fortress shipwreck* (IDM-002*)* and the *São José* (MOG-003), and many of their artefacts were sold at auctions (AWW/PI 2014; Duarte *et al*., 2015).

The ship *Nossa Senhora da Consolação* (IDM-003) which is used as a case study here, sank in 1608 according to the written record (Durão 1633). The ship was a Portuguese Indiaman (in Portuguese *Carreira da India*) from the 'Age of Discoveries' and her wrecking is linked to the attack on Mozambique Island by the Dutch in 1608 (Durão 1633; Da Fonseca 1964). After the formation of *Verenigde Oost-Indische Compagnie* – Dutch East India Company – in 1602, the Dutch repeatedly attacked Portuguese East India ships. Mozambique Island was a strategic port for Portuguese ships and the Dutch East India company made three attempts, in 1604, 1607 and 1608, to occupy the island and control the East Indian trade (Murteira 2006; Arnold 2014).

The *Nossa Senhora da Consolação* was captured in 1608 by the Dutch near the São Sebastião fortress and was taken away from the island by the Dutch, however due to low tide it grounded in the shallow waters near Cabaçeira Pequena. Taking advantage of the situation, the commander of the São Sebastião Fortress, Dom Estevão de Ataíde ordered Portuguese soldiers to burn the ship to avoid it being taken by the Dutch (Durão 1633; Da Fonseca 1964; Murteira 2006, Arnold 2014). The existence of the shipwreck *Nossa Senhora da Consolação* has been well known through written sources[1] but the actual location of the wreck was unidentified for four centuries.

An attempt to locate the wreck was made by Quirino Da Fonseca in the 1960s, but without success. Years later, underwater researchers from the Department of Archaeology and Anthropology at Eduardo Mondlane University (DAA-UEM) reported the existence of a wreck near Cabaçeira Pequena and Mozambique Island. Though no details or descriptions were provided about the wreck, it is likely to have been the *Nossa Senhora da Consolação.*

In 2001, the AWW/PI officially located the wreck and codenamed it IDM-003. The site was extensively excavated by AWW/PI between 2005 and 2006, resulting in the recovery of a large number of artefacts, among which were five tons of lead ingots that were sold. The wooden hull structure of the wreck was exposed as a result of the excavations and an attempt was made by AWW/PI to describe and document the structure. The quality of this documentation is low and there were no attempts to mitigate the negative effects of the exposure of the hull remains in terms of preventing the decay of the structure itself (Mirabal 2005, 2006, 2013). The excavation of the *Nossa Senhora da Consolação* (IDM-003), has been used by the company as a positive example of the high scientific quality of the archeological work of AWW/PI.

[1] See the book *Cercos de Moçambique defendidos por D. Estevão de Ataíde*, a manuscript from Antonio Durão, a Portuguese soldier present in the São Sebastião fortress at the time the *Nossa Senhora da Consolação* sank.

However, as I will discuss here the methodologies used in excavation, artefact description and interpretation, as well as site preservation were not up to the standard of an archaeological project in terms of documentation, conservation and presentation.

1.2.Defining the research aims

When AWW/PI completed their excavation at *Nossa Senhora da Consolação* (IDM-003), the hull structure was abandoned, exposed and vulnerable to activities of woodborers which in combination with other factors progressively degraded the wood. Though AWW/PI later attempted to cover the structure, the work was insufficient. The wood hull structure has remained exposed as a result of the excavation. This dissertation, therefore is aimed at the discussing the potential for *in situ* preservation of the hull structure and analyses the physical, biological and human factors detrimental to its preservation. In this dissertation the impacts of threats to the site will be discussed and potential mitigation strategies for *in situ* preservation and monitoring methods will be explored.

Similar studies carried out on shipwrecks in Europe, such as the Monitoring, Safeguarding and Visualizing North-European Shipwreck Sites project/MoSS project (see Cederlund 2004) and the EU project *WreckProject* (see Björdal *et al.,* 2012), have developed tested methodologies for *in situ* preservation of wreck sites. Shipwrecks that have been studied showed a close relation between physical and biological factors threatening the sites. These studies provide a good comparison to the context of the *Nossa Senhora da Consolação* (IDM-003) and will be used to understand her degradation rate. Therefore, this dissertation will be looking at the degradation of archaeological materials on the *Nossa Senhora da Consolação* (IDM-003) with three main objectives. The first is to assess the extent of the site and its level of degradation using traditional methodologies. The second objective is to analyse physical, biological and human threat factors contributing to the site degradation. The third objective is to determine stabilization and monitoring strategies that can be used on the *Nossa Senhora da Consolação* (IDM-003).

As part of this dissertation, a comparative analysis will also be carried out with other Portuguese wrecks containing similar features to the *Nossa Senhora da Consolação* (IDM-003) which seems to be contemporaneous with the *Nossa Senhora dos Mártires* (1606) wreck found in the Tagus River in Portugal (Mirabal 2013; Arnold 2014). Some indicative artefacts found at *Nossa Senhora da Consolação* (IDM-003) were compared with similar material from other wrecks to contextualize the chronology and origin of the materials.

1.3.Presentation of the dissertation

As a pilot study, this dissertation explores some of the most basic low tech methods to preserve and monitor underwater archaeological sites *in situ* against the many different threats to the integrity of sites. Chapter One introduces in more detail the background and history of the problem analysed in the dissertation and the methods that will be used in the study.

Chapter Two provides the reader with a brief historical view of the development of underwater archaeology and treasure hunting in a broader perspective. In the second part of Chapter Two the Mozambican context will be specifically discussed and also the recent approaches toward the UCH at Mozambique Island.

Chapter Three defines the basic setting of the study area, with descriptions of Mozambique Island, and a brief history of the identification of the *Nossa Senhora da Consolação* (IDM-003), as well as the historical context of the ship. The Chapter describes the excavations carried out by AWW/PI and methodologies applied.

Chapter Four also provides a description of the wooded hull structure of the *Nossa Senhora da Consolação* (IDM-003) and its condition. Furthermore, a comparative analysis of the artefacts collected by AWW/PI from the *Nossa Senhora da Consolação* (IDM-003) is made with other sites along the coast. The Chapter closes with a discussion on the AWW/PI *modus operandi* on this particular site.

Chapter Five goes into methodological aspects regarding *in situ* management strategies for the *Nossa Senhora da Consolação* (IDM-003). The methodology used to determine the extent of the site to be conserved and the samples collected are described in detail. Chapter Six discuss the results of the analysis and the strategies that can be used to mitigate and monitor a wreck site *in situ.*

The final Chapter discuss the results of the methodology applied for *in situ* preservation of the *Nossa Senhora da Consolação.* The Chapter also addresses some of the most significant impacts of this study as well as the next steps forward in the Mozambican underwater archaeology context.

CHAPTER 2 – SETTING THE SCENE: UNDERWATER ARCHAEOLOGY AND TREASURE HUNTING

2.1. Development of underwater archaeology as a field

The origins of underwater archaeology can be traced back to the 19th century, when a handful of intrepid archaeologists began to use helmet diving methods or employ sponge divers to look at submerged ruins and wrecks (Flemming & Redknap 1987). These methods were used on several sites until the end of the Second World War, when the so called aqualung, a self-contained underwater breathing apparatus (SCUBA), was invented in the early 1940s by the Frenchmen Jacques-Yves Cousteau and Emil Gagnan (Hosty & Stuart 1994).

SCUBA technology made it possible for scientists and explorers to work cheaply and easily in waters up to 50 meters deep (Hosty & Stuart 1994). The invention of SCUBA and its commercial production and spread raised people's interest in shipwrecks in many ways. Some people enjoyed exploring shipwrecks for pure leisure, while others were interested in shipwrecks as an archaeological resource to build knowledge of the past. But the invention of SCUBA technology also allowed the increasing interest in treasure hunting and facilitated the looting of shipwrecks (Prott & O'Keefe 1987; Hall 2007).

The individuals interested in shipwrecks as archaeological resources played a big role in the development of underwater archaeology as an academic field, from what was in the beginning dominated by antiquarianism and treasure hunting into a systematic and disciplined field (Prott & O'Keefe 1987; Hosty & Stuart 1994). The field of underwater archaeology is concerned with the identification and interpretation of physical remains of human activity from submerged environments. The aim of the underwater archaeology is not simply the description and interpretation of the underwater material, but also its interpretation to explain social, economic, cultural and environmental events in a local and global perspective (see discussion in Muckeleroy 1978; Bass 2011; Gould 2011).

During the course of the 20th century, underwater archaeology saw significant advances in survey and excavation methodologies, controlled laboratory methods for artefacts conservation and theoretical approaches for interpreting submerged artefacts and sites. As Muckeleroy (1978), Musgrave (2006) and Gould (2011) have emphasised, these developments generated new insights on the interpretations of past society.

Broadly, the development of underwater archaeology can be divided into two phases. The first phase was characterized by divers who were interested in shipwrecks but lacked training in archaeology and thus lacked the skills to properly document and interpret archaeological sites (Gibbins & Adams 2011; Bass 2011). This lack of archaeological training was a problem and commenting on those early days, George Bass (2011), who is considered the father of underwater archaeology, stated that it was far easier and more constructive for underwater archaeology to teach diving to a trained archaeologist than the other way around.

Nevertheless, some pioneering projects took place in the 1950s. For example, the excavation of Roman shipwrecks in Grand Congloue, at Cape Dramont and Ile du Levant in France and the excavation of Mahidia off Tunisia, and at Albenga in Italy (Muckeleroy 1978). During these excavations, French and Italian divers for the first time used standard tools like airlifts to remove sediments, and metal grids to map the sites. The divers also adapted filming for underwater conditions to allow archaeologists to guide and follow the progress of the work from the surface (Muckeleroy 1978; Flemming & Redknap 1987). Though there were efforts of establishing a standard procedure, the methodological expertise in underwater archaeology in the 1950s was still limited as practitioners were untrained in site and artefact interpretation and conservation.

The recognition of these limitations and challenges led to stronger efforts to standardise methods and approaches in underwater archaeology, in what is here referred to as the 'second phase' of development of underwater archaeology which took place from the 1960s. This phase in the development of underwater archaeology is characterized by more sophisticated methodological and theoretical approaches and an increasing professionalization. A major shift occurred when archaeologists were trained to dive and started to perform excavations themselves, leading to more knowledgeable artefact and site interpretation, and also, most importantly, to strategic conservation work (Muckeleroy 1978; Flemming & Redknap 1987). From the 1960s, some remarkable projects were carried out. Examples are the excavation of a Bronze Age shipwreck at Cape Gelidoya in Turkey by George Bass and the rescue of the Swedish warship *Vasa* (1628) sunk in the Stockholm (see review in Bass 2011).

In a Chapter he wrote in the Oxford Handbook of Maritime Archaeology, *The Development of Maritime Archaeology*, George Bass (2011) describes his own endeavours in developing underwater archaeology. Bass pioneered the use of recording and documentation techniques, for instance using grids to produce accurate site plans. These innovations enabled underwater archaeologists to apply and maintain the same site recording standards as would be expected on land (Flemming & Redknap 1987; Gibbins & Adams 2011). There were likewise other achievements in terms of artefact conservation. The level of accuracy in descriptions of deposits and the position of finds produced by Bass demonstrated that methodological approaches used in terrestrial archaeology could be equally well applied in the underwater environment (see discussion in Bass 2011).

The development of theoretical approaches for interpreting underwater site formation processes was pioneered by Keith Muckeleroy in the 1970s. In his book, *Maritime Archaeology*, Muckeleroy (1978) demonstrated how the formation of an underwater site is influenced by physical, biological and human factors and the different stages which affect the preservation or decomposition of the site (see Chapter 5 below). Later in the 1990s, Muckeleroy's work was complemented by Ward (1999), adding to our understanding of underwater site formation process in terms of chemical factors influencing sites.

All these advances in methodology, theory and dive training for archaeologists, resulted in the appearance of several underwater projects carried out in different places. Consequently, hundreds of books and magazine articles were written on underwater archaeology giving massive publicity to the field (Muckeleroy 1978). With this expanding interest, underwater archaeologists had opportunities to share knowledge and experiences thus enhancing the inter-disciplinary nature of the field. This included collaborations between natural sciences and the arts and social sciences, which contributed to broaden further the perspective and interpretation of underwater archaeology material (Gould 2000; Musgrave 2006; Bass 2011).

Through the years, underwater archaeology has established methodologies for excavation and conservation and a conceptual apparatus for interpreting archaeological material found in submerged contexts (Gould 2000). The development of the field has also been strongly influenced with the rapid development in technologies and marine science (Gould 2011). New, cutting-edge technologies are regularly introduced and tested by the field which enhance the capabilities of diving and enable archaeologists to work underwater comfortably and with greater mobility, further expanding underwater archaeology as an academic field.

2.2. The history of treasure hunting and related debates

Throughout history, the sinking of a boat or a ship has been accompanied by looting or rescue missions in various ways. As early as the 3rd century BC, Alexander the Great was lowered in a diving bell, a technology that allowed divers to descend some meters underwater while breathing (De Carvalho 2007). Later in 1531, the Italians developed a technology using slings to attach a bell to the body, which enabled divers to collect artefacts from shipwrecks (Prott & O'Keefe 1987). However, as already discussed above it was the invention of SCUBA in the 1940s and its commercialization which allowed increased numbers of people to access to wreck sites, resulting in a massive looting of shipwrecks in different parts in the world (Williams 1997; De Carvalho 2007; Pringles 2013).

Treasure hunting developed from an amateur activity into a profession with the acquisition of sophisticated equipment that allowed diver to reach shipwrecks even in more remote waters. Modern technologies have been used not only by professional archaeologists but also treasure hunters, who have been using these technologies to locate and loot sites. With the recent invention of Remote Operated Vehicles (ROVs) and Autonomous Underwater Vehicles (AUVs), no wreck is now out of reach for treasure hunters with access to these technologies.

Treasure hunters have been able to locate and loot many wrecks lying very deep, examples are the RMS *Titanic* lying at a depth of 3.800 meters (Aznar & Varmer 2013), or the *Nuestra Señora de las Mercedes* wreck lying at a depth of 1.138 meters (UNESCO 2019). In both cases, treasure hunters used ROVs to access the wrecks at depths that human beings could not reach. Over time, there has thus been an increasing involvement of underwater archaeologists in the protection of shipwrecks from treasure hunting activities through legal measures (Bass 2011).

But let's pause and ask what the definition of treasure hunting is in comparison to underwater archaeology. Delgado (1988:424) writes that, *in its pure sense, treasure hunting is essentially an activity devoted intrinsically to collect valuable objects from historical or archaeological sites, for personal or private gain*.

Treasure hunting is carried out either by amateurs or professionals, either organized individually, or in groups or in companies. Amateur treasure hunters are often single individuals or small groups of individuals devoted to looting shipwrecks, collecting valuable artefacts for private gain as Delgado writes above. Professional treasure hunters on the other hand, tend to be organized in small or big companies with the funding and resources to massively loot shipwrecks. In both cases, amateur and professional treasure hunters have a detrimental effect on underwater cultural heritage, as their main and only objective is to recover valuable artefacts for sale or to keep in private collections.

Amateur treasure hunters frequently scavenge shipwrecks looking for souvenirs, for instance coins or ingots to sell or to keep in a private collection or simply because they have a general interest in old materials. The activities of amateur treasure hunters are not usually accompanied by appropriate documentation or preservation measures and the scientific value of the collected material tends to be lost as, emphasised by Williams (1997) and Pringle (2013). Professional treasure hunters are generally equipped with cutting-edge technologies capable of identifying and recovering thousands of artefacts very quickly to sell to collectors, museums or specialized antiquity dealers (Pringle 2013). Therefore, the impact caused by professional treasure hunters on shipwrecks is often catastrophic.

The existence of a ready market for shipwreck artefacts, through international auction houses has turned treasure hunting into a big business. International auction houses like Christie's have become world specialists in the sale of items recovered through underwater activities. Christie's has also helped to whitewash the sale of items recovered from illicit, shady or 'licenced' underwater activities under the label of "*material recovered legally or under license from historical shipwrecks* (De Carvalho 2007).

The existence of a *finder's keeper*[2] practice was also problematic in underwater archaeology. In the underwater context a person discovering a shipwreck was entitled to extract a percentage of lot, as was the case in Mozambique. This practice have resulted in the excavation and selling of many artefacts from shipwrecks. The practice has made some few individuals famous. Examples are Mel Fisher, Bob Marx, Frank Goddio, Michael Hatcher and Greg Stemm who were all organising groups to locate treasure ships in order to profit from the sale of the recovered objects (Hall 2007; Pringle 2013).

The *finder's keepers* practice has benefited and fostered the development of treasure hunting companies like the Portuguese company *Arqueonautas Worldwide.* This company has intervened in more than 150 shipwrecks in Mozambique and Cape Verde and most of the recovered artefacts were sold at auction (http://aww.pt/ accessed in 04/02/2020). At the same

[2] The finders keepers principle states that a person who located shipwrecks and brought up their cargo was entitled to a reward, either a flat fee or a percentage of the value of the discovery. Sometimes the person could even claim legal ownership of the wreck and its contents (Hall 2007; Pringle 2013)

time the company has a scientific board, it employs archaeologists and produces archaeological reports published on its website. The motto of the company proudly proclaims that it is: *saving World Maritime Heritage since 1995*.

Another example of a company which has benefited from the *finder's keepers* practice is the American *Odyssey Marine Exploration, Inc.*. This company operates a state-of-the-art-ship equipped with high technology equipment specifically to locate shipwrecks. *Odyssey*, like *Arqueonautas* also employs archaeology professionals. *Odyssey* tends to promote its activities through media reporting of spectacular treasures, as in the case of the *Nuestra Señora de las Mercedes* from which the company recovered 500.000 silver coins in 2003 (https://www.odysseymarine.com/ accessed in 04/02/2020).

The *modus operandi* of treasure hunting companies, in developing countries in particular, is to take advantage of the lack in legislation which protects the underwater cultural heritage. The companies negotiate exploration permits with Governments promising to undertake archaeological research, training and exhibit material for the public. The companies then use high technology equipment to produce accurate maps of sites as if they were doing archaeology, which enhances their credibility with the government concerned. They also recover and conserve some artefacts of low monetary value from the seabed to build trust, as if they are interested in non-valuable materials. In addition, they hire professional archaeologists to lend legitimacy to their work. All these measures are done to build credibility in terms of archaeological work with the companies claiming to be ‘saving’ underwater heritage (Hall 2007; Bowens 2009).

However, what these companies are doing cannot be considered archaeology. The artefacts they recover are not kept together as permanent collections, and the quality of their site documentation and recording is usually low. Treasure hunters must also make a profit by selling artefacts to repay the financial backers of their search and operations (Bowens 2009; Sharfman *et al.*, 2012; Duarte 2012; Lane 2012). When the big treasure hunting companies locate a shipwreck their main concern is thus to assess how many commercially valuable artefacts are available on the wreck and a looting process is started immediately by all means available (De Carvalho 2007).

The commercially valuable artefacts they recover will be conserved and sold on the black market, through auctions houses, or sometime kept in a private collection. This dispersal of the collected materials makes future study and re-evaluation of sites impossible. There is also generally a lack of documentation of where and how finds were retrieved. When a collection is incomplete due to its dispersal, the comparison of the find assemblage with other assemblages is greatly reduced (Bowens 2009). For example, the dispersal of the boat-shaped ingots from the *Nossa Senhora da Consolação* (IDM-003) now makes it impossible to establish any comparison with similar collections from other ships, resulting in the overall loss of knowledge (see Chapter 4).

For individual professional archaeologists, working with treasure hunters poses an ethical dilemma. Treasure hunter companies are driven by the profit incentive and archaeologists employed by them therefore do not generally get a chance to explore important question related to the wreck site (Johnston 1993). Consequently, sites that have been excavated by treasure hunters are not completely investigated or documented and excavations are commonly carried out without being guided by research question other than to recover valuable artefacts (Johnston 1993; Hall 2007).

Worldwide the trend is for treasure hunters that have received permits to recover valuable artefacts from shipwrecks and then abandon the sites and those artefacts with no monetary value (Hall 2007; De Carvalho 2007). In many cases, although the Government involved may have legal tools to protect the UCH against treasure hunting, personal interests or ignorance of the law or the nature of treasure hunting companies makes the legislation worthless (Hall 2007; Pringle 2013).

Even when the destructive activities of treasure hunting companies are revealed, their practitioners are seldom prosecuted, and they are not forced to take responsibility for the destruction caused. As a result, wrecks excavated by treasure hunters are often abandoned with their hulls and non-valuable artefacts exposed to deterioration, and require extensive and expensive preservation work. The management of these abandoned sites falls to the Government that issued the permits for treasure hunters. Often the Government has to manage such heritage without proper resources such as staff, equipment and funding.

With the impact of treasure hunting activities on UCH, underwater archaeologists started a movement to create legislation to protect UCH. Worldwide, countries also become increasingly aware of the risks treasure hunting was posing to UCH. The United Nations Convention on the Law of the Sea (UNCLOS) 1982[3] treaty and the International Council on Monuments and Sites

[3] Is an international treaty which regulates the law of the sea, but only the articles 149 and 303 provide obligations for States Parties to protect UCH, however, it does not specify in detail the nature of the protection.

(ICOMOS) 1996[4] Charter although respectively provided some general protections to UCH and established a code of international best practice for its management, have been seen as too weak in terms of protection of UCH. Underwater archaeologists considered that neither of these documents was clear enough to ensure protection of the UCH against treasure hunting activities. Archaeologists and countries called for the development of specific international legislation which could effectively protect UCH against treasure hunting activities and foster collaboration between countries.

Understanding the urgency of the situation, UNESCO assumed the responsibility for creating a legal instrument based on the principles of the ICOMOS 1996 Charter. In 1997 UNESCO´s General Conference decided, at its 29th session, to develop an international convention. Its aim was to protect the UCH, and the matter was pressing because of the looting of the RMS *Titanic* in international waters. As a result, between 1998 and 2001, the UNESCO *Convention on the Protection of the Underwater Cultural Heritage* was drafted at a series of international meetings and before being adopted in 2001. The Convention enables coastal states to effectively protect and preserve their UCH and provides the same universal protection to such sites as accorded to cultural heritage on land (UNESCO 2013).

The UNESCO 2001 *Convention on the Protection of the Underwater Cultural Heritage* recognizes UCH as part of the cultural heritage of humanity and guarantees its preservation through a specific protection and cooperation framework among its States Parties. The Convention recommends the Preservation of shipwrecks *in situ* as a first option, and prohibits the buying, selling and dispersing of artefacts from shipwrecks, as this practice encourages excavation for the marketplace rather than for knowledge and boosts commercial trade in objects of scientific value.

In parallel with the creation of the UNESCO 2001 Convention, countries were encouraged to develop or improve local legislation. National legislation is required to ensure and strengthen the effective protection of UCH against treasure hunting and promote less intrusive activities on UCH, if proper conditions for preservation are not created. These new examples of legislation and procedures, based on the *in situ* preservation approach, have guided the field of underwater archaeology into a new direction.

[4] This charter was created to encourage the protection and management of UCH. It recommends that the preservation of UCH should be done *in situ* and if any destructive operation were to be made, then a research project was necessary and the site and objects should be properly conserved.

Despite the local and international legislative frameworks that are being created to prevent treasure hunting activities, underwater archaeology is still facing challenges mainly in developing countries. The challenges involve educating Governments and the public about the purpose of archaeology and the difference between underwater archaeology and treasure hunting, as well as the value and importance of preserving shipwrecks. However, there are still nations that like Mozambique until 2014, grant permits to treasure hunting companies, won over by promises of financial gain.

In summary, underwater archaeology still needs to strengthen local research and curatorial capacities, including the education of competent professionals, and promote the ratification of the UNESCO 2001 *Convention on the Protection of the Underwater Cultural Heritage*, which specifically states that there should be a refusal of commercial recoveries (Sharfman *et al* 2012; Duarte 2012; Lane 2012). Efforts should be made to compile national inventories of all known underwater archaeological sites and introduce a regular system for monitoring the more significant sites. There is also a need to introduce systems that facilitate the reporting of new finds made by sports divers, fishermen and other members of the public.

In the same way it is important to have a moratorium on all commercially oriented surveys for historic shipwrecks, irrespective of their origins. There is a challenge also to adopt legislation that enforces requirements for Archaeological Impact Assessments ahead of seabed development and, if necessary, mitigation work based on the 'polluter pays' principle and to develop national and regional strategies for maritime and underwater archaeology which identify research priorities and the themes and geographical locations that have the underwater archaeological greatest potential.

2.3. Underwater archaeology in Mozambique

Like in many other places in the world, the history of underwater archaeology in Mozambique was inspired by the developments of archaeology on land. However, for many years the development of underwater archaeology in Mozambique was halted due to legalised treasure hunting activities, which had a catastrophic impact on Mozambique’s UCH. The history of underwater archaeology in Mozambique can be divided into two distinctive periods: the colonial and the post-independence periods, each characterized by different methodological and theoretical approaches, mainly inspired by neighbouring countries – South Africa, Tanzania and Kenya. Local capacity building projects through the support of Swedish, Portuguese and American underwater archaeologists have also been important in shaping underwater archaeology in Mozambique.

2.3.1. Colonial Period

Much of the archaeological activity carried out during the colonial period in Mozambique were conducted in the early 1940s by Portuguese researchers, mainly amateurs. These amateur researchers were mostly collecting and describing artefacts and archaeological sites (Morais 1988; Madiquida 2015). Joaquim Rodrigues dos Santos Júnior, who represented the *Missão Antropológica de Moçambique*[5] (MAM), pioneered archaeological surveys and through the work of the MAM many archaeological sites from different archaeological periods were identified across the country, but all on land. The existence of underwater archaeological sites was acknowledged only in passing (Guambe 2015; Maleiane 2017).

By the 1940s, the main concern of the Portuguese colony was to develop an anthropological and archaeological approach that would emphasize the Portuguese presence in Mozambique since their arrival in the 15th century. With this in mind, in 1947 the *Comissão dos Monumentos e Relíquias Históricas de Moçambique* (CMRHM) was created, focusing on the Portuguese heritage and aiming to legitimise the Portuguese administration of the colony (Mariz 2012). Although some surveys were carried out on Stone Age sites, Madzimbabwe, and rock art sites, the main focus of the CMRHM was to research, classify, conserve, restore and disseminate Portuguese sites and monuments post-dating the arrival of Vasco Da Gama in 1498 at Mozambique (Mariz 2012).

It was during the search activities carried out by the CMRHM that a number of underwater archaeological sites were located and documented, especially in northern Mozambique. Most of these underwater sites were found and reported by fishermen, recreational divers and fishing sports practitioners (Da Fonseca 1964). The first recognised and published identification of an underwater archaeological site was made by Prof. J.L.B. Smith, an ichthyologist, who found fourteen cannons submerged off Baixo Pinda in Nampula province (Da Fonseca 1964). The cannons were photographed and reported to the CMRHM for further investigations. Other reports about the existence of shipwrecks came from Mongicual and Nacala-Porto in Nampula

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[5] The *Missão Antropológica de Moçambique* was created in 1936 to collect anthropological, archaeological and ethnographical cultural material in the Portuguese colonies toward inventory and research of the colonized communities (Morais 1984; Roque 2006).

province, Jangamo in Inhambane province, Bilene Beach in Gaza province and from Inhaca Island in Maputo province (in Barradas 1967; Duarte 2012).

Over time, reports about the existence of submerged sites became increasingly frequent, still mainly from northern Mozambique. This raised the interest of the CMRHM and in particular the attention of Admiral Sarmento Rodrigues and the engineer Nuno Maria Rebelo Vaz Pinto. The two commissioned Quirino Da Fonseca to carry out a small expedition at Mozambique Island (Figure 1), as divers had found remains of what they considered to be a Portuguese shipwreck (Da Fonseca 1964).

Da Fonseca immediately accepted the task, but before going to Mozambique Island, he carried out a literature review about Portuguese voyages to the Indian Ocean and a particular document captured his attention. It was the *Codex of Lisuarte de Abreu*, which describes Portuguese fleets sailing to India between the end of the 15th century and mid-16th century (Da Fonseca 1964). The *Codex of Lisuarte de Abreu* contains drawings made by the author – Lisuarte de Abreu – illustrating the first Vasco Da Gama voyage from 1479 to 1499 and the Captain D. Jorge De Sousa voyage in 1563. In one of the drawings, Mozambique Island is depicted with sixteen ships anchored at the channel entrance to Mozambique Island (Comissão Nacional Para as Comemorações dos Descobrimentos Portugueses 1992).

Figure 1. Quirino da Fonseca carrying out surveys at Mozambique Island in 1960s. Source: Da Fonseca (1964:61)

Another important document that was analysed by Da Fonseca was the book *Cercos de Moçambique defendidos por D. Estevão de Ataíde* written by the soldier António Durão in 1633. In this book, Durão describes how the Portuguese resisted three consecutive Dutch sieges of Mozambique Island between 1604 and 1608. It is from Durão (1633) we have the description of how the Portuguese lost the *Nossa Senhora Da Consolação* in 1608, the ship referred to in the Introduction to this dissertation (see also Chapter 3.3).

Based on these written sources, Da Fonseca organized the first expedition to Mozambique Island to carry out an underwater survey using mainly amateur SCUBA divers. In course of the fieldwork, Da Fonseca also used aerial photos – taking advantage of the clean waters at Mozambique Island – to locate possible shipwrecks. He identified three main areas for shipwrecks (Figure 2), namely: the channel area in front of the São Sebastião Fortress (A), the area near São Lourenço Fort (B) and the Cabaçeira Pequena area (C) (Da Fonseca 1964).

Figure 2. Important shipwrecks areas defined by Quirino Da Fonseca. Source: Da Fonseca (1964:56-57)

The area in front of São Sebastião Fortress was revealed to be the richest and has an estimated four shipwrecks, based on the large agglomerations of ballast stones and artefacts such as anchors, rifle barrels, ballast fragments and cannonball concretions lying on the coral slope (Da Fonseca 1964; Duarte *et al.*, 2015). Da Fonseca in his surveys found an anchor that he considered to be Arabic, which may be evidence of connections that Mozambique Island had established with the Far East, possibly before Portuguese presence. Due to lack of time and resources the other two areas identified by Da Fonseca were not described in detail but his work recognized that the waters around Mozambique Island had a well-preserved UCH and that the colonial Government should consider it the richest museum of underwater archaeology in terms of the Portuguese maritime history (Da Fonseca 1964).

Despite not being an archaeologist, Da Fonseca applied systematic techniques and methodologies to locate wrecks and recognized their importance to reinforce the narrative of the early Portuguese presence on Mozambique Island. The approach developed by Da Fonseca (1964) met the main interest of the program run by the CMRHM to simply recover and describe objects that would be used to glorify Portuguese history and influence exerted over Mozambique, without acknowledging the role played by the local community or even ancient maritime contacts established with the Mozambican coast before the Portuguese presence.

After Da Fonseca's work at Mozambique Island, there were no further reports of other underwater work being carried out in Mozambican waters. In 1964 war broke out for independence of Mozambique against the Portuguese colonial regime. Although some archaeological and anthropological work was still conducted in areas not much affected by war, no official reports on underwater work in this period are available.

2.3.2. Post-Independence Period

The end of the war and the proclamation of Mozambique independence in 1975 saw a progressive development for both land and underwater archaeology. This new momentum gave rise to a new generation of Mozambican archaeologists who carried out archaeological research and contributed to rewriting the Mozambican pre-history and history, based on new archaeological findings and using new methodological and theoretical approaches (Morais 1988; Duarte & Menezes 1994; Macamo 2006; Madiquida 2007, 2015). At the same time, there were efforts to develop legislation promoting the protection and management of archaeological heritage (Macamo 2006). The framework for this legislation was provided by the recently created Constitution of Independent Mozambique, which emphasizes the importance of documentation and dissemination of archaeology and history for the consolidation of individual identity and national unity (Macamo & Ekblom 2018).

Mozambican archaeology now entered into what Macamo & Ekblom (2018) consider to be the formative phase, during which new institutions and legislation were created to research, disseminate and manage archaeological heritage. In this phase, in the 1980s, the Department of Archaeology and Anthropology at the Eduardo Mondlane University (DAA-UEM) was created (Morais 1988). The DAA-UEM brought together a group of researchers from different fields – cartography, geology, history, archaeology and anthropology – committed not only with the reconstitution of the Mozambican past, but also to establishing collaboration with regional and international institutions. There was also the ambition to create a legal and institutional framework which would foster archaeological practice and heritage management in general (Macamo 2006; Macamo & Ekblom 2018).

As a result of these efforts, the Swedish International Development Cooperation Agency-Department for Research Cooperation (SIDA-SAREC) in collaboration with the DAA-UEM, financed an underwater archaeological survey of northern Mozambique. The survey was carried out by the Mozambican archaeologist Ricardo Teixeira Duarte accompanied by the Swedish archaeologist Per Inger Lindquist in 1982. The survey identified several areas with significant UCH (Duarte 2012).

Underwater work was continued by Duarte, who developed survey missions in the northern part of the country, one of them with Jean-Yves Blot from the Portuguese National Centre of Nautical and Underwater Archaeology (CNANS) (Duarte 2012). As a result, more than 10 shipwrecks were located in the region between Baixo Pinda, Mozambique Island and Mongicual in Nampula province (Duarte & Menezes 1994). Of these areas, Mozambique Island was declared the richest UCH area and the formulation of a long-term research programme was recommended.

In meantime, new institutions and legislation were created to foster the protection of cultural heritage. The National Directorate of Cultural Heritage (NDCH) was created, responsible for regulating all the legal activities around heritage management, including land and underwater archaeological sites (Macamo 2006; Macamo & Ekblom 2018). Furthermore, the Government approved law number 10/88 of 22 December 1988, which defines the protection of cultural heritage, procedures and means necessary to protect all cultural heritage assets (Law 10/88).

In addition to the creation of law 10/88 Mozambican archaeologists with support of international partners suggested the creation of regulations for archaeological practise which were adopted by the Ministers Council in 1994 and approved as Decree 27/94 of 20 July (Macamo & Ekblom 2018). Decree 27/94 governs the protection of archaeological heritage and defines the conditions for the conservation of archaeological objects, sites and monuments. The Department of Monuments in the NDCH was made responsible for managing archaeological sites and foster community participation. One of the conditions of Decree 27/94 is that underwater archaeological sites should be conserved *in situ* since the costs of preserving the objects outside their underwater context were higher than if left in their original position (Macamo 2006).

This initial positive momentum of institutionalization of heritage and underwater archaeology practice, raised the attention of treasure hunting companies, among them *Arqueonautas Worldwide* (AWW). From 1998 AWW presented several proposals to the Mozambican Government, with the aim of exploring the Mozambique Island UCH commercially (Duarte 2012). National archaeologists with support of international underwater archaeologists tried to convince the Mozambican Government of the incompatibility of commercially oriented ventures and scientific research programs, but in the end to no avail (Duarte 2012).

Moving forward, between 1998 and 1999, Duarte from the DAA-UEM, with the support of American archaeologists Steve Lubkemann and David Conlin from Brown University, led fieldwork at Mozambique Island intending to establish a long-term UCH research program on the island (Duarte 2012). Several archaeological surveys were conducted in areas between Mozambique Island and Cabaçeira, resulting in the location of underwater archaeological sites in front of the São Sebastião Fortress and near Cabaçeira Pequena (Duarte *et al.*, 2015).

Figure 3. Fieldwork carried out by Ricardo Duarte, Steve Lubkemann and David Conlin in 1999. Photo: Ricardo Duarte, 1998-1999

One of the most significant sites found, is in the area previously located by Da Fonseca in 1960s in front of the São Sebastião Fortress (Figure 2) which the expedition managed to document in more detail. The site is characterized by a large agglomeration of ballast stones covering an area of 50 x 30 meters scattered along a coral slope from 5 to 30 meters deep (Figure 4). Some artefacts were also seen along the slope in the direction of the deepest part of the channel, where Martaban jars, cannon and a big anchor were deposited (Duarte 2012; Duarte *et al.*, 2015).

The surveys revealed the presence of wooden structure beneath the ballast pile which was interpreted as the remains of a possible Portuguese galleon from the 16th century (Duarte 2012). The find was important, and Castro (2008) considers it an extremely rare example of shipbuilding technology of the 16th century which is otherwise poorly known. Due to the importance of the site, it became the target of a careful long-term investigation and preservation program (Duarte 2012). A monitoring program was started in the same year by producing a provisional, partial map of the shipwreck which was named the *São Sebastião Fortress shipwreck* (Duarte *et al.,* 2015).

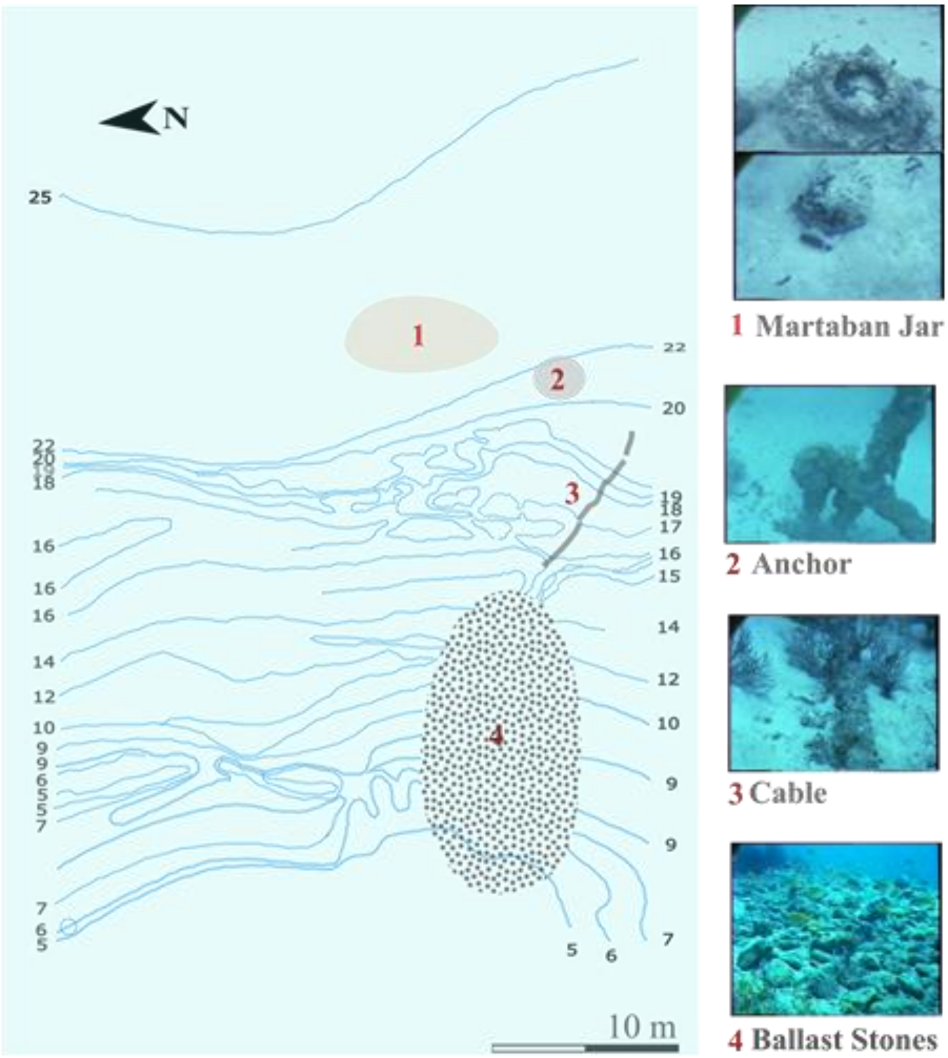


Figure 4. Partial mapping of the São Sebastião Fortress shipwreck. Compiled by Cezar Mahumane, from Duarte *et al.*, (2015:11-12)

During the 1998 and 1999 fieldwork, another shipwreck was located almost a kilometre away from the island and halfway to Cabaçeira Pequena. This wreck was characterized by the presence of olive jars visible on the seabed and some timbers sticking out of the sediment. No further research was carried out on this wreck due to lack of time (Ricardo Duarte *pers. comm. 2018*) but it was later identified as the *Nossa Senhora da Consolação* (IDM-003).

The results of the 1998-1999 fieldwork reinforced the importance of the UCH in Mozambique Island waters and vicinity as previously identified by Da Fonseca (1964), Lindquist (1982) and Blot (1982) and created a positive 'momentum' in the development of national capacities for research and UCH management. The DAA-UEM, Brown University and the US National Park Service began the process of formulating an ambitious underwater heritage project with the support of the SIDA-SAREC and UNESCO. Its aim was to study and preserve the UCH in the National Marine Parks and Reserves of Mozambique and provide public education and linked initiatives to promote local sustainable development, including cultural tourism (Duarte 2012). However, all these initiatives ended abruptly in 1999, when the Mozambican Government, against advice from officials in the Department of Monuments and national archaeologists, decided to develop an extensive program for recovery and commercialization of UCH with the treasure hunting company AWW/PI.

2.3.3. The advent of treasure hunting in Mozambique

Scientific initiatives toward the UCH in northern Mozambique were completely halted with the licencing of AWW/PI's activities by the Mozambique Government. Because AWW/PI had signed a contract with the Mozambique Government with exclusive rights for UCH research, professional archaeologists were blocked from performing proper research or from monitoring the activities of AWW/PI. Companies like AWW/PI mostly get working permits for treasure hunting by taking advantage of the gaps in legislation when it comes to underwater archaeology and the absence of trained underwater archaeologists. The same *modus operandi* used in Mozambique when it comes to lobbying the government, has been observed in Portugal and Cape Verde (De Carvalho 2007).

Arqueonautas Worldwide (AWW) was established on 10th August 1994 on the Island of Madeira in Portugal, as a private shareholding company. According to the information on their website, the purpose of the company is:

> *To protect and save World Maritime Heritage following current professional standards of archaeological practice. This may involve controlled rescue recovery of endangered historical shipwrecks including the conservation and scientific documentation of all related cultural material and cargo, applying sound economic principles. An experienced team of historians, marine archaeologists, research divers, and conservation experts operates from Arqueonautas headquarters in Portugal and offices*

in Mozambique and Indonesia on a large number of search and recovery projects around the globe (http://aww.pt/ accessed on 26/08/2016).

On the African context, AWW initiated its activity in the archipelago of Cape Verde, in West Africa, through an exclusive concession agreement with the Cape Verdean Government signed in 1995, and valid for three years of underwater archaeological activities over the nine islands of the archipelago (De Carvalho 2007). The concession agreement was extended for another three years. After six years of activities, AWW claimed to have located 146 wrecks, of which at least a dozen were excavated. These excavations resulted in thousands of recovered artefacts, many of which were sold on auction at Sotheby's in London's on 19th December 2000 and in Copenhagen on 12th June 2004 (De Carvalho 2007).

Among the artefacts sold by AWW, one of the rarest objects was a silver-plated marine astrolabe dated to the mid-17th century recovered from the *São Francisco* wreck off the Island of Santiago (Castro *et al.,* 2015). The sale of this astrolabe resulted in the organisation of local academics lobbying with the Cape Verdean Government to stop AWW's activities. The Cape Verdean Government decided to cancel the AWW permit in 2002 and then recognized that the country has lost historically valuable UCH (De Carvalho 2007).

On their webpage, AWW claims to have created a conservation centre in Cape Verde, which later became the Archaeology Museum in Praia, and to have trained a team of local archaeological divers and conservation experts (http://aww.pt/about/ accessed on 26/08/2016). These claims are a way for AWW to justify their *modus operandi*. However, to date there has been nothing published except interim reports, which are very limited in data presentation and interpretation, about the collected artefacts or the excavated shipwrecks.

In Portugal, Cape Verde and Mozambique, AWW presented itself as a competent company dedicated to the research and protection of underwater heritage related to European maritime expansion (De Carvalho 2007). This image was presented to the Portuguese, Cape Verdean and Mozambican Government who, lacking knowledge and experience in the rationale of these companies and uninformed about the principle of *in situ* preservation, accepted their credentials.

AWW approached the Mozambican Government intending to negotiate a working permit for Mozambique Island while it was working in Cape Verde (De Carvalho 2007; Duarte 2012). Using its influence and promoting the idea that AWWs aim was to research and preserve UCH, a contract was signed in November 1999, between AWW and its Mozambican Partner *Património Internacional*[6] (PI) and the Mozambique Government to develop underwater activities over an area of 700 km along the coastline between Moma in Zambézia province and Lúrio River, bordering Nampula and Cabo Delgado Province (De Carvalho 2007; Viega 2009; Duarte 2012) (Figure 5).

This exclusive contract was given to AWW on the promise that it would share with the Government half the profit of the objects sold (Viega 2009). The 50% Government share would be dedicated to support the research costs and help build local capacity by training local communities and university students (De Carvalho 2007; Duarte 2012; Pringle 2013). However, these promises were never honoured by the company (Duarte *et al.*, 2015).

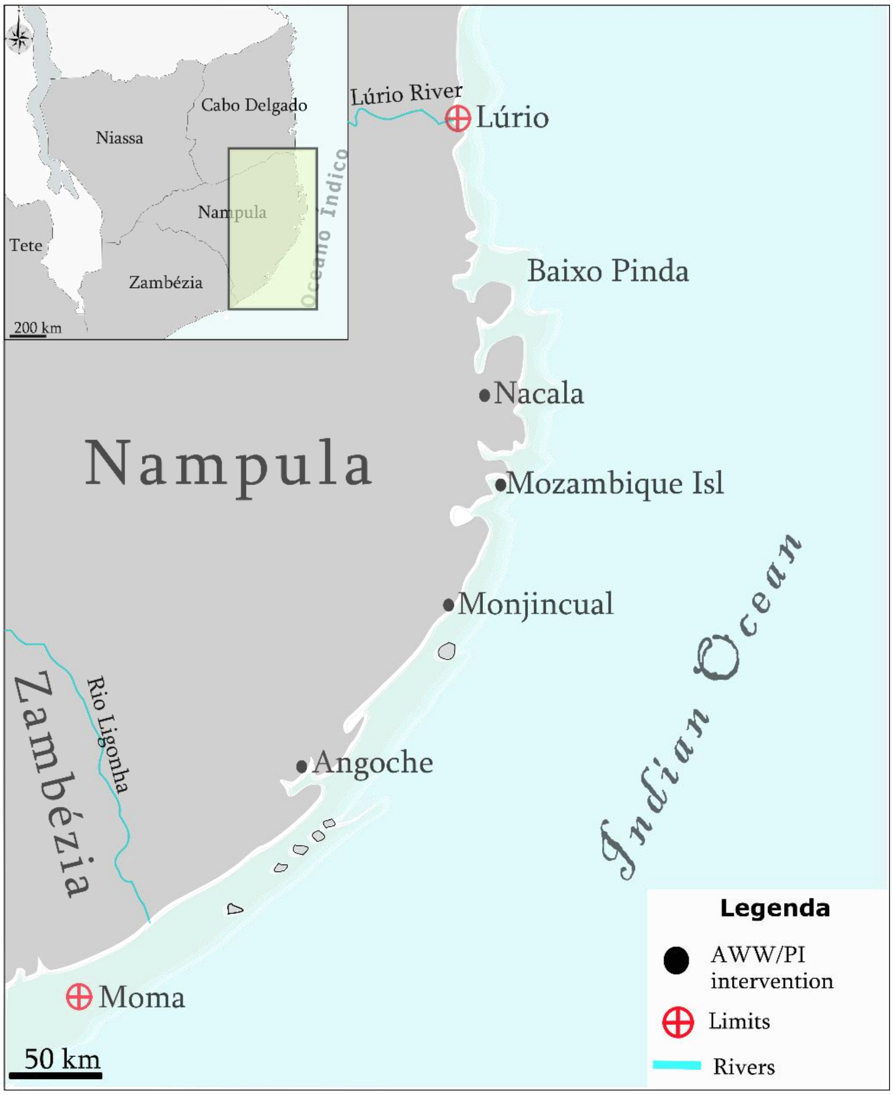


Figure 5. Map of the AWW/PI contract area. Compiled by Cezar Mahumane from AWW/PI (2014:1)

[6] It was a not-for-profit company 80% owned by the Mozambican Government and 20% privately owned.

The contract with the *Arqueonautas Worldwide and Património Internacional* (AWW/PI) consortium generated opposition and criticism led by local and international academics, some members of the Government, and the community at Mozambique Island (De Carvalho 2007). The contract was in breach of law 10/88 of 22nd December 1988, for the Protection of Cultural Heritage, which states that archaeological objects and sites are the inalienable property of the State, and it ignored Decree 27/94 of 20th July 1994, which approved the regulation to protect archaeological heritage (Duarte 2012; Lane 2012). The principles guiding the contract created an uproar and local newspapers denounced the level of corruption and illegality involved in the deal (De Carvalho 2007).

With its working permit granted, AWW/PI installed itself at Mozambique Island. The wreck sites located in front of the São Sebastião Fortress became the first and major targets of AWW/PI activities and between 15th to 30th May 2001, the company reported that it had expanded work on two wreck sites it designated as IDM-001[7] and IDM-002 (Bound 2002; Mirabal 2010; AWW/PI 2014). Soon, it became clear that AWW/PI was aiming to locate the sites found by Da Fonseca in 1960s and those found in 1998-1999 during the survey by archaeologists from DAA-UEM, Brown University and the US National Park Service.

The AWW/PI performed some preliminary work on the IDM-002, the *São Sebastião Fortress shipwreck* and the site was considered most important due to the presence of Chinese porcelain (Bound 2001, 2002 and 2004). Consequently, between October 2001 and September 2002, the IDM-002 was extensively excavated under the direction of British archaeologist Mensun Bound. At least 960 pieces of Chinese porcelain were collected during these excavations (Figure 6). Among this collection, 501 vessels were intact, representing 22 different forms painted with blue and white (Bound 2004). Later in 2004, the bulk of the Chinese porcelain recovered from IDM-002 was sold at auction in Amsterdam (Christie's 2004; Anonymous 2008; Duarte 2012; Lane 2012). The AWW/PI intervention left the site badly damaged and in a poor state of preservation (Duarte *et al*., 2015).

By this time, the company's principal archaeologist, Mensun Bound, had identified the IDM-002 or *São Sebastião Fortress* shipwreck as dating from the mid-16th century and associated with the Age of Discovery when the Portuguese started their expansion to the East (Bound 2004). Documents presented by AWW/PI tentatively identify the IDM-002 wreck as the

[7] IDM is a site code used by AWW/PI composed by three letters belonging to the geographical area, for instance, Ilha de Moçambique, where the site is located, followed by three digits showing the sequential of when the site was found (AWW/PI 2014).

Portuguese ship *Espadarte*, which sank in 1558 with a cargo of almost 2.000 pieces of Chinese porcelain (Mirabal 2010).

After excavating and selling the Chinese porcelain from the IDM-002, AWW/PI continued locating and looting other wrecks. In 2001, AWW/PI reported the location of another shipwreck at Mozambique Island which they designated IDM-003 and tentatively identified as the *Nossa Senhora da Consolação* (Mirabal 2013; AWW/PI 2014). IDM-003 was entirely excavated between 2005 and 2006. Most of the artefacts collected from the site were left in the AWW/PI's laboratory at Mozambique Island, but the five tons of lead ingots recovered were sold to *Global LAL Cooperation Inc.* (Duarte *et al.*, 2015).

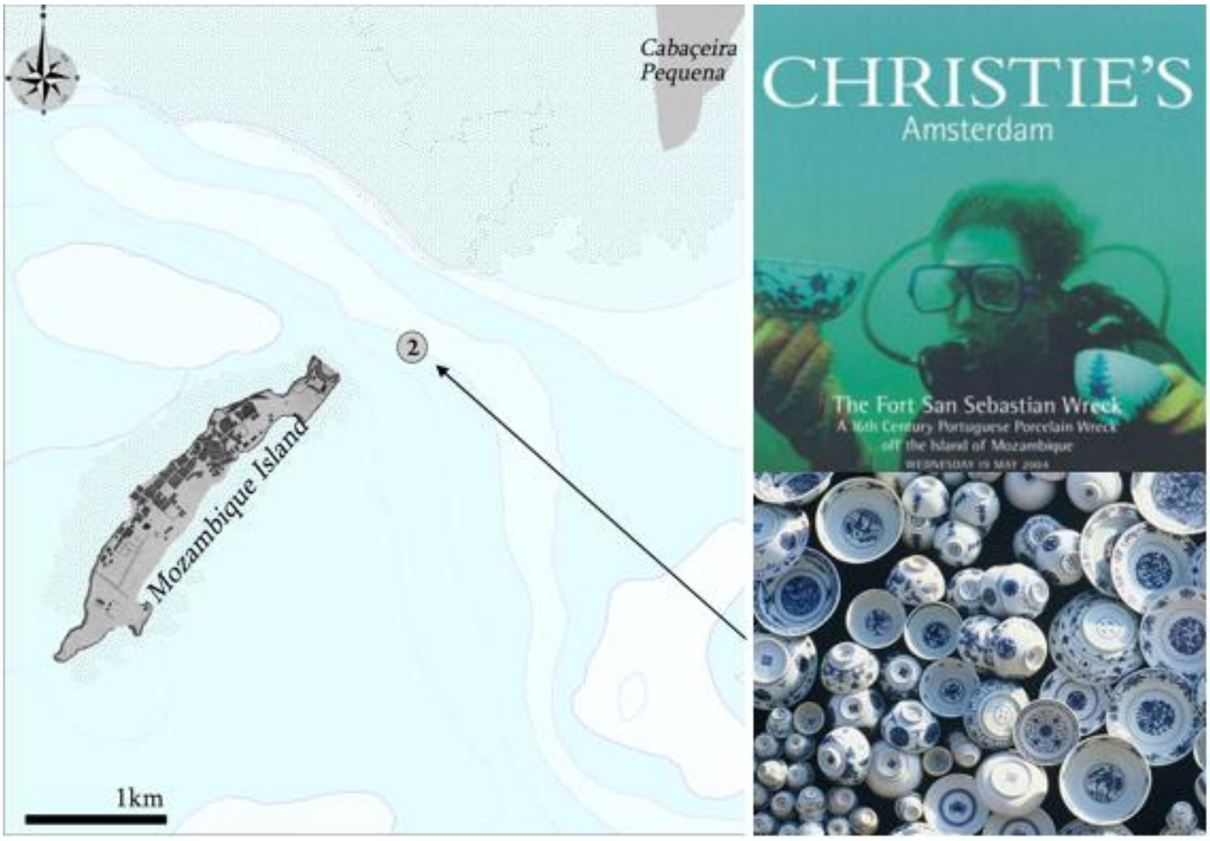


Figure 6. Location of IDM-002 *or São Sebastião Fortress* Shipwreck and Chinese porcelain sold. Compiled by Cezar Mahumane, from AWW/PI (2014:35-36)

In 2004, AWW/PI reported the location of a shipwreck designated MOG-003[8] which it tentatively identified as *São José* wrecked in 1622 at Mongicual off the Caldeiras Island (AWW/PI 2014; Mirabal 2014; Guambe 2015). This wreck was loaded with military

[8] MOG is the site code used by AWW/PI composed by three letters belonging to the geographical area of Mongicual where the site is located, followed by the three digits showing the sequential of when the site was found (AWW/PI 2014).

equipment and nine boxes of silver coins which were partially excavated by AWW/PI. More than 7.525 silver coins were collected and sold at auction (De Carvalho 2007; Duarte *et al.,* 2015).

According to the company's interim reports, AWW/PI located 45 shipwrecks within the concession area it was granted (Figure 5). Among these, 24 are located in Mozambique Island bay and the rest are spread between Nacala and Mongicual. The company claims to have completely excavated three shipwrecks and of these MOG-003, IDM-002 and IDM-003 were the most impacted. Other shipwrecks were partially excavated or merely recorded (see Appendix 1).

2.4. Assessment of fourteen years of AWW/PI operations at Mozambican UCH

The Mozambique Island community played a major role in pressuring the Government to cancel the contract with AWW/PI. Among several attempts to see the contract cancelled, the community started a petition – with more than one hundred signatures – complaining about the contract and pointing out the irregularities of the company against UCH and the community itself. Researchers from DAA-UEM, with the support of international experts in maritime and underwater archaeology also pressured the Mozambican Government to allow an assessment of the 14 years of the company's activities on UCH.

Due to these pressures, in 2014 the Mozambican Government allowed an assessment of the Mozambique Island UCH. The assessment was carried out in June 2014, led by a group of researchers from DAA-UEM, professionals from NDCH together with the local community and international support of a technical team assembled under the auspices of the Slave Wrecks Project[9] (SWP). A preliminary report was presented to the Mozambican Government in the same year, and the results finally pushed for the cancellation of AWW/PI permit. The report was made public in 2015. It reveals the severe destruction of UCH resulting from AWW/PI's activities. The poor documentation, preservation and mitigation methodologies used by company imposed serious limitations to the possibilities for archaeological re-interpretation of the sites (Duarte *et al.,* 2015).

[9] This project assemblage professionals from Smithsonian National Museum of African American History and Culture; IZIKO Museums of South Africa; the US National Park Service's Submerged Resources Centre; the US State Department; GWU - George Washington University, IFAN-Cheik Anta Diop University; DWP - Diving With a Purpose; DAA-UEM.

Considering the geographical spread of the 45 shipwrecks reported by AWW/PI (see Appendix 1) and limited time, the assessment team focused their work on Mozambique Island where AWW/PI based most of its activities and where they reported locating 24 shipwrecks. An *in situ* assessment was carried out at sites intensively excavated by AWW/PI, namely: the *São Sebastião Fortress* shipwreck, (IDM-002) and the *Nossa Senhora da Consolação* (IDM-003), and those partially excavated, being the *Santa Teresa* (IDM-017) and the *São José* (MOG-003) (Duarte *et al.,* 2015).

The *in situ* assessment revealed that the remains of these wrecks were in a deplorable state, partly destroyed, and in a state of erosion with timbers exposed to continuous deterioration (Duarte *et al.*, 2015; see further in Chapter 5). The activities of AWW/PI had significantly aggravated detrimental effects of other environmental factors like strong currents, intensive oxygenation and biological deterioration on the sites. Jeffery (2011) and Duarte *et al.* (2015) suggested that the direct and indirect impacts caused by human and environmental threats to the sites called for urgent mitigation actions.

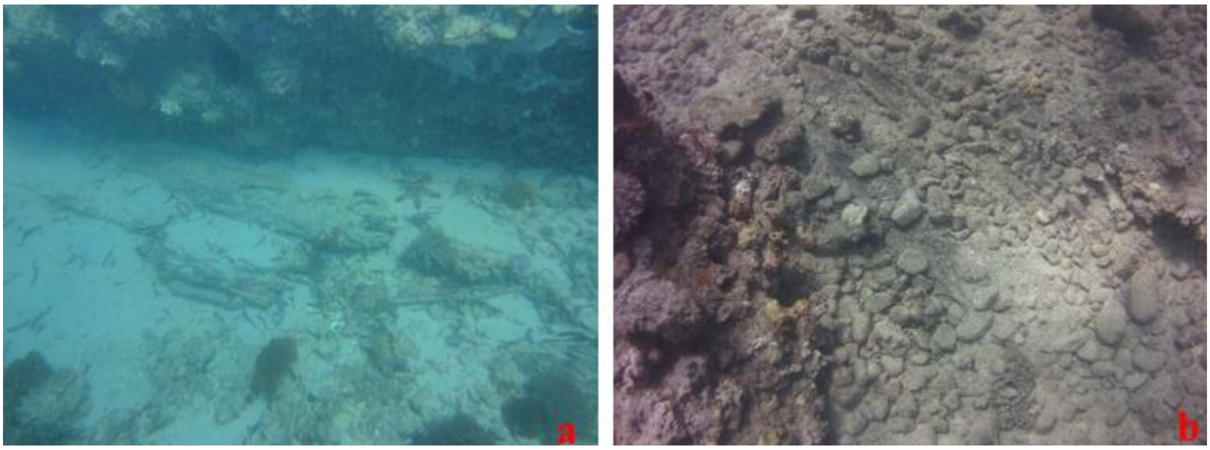


Figure 7. Condition of the sites visited by the assessment team in 2014, (a) IDM-002; (b) IDM-003 wreck. Photo: Ricardo Duarte, 2015

The methodologies used by AWW/PI gave priority to recovering economically valuable artefacts, resulting in a selective and undocumented process of collection objects of commercial interest, and ignoring the other aspects of the sites, such as hull structure, and their cultural importance (Duarte *et al.,* 2015). Only generic maps of the hull structure of the wrecks were eventually produced, most looking like tracings of a photographic mosaic (Filipe Castro *pers. comm.* 2016). These generic maps do not show location of sections, there are no tags, and a competent description of the hull remains is lacking. There is no mention of a timber catalogue, pictures of construction details and features are entirely lacking and the documentation of the characteristics of these important hull remains are far from complete and scientifically unacceptable (Filipe Castro *pers. comm.* 2016).

In the post-excavation phase, AWW/PI reportedly conducted a so-called mitigation operation on the sites to protect the remaining hull structure of the wrecks, which had been left unprotected for a long period after excavations (Mirabal 2010, 2013). The mitigation consisted of the re-deposition of layers of ballast stones on the *São Sebastião Fortress* shipwreck (IDM-002) and on the *Nossa Senhora da Consolação* (IDM-003) and the placement of sandbags on the *Santa Teresa* (IDM-017).

However, by the time these mitigation operations were carried out, especially on the *Nossa Senhora da Consolação* (IDM-003), they were too late and insufficient, since the ballast stones used to backfill the site did not ensure proper coverage and the wooden structure was already in a state of rapid deterioration. The effects of the delay in covering the *Nossa Senhora da Consolação* (IDM-003) and the insufficient measures employed will be assessed at length in Chapter 5.

Most of the original data from the sites worked on by AWW/PI, such as methodological procedures, raw data for site plans, photos and object inventories are no longer available, but interim reports and dive logs were left at Mozambique Island. These lack detail and are difficult to use due to the limited information they contain. However, an effort is still being made by Mozambican archaeologists and their partners to recover raw data and photos from the sites AWW/PI excavated. Although much has been lost forever, access to the treasure hunter's dive logs and photos could help the ongoing mitigation program and inform efforts to explore exactly what kind of information can still be gleaned from the archaeological record as it stands.

It is undoubtedly the case that the activities of AWW/PI destroyed significant archaeological information as a result of the dispersion of many artefacts, and the woeful inadequacies in site documentation, preservation and mitigation. Overall, the methodologies adopted by AWW/PI demonstrate their exclusive interest in collecting objects with commercial value. The poor result in terms of documentation, conservation and interpretive potential is an example of the danger of allowing treasure hunters to guide excavations.

Indeed, Duarte *et al.*, (2015) consider that AWW/PI’s activities on Mozambique Island UCH constitute a typical operational performance of a treasure hunting company which can be summarized as selective excavation without accurate positioning and the abandonment of important evidence, and the presentation of artefacts out of context and without any conservation measures. Apart from exposing the hull, recovered timbers were left in desalination tanks from which the water had evaporated, causing serious and irreparable damage to these artefacts. Added to this is the problem of the alienation and dispersal of archaeological objects taken from original contexts, with large numbers of artefacts sold at auctions. With no original inventory of finds, it is also unclear how many of the artefacts were documented before they were sold. As a result of treasure hunting practice there is serious loss of archaeological data which makes it unclear if all artefacts were recorded *in situ*, whether they were mapped, and how they were cared for upon recovery (Duarte *et al*., 2015).

Another characteristic of a treasure hunting company is that excavation and mitigation are not guided by any archaeological research design or research questions. Reporting and interpretation is also shallow and insufficient (Duarte *et al*., 2015). Adding to this is also the pattern of dishonesty in claiming the 'original' discovery of archaeological sites – as was the case with the *São Sebastião Fortress* (IDM-002) shipwreck. This site was likely found in 1960 by Da Fonseca, as discussed above and then rediscovered by a team of archaeologists in 1999 (Figure 3), yet AWW/PI still made the claim of having discovered the wreck.

The assessment report by Duarte *et al* (2015) in its conclusion advised that, although much had been destroyed by AWW/PI activities, it was time to formulate new approaches toward UCH in Mozambique concerning the research, mitigation and dissemination of the impacted heritage. Thus, future work on UCH must curtail treasure hunting activities and the opportunity should be given to universities, *bona fide* research centres and national archaeologists to develop local capacity to manage the UCH in collaboration with local communities, thus helping to raise awareness and creating sustainable strategies linked to the heritage (Duarte *et al.,* 2015). This dissertation attempts to address some of these challenges.

2.5. Recent approaches to UCH at Mozambique Island

When the assessment report was presented to the Mozambican Government and the contract with AWW/PI was cancelled, the DAA-UEM was given the responsibility to develop a long-term research program over Mozambique Island UCH. This decision was a reflection of more than 14 years of scholarly advocacy and pressure led by Mozambican archaeologists with the support of international colleagues, as discussed above (Mahumane 2020). The scholars advocated for the development of national capacity in underwater archaeological research, conservation and management in Mozambique, guided by best practice in the region.

Since then, Mozambique has made significant strides in studying, protecting and managing the UCH at Mozambique Island. The work has been built on the best practice of the UNESCO 2001 Convention and with international and regional collaboration (Mahumane 2020; Bita & Mahumane 2020). For example, SWP has been contributing to the development of underwater and maritime research in Mozambique since 2009 when an ambitious plan was formulated by SWP to research the history of the slave trade from Maputo to Pemba, focusing on some important hinterland and coastal areas. As a result, between 2012 and 2013, the SWP collaboration contributed to building local capacity, training archaeology students from DAA-UEM in SCUBA diving – including the author of this dissertation. SWP also provided further training in shipwreck recording and artefact conservation. Furthermore, UNESCO also contributed to building local capacity by providing opportunities for Mozambicans to be trained in preservation and management of UCH in Kenya in 2015 (Bita & Mahumane 2020).

In June 2016, the new approach to the UCH at Mozambique Island was outlined as the SWP collaboration was now allowed to work on the island. UNESCO also organised two meetings, which provided additional support. The first UNESCO meeting took place on 8th December 2016 at Mozambique Island, and was aimed at consulting the local community on the safeguarding of UCH within the framework of the UNESCO 2001 Convention. The second was a regional meeting which took place in Maputo between 12th and 13th December 2016 and brought together several experts from African countries to discuss the ratification of the UNESCO 2001 Convention (Bita & Mahumane 2020). The ambition of this meeting was also to improve cooperation between African countries to protect and document their UCH. In this meeting, African countries were encouraged to follow best practice for the protection of UCH set out in the Rules in the Annex of the UNESCO 2001 Convention as a basis for managing their UCH (Mahumane 2020).

Within this framework, the DAA-UEM in collaboration with the SWP and with the support of the *US Ambassadors Grant Fund for Cultural Preservation* launched a program at Mozambique Island in 2016 aimed at building facilities and developing training for local archaeologists to research, conserve and manage Mozambique Island´s maritime and underwater heritage (Figure 8). The collaboration also included training programs for the local community. The collaboration between DAA-UEM and SWP has been a fruitful opportunity for knowledge exchange and the development of research methodologies that promote relevant and realistic protection activities to safeguard maritime heritage and underwater archaeological sites. The collaboration is also an opportunity to develop management practice for UCH at Mozambique Island. Through this collaboration, Mozambique has established archaeological investigations that adhere to international best practice standards and have helped build local capacity, by training local underwater archaeologists and a group of local community divers that have been integrated into the research and management of UCH.

Figure 8. Institutional growth and capacity building through SWP, (a) CAIRIM facilities; (b) and (c) training local community in SCUBA diving. Photo: Ricardo Duarte, 2018

The perspective that is being developed in Mozambique Island UCH, meets what Lane (2012) and Macamo & Ekblom (2018) consider necessary steps to develop a proper research and heritage management practice. The basic principles of heritage management at Mozambique Island are rooted in joint work with national and international partners, and local communities to raise interest in archaeological research *per se*, and engage the public and local researchers to actively participate in the interpretation and management of places, landscapes, shipwrecks and material culture (Lane 2012; Macamo & Ekblom 2018; Bita & Mahumane 2020).

Generally, in Mozambique, research and management of archaeological heritage has only been successful when being built through the collaboration and integration of local communities and legal institutions (Macamo 2006; Jopela 2010; Macamo & Ekblom 2018). Therefore, there are two complementary systems essential for heritage management, (1) the traditional system of custodianship, in which local communities are responsible for taking care of the heritage, and (2) the legal protection of sites ensured by the state through law 10/88 of 22nd December, and Decree 27/94 of 20th July (Jopela 2010; Macamo & Ekblom 2018; Bita & Mahumane 2020).

The efforts that are being developed by DAA-UEM, in close collaboration with the SWP, to implement initiatives to promote research, conservation and management of UCH at Mozambique Island are noticeable for their inclusive and collaborative approach as discussed above. Training has been provided to local underwater archaeologists and the local community, but there has also been the creation of opportunities for institutional growth.

As a result of the work conducted at Mozambique Island since 2014, the Centre of Archaeology, Investigation and Resources of Mozambique Island (CAIRIM) was created in September 2018, funded by the *US Ambassadors Grant Fund for Cultural Preservation*. The CAIRIM has been set up as a centre to promote local research strategies, counsel local scientific and technical programs and disseminate and manage the local cultural heritage. Since its creation, CAIRIM has promoted projects aimed at research, protection, capacity building and dissemination of UCH at Mozambique Island. One of these projects is the *Slave Wrecks Project* (SWP) referred to already, which is researching the slave trade at Mozambique Island, both on land and underwater (Duarte 2020). This project has been run at Mozambique Island since 2016 and has helped the establishment of CAIRIM and creation of a research procedure for Mozambique Island heritage.

Through the years, the SWP has conducted magnetometer surveys and oral tradition research that have revealed the existence of more underwater sites in the Mozambique Island bay. This project has also promoted capacity building, training a group of fifteen local divers to date, who are integrated into the research program. The specific role of these divers is the monitoring of wreck sites around the Island. The SWP regularly provides means – equipment and experts – for most of the underwater work, for training and for the conservation of the artefacts recovered by AWW/PI from different shipwrecks around the island.

The *US Ambassadors Grant Fund for Cultural Preservation* provided funding for the assessment and monitoring of the wreck sites around Mozambique Island, as well as for the institutional development of CAIRIM. This grant was the major funding source for the creation of CAIRIM facilities inside the São Sebastião Fortress and the monitoring of the wreck sites. At the time of writing this dissertation the possibility of getting more funding for an appropriate environmentally controlled laboratory for the conservation of archaeological material was being considered. Through the existing grant, an exhibition of some archaeological material and the work carried out in some shipwrecks and land sites on the island are now displayed at CAIRIM. The exhibition has been used for training purposes and dissemination for local communities and tourists visiting the São Sebastião Fortress.

The *Rising from the Depths Network* (RftD) is an international network which is funding some projects on the East African coast. Through RftD, collaborative work between CAIRIM and British institutions is being carried out in Mozambique Island Bay by surveying geophysical and hydrological features of the channel. Such a survey will be fundamental to building knowledge about the geological composition of the area and potentially how archaeological sites can better be preserved and protected *in situ*.

In addition, Mozambique Island hosted a regional UNESCO training course on underwater survey and underwater cultural heritage management in December 2019, which provided technical and theoretical knowledge to the participants from different African countries. This training course was a great opportunity for young African underwater archaeologists to develop a network, establish and discuss better methods and strategies for the management and protection of UCH, as well as foster the tenets of the UNESCO 2001 Convention in respective countries that have not yet ratified the Convention (Duarte 2020).

Despite all these achievements, Mozambique is a country that is still facing challenges which affect the research, preservation and management of UCH. In the particular case of Mozambique Island, some of the most acute challenges are counteracting the direct and indirect effects of treasure hunting. Another challenge is to build heritage management based on the very dire local socio-cultural and political conditions, as poverty is high and most of the community priority lies in meeting daily living requirements.

For instance, a study carried out by Simbine (2015b) at Mozambique Island describes children collecting different archaeological materials along the beach, that have washed ashore from shipwrecks, and selling these materials to tourists or people who use them to decorate their houses. In the archaeological context, this material may have low interpretational value, but it can still be important as a comparative collection to get more information about their technical components. Simbine (2015b) calls attention to the fact that these archaeological resources scattered on the beaches of the island are getting exhausted and there may be a risk of people going to the wrecks to loot potentially valuable material, even though laws prohibit such practice.

A potential solution to help mitigate this problem is educational programmes, either from Governmental or public groups, about the importance of preserving the region's valuable heritage (see discussion in Duarte 2012). Therefore, there is a need to develop an appropriate program of formal and informal training that will promote the preservation of UCH by the public (Watts Jr & Mather 2002). However, the possibility of establishing parks or sanctuaries to manage and protect UCH should also be considered. Here educational and recreational use by the diving public should be encouraged and by promoting appropriate diving programs on shipwrecks, Mozambique Island can develop a potential new cultural tourism industry.

At the same time, local community trained in diving can supervise and take tourists to visit sites, following itineraries previously agreed with CAIRIM. In view of this, it is also crucial that every shipwreck known so far, has a management plan which, assessing its environmental conditions and archaeological significance.

At the moment, the direct negative effects of treasure hunting must be assessed and mitigated. The destruction of underwater sites and its present state of preservation is a great challenge. For instance, the case study for this dissertation, the *Nossa Senhora da Consolação* (IDM-003) where the exposure of wooden hull structure has led to deterioration and challenges for the protection and preservation of the site (see Chapter 4).

Therefore, there is a need to re-establish the history of the wrecks, attempt an interpretation of the artefacts left by the treasure hunters and assess the condition of the site to ensure its preservation *in situ* (see Chapter 5). Having this in mind, the following chapter seeks to provide a background on IDM-003. Essentially, the chapter contextualizes the historical background of the wreck of the *Nossa Senhora da Consolação* at Mozambique Island and later in this dissertation describes the excavation carried out. Some indicative artefacts are discussed and assessed. At the end of this dissertation, several mitigation strategies are proposed concerning the protection and preservation of the wooden hull against different environmental threats.

CHAPTER 3 – CASE STUDY OF THE *NOSSA SENHORA DA CONSOLAÇÃO* (IDM-003) SHIPWRECK: HISTORICAL BACKGROUND

It took a long time before underwater archaeologists developed coherent methodologies and theories to interpret archaeological material. The study of submerged heritage, reflecting peoples's relationship with the sea, is guided by a multidisciplinary approach that enabled the development of underwater archaeology as an academic field, as we saw in the last Chapter. However, the development of the field has faced major challenges, the most serious of which is the impact of treasure hunting activities on UCH in many places around the world.

As explained in previous Chapter, Mozambique experienced the effects of treasure hunting on UCH for 14 years. From the affected sites, this dissertation focuses on the case of *Nossa Senhora da Consolação* (IDM-003), since it displays a high degree of destruction, compared to the other wreck sites targeted by AWW/PI. Furthermore, AWW/PI has been using its intervention on this wreck as an example for the claim that they have carried out serious and state of the art archaeological work. Thus, in this chapter all their operations at IDM-003 will be presented and discussed against the conventional principles of how to plan, carry out and report an archaeological project.

The present chapter will describe and analyse the geophysical context of IDM-003 and provides an initial background on the work carried out by AWW/PI on the wreck. The chapter also places the the *Nossa Senhora Da Consolação* (IDM-003) in its historical context, from its voyages to its final destiny as a wreck at Mozambique Island.

3.1. The geographical context

Mozambique Island is located in Northern Mozambique, on the east coast of Nampula province and 180 kilometres from Nampula city (Omar 2013). The island is situated four kilometres from the mainland coast at the latitude 15º01'44.07" S and 40º44'35.91" E. It is part of an archipelago constituted by São Lourenço Island, Goa Island (or St. Jorge Island) and Sena Island (or S. Tiago Island). Together these islands cover an area of 445 km² (Arkitektskolen i Aarhus 1985) (Figure 9).

The island forms a diagonal line running NE – SW, shielding Mozambique Island bay from the open sea (Arkitektskolen i Aarhus 1985). It is approximately three kilometres long and between 200 and 500 m wide, covering an area of approximately one square kilometre (Duarte 1993; Fonseca 1996). The island is formed by a coral platform covered by sandy deposits of

Pleistocene origin, exhibiting a high richness in marine biodiversity (Duarte & Menezes 1996; Fonseca 1996). The geomorphology of the island displays different physical settings, as the northern coast contains a bay of coral rocks and the southern coast is bordered by a marshy barrier (Tinley 1971).

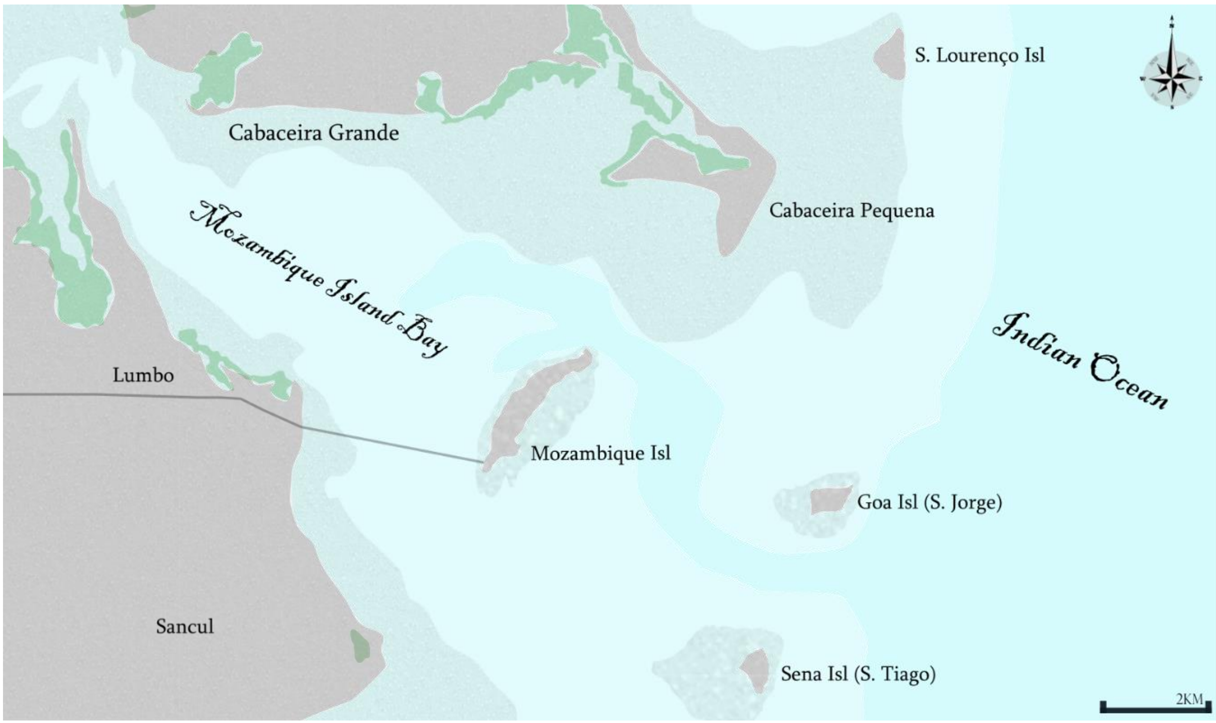


Figure 9. Map of Mozambique Island bay. Drawer: Cezar Mahumane, 2019

The climate at Mozambique Island is tropical humid, with the annual temperature average in the warmest months fluctuating between 27ºC and 29ºC, and in cooler months between 21ºC and 23ºC (Fonseca 1996). The island is located in the southern extent of the Intertropical Convergence Zone (ITCZ) which gives it a dual seasonal climate. The rainy season lasts from November to March, the southern hemisphere summers, with precipitation that varies between 700 and 1200 mm, and the dry season, which is also cool, lasts from May to October (Fonseca 1996; Omar 2013). The movement of the ITCZ also shapes the monsoon that has been important for maritime communication, blowing from north to south during the summer and from south to north during the winter (Duarte 1993).

The waters around Mozambique Island host a rich marine environment, stretching over approximately 11 kilometres between Sancul and Cabaçeira Pequena (Figure 9). The ecosystem is composed by carpets of marine grasses, associated with macro-algae that occur in shallow waters on appropriate substrates (sand-mud) (Fonseca 1996). The seagrass and algae form the basis of many food webs, being vital to the diet of large populations of coral fishes, and protect the coast from erosion by stabilizing substrates (MICOA 2012).

Recent hydrographic data suggests that the mean water temperature at Mozambique Island is 26°C and salinity is 35 grams per litre (Meyer 2012). The seabed composition is formed by sedimentary rocks degrading around the island and marine sediments, in other words, a combination of sand and mud of different origins with a rapidly shifting seabed (Hoguane 2007; MICOA 2012).

The access to Mozambique Island from the sea is through a narrow channel that posed problems for big Portuguese ships of the *Carreira da India* (Arnold 2014). The ships could only use one entrance for access to the inner harbour next to the São Sebastião Fortress. Monteiro *et al*., (1940) and Newitt (2004) explain how ships had to enter the northern channel at high tide, passing between São Tiago Island (actual Sena Island) and São Jorge Island (actual Goa Island) and then passing the São Sebastião Fortress shoal in front of the Chapel of Nossa Senhora do Baluarte. Anchoring was also a challenge because of a tidal range of several meters, reaching up to 6 meters in some areas (Arnold 2014). Big ships generally floated at anchor at high tide, but became stuck on the seabed on low tide causing damage to the hull structure which was already weak after their long voyages (Costa 1940; Duarte *et al.,* 2015).

For centuries, pilots learnt how to benefit from the monsoonal winds in the region. However, the area of Mozambique Island is prone to the effects of cyclones that frequently occur between January and May (Meyer 2012). One example is the famous cyclone that affected the island in April 1858. This storm was described in *Guía de Navegação de Moçambique* by Leote Do Rego, and resulted in many wrecks and destruction on the island (Leote Do Rego 1904).

It is against this geophysical and hydrographical background that the analysis now turns to look at the history of the identification and contextualization of the wreck of the *Nossa Senhora Da Consolação.*

3.2. A brief background on the identification of the shipwreck

The presence of a shipwreck named *Nossa Senhora da Consolação* in Mozambique Island waters was reported by Da Fonseca in the 1960s when he performed systematic archival research followed by a fieldwork survey at Mozambique Island. However, he never mentioned the possibility of having located the wreck itself.

The most important historical account mentioned by Da Fonseca (1964) concerning the wreck of the *Nossa Senhora da Consolação*, is the book *Cercos de Moçambique defendidos por D. Estevão de Ataíde,* written by the Portuguese soldier António Durão in 1633. Durão (1633) narrates in detail the events at Mozambique Island, mainly inside the São Sebastião Fortress from 1600 to 1633. He describes how the Portuguese resisted three Dutch attempts to occupy the fortress in 1604, 1607 and 1608, one of which resulted in the loss of the *Nossa Senhora da Consolação.*

Apart from Da Fonseca's efforts to locate the *Nossa Senhora da Consolação* wreck, an attempt was made in 1998-1999 by DAA-UEM archaeologists when they carried out survey activities in Mozambique Island water and reported the existence of a ballast pile, olive jars and some timbers sticking out of the sediments in an area between Cabaçeira Pequena and Mozambique Island. However, as already explained in Chapter 2, no further research was conducted on the suspected site, as a permit was granted to the company AWW/PI to perform commercially oriented activities at Mozambique Island and other areas of the coast.

On 3rd July 2001 AWW/PI reported the re-location of the same ballast pile when performing an earlier drift dive in the area between Cabaçeira Pequena and Mozambique Island (Mirabal 2007). The wreck was codenamed IDM-003, meaning it was the third wreck located by AWW/PI since the beginning of its operations at Mozambique Island.

IDM-003 is located one kilometre north of the São Sebastião Fortress (Figure 10), between Mozambique Island and Cabaçeira Pequena with the coordinates 15º01.209'S and 40º44.881'E (Mirabal 2007, 2013; AWW/PI 2014; Duarte *et al.,* 2015).

After re-locating the wreck in 2001, AWW/PI conducted several intrusive operations in an apparent attempt to identify the wreck (Mirabal 2001, 2004, 2005, 2013). The site was composed of a stone ballast pile in association with coral formations, sand and mud sediments together with shells and marine grass. Some iron debris could be seen on the seabed, and the use of a metal detector indicated the presence of more ferrous elements underneath the sediments (Mirabal 2013). Test pits were dug through the wreck from which six boat-shaped leads ingots were seen protruding and one ingot was collected, apparently for identification purposes. During the excavation of the test pits, one iron cannon, some ceramic artefacts, olive jars and a wooden structure were also observed, but no further work or recovery was carried out (Mirabal 2004, 2005, 2013).

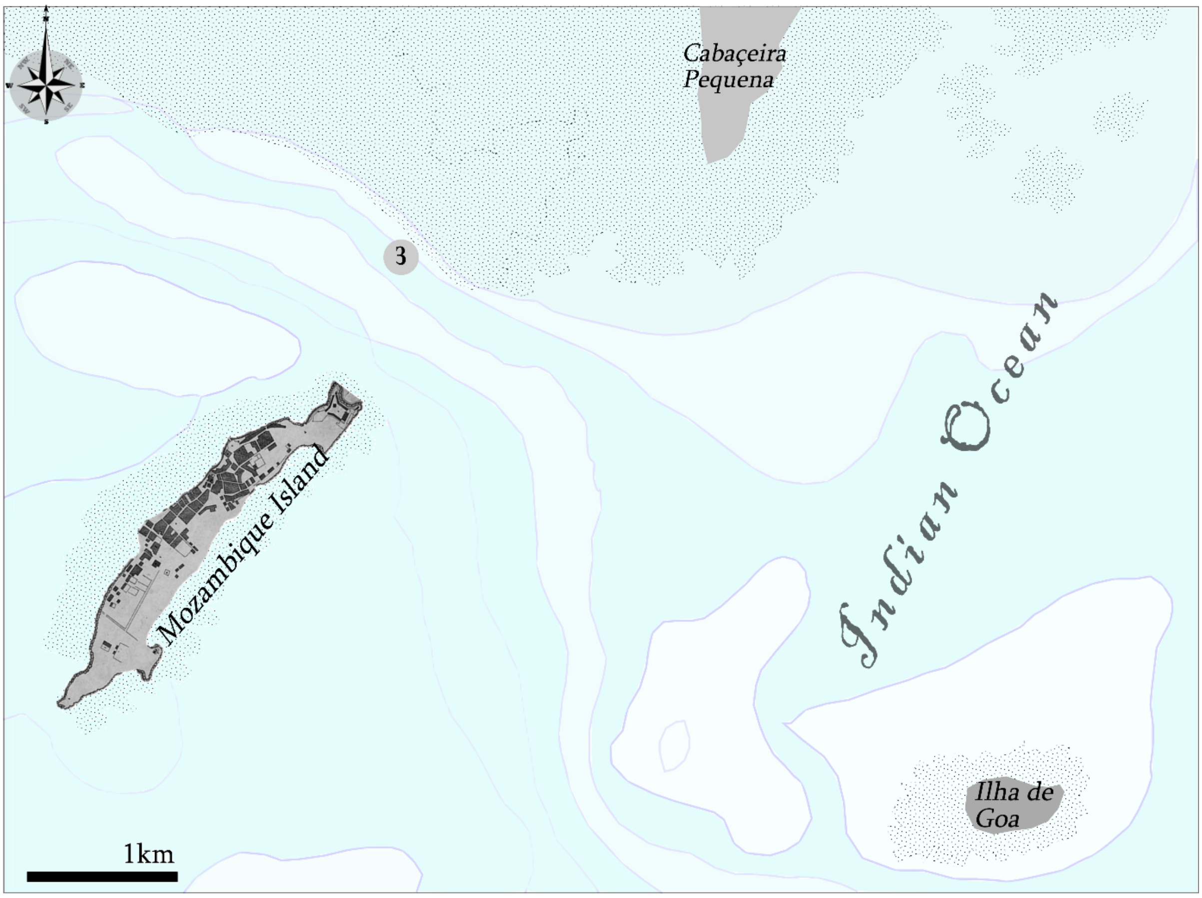


Figure 10. Location of *Nossa Senhora da Consolação* (IDM-003). Drawer: Cezar Mahumane, 2019

The presence of these artefacts was enough to identify this wreck as a possible Portuguese Indiaman dating from the Age of Discovery, between 16th or 17th centuries (Mirabal 2007; AWW/PI 2014). The first hypothesis was that the ship had sunk on its return from India because of fire on board, as some parts of the observed wood were burnt. Based on this assumption and driven by the idea that the wreck could have preserved some of her valuable cargo, AWW/PI undertook an extensive excavation program between July 2005 and 2006 (Figure 13). Only after the excavations did the company identify the wreck as the *Nossa Senhora da Consolação* (Mirabal 2007; AWW/PI 2014).

In this dissertation the identification of IDM-003 as *Nossa Senhora da Consolação* will be further discussed through analysis and re-interpretation on some indicative artefacts recovered by AWW/PI (see Chapter 4). Parts of the wooden hull structure have also been tested in this dissertation through laboratory analysis (see Chapter 5) to aid identification. But before continuing with the analyses of the archaeological finds in this chapter I will review the historical accounts given by Durão (1633) and Da Fonseca (1964) to provide a historical context for the analyses of IDM-003.

3.3. Contextualizing the history of the *Nossa Senhora da Consolação* Ship

In the late 15th century, Vasco Da Gama carried out two successful voyages to India around the Cape of Good Hope, establishing the *Carreira da India* route. As discussed in the introduction, it was the most prosperous maritime route for the European world to gain access to the rich resources of Asia, especially its spices (Arnold 2014). The key role of this trade is discussed by Murteira (2006:6) who writes that: *for almost a century, Portugal was the only European nation with ships sailing to India to buy spices and other exotic goods much appreciated in Europe like Chinese porcelain, and subdue new territories over the Atlantic and the Indian Ocean, generating wealthy and military hegemony to the crown.*

In the late 16th century, this Portuguese dominance on the seas began to change. Portuguese cargo ships were regularly afflicted by piracy, and frequently attacked by British and Dutch ships (Murteira 2006, 2017). At the end of 16th century, the British and Dutch made regular voyages to Asia using the Cape of Good Hope route. Consequently, a competition started between the Dutch and British, with the Portuguese being forced to use big military fleets to escort their cargo ships coming and going to India (Murteira 2006; Ferreira 2007).

The first time Portuguese and Dutch ships came across each other was on 4th May 1595 near Cape Verde and the Equator. A Dutch fleet composed of four ships under the command of Captain Houtman was sailing to Asia using the Cape of Good Hope route. This event has been described as friendly, and both crews exchanged food supplies (Murteira 2006). However, the second time Portuguese and Dutch ships came into contact with one another was on 24th May 1597 near St Helena Island[10] and the result was a battle. The Portuguese ship *Vencimento do Monte do Carmo* fired at the Dutch ship *Hollandia* and both ships were separated from their fleets (Murteira 2006). When the Dutch noticed the presence of three more Portuguese ships, they decided to continue their journey to avoid a bigger conflict. Two days later, the rest of the Dutch vessels – *Mauritius* and the *Pinas* – joined the *Hollandia* and they continued their way back to Netherland (Ferreira 2007).

[10] This Island is located in the South Atlantic and it was recognized as a place where water and shelter could be found by those in trouble on the long haul from Mozambique to Cape Verde (Livermore 2004). Since it was claimed in 1502 by the Portuguese João Nova, the Island became a permanent battlefield between Portuguese, British and Dutch. From 1502-1633 it was formally claimed by the Portuguese. The Dutch attacked the island since 1600, this caused the Portuguese to abandon St Helena in 1602, and however, they never formally occupied the Island. From 1608 onwards the island was under British control (Livermore 2004; Murteira 2006; Arnold 2014).

The first Dutch voyage to India (1595-1597) around the Cape of Good Hope route was a success and generated a lot of enthusiasm in Netherlands (Murteira 2006; Ferreira 2007). As a result, in 1598 five fleets left the Dutch ports heading East. The aim was to invest in the Indian Ocean trade, which meant that the Portuguese ships now had strong competition from the Dutch in the East India trade (Murteira 2006; Ferreira 2007). The Dutch decision to invest in Indian Ocean trade, exposed Portuguese ships to new threats and competition, resulting in regular conflicts between ships of the two nations.

An example was a battle on 25th April 1600 at St Helena Island between the Portuguese ship *São Simião* and two Dutch ships the *Leeuw* and *Leeuwin* over both the place of anchorage and food resources (see Frei João Dos Santos [1609]1999). The Portuguese won this encounter, but in the same harbour, on 25th September 1601, another battle had different outcome. At this time the Portuguese galleon *Santiago* coming from Goa, arrived alone and overloaded at St Helena Island, where it was captured by the Dutch ships *Langebark* and *Zeelandia.*

As a result of constant conflicts and losses caused by the Dutch presence at St Helena Island, the Portuguese King Filipe III decided that all the ships involved in the *Carreira da India* must avoid visiting St Helena (Barradas 2018). This decision meant that the Dutch were gaining more territory and could send more ships via this route.

Because of these victories and the profitability of the trade with the East, the Dutch created a company named the VOC or *Verenigde Oost-Indische Compagnie* – Dutch East India Company, on 20th March 1602 (Murteira 2006; Ferreira 2007). The aims of the VOC were first, to end internal commercial competition between different Dutch companies sailing to East and to control and raise the price of spices in Europe. A second aim was to gather forces to build a unified military force that could fight King Filipe III of Portugal and attack Portuguese *Carreira da India* ships (Murteira 2006, Ferreira 2007; Arnold 2014).

With the foundation of the VOC, the Dutch cast longing eyes at Mozambique Island which was a strategic island for Portuguese ships. On three occasions – in 1604, 1607 and 1608 – they attempted to occupy the island resulting in the loss of many *Carreira da India* ships including the *Nossa Senhora da Consolação* (Murteira 2006; Ferreira 2007; Cardoso 2013; Barradas 2018). As the sequence of events during these attacks is important for understanding and identifying the underwater remains, a detailed description will be given of these events.

3.3.1. First Dutch siege of Mozambique Island 1604

The first Dutch attempt to besiege Mozambique Island was made in 1604 by Steven Van Der Hagen, who left the Netherlands with a fleet composed of twelve ships – *Vereenigde Provincien*, *Amsterdam*, *Dordrecht*, *Hoorn*, *West Friesland*, *Gelderland*, *Zeelandia*, *Hof van Holland*, *Delft*, *Enkhuizen*, *Medenblik* end *Duifken* (Murteira 2006, 2017; Ferreira 2007). Their main task was to attack *Carreira da India* ships in the Mozambique Channel on their way to India. Once that aim was accomplished, Van Der Hagen should sail to the Western Indian coast where he should destroy any Portuguese ships found and establish political and economic agreements with local leaders (Ferreira 2007; Arnold 2014).

Van Der Hagen had no formal orders to invade Mozambique Island, but when he reached the Mozambique Channel, he decided to conquer the island and occupy the São Sebastião Fortress. The reason for this decision was to have a better position to trap *Carreira da India* ships coming and going to India (Ferreira 2007; Arnold 2014). When the Dutch arrived at Mozambique Island on 28th Jun 1604, they attacked a Portuguese ship – its name remains unknown - collecting its cargo of ivory and setting the ship on fire (Murteira 2006).

Figure 11. Hypothetical reconstruction on the capture of the nau de Trato. Source Barradas (2018:122).

This ship was one which made annual voyages between Goa and Mozambique under the command of D. Martim Afonso de Castro, and the event was described by Dos Santos in 1609 (Frey João Dos Santos [1609] 1999). Soldiers at São Sebastião Fortress were unable to protect the ship as their firepower was not enough to stop the Dutch (see also Arnold 2014). In his book, *Etiópia Oriental e vária História do Cousas Notáveis do Oriente* Frey João Dos Santos

([1609] 1999), who was inside the fortress when the Dutch attacked the island, relates that less than hundred and forty soldiers were in the fortress and most of the population from the island sheltered there.

Dos Santos ([1609]1999) describes how the Dutch tried to conquer the fortress without success, as the Portuguese soldiers responded energetically to counter the attacks. However, by this time, the Dutch had conquered most of the houses and churches outside the fortress. Van Der Hagen wrote a letter to the Capitan of the fortress informing him that, if he wanted to rescue the houses and churches, he should send two men to negotiate terms. The Capitan refused and the Dutch set fire to the houses and churches, destroying them completely. Van Der Hagen decided to stay on the mainland with the fortress under siege, waiting for more ships coming from India. As the expected ships became delayed, Van Der Hagen decided to sail to India to meet and attack Portuguese ships on their way from India to Mozambique Island (Barradas 2018).

The threat imposed by the presence of Van Der Hagen in the Mozambique Island area also made the Portuguese fleet delay their arrival at the island (Murteira 2006, 2017). Despite this the Portuguese soldiers at the fort managed to defend Mozambique Island throughout the siege, and thereby keep control over their important way station for the *Carreira da India* shipping. After this event, Portuguese became acutely aware of the likelihood of another Dutch attempt to conquer the island (Arnold 2014; Barradas 2018).

3.3.2. Second Dutch siege of Mozambique Island 1607

The second Dutch expedition to conquer Mozambique Island in 1607 was led by Paulus Van Caerden with a fleet of eight ships – *Banda*, *Walcheren*, *Bantam*, *Ter Veere*, *Zierikzee*, *China*, *Patane* and *Ceylon* (Ferreira 2007). Van Caerden arrived at Mozambique Island on 29th March 1607, in the season when many *Carreira da India* ships would be arriving from India (Ferreira 2007). Nine days before Van Caerden's fleet arrived, two Portuguese galleons had arrived at Mozambique Island coming from India (Ferreira 2007; Barradas 2018). The Dutch arrived out of the monsoonal season, having sailed against the monsoon wind taking the Portuguese with great surprise (Barradas 2018).

The Dutch Capitan Van Caerden again had no official orders to occupy the fortress, however, he took the decision to attack the fortress after a Portuguese prisoner informed him that a big fleet was coming to the island (Murteira 2006; Ferreira 2007; Arnold 2014). Van Caerden wanted to control the island before the arrival of the Portuguese fleet and therefore used all the military force available to him to try and take the fortress. As had happened in 1604, the São Sebastião Fortress was unable to defend anchored ships or prevent the occupation of the island (Cardoso 2013; Arnold 2014). However, in a night attack, the Portuguese set fire to the Dutch camps and some of the boats anchored near the fortress causing many deaths on the Dutch side. Van Caerden decided to lift the siege at the island because of the losses incurred. A contributing factor was also the fact that, after a month on the island at least 20 to 30 Dutch were getting sick or dying every day due to disease (Murteira 2006, 2017).

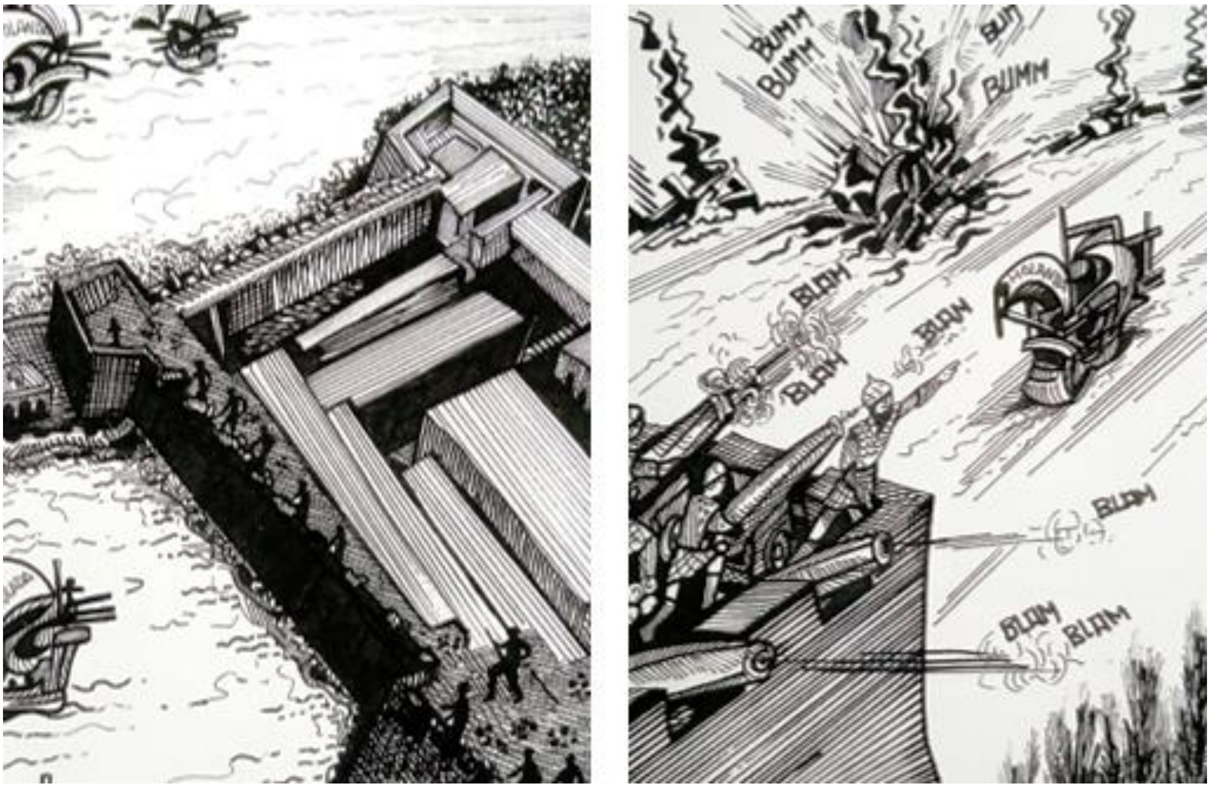


Figure 12. Drawing on hypothetical Dutch attack and Portuguese defence to São Sebastião Fortress. Source: Cardoso (2013:24)

Van Caerden instead established himself on the mainland and built contacts with local communities while waiting for the arrival of the fleet coming from Portugal with the monsoon wind (Arnold 2014). In the meantime, at the fortress, D. Jeronimo Coutinho placed five heavy artillery pieces in a strategic position to discourage another Dutch attack. The first part of the Portuguese fleet, composed by the naus *Jesus, São Francisco* and the *Nossa Senhora da Penha da França* arrived at Mozambique Island harbour (Ferreira 2007; Arnold 2014). A small boat was sent from the fortress to Angoche to alert the second part of the fleet to avoid Mozambique Island due to the Dutch presence and with orders that they should continue directly to India.

The second portion of the fleet was composed of the galleons *São Filipe e Santiago* and *Santo André*, and the naus: *Nossa Senhora do Loreto* and *Nossa Senhora da Consolação*[11] (Durão 1633). Only the *São Filipe e Santiago* and the *Nossa Senhora do Loreto* received the alert, and they were therefore the only ships to avoid Mozambique Island (Durão 1633).

Van Caerden decided to leave the mainland on 20th August 1607 when he noticed that the expected *Carreira da India* ships were taking longer than expected to reach Mozambique Island and realising that they might have changed their course and sailed directly to India. Van Caerden decided to go in pursuit of the ships on their way to India and captured the nau *Nossa Senhora do Loreto* near Ilheus Queimados after a long chase (Murteira 2006; Arnold 2014; Barradas 2018). Overall, Van Caerden captured seven Portuguese ships bound for India in 1607 and three more did not reach India because of the Dutch presence. For example, the *São Francisco* while trying to complete her voyage to India, hit a shoal in the area offshore of the church of Nossa Senhora do Baluarte on Mozambique Island and was declared not to be seaworthy (Arnold 2014).

Two ships, the *Nossa Senhora da Consolação* commanded by Captain Diego de Sousa and the galleon *Santo André* commanded by Captain Luís de Brito, had delayed their departure from Portugal and only arrived at Mozambique Island in September 1607. In this season the monsoon did not allow them to sail and because of the Dutch threat on the way to India they had to winter at Mozambique Island until the monsoon season in the following year (Durão 1633; Arnold 2014).

3.3.3. Third Dutch siege of Mozambique 1608

The 22nd December 1607, a third Dutch expedition was launched commanded by Verhoeff, who left the Netherlands in a fleet composed of nine big ships – *Geunieerde Provincien*, *Middelburg*, *Hollandia*, *Amsterdam*, *Roode Leeuw met Pijlen*, *Zeelandia*, *Rotterdam*, *Delft* and *Hoorn* – and four small boats – *De Pauw*, *Den Arend*, *De Valck* and *Griffioen* (Ferreira 2007).

The orders given to Verhoeff were the same as those given to Van Caerden: to attack *Carreira da India* ships in Mozambique Channel and Goa. Verhoeff was advised to avoid Mozambique

[11] *Nossa Senhora da Consolação* was a nau with three or four decks and fully integrated fore and stern castles, bearing three masts and a bowsprit, rigged with square sails, except the mizzenmast (Mirabal 2013). The mizzenmast, intended for steering, was rigged with a lateen sail. *Naus* could have measured 30 meters in length, having a capacity of 232 tons (Mott 1997:146; Castro 2008:80). The maximum breadth of this nau could have been 11 to 13 meters, with a depth of 8 meters (Mirabal 2013).

Island after the failures of 1604 and 1607, and instead was advised to wait for the *Carreira da India* ships at Comoros Island (Murteira 2006). Verhoeff decided against this advice in favour of waiting for the ships at Mozambique Island, and while based here he would try for the third time to occupy the São Sebastião Fortress (Ferreira 2007; Arnold 2014).

On 28th Jun 1608, the Dutch fleet commanded by Verhoeff anchored in front of Mozambique Island, and although there were ships that had wintered there, no new ships had arrived from Portugal in that year (Durão 1633; Arnold 2014). Verhoeff, anxious to engage in battle, decided to attack the fortress, though he had limited time available as he had to leave for India during the August monsoon (Murteira 2006).

The Dutch fleet was seen approaching the São Sebastião Fortress and D. Estevão de Ataíde – Governor of Mozambique Island in that time – organised the defence to protect the fortress and the ships anchored in the port (Durão 1633; Murteira 2006; Barradas 2018). The ships anchored in shallow water and near the fortress were saved (Durão 1633). However, the firepower and range of cannons from the fortress was not sufficient and once again, as had happened in 1604 and 1607, the Dutch captured those ships anchored outside the range of fire from the fortress. Outside the range of fire, Verhoeff found the nau *Nossa Senhora da Consolação* which had been wintering at the island since the previous year. The galleon *Santo André* had already left for India by this time. The *Nossa Senhora da Consolação* was getting ready to follow the *Santo André* when it was captured by the Dutch with 36 people on board who were unable to resist the attack (Durão 1633; Ferreira 2007; Barradas 2018).

The *Nossa Senhora da Consolação* was loaded with cloth, ivory, hippopotamus tusks, wine, spices and 40.000 *cruzados*, all to buy goods in India. However, much of her cargo had been transported to the fortress during the time it was overwintering and it seems that at the time the ship was attacked it was just being reloaded with her goods to continue her journey (Durão 1633; Murteira 2006; Arnold 2014). During the attack, the Dutch tried to move the *Nossa Senhora Da Consolação* away from the fortress using four small boats, *De Pauw*, *Den Arend*, *De Valck* and *Griffioen*, but due to the low tide the ship stranded on the shoals near Cabaçeira Pequena (Durão 1633; Da Fonseca 1964).

During the night of 25th July 1608, D. Estevão de Ataíde, the commander of the São Sebastião Fortress, sent soldiers to set fire to the stranded ship to ensure that the Dutch would not take her (Durão 1633). The mission was led by Bartolomeu Correia, the master of *Nossa Senhora da Consolação* and five soldiers using a small boat. The group managed to use fire and gunpowder to set a large fire, severe enough to prevent boats from approaching the burning ship. The first Dutch boats that tried to approach the ship to put the fire out were burnt, deterring other ships from approaching (Durão 1633; Da Fonseca 1964).

Overall, as a result of the Dutch siege of Mozambique Island in 1608, the Portuguese lost the *Nossa Senhora da Consolação,* a small *nau de trato* or *galeota de trato,* the galleon *Bom Jesus* and close to Goa they also lost the *nau Nossa Senhora de Oliveira* (Arnold 2014). Furthermore, in that same year, there were several other losses of ships to other causes, such as the nau *Nossa Senhora Da Palma* off Mongicual shoal, the galleon *Espírito Santo* or *Santo Espírito* off what was called 'the Costa da Cafraria' most likely near Natal, and the nau *Salvação* at the bar of Mombasa (Arnold 2014).

Thus, in 1608 no ship of the Portuguese outward-bound fleet arrived in India, either due to military operations by the Dutch or because of shipwreck from other causes. The same year was good for the Dutch as they did not suffer any loss of ships (Arnold 2014). The presence of VOC fleets in the Indian Ocean undoubtedly displayed the considerable maritime strength of the Dutch, becoming a real threat to Portuguese *Carreira da India* ships and causing the loss or wrecking of many ships, among them the *Nossa Senhora da Consolação.*

Part of the cargo of the *Nossa Senhora da Consolação* was captured by the Dutch, probably some of the cloth, ivory, hippopotamus tusks, wine, spices and the *cruzados.* But some of the cargo was lost with the ship, and those artefacts excavated by AWW/PI have enabled the identification of IDM-003 as the *Nossa Senhora da Consolação*. The types of recovered finds are commonly found on ships sailing to India during the 17th century. However, on the ship there were also everyday items reflecting the personal lives of the people living on the ships.

All the artefacts collected by AWW/PI from the *Nossa Senhora da Consolação* (IDM-003) are discussed in detail in the following chapter where I attempt to contextualize them within a chronological and spatial framework. The next chapter also assesses the methodologies used by AWW/PI to excavate the wreck and the post-excavation measures and reporting in more detail. The potential of the recovered material in terms of archaeological knowledge is also assessed and discussed.

CHAPTER 4 – THE ARQUEONAUTAS EXCAVATION

AWW/PI reported the IDM-003 site on 3rd July 2001 as being characterized by a stone ballast pile, some exposed olive jars and wood. It was initially identified as an unnamed Indian trade ship, and only later identified as the *Nossa Senhora da Consolação.* From 2001 to 2003, the company carried out successive intrusive operations on the site, first for identification purposes, having collected some materials such as a boat-shaped lead ingots, wood and pottery. In 2005 and 2006, an extensive excavation was then carried out and many more artefacts were recovered. This Chapter aims to describe the excavation process and analyse some indicative artefacts found by AWW/PI in an attempt to contextualize them within a chronological and spatial framework. The Chapter also discusses AWW/PI's *modus operandi* on IDM-003 in relation the principles which should guide any archaeological research project.

4.1. Excavation operations on the *Nossa Senhora da Consolação* (IDM-003)

In 2001, a test pit was opened on the site by AWW/PI to assess the condition and materials. The test pit revealed six boat-shaped lead ingots with identification marks and weighing 50 kg each (Mirabal 2001, 2004, 2005; Duarte *et al.,* 2015). One ingot was recovered for identification, but nothing was recorded regarding the location, possible origin and function of the ingot. By this time, AWW/PI was also busy excavating the *São Sebastião Fortress* shipwreck (IDM-002) (Figure 6), from which an extensive collection of Chinese porcelain was recovered and sold in auction at Amsterdam in 2004 (see Christies 2004, lots 601-645).

In 2003, AWW/PI focused its attention on IDM-003, excavating four test pits at different sections of the wreck. One test pit was opened at the north end of the wreck and the other three along the southwestern edge (Mirabal 2004, 2005, 2013). The northern test pit (S1), revealed four boat-shaped lead ingots, of the same type as those found in 2001. The test pit (S1) also revealed earthenware ceramics and some wooden remains (Mirabal 2004). The three test pits located in the southwest (S2, S3 and S4), revealed mostly olive jars, sections of the wooden hull structure, fragments of Martaban jars, lead seals, silver coins and an iron cannon (Mirabal 2004).

Further metal detecting searches were carried out on the site, but AWW/PI decided to postpone excavations until 2005 when a bigger team and equipment could be mobilised (Mirabal 2013). By that time AWW/PI had identified the MOG-003 shipwreck or *São José.* This ship had cargo assessed as being more commercially valuable than that on IDM-003, including the silver coins collected and sold by the company (see Chapter 2), and further excavation of IDM-003 was therefore postponed. Only when the potential of *São José* had been exhausted, did AWW/PI decide to develop an extensive excavation programme on the IDM-003 wreck. The excavation was mostly driven by findings from previous test pits and metal detecting searches that revealed the existence of considerable amounts of wreck material beneath the seabed. The excavation carried out by AWW/PI was not driven by archaeological principles, as there were no research questions asked (Duarte 2012: Duarte *et al.,* 2015). There was also no plan for artefactual conservation and interpretation. Furthermore, the excavation of the wooden hull structure was not accompanied with a strategy to mitigate deterioration of the wood (Castro 2013).

The first extensive excavation season begun on 04th July 2005 under supervision of Alejandro Mirabal who wrote short field reports on this work (2005, 2013). Mirabal claims to have set a web of permanent datum points to provide measurements of the seabed terrain and wreck remains. The areas to be excavated were defined in relation to these permanent datum points and 5 m x 5 m scaled grids which were set and numbered from S1 to S18, covering a total area of 450 m^2. The equipment used in the excavation comprised lifting bags to remove ballast stones and coral heads from the structure, an airlift to remove sediments and divers equipped with measuring and drawing kits to record features and object positioning (Mirabal 2005, 2013).

During the first season, nine grid squares were excavated, covering an area of 225m^2 in the western and northern sector of the site, corresponding to about 40% of the total area of the wreck. This excavation, according to Mirabal (2013) revealed a diversity of artefacts that reflect life on board and the kind of activity this ship was involved in at the time it was wrecked. Finds included part of the hull structure, olive jars, earthenware ceramics, Chinese porcelain, two complete local pots, and also two boat-shaped lead ingots. Other find reported were Martaban jars, hippopotamus and elephant tusks, silver coins, copper objects, navigational tools and seals (Mirabal 2006, 2013). The first excavation season was concluded on 19th November 2005 and the opened squares were backfilled with excavated sediments.

Documentation of artefact positioning or context was not a major concern for AWW/PI, and most of the artefact positions and contexts are, therefore, unknown, limiting any interpretation of the artefacts relationship with the hull structure. For archaeologists such context is extremely important. The context gives authenticity and significance to the objects and allows more to be known about the material associations. Even so, the collection recovered in the first excavation season has the potential for long term research on utilitarian objects, cargo and transactional material, and can contribute to understanding the social, cultural and commercial dynamic of that period. One of the aspects which make this wreck more interesting is the presence of two locally produced ceramic pots (Figure 25) which raises many questions. As will be discussed further below, the lack of documentation and recording during excavations may have misidentified these pots as belonging to IDM-003 when in fact they may belong to another older wreck on the same site (Duarte *personal communication 2020*, see further below).

The second excavation season was took place between 1st May 2006 and 2nd November 2006. The aim was to remove all the ballast and completely expose the wooden hull structure, collect all the remaining artefacts and record the structure (Mirabal 2006). The methodology was the same as for the first excavation season and 5 m x 5 m grids were re-established, with the excavation being continued from the tenth to the eighteenth grid. Although the ship structure was recorded in most of the grids, no artefacts were reported except in the grid S14 which contained 106 boat-shaped lead ingots and a cannon concretion (Mirabal 2006, 2013).

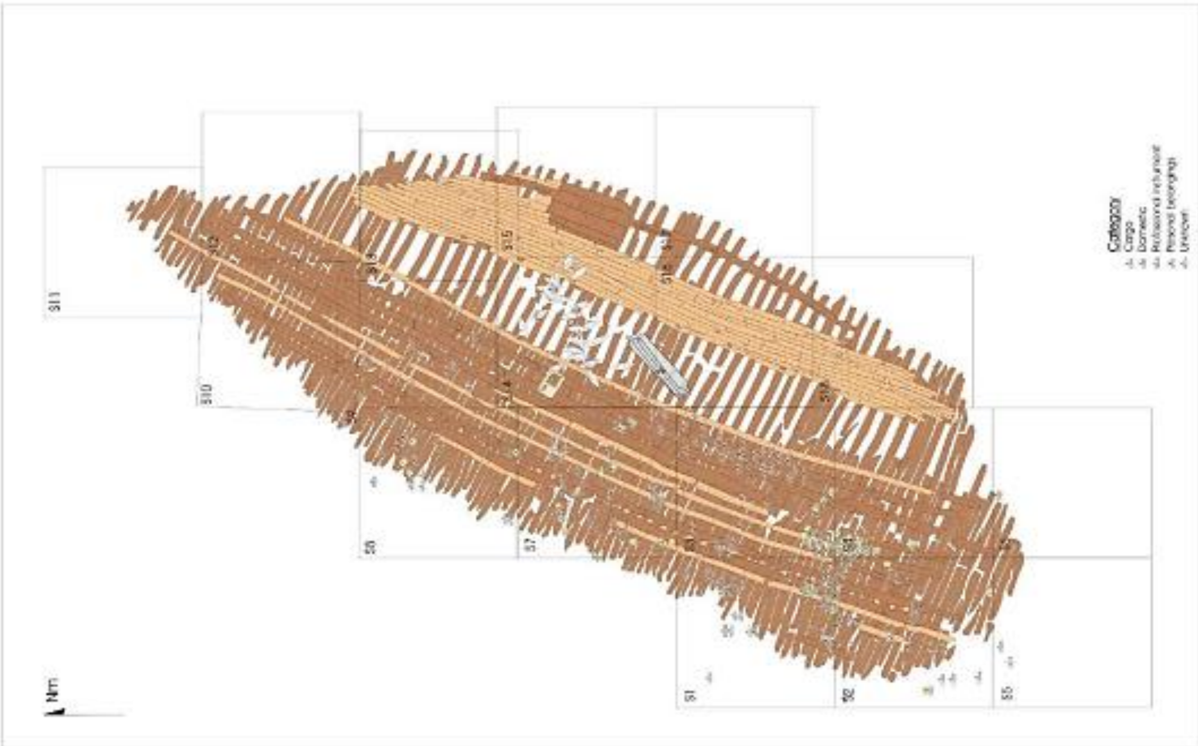


Figure 13. Map of the excavated grids and exposed hull remains by AWW/PI. Source: Mirabal (2013:33)

4.2. Description of the wooden hull structure

The 2006 excavation season by AWW/PI exposed the complete wooden hull structure of the ship, which had been safely buried by sediments for over 400 years. Filipe Castro (2013) considers this hull one of the best, largest and well-preserved remains of an early Portuguese Indian career ship ever found (the construction of which began in the 17th century). Mirabal (2006, 2007 and 2013) described the wooden hull features based on measurements, photographs, drawings and *in situ* observation of the structure. Mirabal's site map was drawn based on a photomosaic of the entire surviving structure, comprising a total of 158 photos covering 4 m^2 each from the total of 731 photos taken (Mirabal 2007) (Figure 14), however as will be discussed below this documentation was not sufficient to understand the structure of the hull.

Based on the bow, the structure was oriented 35º to the magnetic North with a length of 32.5 meter and width of 12.9 meter. The structure is part of the starboard side of the ship (Mirabal 2013). The wreckage included the keelson with the mast-step; 45-floor timbers; 65 strakes of the ceiling planking; 60 first futtocks; 59-second futtocks, 5 stringers; 2 decks clamps; 2 waterways; 2 spirketings; 4 baulk fragments; 1 small knee; 25 deck beams and 136 frames (Mirabal 2006, 2013).

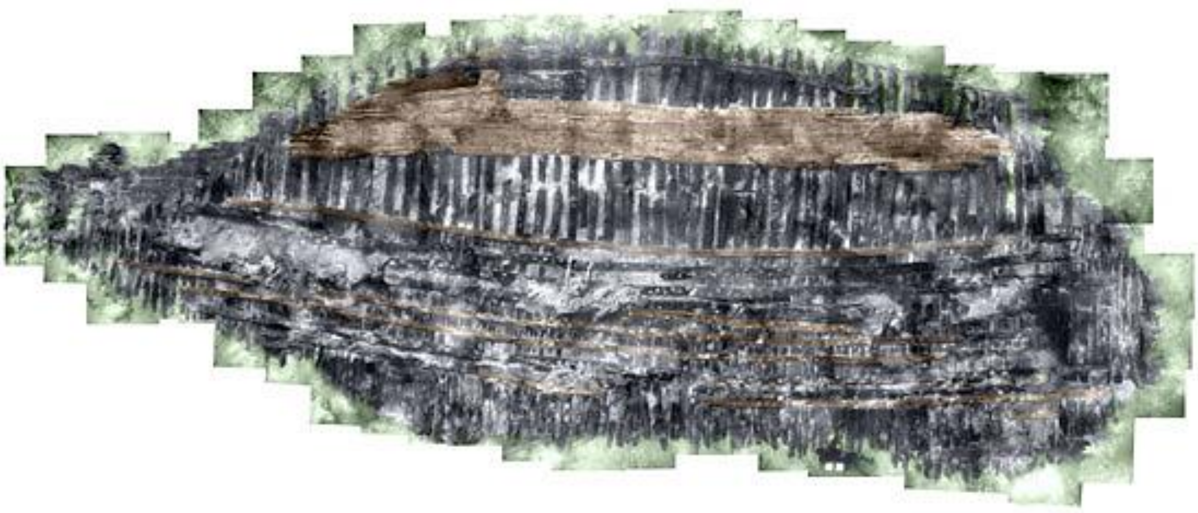


Figure 14. The exposed wooden hull remain on photomosaic by AWW/PI. Source: Mirabal (2013:77)

The structural elements described (the hull planking, keel and keelson, mast step, rabbets and scarfs) confirmed that this ship was built in the Portuguese tradition of ship construction (Mirabal 2013; Arnold 2014). Analysis show similarities between the *Nossa Senhora da Consolação* (IDM-003) (1608) and the wreck of *Nossa Senhora dos Mártires* (1606), fixing them in time to the beginning of the 17th century (Arnold 2014). This comparison is supported by historical documentation on ship construction process, and the measurements of details on both hull structures (Arnold 2014). Therefore, the *Nossa Senhora da Consolação* (IDM-003) fits into the definition of a *nau* of the early 17th century. The *nau* was a three-masted ship with two square sails on each mast, and had an approximate length of 27.5 meters (Castro 2008; Arnold 2014).

AWW/PI did not analyse the type of timber used to construct IDM-003. This is unfortunate as wood analysis may give crucial information on the origin of the ship (Oliveira 1991, Castro 2008, Arnold 2014). In the Portuguese tradition of ship construction specific wood such as cork-oak (*bot*. *Quercus suber*) and pine was used for some of the structural elements of the hull, like frames and planking. Cork-oak was generally used for frames and pine was used for hull planking. In the absence of cork-oak, holm oak *(bot. Quercus ilex)* and coppice-oak (*bot. Notholithocarpus densiflorus)* were used, because the wood is also hard and similar to that of cork-oak. For the planking, an alternative to pine was to use fir *(bot. Abis)*, larch *(bot. Larix)*, walnut *(bot. Juglans regia)* or white poplar *(bot. Populus alba)* (Castro 2008; Arnold 2014).

In order to build our understanding of the origin and construction of the IDM-003 wreck, samples of wood were collected on different structural parts of IDM-003 wreck, during the 2019 fieldwork undertaken for this dissertation. The samples were also used to assess the state of preservation of the site and the state of deterioration of the wood. Laboratory analysis revealed that pine was used in planking and oak for frames, confirming the European origin of the ship (see Table 7 in Chapter 5).

4.3. Preservation of the wooden hull structure post-excavation

After the completion of the full excavation of the site in 2006, AWW/PI abandoned the wooden hull structure without taking any mitigation measures to protect it from different environmental degradation threats (Mirabal 2007, 2013; Duarte 2012; Duarte *et al.,* 2015). For over three years the hull remains were exposed with no action taken towards their preservation (Castro 2013; Duarte *et al.,* 2015). In mid-2009 the site was backfilled by AWW/PI using a layer of ballast stones from the excavation. However, the procedure was insufficient, considering that, of the 250 tons of ballast removed from the site, only 100 tons were returned (Mirabal 2007, 2013). As the hull structure remained uncovered for almost three years an aerobic environment was created around the structure which facilitated an infestation of wood-borers in the wood (Mahumane 2020) (Figure 15). In addition, different environmental and human threats may have affected the site and the remaining archaeological objects, leading to progressive degradation.

Concerns about the preservation of the site after the 2009 reburial were made public by the archaeologist Bill Jeffery, who visited the site in 2011 when Mozambique Island hosted a seminar to discuss the UNESCO 2001 *Convention on the Protection of the Underwater Cultural Heritage* and how the maritime and underwater cultural heritage (MUCH) could be protected and managed. During this UNESCO event, four wreck sites were visited, IDM-003 was among them. Jeffery in a report for the Centre for International Heritage Activities (2011:9-10) described the condition of the site referring to the diver *Eduardo Artur Furtado dos Santos* who had seen the wreck in different stages:

> *It was last seen by Eduardo Artur Furtado dos Santos*[12] *c. 5 years ago when 2-3 metres coral heads were covering it, and considerable flora and fauna could also be seen there. Today the site is denuded of all the natural material and is laying exposed. A thin layer of ballast stones covers an area of seabed of about 25 x 10 metres and a considerable amount of timber from the ship's hull can be seen in amongst and outside of the ballast. At least one concreted cannon can be seen—in a disturbed state. This was the first time Eduardo Artur Furtado dos Santos had seen the site in 5 years and he was shocked by its very poor and exposed condition. The ballast stones may have been removed to uncover the hull timbers and replaced or the site could have been simply exposed and left like this. The exposed nature of the site will contribute to further site deterioration and perhaps uncovering—from storms, given the shallow depth—and possibly from human interference. The site should be covered to stop further deterioration and then monitored* (Jeffery 2011:9-10).

As is clear from this description, the reburial methodology used by AWW/PI to prevent the further decomposition of the wreck was largely insufficient and the site was being continuously exposed to degradation.

In mid-2014, when AWW/PI had their permit cancelled by the Mozambican Government an assessment team was assembled to inspect and assess the condition of sites they had intervened in, including IDM-003 (see Chapter 2). The results of this assessment revealed the worrisome

[12] Eduardo Artur Furtado dos Santos worked with Arqueonautas for a short time. He disagreed with how and what Arqueonautas was doing on the shipwrecks. He is a very committed member of the Mozambique Island community when it comes to protecting the sites for community benefit.

condition on IDM-003 which was covered by only a thin layer of ballast stones scattered over an area of 30 x 15 meters. Within the thin ballast layer covering the wreck, large timbers of the hull structure were exposed and were much deteriorated. Many fragmented objects, particularly pottery, could be seen scattered about the site and in the central area of the wreck there is an exposed concretion of three iron canons that have been colonised by coral (Duarte *et al.* 2015; Mahumane 2016, 2020).

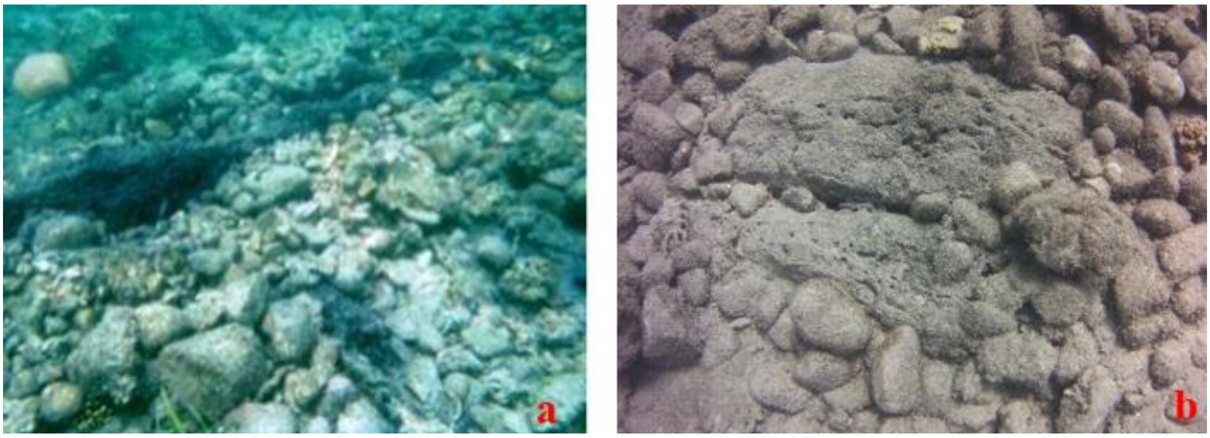


Figure 15. Site condition, Jeffery 2011(a) and Duarte 2015(b).

The dimensions of exposure given by Duarte *et al.*, (2015) are extensive when compared to those originally given by Jeffery (2011) which means that the site was becoming increasingly exposed over time. This increase in area of exposure can be the result of both natural and human factors which will be discussed in more detail in the next chapter. The condition of the wood had degraded further and by 2015 it was getting much more exposed and consumed by woodborer. When comparing the condition of other wrecks excavated by AWW/PI, IDM-003 was the one which showed by far the most progressive degradation.

The recommendation of the 2015 assessment report (Duarte *et al.*, 2015) was therefore to prioritise the protection of the wreck site against further degradation. Besides the worrisome condition of the hull of IDM-003, the AWW/PI had extracted many artefacts from the wreck, which were left without proper descriptions or interpretation and which were also stored without appropriate preservation measures. Consequently, it was concluded by the assessment team that the preservation condition of the IDM-003 demanded an urgent intervention to protect the site from further deterioration threats and a monitoring procedure to assess the condition of the site over time (see Chapter 5).

4.4. Artefact description

Some of the artefacts collected by AWW/PI during the course of the excavations performed between 2005 and 2006 at IDM-003 could have been part of her cargo. Most of the collected artefacts were roughly described in a database and in a book published by Mirabal, *The excavation of the Nossa Senhora da Consolação (1608)*[13]. Part of the artefact collection from the excavation is now available for study on Mozambique Island after being transferred in 2017 from the AWW/PI storage at *Capitania*, due to poor conservation conditions there. The collection is now stored at the Museum of Mozambique Island.

On August 2019, an analysis was carried out on the artefact collection from IDM-003 (see the full list of artefacts collected on the site in Appendix 2). The method of analysis was based on a comparative study of indicative artefacts with assemblages recovered from other relevant and contemporary shipwrecks around the world. The results of this comparative analysis are discussed below, and at the end of this chapter recommendations for further research of the remaining artefact collection are given.

4.4.1. Boat-shaped lead ingots

When IDM-003 was located by AWW/PI in 2001, the company found six boat-shaped lead ingots and a sample ingot was collected for identification purposes. However, nothing has been published about the identification or analysis of these lead ingots. Additionally, the 2006 excavation revealed 106 similar boat-shaped lead ingots in one single square (S14), which were all recovered from the site (Mirabal 2006, 2013).

The collected lead ingots were each approximately 50 kg in weight and 65 cm in length. They all had a triangular transversal section, and were narrower toward the ends. One of the flat surfaces of the ingots showed circular marks that might be an indication of the ownership (Mirabal 2013) (Figure 16). The identity of this marker was not pursued. Unfortunately, the whole lead ingot collection was sold by AWW/PI in 2006, to the Company *Global Cooperation Inc*. (Duarte *et al.*, 2015). The IDM-003 lead ingot analysis presented is therefore based on the comparison of the available images and the inventories of collections of similar boat-shaped lead ingots found on other shipwreck sites.

[13] The publication is a compilation of interim reports from 2005, 2006 and 2009, which describe the site condition, excavation, hull and artefacts collected without further interpretation.

Figure 16. ***Images of the boat-shaped lead ingots and a marking present on the ingots.*** **Compiled by Cezar Mahumane, from AWW/PI (2014:38)**

Generally, lead ingots in underwater archaeology are well published, thanks to the work of Willies (1985), Stedman (2009) and Van Duivenvoorde *et al*., (2013). Based on this work, most of the boat-shaped lead ingots, found in several wrecks of the Dutch East Indiaman sailing from Europe to Asia have been identified. The boat-shaped ingots share similarities in shape, weight and marks, but are not identical. The specific boat-shaped lead ingots from IDM-003 have not been identified in any of the literature so far and are not featured in Willies' (1985) typology.

Similar, but not identical lead ingots have been found on the *Zeepaard*, which was lost on 28th October 1665 off the Shetlands during a storm (Brady 2017). Eight boat-shaped lead ingots were recovered from the wreck of the *Zeepaard*, each with a different length: two ingots were 70 cm, four were 80 cm and the rest were 78 cm long. All ingots, except one, had stamped marks on their surfaces and at least 13 different stamp designs were recognised (see Brady 2017 for further details). The most precise method of dating ingots is by identification of the markings, as it provides authentic information concerning metal trade by the company or year of manufacture (Tripati *et al.*, 2003; Stedman 2009). The boat-shaped lead ingots from IDM-003 all had a mark stamped on the surface. However, the one available image of this mark stamp is not clear enough to allow further comparison with markings from other boat-shaped lead ingots collections.

The other potential dating and identification method is based on a comparison of the size and shape of the ingot which can be compared with the typology established by Willies (1985). The six ranges of lead ingots found at *Zeepaard* wreck and those from the IDM-003 fit into what

Willies (1985) calls *"great pigs"* or pig-shaped ingots. These were common in the 17^{th} century and were produced in north England. The Dutch were the main buyers of this type of ingot. Historical records mentioned by Stedman (2009) and Van Duivenvoorde *et al*., (2013) confirm that the Dutch procured large quantities of lead from English sources and recent chemical analyses of lead ingots from other wrecks like the *Zuiddorp (1712)* and *Poompuhar (1792)* suggest that the ingots came from England (Tripati *et al*., 2003; Stedman 2009; Van Duivenvoorde *et al*., 2013).

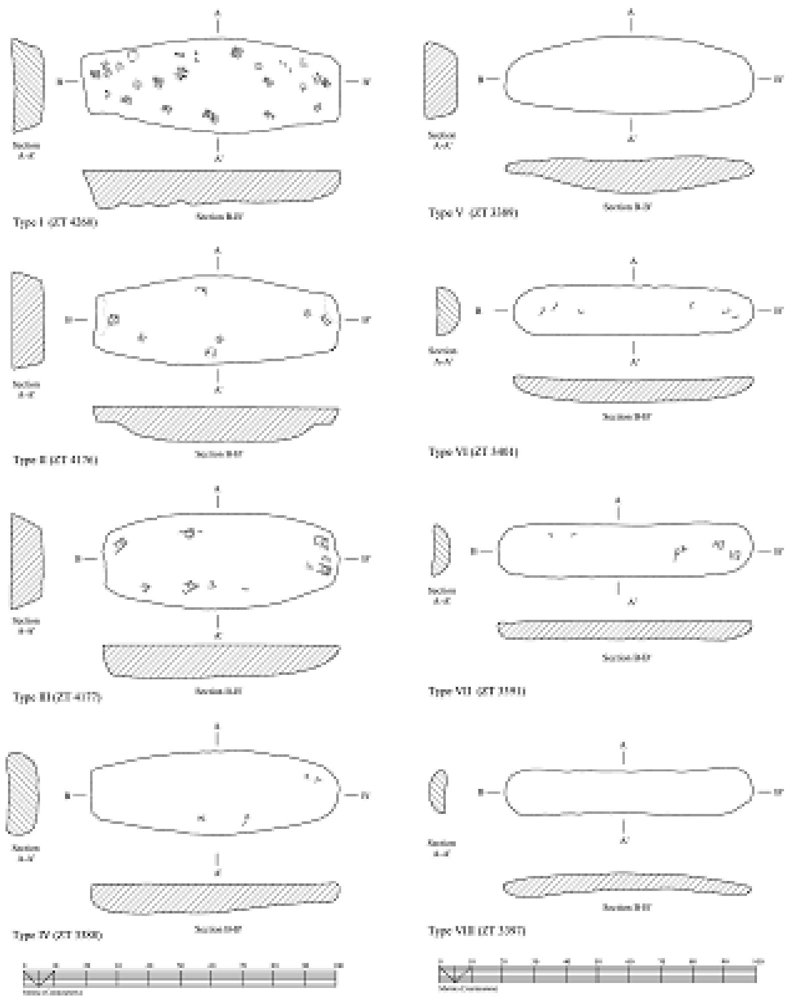


Figure 17. ***Ingots Typology according to Willies (1985)***

In the history of trade, lead has played a major role, as by the 17^{th} century, it was being used for multiple purposes such as coin minting stock, water- and drainpipes, sheathing for the hulls and sternposts of ships, the linings of wooden crates and for armour. Apart from these uses it also had functional use as ballast for sailing ships and it could then be re-smelted into musket balls and cartridge shot, anchor-stocks, gutters, seals and stamps and furniture and table decorations (Tripati *et al*., 2003; Stedman 2009; Van Duivenvoorde *et al*., 2013).

Many European countries were buying lead for use as cargo or paying ballast in ships because, unlike sand and stone ballast which were simply dumped at the end of a voyage, lead was profitable. Most ships needed ballast and it appears that the vessels during the journey east from European countries, instead of travelling empty used to bring lead which was relatively cheap, heavy, durable and had a ready market value (Tripati *et al*., 2003). The amount of lead found in the excavation clearly suggests that lead may have been considered more as cargo than ballast. It also suggests that the Dutch were not the only nation acquiring lead in great quantities, but also Portugal.

Like other kinds of metal, lead is an evidence which can provide clues for dating shipwrecks and also to reconstruct trade patterns. Techniques have been developed and used by archaeologists to date and interpret the metal origin, an example is the XRF (X-ray fluorescence) method which can help address questions concerning the history of the metal, manufacturing process and provenannce (Guerra 1998). This sort of archaeometric approach could have been employed if the IDM-003 boat-shaped lead ingots collection was still present on Mozambique Island. However, as the collection in its entirety is lost, this type of analysis is now impossible.

4.4.2. Coins

In course of the excavations, AWW/PI claims to have found 37 silver coins, which were in poor condition, and from which it was almost impossible to gather any further information (Mirabal 2013). However, some of the marking on the coins are still visible and their origin could potentially be reconstructed. Most of the coins do not show any Portuguese markings which suggests that they are more likely to have emanated from the Spanish Empire. At this time Portugal was linked to the Spanish Empire by the Filipes´ Dynasty.

Historical accounts indicate that during the mid-16th century, European countries did not have silver mints and Spain was the only nation who was mining silver in its Mexican mines. Silver coins were the dominant currency on European and international markets for more than three centuries (Cardoso *et al.,* 2014, Banco do Mexico 2018). In the 17th century, the demand for silver coins increased, and Spain had to increase coin production, opening new silver mints at Potosi (Bolivia) and Lima (Peru).

Similar coins collection to those found at IDM-003 have been identified on the *Nossa Senhora dos Mártires* wreck (1606). Cardoso *et al.*, (2014) analysed the *Nossa Senhora dos Mártires* coins collection composed by 507 coins. From the whole collection, only 25 coins were Portuguese and the rest were Spanish. The Portuguese coins in question were called *Macuquina,* and they were minted and inscribed with the dates of King Filipe II who reigned over Portugal and Spain at the same time (Cardoso *et al.*, 2014; Banco de México 2018).

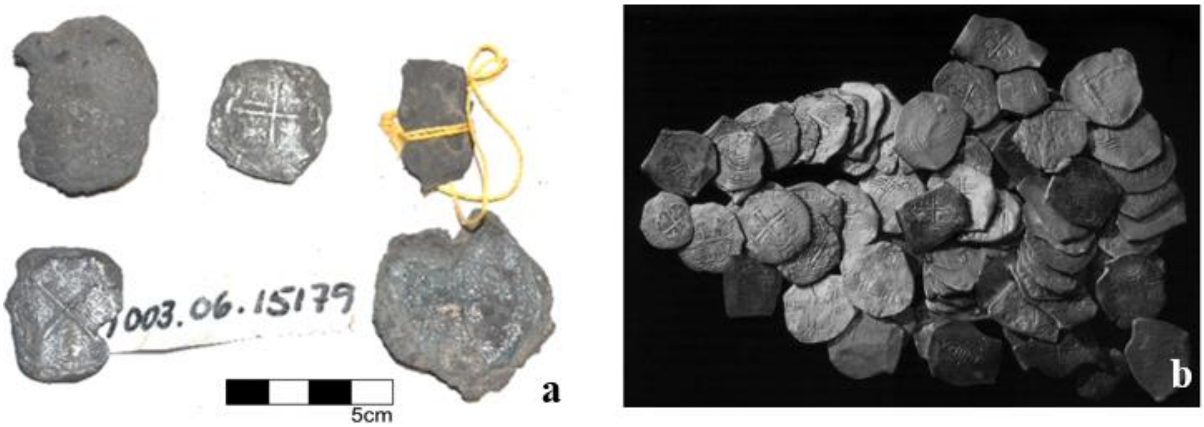


Figure 18. Comparative coin collection, ***(a) Nossa Senhora da Consolação (IDM-003); (b) Nossa Senhora dos Mártires.*** **Compiled by Cezar Mahumane, 2019**

The analysis by Cardoso *et al.*, (2014) on the *Nossa Senhora dos Mártires* coin collection could be applied to the *Nossa Senhora da Consolação* coins collection aiming to determine the origin of the coins and associate the collection with the wreck. The methodology of Cardoso *et al.*, (2014) also comprised comparisons of Portuguese and Spanish markings, dates and values inscribed on the coins. The results revealed that Spanish coins were dominant in the *Nossa Senhora dos Mártires* collection, similar to other European wrecks used in commercial voyaging in America, Africa and Asia during the 17th century (Cardoso *et al.*, 2014), as it was the case of the *Nossa Senhora da Consolação*.

Despite the poor condition of the IDM-003 coins collection, it shows great similarities with that of the *Nossa Senhora dos Mártires* (Figure 18), which provide additional data to contextualise the ship chronologically and reconstruct the commercial activities it was involved in. In general, the association of coin collections with specific wrecks can only be done with contextual information and analysis from other types of archaeological materials with chronological and typological significance. Through time, archaeology has built the capacity of tracing back the origin of metals using different types of analysis such as the XRF as discussed above, which is capable of analysing metallic proprieties, that helps understanding technologically of minting, providing a base for comparisons (Guerra 1998; Cardoso *et al.*, 2014). This sort of analysis and comparison are useful tools to understand social dynamics and commercial importance of metals, especially coins that were used in the international trade network. Coin analysis in archaeology can be used as an absolute dating method, providing a wide range of data used to ascertain details about a particular period much more accurately than literary evidence (Guerra 1998). Despite the similarities mentioned between the *Nossa Senhora dos Mártires* coin collection and the IDM-003 collection stored at Mozambique Island Museum, this needs further investigation using the above proposed methodologies or others which can contribute to contextualizing the collection with the wreck and the global commercial network. Fortunately, the collection was fragmented enough not to be sold and the coins now remain for further analysis.

4.4.3. Lead Seals

At IDM-003, AWW/PI found 49 lead seals that were analysed by Mirabal (2013). The lead seal collection was divided into two different types. Type A, constituted a shape formed by two lead discs attached by a lead strip, allowing the two discs to be pressed together. Type B is a flattened octagonal cylinder with small stamps on both flat faces, which Mirabal (2013) considered not to be a proper seal, as it lacks an apparent sealing function.

However, De Sousa (2016, 2019) has developed a comparative framework for European lead seals[14] which categorized 15th to 19th century Portuguese lead seals on the basis of the iconography depicted on them ranging from royal army, private braziers, city braziers, religious or company symbols, each of which provide information about the origin or function of the seal. From this comparison of motifs De Sousa identified three main categories of seals, namely: customs seals, cloth seals and personal seals.

The collection of seals recovered and described by AWW/PI falls within De Sousa's type A, which lies in the category of cloth seals and were used to certify cloth quality or its provenance. This kind of seal was first used by the Dutch in the 13th century to certify the quality of cloth produced in Leiden, but later in the 15th century cloth seals were compulsory in Europe and many countries used them to distinguish both cloth quality and provenance (De Sousa 2016).

[14] The iconography represented on seals allows the identification of the entity that issued, the provenience, the taxes paid and even the dates (De Sousa 2016).

In the cloth seal assemblage found on IDM-003, there are two peculiar seals with different iconographic motifs depicted. One has three letters (A and two C´s linked), and it is likely to be an indication of a private or personal seal of someone responsible for cloth production or it may represent the ownership of the product sealed. It was common in England that a private seller or cloth producer had a private seal with their initials depicted, which attested to the quality of the product. It is also likely that these seals were used to identify the owner of the product (De Sousa 2016). The second seal has a horse with a pole and Mirabal (2013) describes it as a representation of *Agnus Dei,* a traditional representation of Jesus Christ. The representation of religious symbols was directly linked to the hope that God would protect the products along the way against piracy or wreckage, as their losses were expensive (De Sousa 2016). In an email communication (12/09/2019) with De Sousa, concerning this second seal, he has identified it as French and he also identified its possible origin the cities of Rouen, Bourges or St Omer. Because of the high level of erosion of the reverse of the seal, not much further information could be obtained. Still, this added information shows that if investigated properly, the artefacts recovered from IDM-003 can provide a wide range of information about the international trade network in which the ship was involved.

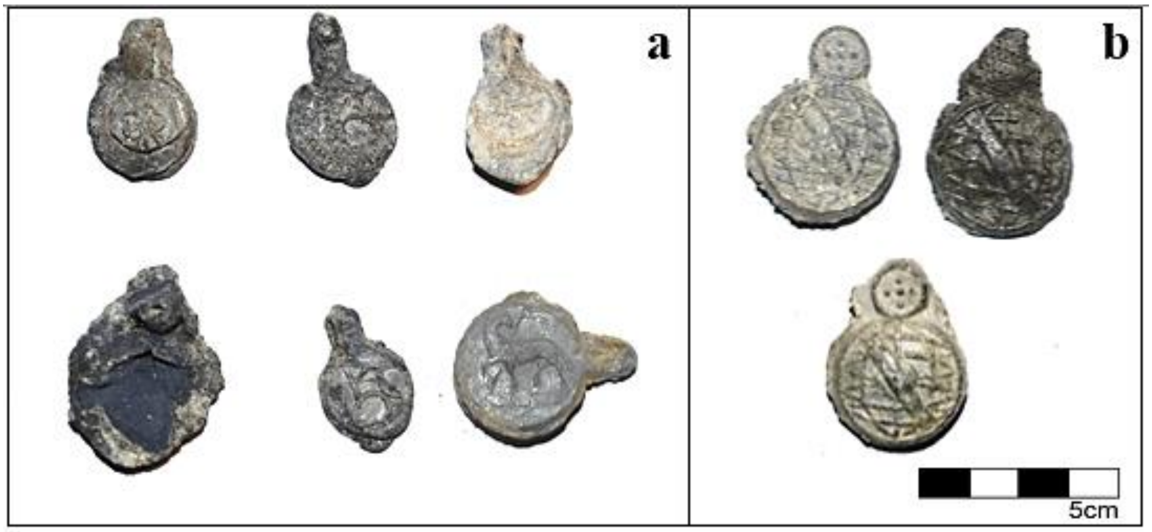


Figure 19. ***Cloth seals found at Nossa Senhora da Consolação (IDM-003), (a) personal and private seals; (b)Custom seals.*** **Photo: Cezar Mahumane, 2019**

The lead seals categorized as Type B by Mirabal (2013), are known by De Sousa (2019) as customs seals. These seals were introduced in Portugal on 21st January 1547 to control imported and exported goods. Thus taxed goods were certified using these lead seals. The iconography represented on customs seals was rather uniform through most of the customs houses that controlled goods exchanges, but many carried the name of the city where the taxes were paid

(De Sousa 2019). The main iconographic feature seen on this type of seals from IDM-003 is the representation of the *Esfera armilar*[15] which was introduced by King D. Manuel I (1504), and was a symbol of maritime, economic and political power linked to navigation, representing Portuguese supremacy on the world.

Among the seal categories defined in his book, De Sousa (2019) has identified this type of customs seal as EA11. De Sousa (2019) has also specifically associated the EA11 types with Mozambique (Figure 20). It is unclear however if these seals were specifically used for goods being traded to Mozambique.

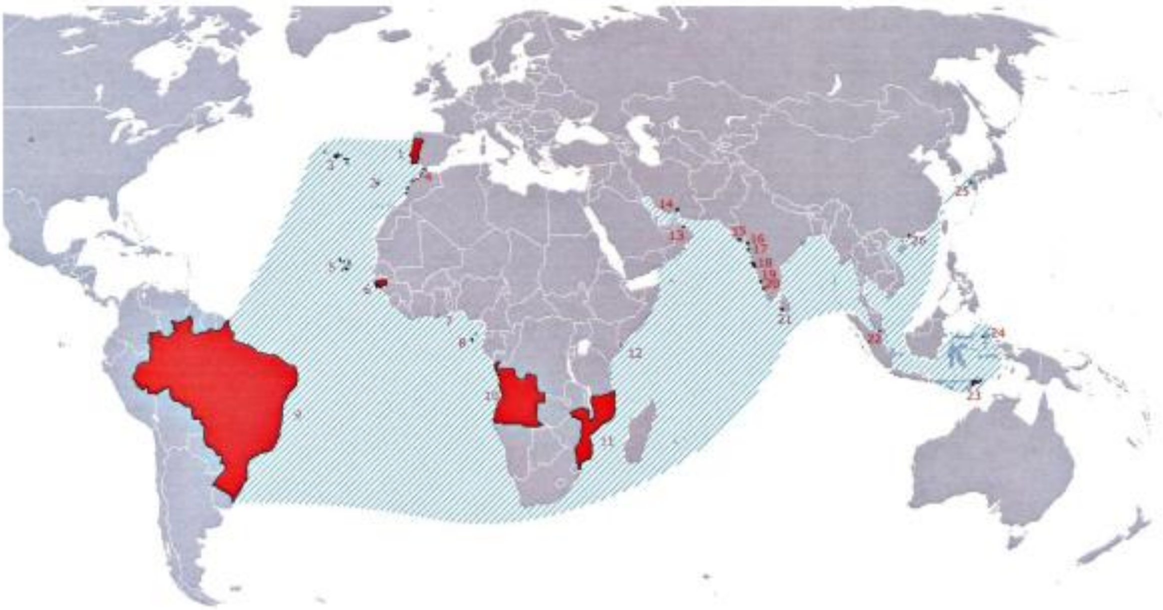


Figure 20. De Sousa Map and the representation of the Custom seal. Source: De Sousa 2019:25

4.4.4. Hippopotamus and elephant tusks

The tusks and teeth recovered from IDM-003 by AWW/PI have been described as belonging to the African elephant *Loxodonta Sp* and the hippopotamus (*Hippopotamus amphibious*) (Mirabal 2013). There is no reference in AWW/PI's records to any kind of specific studies to identify these tusks or where they were coming from. A comparison must then be made with more general studies discussing the origin and function of hippopotamus teeth and elephant tusks found on *Carreira da India* shipwrecks. Tripati & Godfrey (2007) and Mowa, Nkengbeza & Kangumu (2018) have two different approaches regarding the place of origin of most

[15] It is the tridimensional representation of the cosmos, with the earth in the centre of the universe. It has rings representing the global parallels and meridians and a 23.5 diagonal line (De Sousa 2019:23).

hippopotamus and elephant tusks traded in the *Carreira da India.* Their discussion is essentially based on historical accounts and DNA analyses in tusks found in different shipwrecks.

During the mid-16th and early 17th century, the Portuguese had the monopoly of trading elephant and hippopotamus tusks to India and obtained finished objects from here which were then brought back to Europe to satisfy its increasing demand of ivory. The demand for ivory can be seen from the number of tusks found on wrecks. For instance, the *nau Narazé* that sunk in 1523 was carrying an unspecified number of elephant tusks, and the *nau São Miguel* is reported to have sailed from Mozambique to Goa carrying eighty pieces of elephant tusk (Tripati & Godfrey 2007). The *nau Bom Jesus* was found with 105 elephant tusks which may have been obtained in West Africa and which were then on route to Lisbon (Chirikure *et al.,* 2010; Mowa, Nkengbeza and Kangumu 2018). From IDM-003 there were an unspecified number of elephant and hippopotamus tusks recovered by the treasure hunters.

The majority of elephant and all hippopotamus tusks found in *Carreira da India* shipwrecks are likely to be African. By comparison, Asian elephant tusks are smaller, whiter, softer and more opaque with a tendency to discolour and they take a less fine polish than African ivory. When exposed to light Asian ivory tends to become dull in appearance, whereas African ivory often takes on a porcelaneous sheen (Tripati & Godfrey 2007). African ivory is of the highest quality, hardest and most brilliant, tending to retain its yellowish-white colour better as it ages. An African elephant tusk can measure up to 2 m in length with diameters of 9 to 11 cm and can weigh up to 90 kg (Tripati & Godfrey 2007; Mowa, Nkengbeza & Kangumu 2018).

In general, maritime trade records suggest that elephant and hippopotamus tusks are likely to have been taken in Central and West Africa (the Congo, Senegal and Angola) and on the East African coast (Mozambique and Tanzania). From here the ivory was transported to the great trade centres in India (Cambay, Surat and Gujarat) where artisans were the most skilled in working this material (Alpers 1975; Tripati and Godfrey 2007; Mowa, Nkengbeza and Kangumu 2018). Alpers (1975) and Tripati & Godfrey (2007) suggest that the best African ivory comes from Mozambique and Zanzibar. Alpers (1975) adds that the Yao and Makua traders in Mozambique transported ivory from the interior in the Western Maravi and Chewa areas. But traders also bought ivory from the Lenje and Bisa hunters who inhabited the area of Zumbo located at the confluence of the Zambezi River and the Luangwa River in south-eastern Africa. In the 17th century, more than 50% of the ivory that was being traded to India from

Portuguese ships was sourced from Mozambique, as shown by Tripati & Godfrey (2007) (see Table 1).

Table 1. Amount of ivory traded by Carreira da India Ships Tripati & Godfrey (2007:334)

Year	Volume (in kg)	Amount invested in Xerafins	Imported from
1613	26691	79332	Mozambique
1614	23282	69246	Mozambique
1619	11641	17695	Mozambique
1620	2308	3476	Mozambique
1621	2622	3985	Mozambique
1625	1232	1870	Mozambique
1626	1311	1993	Mozambique
1644	944	1432	Mozambique-Lisbon
1646	44834	72996	Mozambique-Diu
1650	1229	1846	Mombasa
1661	55884?	84944?	Mozambique
1661	34642	52655	Mozambique

Chirikure *et al.*, (2010) and Mowa, Nkengbeza & Kangumu (2018) present a different approach to sourcing the origin of ivory in the example of the *Bom Jesus* wreck. They consider that the ivory found in this wreck is most likely to be from West Africa, as the Central and West African regions were inhabited by Forest and Savanah elephants with tusks similar to those found in many 17th-century shipwrecks. During this period, elephants were hunted in numbers and there were ready markets in Central and West Africa which were opened to Portuguese traders. Both elephant and hippopotamus teeth from the wooded and humid regions of Africa was considered better for carving sculptures, statues, bangles and other objects of religious and secular art.

Hippopotami have been hunted for millennia for their meat and teeth. The teeth of a hippopotamus are hard, retain their whiteness for a long time and do not change colour when cut and polished. A hippopotamus has enormous jaws that hold the long, curving teeth which consist primarily of enamel (Tripati & Godfrey 2007:335). As hippopotami are now confined to only Africa, the hippopotamus teeth almost certainly came from Africa. The co-location of hippopotamus with elephant tusk material may indicate that both of these products are likely to have been sourced in Africa, although it is still unclear whether the elephants and hippopotamus tusks were of Mozambican origin or came from another part of Africa.

The hippopotamus teeth and elephant tusks recovered by AWW/PI from IDM-003 are still available on Mozambique Island and further investigation may shed light on the origin of the tusks. Different types of analysis as DNA and Isotope analyses can contribute to gaining new information about geographical provenance, which can help characterise elephants and hippopotamus from different habitats across the region (Coutu *et al.*, 2016). This sort of archaeological data can be used as a baseline for comparison and better understand historic elephant and hippopotamus distribution and the past hunting areas as addressed in the Coutu *et al.,* (2016) study.

Figure 21. Elephant tusks and hippopotamus teeth left at Mozambique Island by AWW/PI. Photo: Cezar Mahumane, 2019

4.4.5. Martaban jars

The excavation performed by AWW/PI on IDM-003 recovered two intact Martaban jars and many shards that pieced together may have similar size with the intact jars. Mostly considered as storage ware, these jars were used to contain, store and preserve liquids and solids, and for the transport of delicate and precious goods on board ships (Coelho 2008; Simões 2009; Borell 2014).

The use of these jars has been reported since the Song (960-1279) and Ming (1368-1644) dynasties when they were used to transport good overland from China to Burma (now Myanmar) and from whence they were shipped to West-Asia, India, Africa and later, after the 16th century, to Europe (Borell 2014). The precise origin of these storage jars is still unknown, but they were made in China or in Southeast Asia and they were known as Martaban or Martavaan jars. The name came from the Arabic pronunciation of the port on the Gulf of Pegu, now Myanmar, a meeting point for trade routes in the Far East, and a place of compulsory passage for European merchants and navigators since the 16th century (Simões 2009; Borell 2014).

Since the 16th century, this port city has been known for its intense trade and has been famous for its large clay jars which were recorded in the writings of several travellers. One of the main characteristics of these jars is their resistance to breakage, which is conferred by the type of coarse clay they are made from. The clay has a consistent grain size and becomes more solid and waterproof upon firing since it contains feldspars and quartz. These characteristics of the fabric explain why these Martaban jars were suitable as liquid containers, safely carrying water, wine and oils (Simões 2009).

There is not much known about the functionality of the jars in the *Carreira da India* ships. Despite the fact that there have been some studies on the Martaban jars found on European shipwrecks and on terrestrial sites, the most advanced studies on these jars were made on the *Nossa Senhora dos Mártires* (1606) wreck by Simões (2009) and Coelho (2008) who agree that they were used as containers for different goods, mainly water, on the long voyage from India back to Portugal and vice-versa.

The two intact Martaban jars and many other shards found at IDM-003 share similarities with fragments on the *Nossa Senhora dos Mártires* at São Julião da Barra, Portugal (Simões 2009). The jars from these wrecks are of large dimensions, are robust and have a brownish and blackish tonality. They have a flat and uneven base that served to make them stable, increasing the friction between the jar and the surface on which it rested. The body and the neck area is decorated with vertical and horizontal parallel white lines with circular applications, which forms *efeito de pregaria* – a nail-like effect – (Simões 2009).

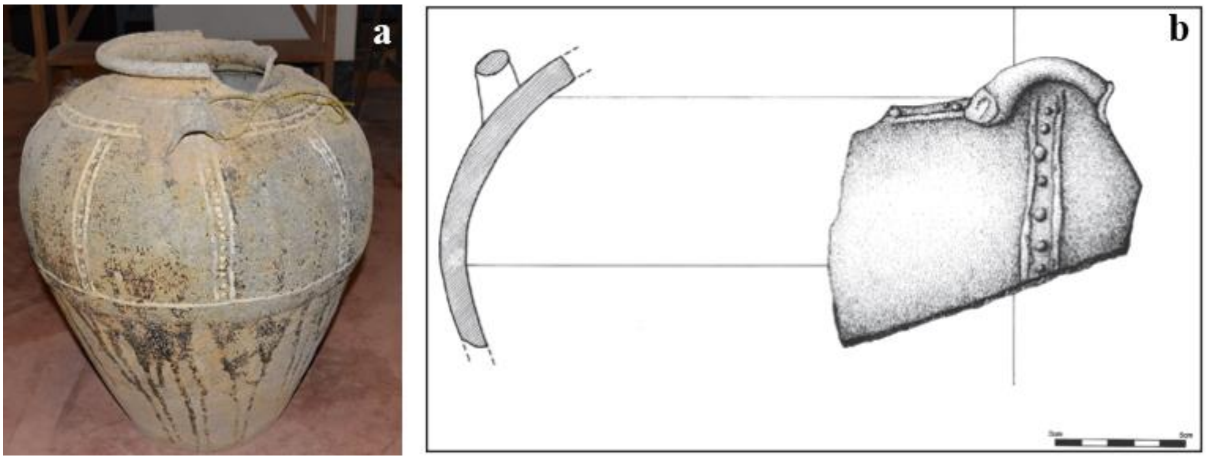


Figure 22. Comparative Martaban jars, (a) ***Nossa Senhora da Consolação*** **(IDM-003); (b)** ***Nossa Senhora dos Mártires.*** **Compiled by Cezar Mahumane, 2019**

Close to the neck, there are applied handles. These handles could not have been used to hold or suspend the jars, since they are applied and very small considering the proportions of the whole jar. The handles offer low resistance and are unable to bear the weight of the jars, especially when these are full. However, this does not imply that they were completely devoid of functional use. In some cases, they may have been used as a means of holding ropes attached to a lid or may have been used to tie the jars to each other during the voyages, preventing them from being damaged, due to the impact caused by the rocking of the ships (Simões 2009).

The Martaban jars from IDM-003 are contemporaneous with those from the *Nossa Senhora dos Mártires* and the typologies indicates that these jars would have started to arrive in Portugal in the late 16th century. Most of the Martaban jars arrived in Portugal and Europe in the 17th century, as this was the most intense period of voyaging between Asia and Europe. Among Europeans, these jars were in great demand for such essentials as freshwater storage, not only aboard ships, but also for household use in tropical climates. Their special quality for conservation of water and other organic goods made them invaluable for life in the tropics. To a great extent, their distribution from China to Africa and Europe was dictated by the needs for these jars from the travellers themselves. On board Portuguese ships, the jars arrived at the Portuguese forts on the Eastern African coast such as Fort Jesus in Mombasa, Kenya and São Sebastião Fort on Mozambique Island (Borell 2014).

The presence of these Martaban jars provides some of the best evidence for the context of trade routes, as well as for economic exchanges occurring in societies. These jars witnessed the convergence of cultural traditions resulting from contact between different civilizations integrated in the large-scale international trade network (Simões 2009).

4.4.6. Olive Jars

So called 'olive jars' are common finds on shipwrecks from 16th and 17th centuries. When AWW/PI excavated the IDM-003 several olive jars were recovered and are now at Mozambique Island Museum. Olive jars are smaller in size (height 25 to 33 cm and diameter 8.5 to 10 cm) than Martaban jars, and were produced in Spanish and Portuguese, unlike the Martaban jars which were from the East. Olive jars were primarily used to contain liquids like olive oil, or olives in brine and wine. They could also have been utilised for transporting condiments and vegetables, such as beans and chickpeas, as well as lard, pitch and tar (Cook 2012).

The thick walls and rounded form of the jars resulted in considerable structural integrity, they fit well in limited cargo space, stacked efficiently against rounded hulls, and their round opening was easily secured with minimal airspace to protect against spoilage (Cook 2012; Malcom 2017).

John Goggin (1960) has done considerable research on olive jars and has defined a chronology based on form, paste and surface treatment. Goggin divided the vessel types into three periods: early (1490-1580), middle (1580-1780) and late (1780-1850 or later). According to Goggin's (1960) scheme, olive jars started as thin-walled, rounded vessels with two opposing handles arcing from the shoulder to the rim (Figure 23). In the middle period, the jars changed to heavier, more elongated, egg-shaped vessels of three different sizes, all with thickened rims. In the late period, the bulbous bodies remained, but jars of a sharply conical design also came into use. Over time the design of the rims narrowed from a heavy, almost rectangular cross-section; some late-period olive jars show a paste with very little sand temper.

The olive jars recovered at IDM-003 are most similar to the middle style forms described by Goggin (1960) and can be included in the styles A, B and C. The middle style A is characterized by the classic shape of a tall ovoid body surmounted by a short, high-set rim above a rounded shoulder inclining relatively smoothly to a gently rounded base (see Avery 1997). The rim profiles are angular and incorporate a wide overhang above and covering the neck (Avery 1997; Kinsley *et al.*, 2014). The lip is often pinched to form a vertical terminal. Broad riling occurs across the upper shoulder and lower quarter of the body; lighter riling occupies the central body area. Small air bubbles are common in the body walls (Kinsley *et al.*, 2014). The middle style B is characterised by being a small, compact globular jar, almost circular in anatomy, with a continuously rounded base, body and shoulder. The style displays a more pronounced neck and higher rim (Kinsley *et al.*, 2014). The middle style C is described as being a carrot-shaped vessel, far narrower than the other styles, with a slender body, more V-shaped in profile and leading to a more pointed toe (Pasinski & Fournier 2014) (Figure 23).

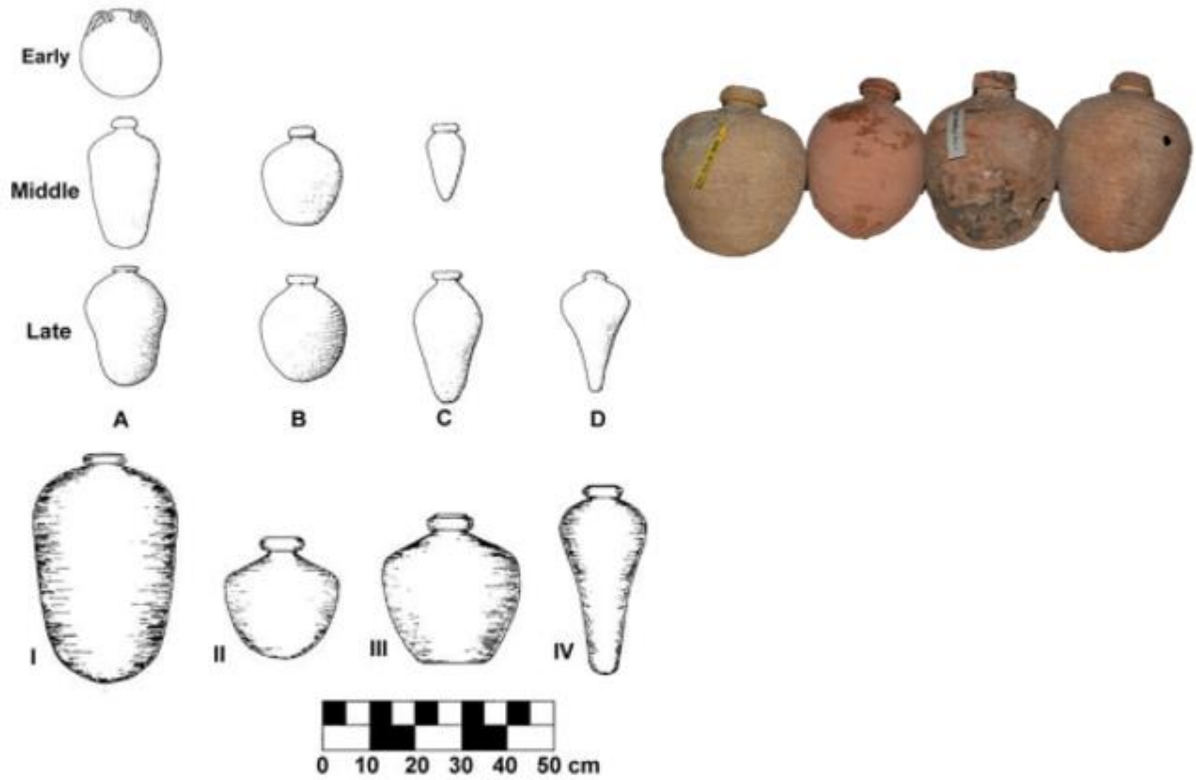


Figure 23.Typology of olive jars according to Goggin 1960.

Olive jars with similarities like those from IDM-003 have been observed on other 17th century wrecks such as the *Tortugas* wreck (1622), off Dry Tortugas Island in the Florida Keys and the Spanish wrecks of *Nuestra Señora de Atocha* and *Santa Margarita* (1622) also in Florida, USA. The similarities of the jars from these three wrecks confirms a 17th century date.

By the 17th century, Portugal and Spain were both producing this type of jar, but Portugal adopted and tended to maintain a wheel-thrown, globular, two-handled vessel for its oceanic commerce (Pasinski & Fournier 2014). Although most literature classifies olive jars as exclusively Spanish in production, it is known that Portugal also produced these type of jars. The city of Aveiro, was known for the manufacturing of olive jars, shipped for trade in large quantities from the mid-16th century onward (Casimiro and Newstead 2019). The Portuguese olive jar shape was rather similar to the Spanish.

This discussion of the origin of olive jars lays out the idea of peoples' mobility in Europe and other parts of the world where wrecks are found loaded with these jars. It also opens up the possibility of studying the relationship between these jars and local pottery. In wrecks of *Carreira da India* ships found in East Africa, olive jars have been found in association with local pottery. Apart from IDM-003 itself other examples are, the wreck of *Santa António de Tana* in Kenya (Sasson 1981), and IDM-002, also found at Mozambique Island.

4.4.7. Local Pottery – The Lumbo Pots

Much of the archaeological material collected by AWW/PI during excavations at IDM-003 was imported material. However, two complete locally made pots were found (height 25 to 27 cm and diameter 12 to 15 cm), both classified as belonging to the Lumbo tradition. The Lumbo pottery tradition was named by Paul Sinclair in 1985, when he carried out excavations on the mainland Lumbo area, opposite Mozambique Island (Madiquida 2015).

In the Lumbo excavations, Sinclair has found a significant pottery collection which allowed the description of the pot tradition characterized by bowls with impressed areal decoration in bands with geometric irregular surfaces, immediately below the rim (Duarte 1993; Madiquida 2015; Duarte *et al.,* 2015). The Lumbo pottery tradition is mostly associated to coastal communities and archaeological evidence found to date suggests that this tradition stretches along the coast from Sofala to Cabo Delgado and has been linked to the development based on maritime resource exploitation for food supply and economic exchange (Duarte 1993; Madiquida 2015). Before the Portuguese presence in the area, Indian Ocean communities based their trade system on exchange and redistribution run by the Swahili, Arabs and Indians. This system helped develop commercial centres, especially in Northern Mozambique at sites like Lumbo, Somaná, Matemo and the Quirimbas archipelago. Therefore, the Lumbo pottery tradition occur massively in these areas (Duarte 1993, Duarte & Menezes 1994; Chami 1994; Madiquida 2007). However, this situation came to change when the Portuguese settled Mozambique Island from the 16^{th} century.

The Portuguese transformed the island into the most important harbour for the *Carreira da India*, introducing a new trade system purely based on capitalism and profit generation for the Portuguese Crown (Duarte & Menezes 1994). The original trade system in the Indian Ocean was interrupted but Duarte & Menezes (1994) suggest that the redistribution system is likely to have continued along the coast at small scale, and that the Portuguese traders may have been integrated into this local trade. One potential piece of evidence for the persistence of local trade systems is precisely the presence of local pottery on some of the Portuguese shipwrecks. This presence provides an important clue to analyse the coastal trade and an indication that the Portuguese trade also interacted with local economies (Duarte 1993, 2012, Duarte & Menezes 1994). The possibility of studying these trade relations depends on a good knowledge of original context of any artefacts and access to enough contextual information to build interpretation. However, the detrimental treasure hunting activities over wreck sites, poor documentation, and a disregard for locally produced material, have resulted in the destruction of many important site contexts.

There are few examples of Portuguese wrecks found with locally made artefacts material at Mozambique Island. The presence of two complete Lumbo pots in IDM-003 was thus of high relevance for reconstructing local trading patterns. The presence of Lumbo pottery raises intriguing questions about the temporal spread of this pottery tradition as it was previously dated between the 13th and 14th centuries (Duarte 1993). This chronology was based on radiocarbon dates from two land sites. However, the two Lumbo pots found underwater in the IDM-003 were associated with a 17th century Indiaman. By the time this ship sunk, the Lumbo pottery tradition was no longer in production (Duarte *et al.*, 2015).

Based on the available archaeological data from land sites and the fact that Lumbo pots were found on a 17th century wreck, two hypotheses can be posited. The first is that there has not been enough absolute dating on terrestrial archaeological sites to confidently pinpoint this tradition in time. Therefore, there is not enough data to help contextualise the presence of these pots on the IDM-003 wreck. More dates need to be acquired from ‘Lumbo’ tradition terrestrial archaeological sites so that the temporal extension of this tradition can be clarified.

The second hypotheses question the accuracy of artefact recovery and recording by AWW/PI. Their excavation at the IDM-003 was hurried and the site plans produced lack detail. It is possible that the recovered Lumbo pots may not belong to the wreck context itself. Duarte (*personal communication 2020*) raises the hypothesis of there being another wreck lying adjacent to IDM-003 from which these pots may have been collected. This hypothesis was raised after a fieldwork in 2017 which revealed another ballast pile three meters west of the IDM-003. This pile is covered by seagrass and consists of small, rolled ballast stones, some small wood remains, and pieces of local ceramics were observed.

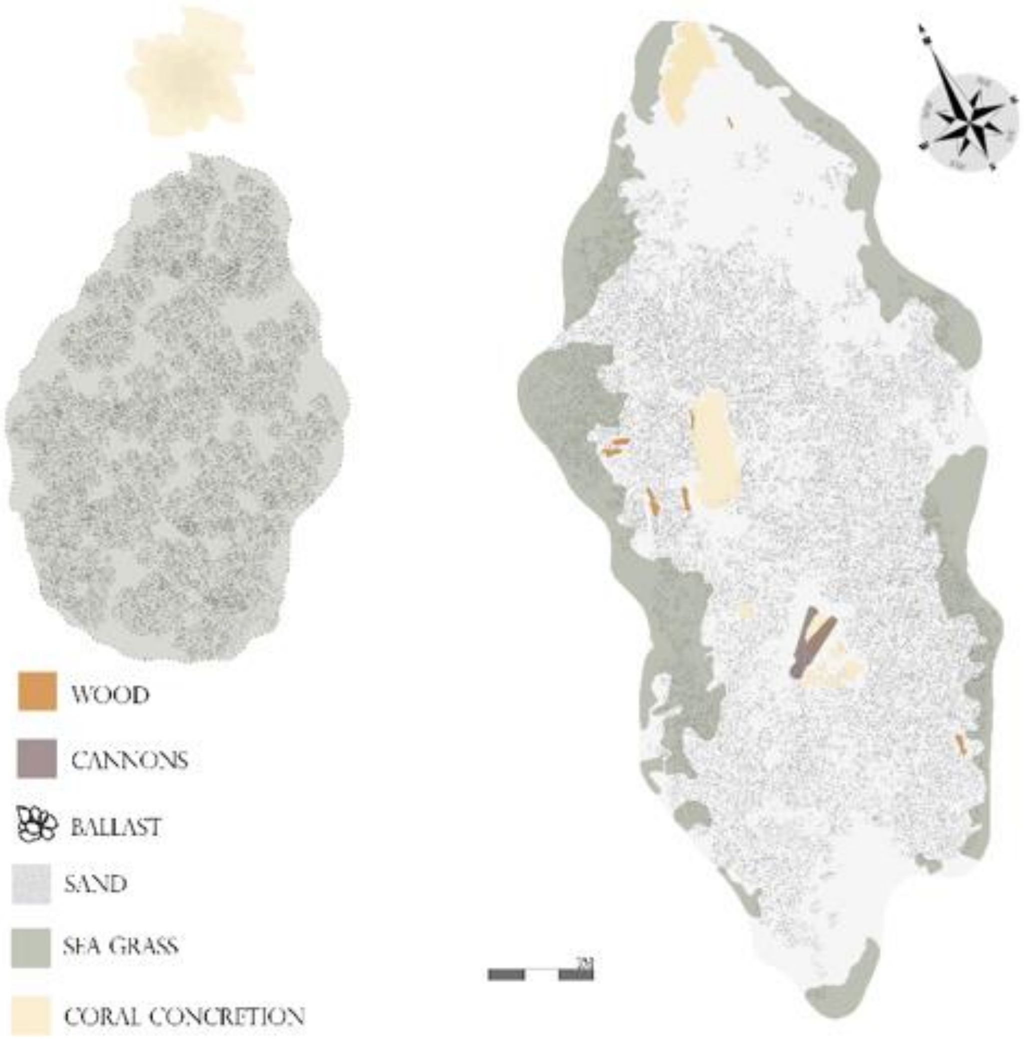


Figure 24. Map of the ballast pile sitting next to *Nossa Senhora da Consolação* (IDM-003). Drawer: Cezar Mahumane, 2019

There are other examples of local pottery from Northern Mozambique found on Portuguese shipwrecks. One example is the ship *Santo Antonio de Tana* (1698), which sunk in Mombasa after leaving Mozambique Island (Duarte 2012). The excavation revealed some local pottery shards described by Sasson (1981) as being pots with a band of short diagonal incised hatching divided into groups which run in alternating direction. Beneath the band, a double incised line extended diagonally downwards to form triangles over the shoulder. There was also a bowl with a flat upper surface of the rim that has been burnished with graphite, the interior of the bowl has been coated with red ochre paint (Sasson 1981).

The presence of this local pottery suggests that the *Santo Antonio de Tana* was used for small scale trade along the East Africa coast (Sasson 1981). Duarte & Menezes (1994) have reported pottery shards with similar characteristics in excavations at Mozambique Island. However, Sassoon's (1981) description suggests that the mentioned material found may belong rather to the Sancul tradition (Duarte 1993, Sinclair 1987), a later tradition which is found on several land sites along the Mozambican Northern coast dating 16th to 18th century (Duarte 1993).

It is clear that local pottery on Portuguese shipwrecks needs to be compared with a more solid chronology and better contextual information. This is especially so when it comes to the possible presence of Lumbo tradition pottery on IDM-003 that would stretch this tradition's chronology to the 17th century. Despite the irregularities by AWW/PI when collecting and describing material from IDM-003, some of the artefacts analysed here shows similarities with other wrecks from the same period. But the Lumbo tradition presence in an underwater context may bring new insights about the chronologies of this pottery tradition or confirm the existence of another wreck near IDM-003.

Scholars working on the archaeology of Mozambique Island needs to find a balance to associate and interpret archaeological artefacts found on land and underwater. Some of these artefacts share similarities, but others are totally distinct from each other. These artefacts are potential witnesses to the cultural, social and economic role played by the island as an important harbour even before Portuguese presence. Therefore, new analysis and dating may provide better information about temporal and spatial spread of the artefacts on the region and globally.

Figure 25. Lumbo pottery found at *Nossa Senhora da Consolação* (IDM-003): Photo: Cezar Mahumane, 2019

4.5. Assessing AWW/PI's *modus operandi* on *Nossa Senhora da Consolação* (IDM-003)

Muckeleroy (1978), Flemming & Redknap (1987), Bowens (2009 and 2011) and Gould (2011) have all called attention to the *modus operandi* of treasure hunting companies on UCH. In most cases, these companies try to apply archaeological methodologies to their operations and claim to do archaeology. In other cases, treasure hunting companies hire professional archaeologists to legitimise their work and establish exploration agreements with governments that are not aware of the detrimental consequences of treasure hunting to UCH.

For instance, AWW/PI intervened in many wrecks at Mozambique Island after establishing a UCH exploration contract with the government (see Chapter 2). The excavation carried out at *Nossa Senhora da Consolação* (IDM-003) has been used by the company to claim and advertise that archaeological work had been conducted. However, a closer investigation of the AWW/PI activities on this wreck site, in terms of documentation, the treatment of recovered material, reporting and post-excavation mitigation shows such serious lapses that should not be considered archaeology.

The aim of AWW/PI was to make a profit by the selling of historical artefacts taken from shipwrecks (De Carvalho 2007). When it comes to making a profit, time is essential. However, archaeology require time to plan, to excavate and record a site in detail and to interpret all the materials found on a site. AWW/PI did not have much time to investigate IDM-003 as test pits dug were constantly interrupted because the company had located other sites with more commercially valuable cargoes. For example, the 2001 test pits at IDM-003 were interrupted because the company, with the same excavation team, had started to excavate IDM-002 – the Espadarte or *São Sebastião Fortress shipwreck* (Figure 6).

In 2004, AWW/PI dug some test pits and conducted a metal detector survey at IDM-003, and again this was interrupted because, in the meantime, the company had located the *São José* wreck (1622) in Mongicual from which they recovered silver coins eventually sold at auction. By 2005, IDM-003 seemed to be the only site with some commercially valuable material that the company could loot, as previous test pits – 2001 and 2003 – had revealed lead ingots (Figure 16) and recurrent metal detector searches had picked the presence of more material on the site.

This shifting from one site to the other with the same team of excavators, clearly shows that the company were only interested in intervening on sites containing commercially valuable materials. This *modus operandi* can never be compatible with archaeological practice which is guided by research questions, clear aims and methodologies, conservation and mitigation programs that provide scientific approaches and allows the interpretation of recovered materials.

When in 2005, AWW/PI begun an extensive excavation program at IDM-003 to recover archaeological material, they excavated the wreck so quickly there was not enough time to accurately record object positions. During this first excavation season, many artefacts were recovered from nine 5 x 5 m grids covering an area of 450 m^2 but the exact location cannot be pinpointed (Duarte *et al.*, 2015). In 2006, the second excavation season was launched resulting in the exposure of the whole wooden hull structure (Figure 14).

However, besides the 106 lead ingots found together in grid square S14, it is intriguing that during the course of the second excavation season no other artefacts were reported (Mirabal 2013). These lead ingots were all sold later in the same year. There was no explanation regarding the occurrence of all these lead ingots in the same grid square and no association was made with the hull structure or other artefacts, leaving only a lack of fundamental information and a suspicion that there may have been unreported finds.

It is commonly known that archaeology is by nature a destructive practice, therefore all efforts must be made to carry out detailed excavation and proper documentation of the features and position and contextual information of artefacts. This mission is even more challenging when it comes to excavating a wreck site underwater. The rate at which IDM-003 was excavated shows that the aim here was to recover material as quickly as possible. The result was a lack of information on context, artefact association, description and interpretation, as can be seen in many interim reports and books published by AWW/PI. These reports and books do not qualify as a scientific reports or interpretation of the wreck site and the archaeological material. Even the basic description and a potential place of origin of the wreck was not reported.

Some of the artefacts collected by AWW/PI from IDM-003 are stored in the Museum of Mozambique Island (see Appendices 2) and they look to be fairly well conserved, as most of them still present reasonable conservation to date. However, there is no record about the conservation procedures used or the find context before recovery. AWW/PI has produced a site plan which displays the apparent position of the artefacts, but when compared to the existing numbered collection, some objects simply do not match what is represented on the site plan (Simbine 2015a; Duarte *et al.*, 2015).

The lack of information shows that recording material on site was not a major concern of AWW/PI. The numbering of artefacts was another problem found with the IDM-003 collection and the criteria used by AWW/PI is not clear. This evidence also shows basic problems in cataloguing and inventorying artefacts. Most of the artefacts collected were described and presented in Mirabal´s book (2013), although their actual contextual associations to the wreck have not been made and there is no interpretation as discussed before.

The comparative investigation carried out of some of the artefacts collected at IDM-003 and presented here opens up an opportunity to zoom in on the wide network of activities this ship was involved in in the early 17th century. Most of the materials found were part of her cargo and came from different continents that fed into the maritime trade that linked together Europe, Africa and Asia.

For instance, the boat-shaped lead ingots found on IDM-003 are likely to be English and only the Dutch used to buy lead in this shape in England. However, the occurrence of these lead ingots in a Portuguese ship shows that other nations were also buying boat-shaped lead ingots mostly to be used as ballast because it was relatively cheap and heavy (Tripati *et al*., 2003; Stedman 2009; Van Duivenvoorde *et al*., 2013). Although the Portuguese were interested in spices from the Orient, they had to supply commodities that were in demand to maximize their profit (Chirikure *at al.*, 2010).

The trans-oceanic trade between Europe and India via Africa required financing for it to flourish. Therefore, the presence of silver coins at IDM-003 is hardly surprising. These coins were used in global transactions between America (where the coins were minted), Europe, Africa and India. These coins were minted by the Spanish empire and became a dominating currency in European and international markets for more than three centuries (Cardoso *et al.*, 2014; Banco de México 2018) (Figure 18). The research and methodological approach proposed in the study of coins to interpret wreck sites and the associated material within a specific cultural, economic and social context, goes beyond the willing of treasure hunters who only seek to collect commercially valuable materials, such as coins, to sell and make a profit, ignoring all other materials which provide context to shipwrecks.

The IDM-003 lead seal collection is also evidence of a large trade network with goods that needed to be taxed for border control and quality control. The seals were also an indication of private initiatives, as people responsible for cloth production used customized seals attesting the product quality (De Sousa 2016) (Figure 19). Therefore, seals were an important trademark that stopped people from selling fakes and sub-standard materials (Chirikure *at al.,* 2010).

Unworked hippopotamus teeth and elephant tusks on board IDM-003 suggests that African elephants were hunted and the ivory was traded to great centres in India (Cambay, Surat and Gujarat) known to have the most skilled artisan in working this material (Alpers 1975; Tripati and Godfrey 2007). The presence of large and small tusks suggests that there were no particular preferences for the ivory from large bulls as was the case in other parts of Africa such as the Zimbabwe plateau where Portuguese were highly selective in the tusks which they traded in (Chirikure *et al.,* 2010). The variable size of the tusks does not confirm their place of origin in Africa, but isotopic work on the ivory is important in throwing light on the source of the ivory which can also inform on the trade and exchange relationships (Chirikure *et al.,* 2010).

When it comes to shipment and life on board IDM-003, there is evidence of conventional material such as the Martaban and olive jars, generally used to store liquids and spices. The frequent use and re-use of these jars also shows the global network in which this ship was involved during the 17th century (Figure 22). The Martaban jars were brought from Asia their place of origin and they were used at the same time with olive jars of European origin to store grain size goods and liquids.

Perhaps the most significant finding during the excavation of IDM-003 was the recovery of two locally made pottery bowls belonging to the Lumbo Tradition (Figure 25). These artefacts are evidence of the involvement of modern European ships with local economies. Although it is still unknown what the level of involvement was. More research can contextualise and provide clues to analyse the presence of local material in long distance trade ships.

There is much that cannot yet be reconstructed about the shipboard community life, but some of the ‘everyday items’ from IDM-003 are of high quality, such as decorated glasses, knife handles, as well as the presence of porcelain, which together suggest a degree of wealth among the ship´s compliment, however, these items could be for officers and would have been stored in a certain part of the ship. Together with weapons, domestic items and navigational instruments could probably all have been privately owned, which suggests a well-equipped ship and a professional crew (Chirikure *et al.,* 2010).

The story told by the objects from the shipwreck is that of the beginning of an increasingly globalised trade through trans-oceanic commerce and the voyages of discoveries, although to understand this complexity artefacts need to be found in a secure context, recorded and recovered properly to allow appropriate interpretation. AWW/PI made no association of the wreck material and did not provide the context of the artefacts with the ship´s structure, but the artefacts found during IDM-003 excavation match those reported by the Dutch when they captured the ship (see Chapter 2). All things considered, at least the identification of IDM-003 as the *Nossa Senhora da Consolação* seems to be correct.

The above evidence is supported by historical accounts presented by Durão (1963), Da Fonseca (1964), Murteira (2006), Ferreira (2007), Cardoso (2013), Arnold (2014), and Barradas (2018) which were reviewed in Chapter 3. Furthermore, recent laboratory analysis of the wood samples collected on some structural parts of IDM-003 has shown the wood to be European, reinforcing the idea of the wreck being Portuguese.

When the IDM-003 wooden hull structure was completely exposed in 2006, a description of the hull structure was made by Mirabal. He presented a description of the hull in an interim report written in 2007 and his book published in 2013. However, the drawings and the analysis presented are inadequate and they are of little use to the scientific community due to their lack of detail. The same can be said about the photomosaic presented, despite its reasonable graphic presentation (De Carvalho 2007; Filipe Castro *personal communication* 2016).

The underwater archaeologist Filipe Castro in 2013 wrote a review on the documentation of the hull structure of IDM-003 with strong criticism of the limited descriptions and lack of interpretation. IDM-003 was one of the best-preserved remains of a Portuguese Indiaman ever found, due to its level of preservation and size (Castro 2013). Castro (2013) criticises the level of omissions in the hull description that otherwise could have provided clues about the shape, the size of the ship and the construction sequence.

Moreover, some basic methodological procedures were not respected such as the conventional numbering and label on the timbers which was missing, as well as the absence of a transversal and longitudinal section of the timbers (Castro 2013). It is clear that AWW/PI was not doing archaeology but destroying the site and wasting an opportunity to fully interpret one of the few preserved remains of a European ship of the Age of Discovery (early 17th century) and fundamental in our attempt to document aspects of the early European navigation trade with India through the route of the Cape of Good Hope.

CHAPTER 5 – MANAGEMENT STRATEGIES FOR *NOSSA SENHORA DA CONSOLAÇÃO* (IDM-003)

The excavation of the *Nossa Senhora da Consolação* (IDM-003) resulted in the recovery of many artefacts and revealed a wooden hull structure, considered one of the best-preserved ever found from a 17th century *nau* (Castro 2013). However, the hull structure was left unprotected, vulnerable to the effects of many environmental threats. When mitigation actions were taken in 2009 to protect the wooden hull, it was already late, as environmental threats had impacted the site. Since 2016, actions have been taken toward the *in situ* preservation and management of the IDM-003 wooden structure. The present chapter discusses how physical, biological and human activities may pose threats to the preservation of the site. The chapter assesses different strategies that can be used to mitigate and monitor the site. These discussions are crucial also for defining appropriate *in situ* management practices suitable for wreck sites in Mozambique.

5.1. Environmental threats to *in situ* preservation

Over the past few decades, the underwater archaeology community has been moving away from more traditional methods of excavation and recovery of the UCH towards a less intrusive management approach based on *in situ* preservation. This approach is essential to protect, monitor and manage the UCH where it lies on the seabed (Gregory *et al.,* 2012; Richards *et al.,* 2012). Additionally, the international instruments such as the ICOMOS 1996 Charter and the UNESCO 2001 Convention promote *in situ* preservation as fundamental for the protection of UCH. *In situ* preservation should be considered as the first option and non-intrusive methods to document and study UCH should be used whenever possible (Manders *et al.,* 2004; Ortman 2009; Richards *et al.,* 2012).

In situ preservation in underwater archaeology has been growing over the last c.70 years. It is a less interventionist way to manage UCH, which is extremely sensitive to disturbance and decay. Some archaeological work on complex shipwrecks requires an enormous amount of funding for conservation and few projects are able to raise the finds needed for appropriate preservation measures, while many projects preserve the shipwreck remains *in situ*. Thus, the current international tendency is to foster *in situ* preservation of wrecks and their materials (Gregory 2009). However, *in situ* preservation does not mean simply leaving the site where it is and hoping that it will be there when archaeologists and conservators have the capacity, research question and desire to investigate it in the future (Ortman (2009). There is a fundamental need to ensure successful and responsible *in situ* preservation by formulating a process-based approach to understand both the wreck site environment and the processes leading to preservation or deterioration of the site and also to assess the temporal stability or instability (Gregory 2009).

Although there is no standard procedure to assess wreck site environments and deterioration rates, Manders *et al.*, (2004), Gregory (2009) and Gregory *et al.*, (2012) propose following five steps to assess site environment. These steps involve determining:

- The extent of the site to preserve;
- The most significant physical, chemical and biological threats to the site;
- The types of material present on the site and their state of preservation;
- The strategies to mitigate deterioration and stabilise the site;
- The subsequent monitoring of the site and implement mitigation strategies.

These steps have been closely followed here. Given this the methodology, it must be noted that each wreck site environment is different and exhibits a unique set of natural, chemical and human threats that can lead to radically different preservation and deterioration processes (Pournou *et al.*, 2001; Fernández-Montblanc *et al.*, 2014).

Models have already been created to predict the preservation and deterioration process of wreck sites by analysing the environmental conditions. For example, Keith Muckeleroy (1978) established a model relying mostly on the role played by the natural and human processes in the preservation and deterioration of underwater sites. Later, Ward (1999) and Ward *et al.* (1999) formulated a model that addressed the importance of biological and chemical process, in which sedimentation rate is a dominant and influencing element for site preservation and deterioration. The application of these two models together is useful to predict the preservation and deterioration potential of a site in a variety of special scales. When a wooden ship sinks, the rate of preservation or deterioration will depend on the nature of the environment and the construction and nature of artefacts of the ship, the manner in which it was wrecked and in human or natural disturbance (Wheeler 2002; Gregory & Manders 2015).

Generally, underwater sites initially undergo a continuous rapid decay. This goes on until enough sediments are deposited over the remains and result in anaerobic conditions. As the environment becomes anaerobic, decay eventually changes to a state of equilibrium when the chemical, biological and physical threats of the environment almost cease (Ward *et al.*, 1999; Wheeler 2002; Gregory & Manders 2015). The equilibrium may occur after the gradual destruction of a ship has ensued, although some components of the wreck may survive, if buried. In a more protected environment, deterioration may be minimal before equilibrium is reached (Wheeler 2002). Nevertheless, the natural equilibrium can be easily disturbed by environmental or human interference (Brown *et al.,* 1988; Fernández-Montblanc *et al.,* 2014).

When disturbed, sunken ships can be exposed to two different types of environment: the open seawater environment and the seabed environment (Gregory 2009; Manders 2011). In the open seawater environment, physical and biological threats are the major causes of deterioration of organic material, although chemical threats can also affect the corrosion of iron from the wreck (Ward *et al.,* 1999:566). In addition, human threats can cause serious damage to the wreck (Bowens 2009). In the seabed environment, biological (microorganism) and chemical threats are the major cause of deterioration that even at a very low rate progressively impact buried archaeological materials (Gregory *et al.,* 2012).

In the seabed and open seawater environment, all the threatening factors can act simultaneously. For example, physical threats influence the rate of deterioration on wreck sites, therefore it is important to measure temperature, light, depth, currents, pH and dissolved oxygen levels to determine the role they play on the wreck decomposition, and to understand the distribution and development of the biological organisms, as the water proprieties define the distribution and abundance of marine organisms (Gregory 2004, 2009; Stainforth & Shefi 2010; Gregory & Manders 2015).

The biological activity will increase if the wreck provides food and habitat resources, especially for macrobiota. Thus, exposed parts of wrecks tend to be affected by aerobic bacteria, while buried parts will tend to be affected by the activity of anaerobic bacteria (Wheeler 2002; Manders 2011; Gregory & Manders 2015). The chemical threats can affect the integrity of archaeological artefacts and dictate the nature and rate of chemical degradation, especially through direct reaction with seawater and indirect reaction with the surrounding sediments (Ward *et al.,* 1999). The most common chemical process is corrosion and concretion of metalliferous artefacts exposed to seawater, although other materials are also susceptible to chemical degradation (Gregory 2004; Manders 2011).

Many wreck environments are dynamic, resulting in periodic exposures and reburials of the site, causing oscillations between a state of stability and instability. If equilibrium is disturbed, either by natural or human threats, it often leaves remains exposed, which are then vulnerable to attack by marine biota (Stainforth & Shefi 2010; Manders 2011:25). In such cases, if an environmental assessment of the site reveals that it is unstable, strategies should be implemented to mitigate the threats, using *in situ* mitigation strategies (Gregory 2009; Gregory, Jensen & Straetkvern 2012). In the right circumstances, mitigation strategies can alleviate and prevent site deterioration by creating an anaerobic environment. From the moment a mitigation strategy is applied, there is a need to monitor its performance until the site is stable again (Gregory 2009; Stainforth & Shefi 2010; Richards *et al.,* 2012).

In this thesis, the *Nossa Senhora da Consolação* (IDM-003) wreck, has been used to develop an approach based on *in situ* preservation which will be studied and evaluated in this dissertation. The methodologies used to assess the environmental conditions and the mitigation strategies are based on the process suggested by Manders *et al.*, (2004), Gregory (2009) and Gregory, Jensen & Straetkvern (2012) and are described in detail below.

5.1.1. Estimating the extent of the site to conserve

Fieldwork activities concerning the *in situ* preservation of the IDM-003 begun in mid-2016 and stretched until mid-2019. This fieldwork was carried out by a team from DAA-UEM (including the present writer) in partnership with the SWP and in coordination with UNESCO. The aims of the activities were: first, to record the condition of the site using traditional direct survey measurement (DSM) (Figure 26), in combination with photogrammetry (see Appendix 3) to generate a baseline site plan for monitoring the extent of disturbance on the site and the areas needing protective intervention or monitoring. Secondly, the aim was to analyse potential physical and human threats to the site in terms of deterioration and third, to develop strategies to mitigate the deterioration rate and stabilise the wreck.

To accomplish the first aim, a fieldwork campaign was launched on the 30th July 2016, recording all the visible artefacts from the wreck using non-disturbance methods. The recording process used a combination of photographs and detailed drawings (Steffy 1994). To provide accuracy and develop recording methodologies, it was merged with direct survey measurement and digital photogrammetry. All the data generated in this process have then been used to monitor the changes on site continuously since 2016.

In the field, the recording process begun with the creation of datum points on the site, from where a baseline of 30 meters was created. Cookies[16] were placed every two meters along the baseline. The cookies were used to measure the positions of visible artefacts and wooden

[16] White small circular plastic objects used to mark numbers corresponding to meters on a baseline.

structure. The visible artefacts – ivory and pottery shards – and the ballast pile outline were tagged with pin flags within an area of 30 x15 meters. The wood visible between ballast stones was tagged on both edges, to get shape and dimension.

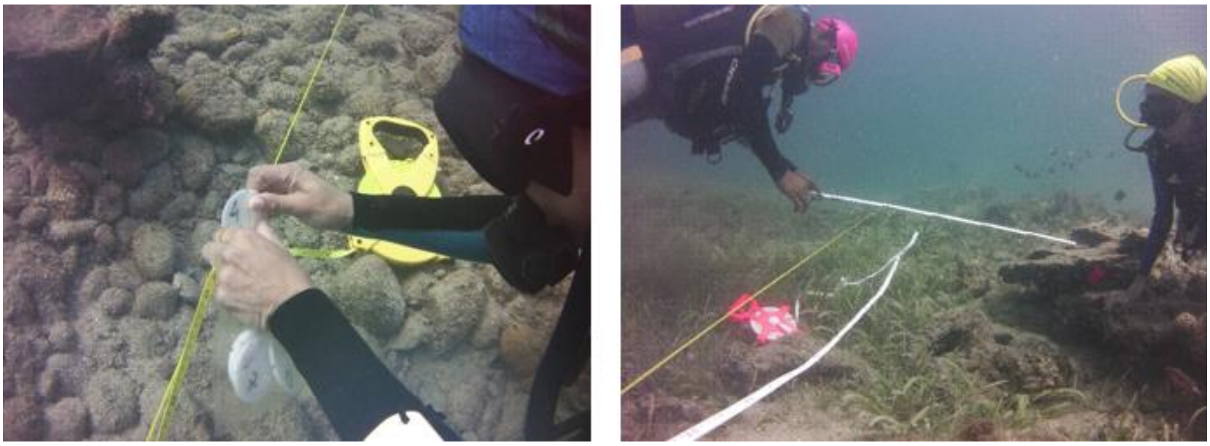


Figure 26. Recording of the *Nossa Senhora da Consolação* (IDM-003). Photo: Ricardo Duarte, 2016

To record the artefacts, offset and trilateration measurements was used, depending on their positioning in relation to the baseline. *In situ* drawings were made of artefact shapes, orientation and specific details. However, those drawings were not accurate enough for monitoring purpose. The solution adopted was photographing each artefact and subsequently redrawing the finds on the computer using Inkscape®[17] software (Figure 27).

Inkscape® is not a software made for archaeology, but it has been adapted for underwater archaeology during the fieldwork of the DAA-UEM underwater archaeology training courses. This software has the potential for arranging mapping data in different layers, accommodating a variety of information which can be then displayed separately or at the same time. When processing the raw data from IDM-003, several layers were created to include different aspects from the recording process, namely: datum points, baselines, ballast outline, artefacts and wood positioning, and layers to accommodate photographs used to draw artefact details and overlap them on their respective position and orientation.

When the traditional recording was finished on IDM-003, a detailed three-dimensional (3D) model of the site was produced using photogrammetry. The idea was to provide a

[17] A professional quality vector graphics software that uses open standard Scalable Vector Graphics --SVG-- as its native format, and is free and open-source software. It has drawing tools and it can import and export various file formats, including SVG, AI, EPS, PDF, PS, JPEG and PNG (https://inkscape.org/en/about/).

complementary and realistic view of the site condition for 2016 which could later be used for comparison.

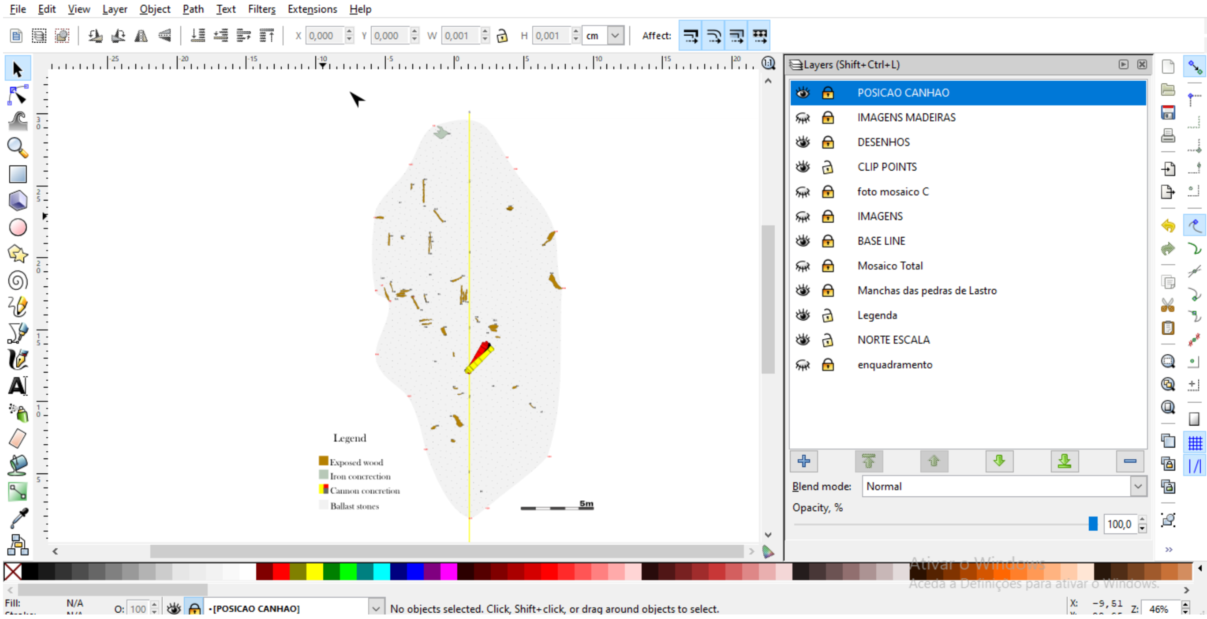


Figure 27. IDM-003 Site plan on Inkscape during 2016 processing data. Drawer: Cezar Mahumane, 2016

Historically, photogrammetry on shipwrecks started in 1960 and archaeology used underwater photography as a basic recording tool (Baker & Green 1976; Green 2004). In the 21st century, photogrammetry has developed as a technique of producing accurate 3D models from multiple images of an object and has become an important tool for archaeologists, mainly in underwater context (Yamafune *et al*. 2016). Underwater photogrammetry consists of three phases. The first is data acquisition through photographs which is non-intrusive and less time consuming than traditional site recording methods (Drap *et al.* 2013).

When collecting data some aspects must be considered, such as the site environment composition, site dimension, type of camera and coded targets or marks that are used to create automated scales of the model. Each one of these aspects plays an important role when it comes to producing a coherent and useful 3D model. Therefore, a methodological procedure for taking photos also needs to be defined. Yamafune *et al*. (2016:12), suggests that the photos have to be taken from several angles, swimming in transversal and longitudinal paths and that the coded targets or scale bars must be placed on the site before starting to take photographs.

The second phase involves data processing and storage, and it is carried out in a laboratory. This phase is mainly automated, and includes homologous point determination from the photos and the construction of a 3D model using specific software such as *Agisoft PhotoScan*®. This is a package that does not require calibration of the cameras utilized and works well with photos taken underwater which have considerably less light or visibility than the ideal circumstances of photography. The third phase is data interpretation, which may include the combination of other software to obtain further information about the conditions of the site and the number of other combinations that can be done between photogrammetric outputs and other analyses (Drap *et al.* 2013; Yamafune *et al.* 2016).

The first 3D model of IDM-003 was produced from 918 photos taken longitudinally and transversally and covering the complete area of the site. Eight scale bars with coded targets were placed along the outline of the site. The camera used was a SeaLife Micro HD+Camera with 13MP resolution, 3.5 mm of focal length and 32GB Memory and the data obtained were stored on two hard drives, then copied to a central computer used to process the data. Data were processed in *Agisoft PhotoScan*® software following the process described on the table below.

Table 2. Operations used to generate the IDM-003 photogrammetry model on Agisoft PhotoScan®

Tasks	**Operations**
Align Photos	Accuracy » high
	Pair preselection » generic
Built Dense Cloud	Quality » medium
	Depth filtering » mild
Build Mesh	Polygon count » medium to low
	Interpolation » enabled
Build Texture	Mapping mode » adaptive orthophoto
	Blending mode » mosaic
	Texture size/count » 4000-6000 x 2-4

The result obtained was a 3D model that was exported as an orthophoto, with high-resolution JPEG images accurately scaled. The orthophoto was imported into Inkscape® and overlapped with the site plan obtained through the traditional mapping. This procedure allowed for merging two different types of data – using the traditional recording method and the digital method – into a unique system to produce a more realistic site plan with the perspective of the archaeological material and the environment of the site. The combination of these two datasets allowed for looking carefully into all the features from the whole site and building a first complete picture of the exposed material. Although the quality of the end result enables a high degree of accuracy the process is highly laborious. The data analysis and processing is a time-consuming process especially of photogrammetry which requires powerful computers (Mahumane 2020).

By the end of September 2016, all the IDM-003 mapping data had been completely processed. Now, the concern was to understand how different natural and human threats interacted on the site toward its deterioration. Thus, further fieldwork was launched from 2nd to 15th December 2016. During this fieldwork, a visual inspection of the site was carried out and several changes were observed in the four months since the baseline survey had been completed. A decision was made to produce a second site plan using photogrammetry to provide another baseline for comparison with the previous site plan and to build a better understanding of the changes occurring on the site.

The persistence in using photogrammetry to monitor the site was based on the fact that it is less time-consuming in terms of data acquisition. Photogrammetry can also generate outputs that are used for different analytical purposes, such as spatial analysis and changes, object positioning and condition, and it can be used for public display of the underwater environment. The second photogrammetric documentation of IDM-003 followed the same methodology and procedure as used in the first documentation. In 2016, 1010 images were used to produce a 3D model of the whole site, and the data was again processed in *Agisoft PhotoScan®* using the same settings described in Table 2.

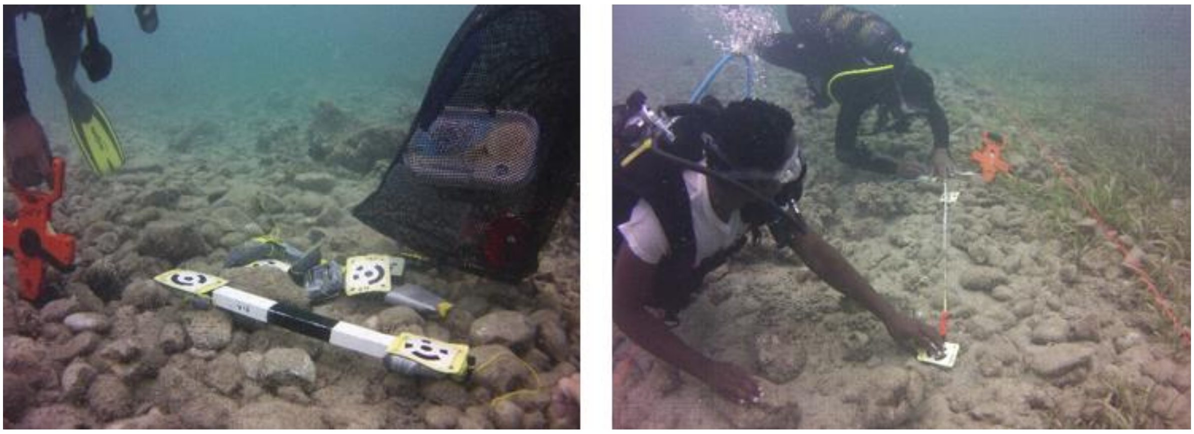


Figure 28. Collecting data for photogrammetry at IDM-003. Photo: Ricardo Duarte, 2016

The results obtained were used for a series of analyses, mainly in terms of spatial changes and the amount of wood exposed, sediment movement and ballast stones distribution. Much of these analyses were made in other software, *Cloud Compare*, which uses dense cloud points generated on *Agisoft PhotoScan®* to perform interpolations between data, including a comparison of data from different periods (see Appendix 3 for photogrammetric data processed and Appendix 4 for the Cloud Compare data).

The data obtained from the first photogrammetric documentation was compared with the data obtained from the second and the results revealed that new areas of wooden hull structure were exposed and those that had previously been exposed were in a high state of deterioration. Pieces of wood were now scattered around the site showing the gradual decay of the structure. The comparison showed that sediments were being moved by currents in areas where ballast stones were scarce and because of this movement, seagrass did not develop fast enough to stabilise the sediments. The currents were also responsible for the dispersal of small pieces of wood that had lost density because of bacterial attack and abrasion created on their surfaces. The presence of fishing nets and fish traps on the site showed how in the exposed condition of the structure, human influence continued to speed up the deterioration (see Chapter 5.2 below). These observations showed that the site was exposed to a range of physical and human threats.

Consequently, in the next round of fieldwork on 27th July 2017, it was decided to experimentally use geotextile as a physical protection method to mitigate the deterioration, and also to keep monitoring the rate of decay of the site. The use of geotextile in underwater archaeology protection, although still in an experimental phase, looks to be an efficient method of creating a physical barrier against biological agents and currents as it filters the finest sediments which contributes to an anaerobic environment (Manders 2011). Before covering the site with the geotextile, a third 3D model was produced of the wreck, to have available the current configuration and extent of the site and as a baseline to assess the effects of the geotextile (Mahumane 2020). Over the next year the geotextile was inspected regularly and the results seemed to be encouraging (see 5.3.2 this Chapter).

In 2017, there were no means available in Mozambique to specifically measure and analyse other physical and biological threats leading to the deterioration of IDM-003. Therefore, most of the analyses were made based on a general knowledge of the site and the surrounding areas, and the interpretation of photogrammetry results. This situation changed with the opportunity to measure some of the environmental threatening factors on IDM-003 more closely, using laboratory analyses. Data loggers and samples were used for more detailed laboratory analyses, which contributed to determining significant threats to the site and understanding its interaction with the environment more closely.

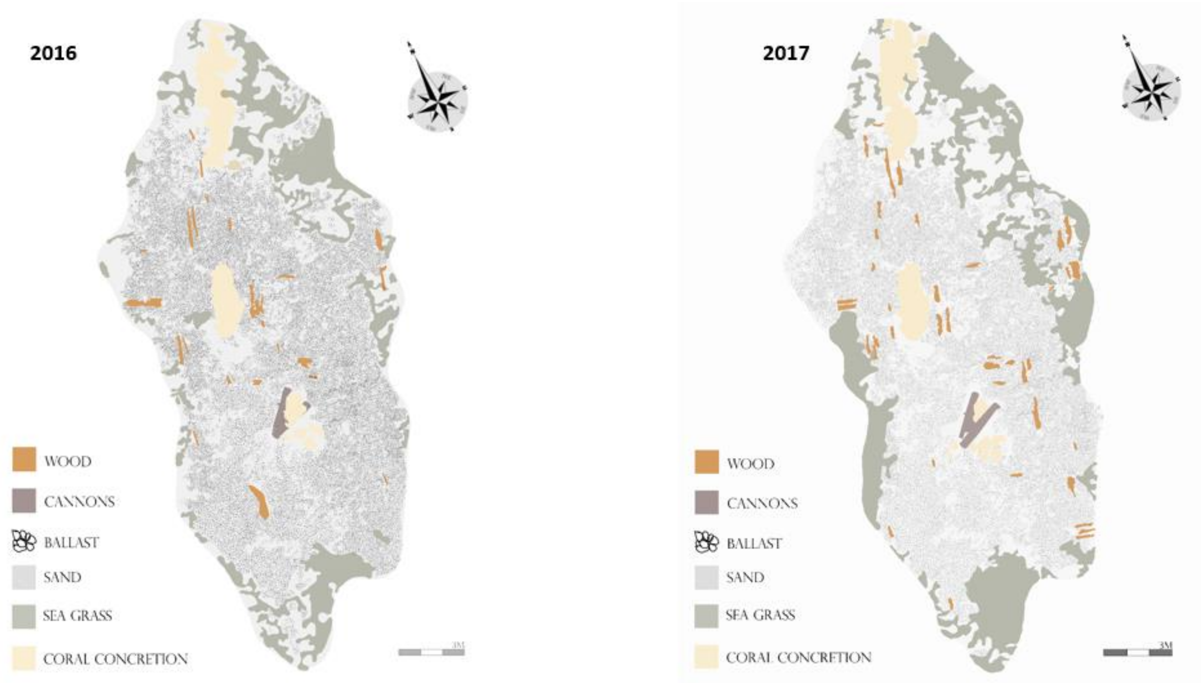


Figure 29. Mapping of IDM-003 showing the differences in one year period. Drawer: Cezar Mahumane, 2019

5.1.2. Assessing threats to the site

To sample for laboratory analyses, fieldwork conducted by the present writer, as a component of the CAIRIM program of Mozambique Island UCH protection, was carried out from 20th July to 16th August 2019. The aim was to measure the effects of some physical environmental threats, namely: dissolved oxygen, temperature, light and pH. Therefore, wood and sediment samples were collected and the potential human threats to the site were also observed.

Two data loggers borrowed from the Maritime Archaeology Unit in the Social History Department at Iziko Museums, Cape Town were used in the sampling. The first data logger was an ONSET HOBO U26-001, which measures dissolved oxygen in milligram per litre and temperature in degrees Celsius (Figure 30a). This data logger has an optimal sensor that provides 0.2 mg/L accuracy and can measure dissolved oxygen from 0 to 30 mg/L and temperature from -5 ºC to 40ºC with an accuracy of 0.2ºC.

The second data logger was an ONSET HOBO PENDANT UA-002-64 which measures light intensity in lux and temperature in degrees Celsius. It has the capacity of measuring light from 0 to 320.000 lux and temperature from -20ºC to 70ºC (Figure 30b). The pH was measured using a digital pen style pH-107 meter, capable of measuring pH from 0.0 to 14.0, with an accuracy of 0.1 and operating at temperature from 0 to 50 ºC.

The data loggers were deployed on the northern edge of the site and recorded readings every 15 minutes for 28 days. pH measurements were taken at the site once a week, and water samples were collected at the bottom and measured immediately on board the boat.

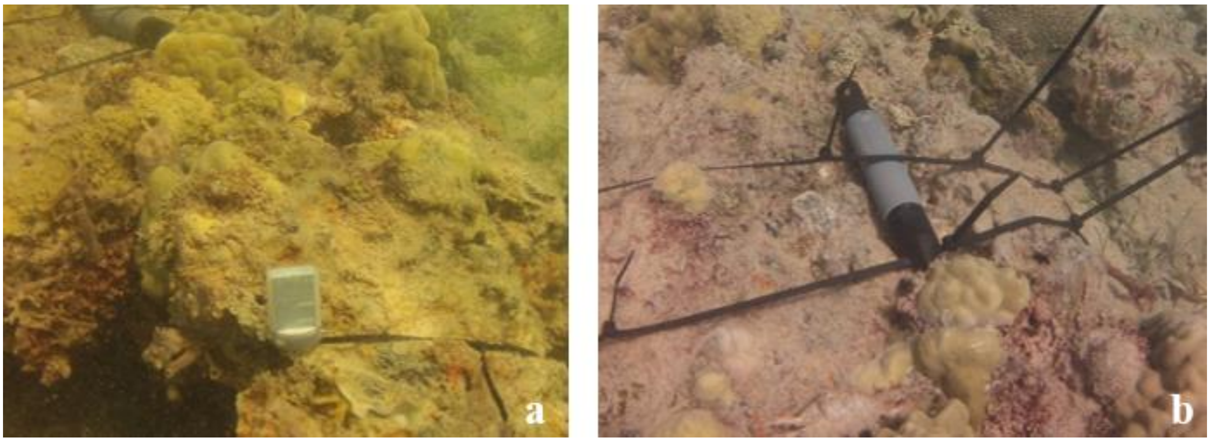


Figure 30. Images of the data loggers on the site, (a) temperature and light data logger; (b) dissolved oxygen and temperature data logger. Photo: Cezar Mahumane, 2019

Samples of wood and sediment were collected in different parts of the wreck to analyse the wood condition and the type of sediments deposited on the site (Figure 31). Five samples of wood were collected on structural parts of the wreck by cutting small pieces with a chisel and hammer. At each of the wood sample positions, a yellow tag was left to indicate the sample number.

Sample 1 (S1), was collected on what is expected to be the keelson of the ship. Sample 2 (S2) was collected on a frame located under a coral concretion. Sample 3 (S3) is also another piece of the frame and was collected next to the iron cannon concretion. Sample 4 (S4) and Sample 5 (S5) are both parts of the hull planking. At the same time, sediments from the seabed were collected in the areas where wood samples were taken, and the same numbering sequence was applied, namely sediment sample 1 to 5 (SS1-5) (see Appendix 5: Map of all the sampling area).

The data collected during this fieldwork does not provide a full understanding of how different environmental threatening factors interact in the deterioration of IDM-003 and ideally more samples should be analysed. The short period for data collection (28 days) was determined by funding and equipment availability, but this dissertation should be regarded as a first assessment of methodologies for assessing risks. Furthermore, when analysing and interpreting the collected data, no other research was available on the East African coast that could be used as a comparative base for this study. The data interpretation was done referring to studies on purely marine environments, in conjunction with *in situ* preservation research projects conducted in the European context. Considering these limiting factors, this research project should be seen as exploratory and rather as a baseline for further research on the assessment of environmental threatening factors for the *in situ* preservation of UCH.

Figure 31. Wood and sand sampling. Photo: Celso Simbine, 2019

5.2.1. Physical environmental threats:

5.2.1.1. Tidal currents and sedimentation

Currents are one of the most severe physical threat which determines the rearrangement of shipwreck features on the seabed (Wheeler 2002). Currents can either contribute to protecting a shipwreck by depositing sediments until it is completely covered, or can be detrimental by removing sediments and exposing archaeological features to abrasion or scour (Ward *et al.,* 1999; Fernandez-Montblanc *et al.,* 2016; Gregory & Manders 2015:52). The scour and abrasion process are likely to happen even in areas where the current speed is relatively slow, in other words, less than 4 cm/s (Palma 2004; Danilovic 2014). In the area around Mozambique Island bay, the current flows at a speed of 5 cm/s which falls within the range of a slow current (Hoguane 2007; Meyer 2012).

However, inside the bay, where many wrecks are located, the current speed varies, depending on the tidal regime, seabed topography and water depth. Stronger current speed is normally observed during tidal changing to high or low tide (Nawroozi *et al.*, 1968; De Marchis *et al*., 2012). Tidal changes generate tidal currents responsible for sediment deposition and redeposition, defining the seabed topography (Nawroozi *et al.*, 1968; Holmes & Tappin 2005).

The seabed around IDM-003 is predominantly flat and composed by seagrass, sand and mud, although some sandbanks can be denoted as a result of the excavation performed on the site by AWW/PI between 2005 and 2006, which disturbed the natural sedimentation process. At the time IDM-003 was excavated, almost three meters of sediment were removed, accounting for nearly 400 years' worth of sediment deposition. The excavated sediments were deposited on the surroundings of the wreck and apparently, since excavations there has not been enough natural sediment transportation to cover the wreck, or sediments are not being sufficiently trapped by the wreck after excavation. Shallow water environments can be subject to rapid sedimentation fluxes due to considerable low turbidity and currents (Missiaen, Wardell & Dix 2005:83). However, even after the delayed AWW/PI intervention at IDM-003, the site captured quantities of sediment too low to be able to rebury the wood and stabilize itself.

There are different methods to assess the amount of movement of sediment – or the turbidity. Turbidity can be estimated from the light scattered by suspended material in water (Gregory 2004). In other words, in turbid sediments in turbulence result in a low amount of visibility and light. Thus, measuring the light conditions can be an indirect way to measure currents. However, interpreting this sort of data is complicated, as the atmospheric condition can influence light, despite the presence of suspended material in water (Gregory 2004). Even with this method it is difficult to determine how much sediment is actually being transported on the wreck site.

A more precise way to record data on the amount of sediment transported on the site is by measuring turbidity and current flow recurring to data loggers. The analyses undertaken on sediments were based determining the range of grain size categories present on IDM-003. The five sediment samples collected in the same locations as the wood samples were also taken were pre-treated in the field by drying them (Figure 32). Following the pre-treatment, all samples were sieved using sieves ranging from 2 mm to 63 μm. Thereafter, the sieved samples were weighted and rinsed using hydrochloric acid to dissolve calcium carbonates. The sediment solution was rinsed in water and the remaining particles were dried in oven and weighed again. The second weighing was used as the reference measurement for the grain size analysis using the Wentworth (1922) scale.

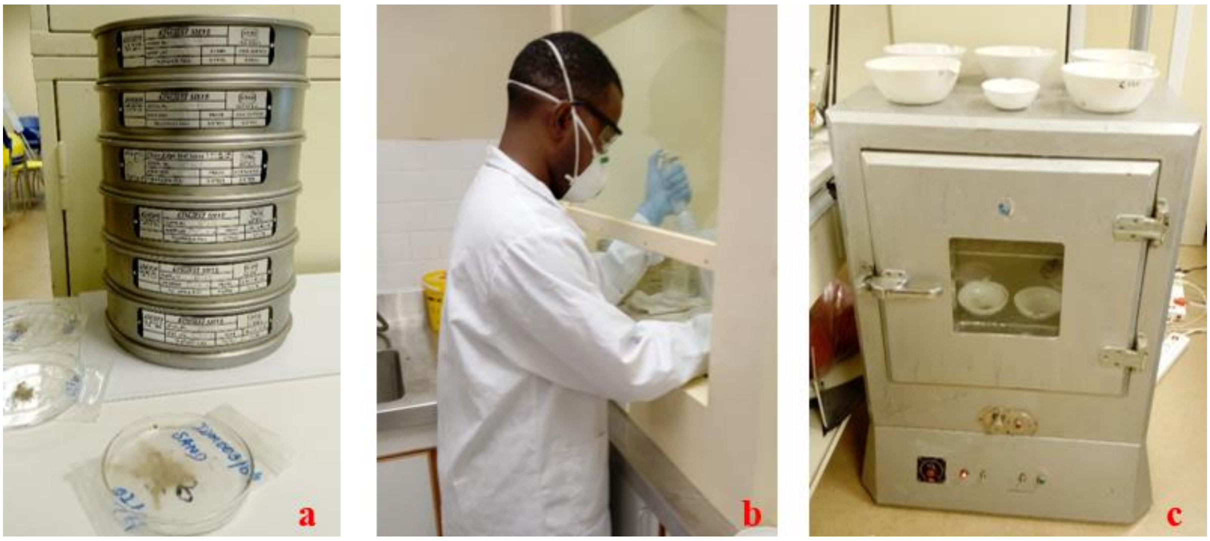


Figure 32. Analysing sediments from IDM-003, (a) sand sieves; (b) rinsing sand on hydrochloric acid; (c) drying and weighing the sand. Photo: Cézar Mahumane, 2019

Based on the Wentworth (1922) classification, the sediments collected at IDM-003 fall in the grain size class of *sand*, which includes grains smaller than 1 or 2 mm to 63 µm. However, the Wentworth (1922) sand class is composed of different subclasses including *very coarse, coarse*, *medium*, *fine* and *very fine sand*. Looking to the sediment grain size analysis and the areas where samples were collected, the northern area of IDM-003 is predominantly composed by *fine sand*, measuring 250 mm on diameter and with a representative weight of 4.35 grams. The north-western area is also composed of *fine sand*, which most representative grains measure 250 mm weighing 0.65 grams. The east area has revealed *fine sand* weighing 1.41 grams. The southwest area has provided *very fine sand* grains measuring 125 mm, with a representative weight of 3.34 grams. Table 3 below summaries the samples and the measurements obtained when analysing the sediments and its classification based on Wentworth (1922).

A more easy and efficient way to analyse sedimentation on a site is using sub-bottom profilers. However, if those means are not available, as was the case here, it is possible to analyse sedimentation by looking at the tidal current influence and collecting sediment samples to analyse the changes in grain size over time. The grain size analysis for IDM-003 suggests a relatively high turbulence around the wreck as it does not allow the finer more stable grain sizes, such as silt or clay to settle around the site. This study needs to be followed up over time with similar analyses to establish if conditions have changed, especially with the covering of the wreck with the geotextile mat to trap sediments.

Table 3. Sediment samples and classification

Sample	Side	Weight (gr)	Size (mm)	Class
S1	Northern	4.35	250	Fine sand
S2	Northwest	0.65	250	Fine sand
S3	West	1.41	250	Fine sand
S4	Southwest	3.34	125	Very fine sand
S5	East	2.74	250	Fine sand

5.2.1.2.Dissolved Oxygen, Temperature, pH and Light

The measurement of seawater threats is fundamental to assessing site preservation rate, as their high presence in open seawater environment may be favourable to the development of marine woodborers in great variety and diversity (Pournou *et al.*, 2001). The presence of woodborers may cause damage and loss of archaeological information to exposed shipwrecks in a relatively short period and precipitate chemical reaction of archaeological material (Wheeler 2002; Gregory 2004; Gregory & Manders 2015).

The most determining factor for the colonisation of wooden shipwrecks by marine woodborers is the availability of dissolved oxygen as oxygen is vital for all organisms in seawater. High availability of dissolved oxygen can also catalyse a chemical reaction with some archaeological materials (Wheeler 2002; Gregory 2004). The presence and abundance of dissolved oxygen is defined by temperature, depth and photosynthesis from seawater plants (Manasrah *et al.*, 2006). Depletion of dissolved oxygen or insufficient levels of oxygen can cause the death of marine organisms which then cannot survive or respire (Abowei 2010). Such conditions are only possible in deep waters or buried environments in which the gradual decay of organic matter itself consumes the available oxygen, creating an anaerobic environment conducive for shipwreck preservation (Gregory 2004; Abowei 2010).

The dissolved oxygen concentration in seawater also is closely related to temperature (Manasrah *et al.,* 2006). Higher seawater temperature leads to low dissolved oxygen content while low temperature tends to increase the dissolved oxygen (Palma 2004; Gregory 2004; Abowei 2010). Seawater temperature thus has an effect on the deterioration rate of shipwrecks by determining the distribution and growth of marine organism and chemical reactions (Palma 2004).

Meanwhile, the seasonal variability in seawater temperature can also cause variation in dissolved oxygen, salinity and pH (Abowei 2010). Some literature on the East Africa coast (Alabaster & Lloyd 1980; Duarte 1993; Fonseca 1996; Madiquida 2007, 2015) suggests that seawater temperature along the coastline in Northern Mozambique varies between 25ºC to 35ºC annually. In the Mozambique Island Channel, hydrographic studies have shown that seawater temperature has an annual average of 26ºC (Fonseca 1996; Meyer 2012).

The data loggers placed on IDM-003 recorded the range of water temperature on the site. Both the dissolved oxygen and the light data loggers had temperature sensors, but the temperature results described here were given by the dissolved oxygen data logger as it has a smaller error range when compared to the temperature sensor from the light data logger. The dissolved oxygen content and temperature were measured for 28 days between 20th July to 16th August 2019, and the results obtained support the correlation between dissolved oxygen and temperature.

In the first three days, 21st to 23rd July, the dissolved oxygen content in water registered a slight increase from 7.60 mg/l to 7.90 mg/l, due to a decrease in the water temperature from 25.5ºC to 24.5ºC. For eight days, 24th to 31st July, the dissolved oxygen content increased continuously, reaching a peak of 8.11 mg/l while the temperature kept variable within a range of 24.5ºC. However, at the beginning of August, this situation changed drastically and a drop in dissolved oxygen content was seen while temperature increased steadily to reach a peak of 27ºC and the dissolved oxygen dropped to 7.58 mg/l. Until 16th August, when the data loggers were recovered, the dissolved oxygen registered a steady increase while the temperature was decreasing (Figure 33).

Throughout the reading period, the dissolved oxygen content and temperature were oscillating in opposition, showing a clear negative correlation between them. The measurements show an average of 7.83 mg/l of dissolved oxygen and 26ºC in temperature which are conducive to the survival of marine organism affecting shipwrecks negatively (Palma 2004; Abowei 2010). The environments in which the dissolved oxygen is below 0.5 mg/l can prevent the survival of marine organisms that affect shipwrecks (Gregory 2004).

Salinity is another physical threatening factor which controls not only survival of marine organism detrimental to preservation but can also result in chemical reactions on artefacts, leading to corrosion of metal artefacts and increased fragility of unglazed pottery and wooden material (Wheeler 2002; Gregory 2004; Mustaček 2014). Salinity levels can vary depending on the environmental conditions. Although salinity could not be measured on IDM-003, literature (Meyer 2012) on Mozambique Island hydrology suggests that the salinity level in the channel is 34 °/00, which makes the area quite salty and an optimal environment for the survival of the marine organisms and artefactual corrosion. Though a probe was used to measure water conductivity continuously, it had calibration problems during the fieldwork and only one measurement of 25mV was obtained, which sounds reasonable for the water temperature and salinity.

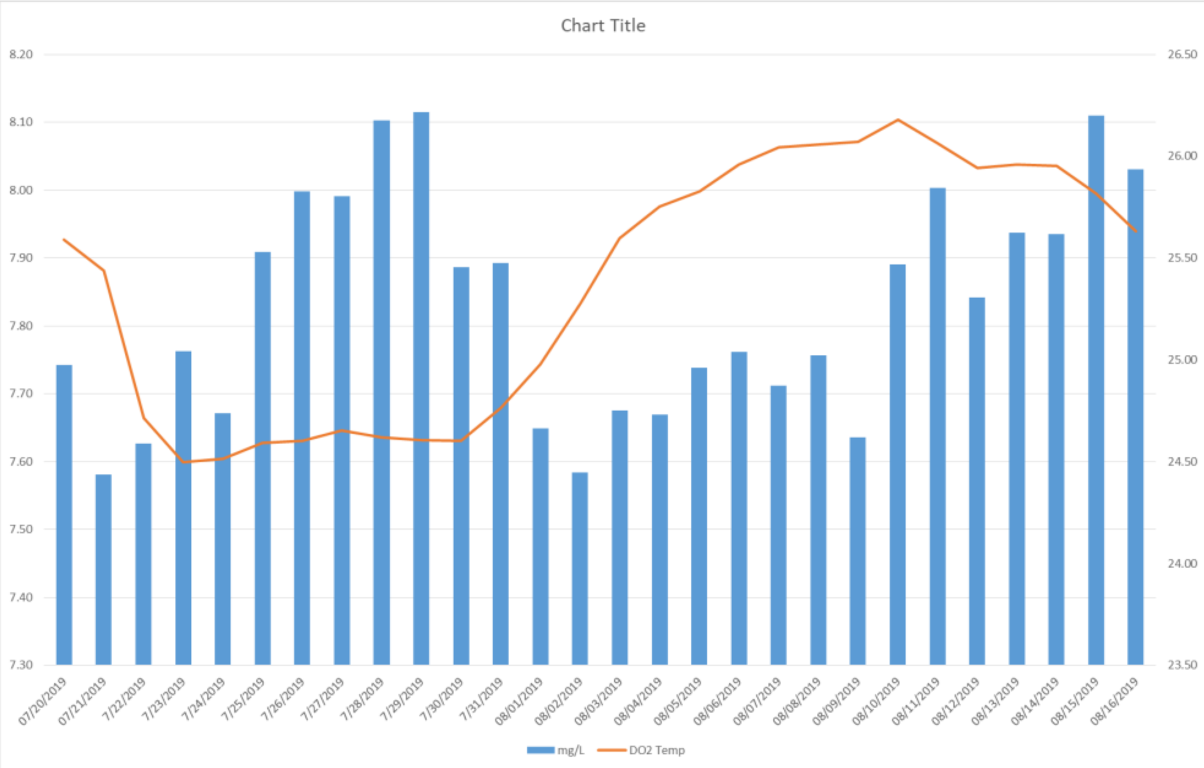


Figure 33. Graphic of dissolved oxygen and temperature at *Nossa Senhora da Consolação* (IDM-003)

Another physical threatening factor related to seawater is pH which can also help determine the condition for marine organism development and chemical degradation. The optimal range of pH in seawater is from 7.4 to 9.6 pH. In environments where the seawater temperature is 25ºC, and salinity 35 °/00 pH values within the 8.3 to 8.9 pH range are expected (Marion *et al.*, 2011). However, pH levels may vary seasonally, influenced by a rainy or dry season (Dublin-Green 1990; Abowei 2010). The pH readings at IDM-003 fall within the mentioned environmental standard and are reasonable for typical seawater. The values obtained on the site are summarized in Table 4. It can be seen that readings were quite similar during the whole period and the average recorded was 8.6 pH, the maximum was 8.9 and the minimum was 8.6 pH.

Table 4. pH readings at IDM-003

Dates	06/08/2019	13/08/2019	20/08/2019	27/08/2019	03/09/2019
pH	8.5	8.8	8.9	8.6	8.5

Another important factor to consider when it comes to preservation assessments of underwater material is light conditions. The presence of light in the underwater environment can lead to photochemical changes in archaeological material, depending on the quantity of light energy that the material can absorb (Schaeffer 2001; Mustaček 2014). The data analysed here were recorded by the light sensor deployed at IDM-003 which recorded readings between 5:45 am to 5 pm for 28 days, from 20th July to 16th August 2019.

The results revealed that on the second day after its deployment (i.e. on 21st July 2019), the light sensor read the largest amount of light established at 1622.09 lux, however light conditions shifted constantly during the next four days from 22nd to 25th July 2019. From 26th to 28th July the light intensity was quite stable but at the end of July and beginning of August, it started to shift again with up and down spikes. During the first and second week of August, the light was fairly stable, although a slight drop in available light was noted. Overall, the maximum light level established was 1622.09 lux and the minimum was 502.40 lux, giving an average of 1110.90 lux. This variation in light can be related to turbidity on the site (as discussed above) or atmospheric conditions, considering that on the last week of data collection, the weather at Mozambique Island was characterized by winds and cloudy days.

The absorption of sunlight does not always lead to chemical changes on the material underwater sites, but it has an indirect effect on the artefactual deterioration as it is essential for the survival of woodborers which have much more detrimental effect on wooden material (Schaeffer 2001; Mustaček 2014). The combination of all these seawater threats on IDM-003 indicates the presence of a current environment around the site, leading to a direct and indirect deterioration of the site. The physical seawater threats measured on IDM-003 compare with the results obtained by Gregory (2004) from the wrecks *Darss Cog, BZN10* and *Vrouw Maria* in temperate conditions. Table 5 below, shows that, despite some similarities, the data obtained from IDM-003 show substantially higher threat values when compared to those from some European wrecks. Thus, the interaction of these physical threats (sediments, currents, pH and dissolved oxygen) creates conditions for the progressive deterioration of the site caused by biological threats.

Table 5. Comparison of physical threats between IDM-003 and other Wrecks

Physical threat	*Darss Cog*	*BZN 10*	*Vrouw Maria*	*N.S. Consolação* (IDM-003)
Temperature (ºC)	2.8-20.8	2.0 – 22.5	3.22	26
Depth (m)	Ca 6	Ca 7	Ca 40	Ca 6
Salinity (PSU)	7 - 23	12 – 23	6.57	34
Dissolved Oxygen (mg/l)	8 - 23	5 – 10	6.10	7.83
pH	7.8 - 8.1	7.8 – 8.1	7.12	8.6
Light (lux)	-	-	-	1110.90
Redox potential (mV)	-250 - -300	-230 - -290	+420	-

5.2.2. Biological threats

5.2.2.1 Wood condition and identification

Wooden ships are among the greatest 'artefacts' built by humankind (Palma & Santhakumaran 2014). However, the wooden hulls of these ships are prone to rapid degradation due to infestation by certain types of woodborer organisms in seawater that lived in and on the wood, attacking its organic components (Palma & Santhakumaran 2014; Huisman *et al.*, 2008; Huisman & Klaassen 2009). The availability and diversity of these organisms is determined by the seawater environment and when the conditions are favourable for woodborers, wood is gradually colonized as it is the main source of their food and energy (Brown *et al.*, 1988; Pournou *et al.*, 2001; Björdal *et al.*, 2012).

After the excavations of IDM-003, the wooden hull structure was left exposed for three years and woodborers settled in the structure. Despite an attempt to rebury the site, the methodology applied was insufficient, as some wooden parts of the hull were still exposed to deterioration (see Chapter 4). Thus, in course of this research, five wood samples were collected on exposed structures, to assess the condition of the wood, its identification and analyse its biological infestation.

The samples were analysed through the following procedures: Photographic documentation of the condition of the samples, microscopy imagery, determination of the deterioration extent, and wood and woodborer identification. Photographs of the samples were taken during their collection in the field and in the laboratory after treatments to stabilize them and immobilise possible active woodborers. The samples were kept frozen at 1ºC for three weeks and before transportation to the Maritime Archaeology Laboratory at Iziko Museum in Cape Town, they were humidified with a 5% ethanol solution.

The photographs taken in the laboratory allowed visual analysis and presentation of the sample condition. The sampled wood was much deteriorated due to woodborer activity that destroyed structural part of the wood, and woodborers were found on the surface and inside the wood. A more detailed assessment of the condition of the wood samples and the activity of woodborers organisms could be made through the microscopy. This observation allowed the visualization of some organisms inside the wood samples and the identification of these woodborers was made through comparison of their activities on other wooden wrecks.

The analysis of the extent of wood deterioration was made based on the rating scheme proposed by Palma (2004:12) and the British Standard (EN 27:1992), which determines the percentage of the galleries dug by woodborers into the wood, rating them from 0 to 4 depending on the condition of the wood (Table 6 and results presented below).

Table 6: Rating scheme for wood degradation (Palma 2004:12) and (British standard 27:1992)

Grade Nº	Description of condition	Condition and appearance of test wood sample
0	No attack	No sign of attack
1	Slight attack	Single or few scattered tunnels covering not more than 15% of the area of the specimen as it appears on the microscopy
2	Moderate attack	Tunnels covering not more than about 25% the area of the specimen as it appears on the microscopy
3	Severe attack	Tunnels covering between 25% and 50% the area of the specimen as it appears on the microscopy
4	Failure	Tunnels covering more than 50% the area of the specimen as it appears on the microscopy

The species identification of the IDM-003 wood samples was made by Kristof Haneca and Marnix Pieters (2020) at Flanders Heritage Agency in Belgium. To identify the botanical species of the wood, thin sections of the samples were cut in transverse, tangential and radial planes with scalpel and razor blades (Haneca & Pieters 2020). The sections were mounted on slides in glycerol (50%) and studied using a transmitted light microscope (100 - 400x).

The taxonomic identification of the wood samples was based on Schweingruber (1990) and Schoch *et al.* (2004). Two taxonomic groups could be identified: Samples 2, 3 and 5 were identified as coniferous wood (*Pinus* sp.), but no further detail could be reported so far, as most pine species are hard (or even impossible) to discern based on their wood anatomical structure. However, as no large window-like piths were observed in cross-fields, *Pinus sylvestris* (Scots pine), *P. nigra* (black pine) and *P. cembra* (Stone pine) can be excluded. Potentially, these timbers were made from a pine-species native to the Mediterranean (Haneca & Pieters 2020).

The samples 1 and 4 were *Quercus* sp. and although these samples were heavily affected by marine shipworm (*Teredo* sp.), on thin sections, the ring-porous nature of the wood and very large rays could be observed, pointing towards an oak species. Further detail on the specific oak species cannot be given. Not only the most common European oak species – i.e. *Q. robur* and *Q. petraea* – but also species native to the Mediterranean, such as stone oak (*Q. ilex*) or Portuguese oak (*Q. faginea*) should be considered (Haneca & Pieters 2020).

The IDM-003 wood samples' condition and identification is summarized in Table 7, which takes into consideration the type of wood identified, which part of the hull structure the wood comes from, and the rate of wood deterioration based on microscopy imagery carried out by the author. Briefly the table analysis shows that samples 1 (keelson) and 4 (frame), both *Quecus sp* shows decay of more than 50% and the woodborer are likely to be the same. While samples 2 (planking), 3 and 5 (frames) are *Pinus sp* less affected as the wood decay is between 15% and 25%.

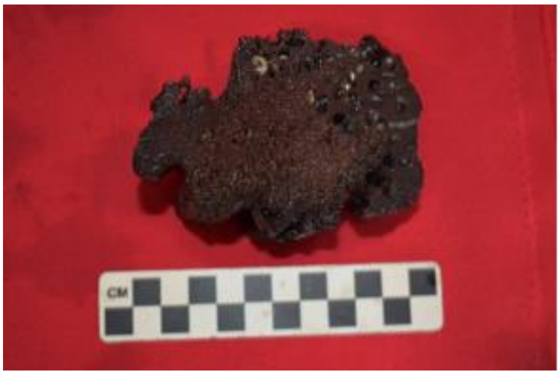
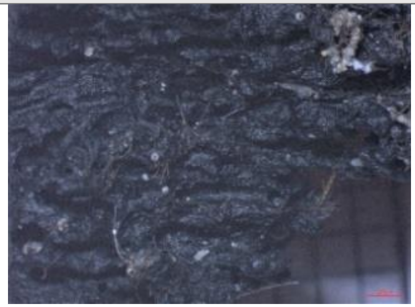
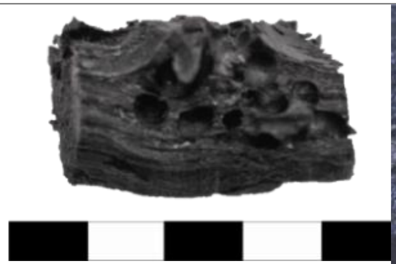


Figure 34. Wood sample and analyses of the process of degradation of the wood. Photo: Celso Simbine, 2019

Table 7. ***Nossa Senhora da Consolação*** **(IDM-003) Wood samples condition and identification**

Sample	Part of the wreck	Type of wood	Grade No	Description	Condition	Photograph	Microscopy Image (200µm)
S1	Keelson	*Quercus sp*	4	Failure	More than 50% of the sample is consumed by tunnelling organism		
S2	Planking	*Pinus sp*	2	Moderate attack	At least 25% of the sample is consumed by tunnelling organism		
S3	Frame	*Pinus sp*	1	Slight attack	Few scattered tunnels covering less than 15% of the sample		

S4	Frame	*Quercus sp*	4	Failure	More than 50% of the sample is consumed by tunnelling organism		
S5	Frame	*Pinus sp*	1	Slight attack	Few scattered tunnels covering less than 15% of the sample		

5.2.2.2.Shipworm – Teredo Navalis

The species of woodborers responsible for consuming wooden shipwrecks in Mozambique Island is still unknown, although, some organisms observed in the wood samples from IDM-003 were compared with those found in other wrecks around the world and the comparison suggested them to be species of the *Teredinidae* (Teredo) and *Limnoridae* (Gribble) families.

There are 65 different types of *Teredinidae*, in the marine environment according to Danilovic (2014), but Palma & Santhakumaran (2014), point to 75 different types. The most abundant woodborer recognized by archaeologists is the *Teredo navalis Linnaeus 1758* also known as 'Shipworm' due to its recurrent presence in wooden structures and ships, specifically (Figure 35).

The *Teredo navalis* is characterized by an elongated worm-like body with two shell valves and cephalic hood at the anterior end and with the siphons and pallets at the posterior end (Danilovic 2014; Palma & Santhakumaran 2014). The shell valves of the shipworm are responsible for rasping off the wood and tunnelling into the wood, with a rotating and forward movement through the suction of the muscular foot, which adheres to the blind end of the burrow (Didžiulis 2011; Palma & Santhakumaran 2014).

The *Teredo navalis* enters the wood at the larval stage, when it is about 55-85 µm in diameter and then never leaves its burrow (Danilovic 2014). Its metamorphosis from larva to adult takes about ten days. As it grows, it enlarges and increases the burrow length sufficient enough to accommodate its entire body. The lining of the burrow walls with the calcareous secretion of the mantle protects the borer from harmful effects of any toxic chemical present in the wood or against conditions which can put it in danger, for example, lower salinity or temperatures from the seawater (Gregory 2009; Didžiulis 2011; Palma & Santhakumaran 2014). The moment *Teredo navalis* settles in the wood, it stays there until the end of its life cycle which lasts 2-3 years, although seawater conditions such as food-supply (wood) temperature, salinity, dissolved oxygen and currents will influence its life cycle and the growth (Palma & Santhakumaran 2014).

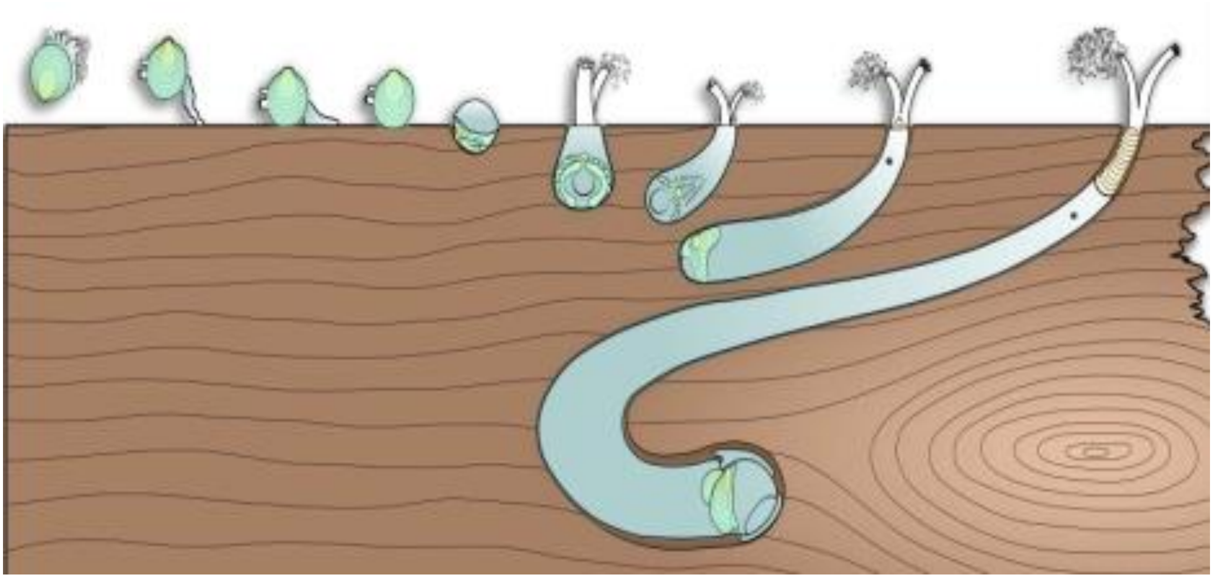


Figure 35. Teredo navalis settling the wood. Source: Danilovic (2014:48)

Results from the Wreck Project (Björdal *et al.*, 2012) and MoSS Project (Cederlund 2004) have revealed the optimal conditions for the *Teredo navalis* growth. This organism inhabits temperate and tropical seawater around the world, however, the temperature range for the survival and colonization is very broad. Temperatures on shipwrecks colonized by *Teredo navalis* could vary from 1ºC to 30ºC, but extreme conditions affect its growth and reproduction. The ideal temperature for its development and reproduction is within the annual range between 11ºC to 25ºC (Pournou, Jone & Moss 2001; Björdal *et al.*, 2012).

Salinity is also an important factor that determines its development and distribution, being found in seawater with a salinity of 5-30‰. Low salinity does not provide an ideal condition for settling *Teredo navalis*, which means that their presence will be much lower and wood material can have a greater chance to survive much longer (Gregory 2004; Didžiulis 2011; Danilovic 2014).

The presence of dissolved oxygen is certainly the crucial factor necessary for the existence of *Teredo navalis* in a particular environment. The organism can survive a few weeks in environments without oxygen, thanks to its preserved glycogen stores. However, a longer period without the presence of dissolved oxygen will cause its death (Gregory 2004). In other words, the anaerobic environment below thick and non-porous sedimentary layers are not favourable for the colonization by *Teredo navalis* (Gregory 2004; Danilovic 2014).

The physical environmental conditions measured on IDM-003 is favourable for the development of *Teredo navalis*. The wood samples collected have shown features similar to the activities of these organisms. Most of the IDM-003 wood samples showed signs of tunnelling burrowed through the interior, however, the organism itself was only seen in one of the samples, sample S4, where the burrow and the two shells valves of the organism were visible through the microscopy. Any sign of the presence of *Teredo navalis* or affiliated species with similar behaviour suggests that the wood is in an advanced stage of deterioration (Danilovic 2014). However, only one of these organisms was found in one of the samples collected on the site so far. In favourable aerobic conditions, these organisms can rapidly colonize wooden shipwrecks and in an extremely short period destroy wood structures.

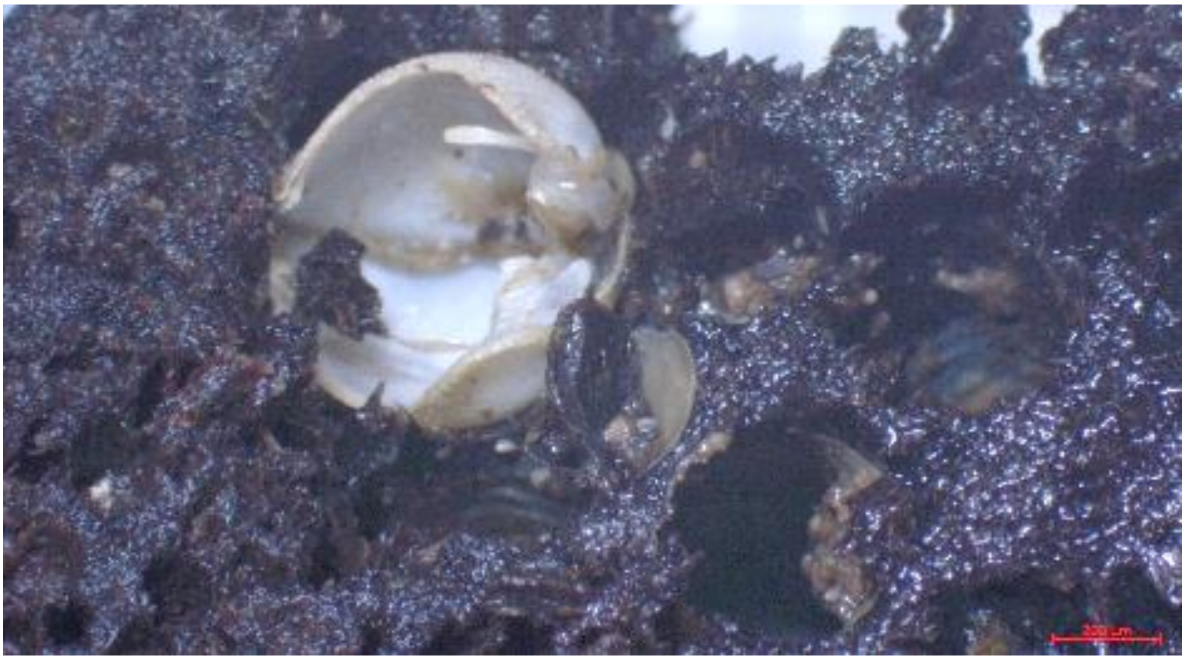


Figure 36. Teredo navalis in sample 4 from *Nossa Senhora da Consolação* (IDM-003). Photo: Cezar Mahumane, 2019

5.2.2.3. Gribble - Limnoria lignorum

The gribble is another woodborer that affects wooden structures in aerobic seawater environments, and like the *Teredo navalis*sample 1 from IDM-003 revealed the presence of gribbles. There are at least 56 different types of gribble within the family of *Limnoridae Isopoda*, considered the second most aggressive species that attack wood and can inflict great damage to wooden materials. The most famous and most dangerous gribble are the *Limnoria lignorum*, *Limnoria tripunctata* and *Limnoria quadripunctata* (Danilovic 2014).

Figure 37. Gribble found on wood sample 1 at *Nossa Senhora da Consolação* (IDM-003). Photo: Cezar Mahumane, 2019

The *Limnoria lignorum* grows to the maximum length of 8 mm, and although very small in size can be present in large numbers. It creates superficial galleries, narrow and runs parallel to the wood grain, creating tunnels of 1-2 mm in diameter and several centimetres long. The body of the *Limnoria lignorum* is grey or off-white, and its length varies between 2-8 mm (Danilovic 2014; Palma & Santhakumaran 2014).

This organism feeds on wood enzymes that allow it to digest linin and its reproduction occurs in the way that the female keeps the eggs beneath her thorax. After the eggs hatch, miniature copies of adult specimens are immediately able to colonize wood. The ambient temperature plays a very important role in the reproductive process, and young individuals develop significantly faster in warmer conditions.

The range of water depth suitable for habitation varies from coastal shallows to depths of 20 meters. Gribbles commonly inhabit colder seawater but can sometimes be found in warmer areas (Danilovic 2014:53; Palma & Santhakumaran 2014:28). Wood sample 1 from IDM-003 showed traces of gribbles as illustrated in Figure 34. The optimal condition for the survival of this woodborer is summarized in the table below.

Table 8: Seawater condition for the presence of woodborers

Woodborer	Temperature	Salinity	Dissolved Oxygen	Currents
Teredo	5-30ºC	9-35°/₀₀	>1mg/l	>2.0m/s
Limnoria	9-26ºC	9-35°/₀₀	>1mg/l	>2.0m/s

From Gregory (2004:40) and Björdal *et al.*, (2012:208)

5.2.2.4.Microorganisms (Fungi and Bacteria)

Besides the very invasive colonization and rapid deterioration that can be caused by macro-organisms such as shipworm and gribbles on wooden shipwrecks, some micro-organisms can slowly destroy wooden shipwrecks (Danilovic 2014). A very large number of different types of micro-organisms can compromise wood, and the most important of them are fungi and bacteria. These micro-organisms can degrade wood in the most diverse environmental conditions, either aerobic or anaerobic (Palma 2004; Gregory 2004; Gregory *et al.*, 2008).

Generally, fungi feed on wood cells in a variety of ways, degrading lignin or carbohydrates and they can be recognized by the type of damage they cause to the wood structure. The so-called white-rot and brown-rot fungi have their activities limited to the terrestrial environment and cannot survive in the marine environment and will, therefore, not be described here (Gregory *et al.*, 2008; Danilovic 2014). Soft-rot fungi decompose wood in marine environments. These - fungi are considered one of the most flexible and most aggressive fungi attacking wood and can cause significant damage. This type of fungi can live at a temperature between 0ºC and up to 65ºC, and can tolerate extremely low percentage of oxygen and salinity. The soft-rot fungi can create a cavity in the secondary wall of the cell structure following the microstructure of cellulose, as well as complete the erosion and degradation of the secondary wall of the wood (Danilovic 2014).

In addition to fungus attacks, there are bacteria which also attacks wood in the marine environment. These bacteria have shown tolerance to extreme conditions - (high or low) dissolved oxygen, temperature and salinity - being sometimes the only organisms that lead to degradation and decomposition of wood together with the soft-rot fungi (Huisman *et al.,* 2008; Gregory et al., 2012; Gregory 2009).

Studies of the degradation of wood carried out before the 1970s confirmed that fungi had the greatest influence on the degradation of wood and the role of bacteria in this process was considered less important. However, recent research suggests that bacteria are an extreme threat in the process of decomposing of wood (Huisman *et al.,* 2008). Bacteria have a much more significant role in the deterioration of wood in respect to fungi, and in some specific environments, such as anaerobic environments, bacteria are the only organisms that can lead to the decay of wooden materials (Huisman *et al.,* 2008; Danilovic 2014; Gregory 2009).

In some cases, the activity of the bacteria and fungi cannot be seen with the naked eye, but only through microscopy analyses. One of their impacts on wood is the destruction of the cell walls which causes a softening of the wood. In such circumstances, the wood may look good from the surface, but the interior has been consumed and the wood offers less resistance: in other words, it loses density (Palma 2004; Palma & Santhakumaran 2014). This pattern of internal wood decay was observed on the IDM-003 wood samples 3 and 5 which presented a well textured surface of the wood, but where the interior texture was spongy as a result of low density of wood from bacterial decomposition.

5.2.3. Human threats

Human intervention on submerged archaeological sites can be unintentional or intentional, but poses a great threat to the preservation and protection of UCH. In general, unintentional activities include large commercial construction works or small-scale activities, which can indirectly endanger UCH. While intentional activities are deliberate and planned by individuals or groups with personal interests and material benefits upon UCH resulting in detrimental effects (Danilovic 2014). On Mozambique Island, the human activities that pose threats to UCH are those defined as intentional, mainly treasure hunting (see chapter 2.4), fishing and sport diving. The last two activities may have a low impact on UCH, but have to be monitored so that they do not become a major threat in the future. Below the various human threats will be discussed in more detail.

5.2.3.1.Fishing

Fishing is an economic activity which involves hunting fish and other seafood for subsistence or commercial purposes. Fishing is the basic subsistence activity for many coastal communities and on Mozambique Island it is considered the core activity. Fishing is likely to interact with other UCH threats and the type and extent of interaction is variable and still poorly understood, with the potential for both positive and negative effects upon fishing and UCH.

There have been some concerns on the potentially wide-range impact of fishing on UCH, as some reports refer to fishermen finding and recovering archaeological material or fishing equipment being entangled with wooden shipwreck structure, as a result of the techniques and methods used for fishing. Fishing methods are always inventive and progressive, raising pressure on marine resources. At Mozambique Island, the techniques used for fishing are mostly traditional and can be divided into two groups: pelagic which operates in the water column and the demersal, which operates close or near the seafloor.

Table 9. Traditional fishing methods in Mozambique Island

Pelagic techniques	Demersal techniques
Beach seine netting –is commonly used in coastal and shallow inshore areas and it is characterized by the use of the one end of the rope deployed and the net is released in a loop or horseshoe shape. The boat returns to the shore with the other end of the rope and the nets are then landed by manual or mechanical pulling over the seabed. **Hand Dredges** - This is a typically small and lightweight toothed device operated by hand in shallow waters or from the shore as well as from small boats.	**Pots, creels and traps** – this technique consists of baskets or cages of various shapes and materials which are typically baited with fish and fish products. The pots may be laid individually on the seafloor or as a string of connecting traps attached to weighted ropes with buoys or physical marker on the floating end. Normally, fishermen deploy their pots for the soaking duration of 24 to 48 hours before retrieving them by hand. This technique is considered to have a low level of impacts on the seabed, with impacts typically only arising from the siting which may result in flattening or snagging of the seabed structures or incidental loss of the fishing gear.

The area where IDM-003 is located is often avoided by the fisherman as they want to avoid their fishing nets being caught on the iron cannon concretion and coral concretions that damage the nets. Instead demersal techniques are normally seen near the wreck.

However, a new and recent fishing practice has been reported in Mozambique Island area. A growing number of boats have been practising non-authorized fishing using compressed air directly supplied from the boat to an underwater fisherman who catches all types and sizes of fishes and other marine animals (lobster, stone fish, lion fish, snapper fish). This activity is having an impact in the fishing activity itself as it is reducing the number of fish available. Additionally, it represents a major threat to UCH as archaeological artefacts are being looted during these activities (Eduardo Dos Santos & Ricardo Duarte *per comm.* 2020).

The potentially damaging effects of fishing upon UCH have become a contentious issue in recent years, and there have been considerable debates about the archaeological implications of the techniques applied (Firth *et al.,* 2013). Therefore, it is important to establish a clear understanding of the nature of fishing and heritage interaction, considering that the UCH around Mozambique Island has been impacted by past commercially-oriented activities.

Improving an awareness of the potential interaction and mutual benefits of sustainable fisheries and UCH will inform future management action and allow us to improve the protection of UCH, whilst at the same time minimizing and mitigating negative socio-economic impacts from a decline in fishstocks (Firth *et al.*, 2013).

5.2.3.2.Sport Diving

With the popularization of recreational diving, several wrecks sites have been discovered and reported to archaeologist or institutions that manage archaeological heritage (Danilovic 2014). The growing number of divers has resulted in the development of organized sport diving centres and institutions. Many of these centres and institutions undertake activities to provide advanced education and training in techniques to study, monitor and protect underwater sites against deterioration and looting, as well as promoting best practice for UCH for the public benefit.

This is the case of organizations as the Nautical Archaeology Society (NAS), which trains professionals and amateurs, aiming to develop awareness, respect and an understanding of the maritime cultural heritage and develop capacity in the maritime archaeology sector (https://www.nauticalarchaeologysociety.org/). Another recently created organization is Diving With a Purpose (DWP), an American organization dedicated to the preservation and protection of submerged heritage resources by providing education, training, certification and field experience to adults and youth in the fields of maritime archaeology and ocean conservation.

The special focus of this organization is the protection, documentation and interpretation of African Slave trade shipwrecks and maritime history and American culture (https://divingwithapurpose.org/). In the recent past, IDM-003 was used to provide both NAS and DWP training to the local community and national underwater archaeologists. The training was organized by SWP and aimed at promoting Mozambique Island's participation in shipwreck documentation and monitoring.

On the other hand, there are also groups of sport divers that represent a threat to UCH, causing a disturbance and leading to its deterioration. There is always the problem of individual divers or entire groups of divers attempting to collect archaeological artefacts as souvenirs. Through the impact of sport diving on UCH is less dramatic when compared to other human threats, it is necessary to provide proper education to the public to raise awareness of the value of UCH to a higher level, which can allow better preservation and create appropriate legislation to protect sites (Duarte 2012; Danilovic 2014).

Figure 38. DWP training at *Nossa Senhora da Consolação* (IDM-003) for community Monitors. Photo Ricardo Duarte, 2017.

One important step has been the creation of the *Code of Ethics for Divers* by UNESCO, which recommends how divers should behave when diving on shipwreck sites. Some of the recommendations are to leave the objects on shipwrecks and ruins untouched and only allowing archaeologists to remove them for proper conservation. Objects should not be taken as souvenirs, as when objects or any kind of UCH remains are displaced, they are deprived of their context and lose part of their significance, they should only be undertaken by those with skills to do this work. Some other recommendations include not selling our common heritage, as it can end in private collection and its community will then not have access to the history of the objects. Another recommendation in the UNESCO code of *ethics* is to report discoveries to the responsible authorities, as it is also recommend by the national Decree 27/94, which can then lead to the investigation and protection of the site and to seek permission to dive on designated sites, as the sites can be sensitive and of great importance.

CHAPTER 6 – ASSESSING DIFFERENT MITIGATION AND MONITORING STRATEGIES

When the assessment of physical, biological and human threats reveals that a site is in danger, or the state of equilibrium is disturbed leading to deterioration, strategies must be implemented to mitigate these threats and stabilize the site by using a range of *in situ* mitigation methods (Bowens 2009; Manders 2011). Generally, the mitigation strategies include using physical protection to cover the sites, such as sandbags, geotextile, artificial seagrass, debris netting, backfilling and reburial. Each of these strategies is orientated to maximise the oxygen limitation within the sediments as quickly as possible, resulting in a reduction of organisms that will consume wood structures (Gregory 2009; Stainforth & Shefi 2010; Richards *et al.*, 2012).

In the right circumstances, these strategies can alleviate and prevent site deterioration. However, in cases where the local environment is not conducive to simply covering the site, the site can be excavated and re-deposited, or reburied in a more benign environment (Bowens 2009:167). Below the different methods to mitigate deterioration will be discussed and assessed in the context of feasibility for IDM-003.

6.1. Geotextile

The geotextile is a fine synthetic fabric used in construction or for protection and prevention of erosion (Figure 39). The geotextile is a cheap and simple strategy, which gives good results in the protection of UCH offering the possibility of preserving large areas (Bowens 2009; Manders 2011). The geotextile is easy to lay on the seabed and easy to remove when needed case for the periodic monitoring of sites or seasonal archaeological fieldwork. This material has been shown to have good results in terms of the protection against colonization of *Teredo navalis* (Stainforth & Shefi 2010; Manders 2011; Danilovic 2014).

6.1.1. The use of geotextile at IDM-003: An experiment toward *in situ* preservation

The pilot experimental protection of IDM-003 with geotextile fabric is part of the CAIRIM program for protecting Mozambique Island UCH. The geotextile fabric is available in different levels of weight, thickness, strength and width, adapted to multiple designs. Some of them are very costly, while others are reasonably priced. At the time the experiment on IDM-003 was carried out, the type of geotextile we had access in Mozambique was the *geotextile geobasic* *str 120 gr*, which consists of 100% polyester, mechanically connected through the production process and with high mechanical properties, measuring 1 x 125 meters per roll.

The proprieties of this geotextile allows the passage of fluid and the filtering of the finest particles through the mesh. It allows for sedimentation of fine particles and protects the material from hydrodynamic forces, preventing deterioration. Additionally, it allows reinforcement and stabilization on surfaces where applied, it avoids contact between two materials of different properties, avoiding mixtures and possible contamination (https://texdelta.com/en/nonwoven-geotextile-polyester-geobasic/ accessed in January 2018).

In terms of procedures, before covering IDM-003 with the geotextile, as described in Chapter 5.1 an up to date plan of the site was produced using photogrammetry. Results showed that the structure was exposed and needed to be covered. Therefore, bags were filled with ballast stone and geotextile strips measuring 1x15 meters were prepared. The ballast stones used were those found on the sides of the wreck when it was excavated by AWW/PI in 2005 and 2006. The strips were wrapped on a stick and iron bar to facilitate the covering process. While unrolling the geotextile strips over the wreck, a group of divers were sewing together the strips and ballast stones were placed on top of the geotextile to prevent it from floating. A liftbag was used to move the ballast.

Figure 39. Unrolling the geotextile on *Nossa Senhora da Consolação* (IDM-003). Photo: Hilard Dean, 2017

The covering process was completed in a week. Since then, regular inspections are carried out once a month to assess the effects of the geotextile on the site. It has been noted that sediments are being continuously deposited on top of the geotextile and marine life is colonizing the area. However, while monitoring the site, some problems were seen with the geotextile. For example, in mid-January 2018 a storm affected Mozambique Island and a section of the geotextile strips were pushed apart, uncovering a part of the wood structure again. The decision was taken to remove the damaged geotextile strips and replace them with new ones. Since then, the geotextile has been quite stable, with the exception of some parts that have had to be replaced.

When carrying out the 2019 fieldwork for this dissertation, a visual inspection of the geotextile textile was made, one and a half year after it was laid. The observations revealed that in some areas of the wreck the geotextile is working fairly well, while on the others, it has moved or is torn. In the north, east and central areas of the wreck, the geotextile is working fairly well and sediments are being deposited continuously, allowing the growth of marine seagrass on top of the geotextile, the establishment of sediment and binding seagrass helping to create an anaerobic environment. However, in the west and south of the site, the geotextile is not resulting in the same level of response, as it constantly moves due to turbulence to expose the wooden hull structure. Therefore, other complementing mitigation strategies have been considered and these possible strategies will be discussed below in the context of IDM-003 and Mozambique waters.

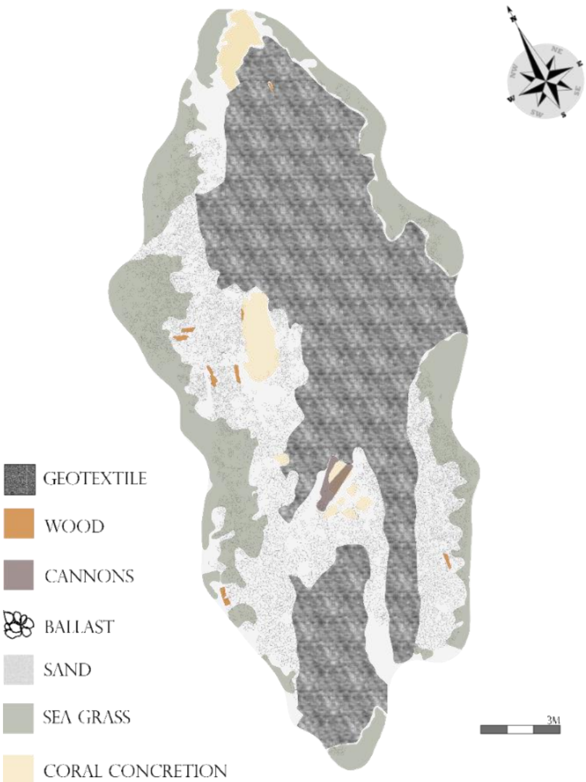


Figure 40. Map of the areas covered with geotextile. Drawer: Cézar Mahumane, 2020

6.2. Other Possible Mitigation strategies

6.2.1. Sandbags

The use of sandbags is a very popular and effective strategy for covering and protecting terrestrial and underwater sites. The weight of the sandbags makes them remain motionless on the bottom, ensuring the immobility of archaeological material, and safeguarding shipwreck sites against erosion (Danilovic 2014). This strategy can be used on different types of underwater terrain and it is effective for shipwreck sites where currents threaten to remove archaeological material (Bowens 2009; Gregory & Manders 2015).

As a basic rule, the sandbag has to be filled a third to half full using fine-grained sand with low organic content. This can make possible to "mould" the sandbags around structures and keep as low a profile as possible. Synthetic sandbags must be used as those made of natural material will degrade very rapidly underwater (Manders 2011). The downside of using sandbags is that they do not provide an effective anaerobic environment in the long term, and consequently do not protect the site from biological threats. Besides being cost-effective in stabilizing shipwreck sites, sandbags are a temporary measure because the material used to make the bags has a finite life. Furthermore, the bags themselves can change the water movement over the site, potentially causing scour which can then cause the exposure of new areas of the wreck (Stainforth & Shefi 2010; Manders 2011; Richards *et al*., 2012; Gregory & Manders 2015).

Considering the environmental conditions around IDM-003 as discussed in Chapter 5, the sandbags measure is not appropriate for the site as it could cause more potential damage to the already fragile wood structure. In addition, though this measure is cost-effective it does not provide long term protection.

Figure 41. Sandbag strategy. Source: Manders (2011:26)

6.2.2. Artificial Seagrass

If there is sediment transportation in the water column around the wreck site this material can be trapped by the plastic fronds of artificial seagrass due to the friction, which slows down the water causing the sediment particles to fall out of suspension and resulting in an artificial seabed or mound which covers the site (Manders 2011; Gregory & Manders 2015). This strategy has been demonstrated to be very useful on sandy sites where there are strong currents and severe erosion.

The use of artificial seagrass fixes sandy and muddy sediments to prevent its transportation. The artificial fronds of seagrass ensure a continuous capture of waterborne sediments to cover archaeological materials (Gregory & Manders 2015). The environmental conditions on IDM-003, with its rather turbulent waters, and the easy availability of artificial sea grass could make it a good substitute for geotextile. The plastic fronds are widely available and at relative low cost. The artificial sea grass would help capture fine sediments, creating adequate anaerobic conditions on the site.

Figure 42. Example of the artificial seagrass strategy. Source: Manders (2011:30)

6.2.3. Debris Netting

This strategy functions in a similar way to artificial seagrass and could work in the similar way if applied to IDM-003. The idea is that the net is fastened loosely over the structure so that it floats in the water but remains over the site. Like the artificial seagrass, the suitability of this strategy is dependent upon there being currents and sediment transport in the water. If there is sediment transport and the grain size is fine enough to pass through the mesh then, because of friction, the sediments will be slowed and come out of suspension and become trapped under the net, creating a burial mound underwater (Manders 2011; Gregory & Manders 2015).Thus, by applying this strategy to IDM-003, the same level of results as the artificial seagrass can be expected.

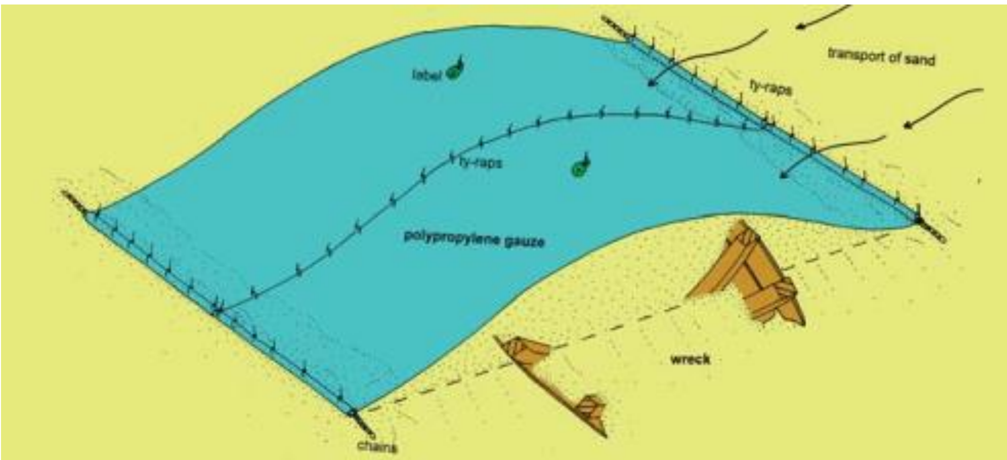


Figure 43. Example of the debris netting strategy. Source: Manders (2011:32)

6.3. Monitoring the site and implemented mitigation strategies

Whether the strategies discussed above will be used or the use of only geotextile will continued, it is important to point out that *in situ* preservation procedures do not stop once on-site mitigation strategies have been fully implemented. There is a need to continuously monitor the implemented strategies and the site to ensure continued stability, as environmental changes may occur which necessitate further mitigation strategies (Gregory 2009; Gregory *et al.*, 2012; Gregory & Manders 2015).

Monitoring involves periodic inspection on shipwrecks after applying any of the mitigation strategies and the success of the whole process depends on the knowledge of all potential threats and their change over time. Any change in the site could be used for comparison with the situation found at the moment an intervention was first made in the site (Danilovic 2014). To monitor these changes some procedures are described and assessed below in the context of IDM-003.

6.3.1. General Visual Inspection

One of the effective methods for monitoring a site is simply visual inspection by divers who can assess the site or the effectiveness of the mitigation strategy being applied. During the surveying operation, divers can inspect the archaeological remains closely and take samples or cores to get some more information about the current condition of the site (Bowens 2009). The greatest advantage of regular visual inspections is the possibility of identifying potential problems that can arise on the site, such as partial exposure of new archaeological features. Additionally, divers can also ascertain whether the site is being attacked by woodborer organism (Bowens 2009; Gregory & Manders 2015).

The use of this method on IDM-003 has been regular in the last four years as part of the CAIRIM Mozambique Island UCH protection program. Divers have been inspecting the site in regular intervals and have been able to identify changes on the deterioration rate of wooden structures, as well as changes in the sedimentation process. The effectiveness of this method relies on the divers' experience and capacity to recognize changes in the condition of the site over time. Therefore, several visits must be carried out to familiarise divers with the site. Diver must also follow a pre-established route around the site every time an inspection is done and the same diver or groups of divers must be involved (Bowens 2009).

Although inspection goes a long way, this method alone is of limited value in monitoring UCH, as the observation and recording depend on the divers' knowledge and skills. Thus, the subjective nature of the visual inspection means that it is best supported by other techniques using more objective equipment (Bowens 2009).

6.3.2. Photographs and Photogrammetry

Photographs and photogrammetry are very important methods to support general visual inspection. When properly applied, photographic images of a wreck site can provide more information on its condition than can be obtained from the verbal or written descriptions of divers (Bowens 2009). These methods have the advantage of allowing a site to be studied and monitored remotely, both by divers and non-divers, without having to revisit it. Photographs can be used to identify errors resulting from descriptions given in the visual inspection. To build up a monitoring process of the site using photographs, site visits have to be taken at different times, so that comparative material is available. Therefore, it is important to take the photographs in the same positions and orientation (Bowens 2009).

Lately, photogrammetry is also being used for monitoring purposes to compare changes on-site. This procedure has been used successfully on IDM-003 over the last four years to monitor the changes on the site. The photogrammetric method has revealed to be quite efficient and less time-consuming in data acquisition than diver recording (see Appendix 3). The results are used for other sorts of analyses and comparisons of the site condition through time.

By creating accurate 3D images of the site, using photos and video stills and the repeated use of photogrammetry we have been able to detect changes on IDM-003 site over time and we now also have baseline data. The method also makes it possible to do further research back on land, which in turn reduces diving time (Gregory & Manders 2015). Those measurements are a valuable method to identify and quantify the changes, provided that they are taken accurately and in a repeatable way. The comparison of changes over time can be an effective strategy for monitoring the movement or collapse of structural elements at the site (Bowens 2009; Gregory & Manders 2015). Therefore, continued regular photogrammetry on IDM-003 and other wreck sites in Mozambique can allow monitoring it through measurements of the different models produced over time in association with the establishment of monitoring points.

6.3.3. Sampling on site and sacrificial samples

Several samples can be taken on a site depending on what needs to be monitored. For example, the testing of sediments, as shown in Chapter 5, has potential and it is possible to extend collection of seabed sediments to assess their origin and grain size. The results of this analysis and expansion of the analyses will generate information about the vulnerability of a site to erosion or its potential for sedimentation.

As shown here, wood samples can be collected on a site to inform about the type of wood, level of deterioration by woodborers and other biological threats affecting the site (Figure 31). Collecting wood samples on different parts of the structure will help determine which parts of the wreck are more or less deteriorated (see Appendix 5). This analysis will highlight areas of particular vulnerability and inform about how long exposed wood is likely to survive (Palma 2004; Gregory, Jensen & Straetkvern 2008).

Sampling should only be considered when the information sought cannot be obtained from other non-intrusive methods. The other solution is deploying sacrificial samples in the sediments for long term monitoring of a site. This process is very laborious since the material has to be made in large quantities, installed on the site and retrieved repeatedly at set periods for laboratory analyses. This method can be valuable in areas where the deterioration process is still unknown (Palma 2004; Gregory & Manders 2015).

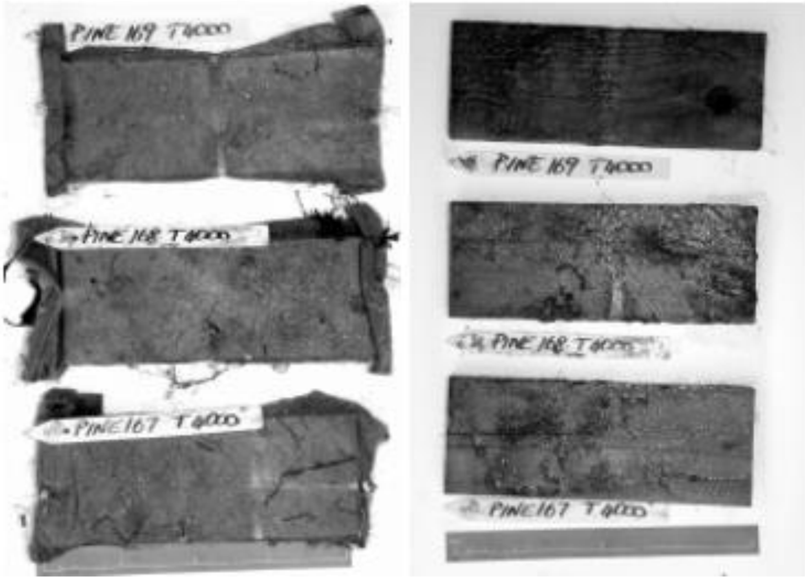


Figure 44. Sacrificial samples and sampling process. Source: Palma (2004:13)

6.3.4. Marine geophysics

This monitoring method uses equipment such as side-scan sonar, single-beam and multi-beam to measure depth, seabed shape and to detect the presence of archaeological material (Gregory & Manders 2015). This method can, therefore, be used to monitor changes in the sediment pattern over time and assess the effectiveness of mitigation strategies on a site such as IDM-003 (Bowens 2009).

Traditionally, the use of marine geophysics equipment required subsequent ground-truthing performed by divers through visual inspection, or the use of Remoted Operated Vehicles (ROV) to interpret and verify the results. However, as both the quality of data and the interpretative data skills of archaeologists have improved, ground-truthing is becoming gradually less necessary (Bowens 2009; Gregory & Manders 2015). The great advantage of using this method is reducing time and the amount of work, because monitoring work that would take weeks or even months for a dive team to accomplish, can now be achieved in few hours using geophysical equipment. Consequently, this method is increasingly being used for monitoring sites, but this technique can be expensive and require those with skills to implement (Gregory *et al.*, 2012).

Nevertheless, it should not be considered a complete solution or one that can work perfectly on all sites. As most of the methods presented here, the effectiveness of this method for monitoring depends largely on the detection of changes between surveys. Thus, more than one survey, separated by an appropriate period, needs to be done (Manders 2011). The major problem with this method is the high costs of operations, particularly when it comes to using equipment like multi-beam, which requires specialized knowledge for its operation and the interpretation of the results (Bowens 2009:166). Therefore, in the preservation of Mozambique Island UCH, although there is minimal possibility of using geophysical equipment like multi-beam due to its cost of operation, its use should nevertheless be encouraged as the amount and quality of data that it generates would allow additional interpretative approaches over the protection and monitoring procedures toward the preservation of the heritage.

6.3.5. Hydrodynamic environment

The shipwreck formation and deterioration processes are influenced by physical, chemical and biological conditions. Therefore, it is important to measure the influence of those conditions so that the stability of the site and the degradation rates of different materials on a wreck can be measured and preserved *in situ.* It is becoming a common trend in underwater archaeology to use data loggers to monitor changes in the environment of the sites. These devices are cost-effective and can provide all sorts of measurable data about seawater condition, such as temperature, dissolved oxygen, conductivity, salinity, redox potential in the sediments, pH, sedimentation rate, depth, currents speed and turbidity. Some data loggers were used on IDM-003 to measure water temperature, dissolved oxygen and light, and the results revealed the presence of an environment conducive to the existence of woodborers.

Projects like MOSS uses specific data loggers built for particular wreck condition and capable of collecting as much data as possible from the wreck environment (Manders 2006, 2011; Gregory *et al.,* 2012). The design of an *in situ* preservation project to protect materials associated with UCH has to be accompanied, as in the case with IDM-003, with the study of surrounding environmental conditions to understand the relationship between the deterioration process and the maritime environment, including hydrodynamic variables, hydrochemical and geochemical factors, sedimentary and biological communities present in the area (Fernandez-Montblanc *et al.,* 2014). Further studies in shipwreck environments around Mozambique Island should use data loggers to gather different sorts of information on the sites' environmental conditions.

CHAPTER 7 – CONCLUSION

This dissertation set out to discuss the potential for *in situ* preservation of underwater cultural heritage at Mozambique Island by analysing the case of the *Nossa Senhora da Consolação* wreck (1608) or IDM-003, after the negative impacts on the site of the treasure hunting company AWW/PI. Besides the *in situ* preservation theme, further research was conducted to re-interpret the history of the wreck and contextualize the collection of artefacts recovered by AWW/PI (Chapter 4). The study was expecting to develop a methodology for *in situ* preservation, mitigation and monitoring for shipwrecks around Mozambique Island and contextualize the wreck of the *Nossa Senhora da Consolação* (see Chapters 3 and 4), but, some unexpected results came out of the study introducing larger perspectives and initiatives towards UCH protection and public involvement at Mozambique Island. This last chapter will describe in summary the three major aims formulated in this study, (1) to assess the extent of the site and its level of degradation using traditional methodologies; (2) to analyse the physical, biological and human threat factors contributing to the site degradation; (3) to determine the stabilization and monitoring strategies that can be used on the *Nossa Senhora da Consolação.* Furthermore, I will describe the unexpected outcomes of the study which involved the community at Mozambique Island, as well as the way forward for underwater archaeology in Mozambique.

7.1. Assessing the extent of the site and its level of degradation

The *Nossa Senhora da Consolação* (1608) wreck or IDM-003 was heavily excavated by AWW/PI and the remaining wood structure was left with no protection (see Chapter 4). Thus, since the beginning, this study was concerned with analysing the different factors causing the deterioration of the site and developing a methodology toward *in situ* preservation, mitigation and monitoring. In underwater archaeology, authors that discuss *in situ* preservation of wooden wrecks (Manders *et al.*, 2004; Gregory 2009; Gregory *et al.*, 2012) consider that there is not a defined methodology to assess deterioration factors. However, a range procedures can be followed, depending on the site environment condition. In this study, I proposed following a methodology which included the: determination of the site extent to preserve; identification of the most significant physical and biological threats to the wreck; identification of material types present on the site and their state of preservation; development of strategies to mitigate deterioration, and to stabilise and monitor the site.

To test the methodology described above, the study focused first on determining the extent of the site to conserve. Here, two survey methods were applied simultaneously. The direct measurement survey (DMS) and digital photogrammetry. Despite the wide use of both methods to record underwater sites, it was the first time they were used to observe transformations on a wreck in Mozambique. Merging both methods, I was able to obtain results that helped to produced accurate and high quality, realistic imagery of the site. This procedure was repeated over the last four years and provided different spectrums (see Appendices 3 and 4). The imagery generated from this procedure proved to be reliable and affordable, when compared to high-cost equipment (side scan or multi-beam sonar) often used to generate imagery of shipwrecks.

Analysis of the imagery generated revealed that tidal currents were causing a seasonal loss of sediments from the site. Thus, measuring tidal current speed on the site was crucial. However, I could not find or borrow an acoustic current doppler profiler (ADCP) from any Mozambican institution and purchasing one was too expensive. The ADCP is an important instrument for this sort of study as it helps determine water speed on sites and consequently the amount of sediment transported. In optimal conditions, the ADCP needs to be deployed on a site for a long period (at least 6, 12 or 24 months) to collect different seasonal data.

7.2. Analysing the physical, biological and human threat

Determining the presence of physical and biological factors that cause the deterioration of a site also requires other data logging equipment. This time, I was lucky to borrow some data loggers from the Maritime Archaeology Unit at Iziko Museums. These data loggers measured dissolved oxygen, temperature, pH and light on the *Nossa Senhora da Consolação* wreck. The data collected brought a major contribution to the study as some conditions of the seawater around the wreck are now known. The analysis of these conditions contributed to building knowledge on how these elements interact in causing either the deterioration or the preservation of the site.

Results have shown that the water conditions on the *Nossa Senhora da Consolação* wreck are favourable for woodborer development which is responsible for the deterioration of exposed wooden hull remains. Unfortunately, the field work conducted to collect these physical and biological data, could only last a month due to financial limitations. Ideally this study would require a 6 to 12 month data collection period, in order to establish the site condition in different seasons.

The methodology proposed in this study also demanded the collection of wood samples to assess the condition of the hull structure to be preserved *in situ*. But wood samples would also bring additional data on wood type and origin that were unknown. Additionally, the wood samples were important to discuss aspects related to ship construction and the identification of the wreck (see Chapter 4). The five wood samples collected at different places on the wreck suggested the presence of *shipworms* and *gribbles* that have been settling in the structure for quite a long time. Furthermore, two species of wood were identified, *Quercus sp* (Oak) and *Pinus sp* (Pine). The latter seems to present a low level of deterioration in all the samples, if compared to the former.

7.3. Determining the stabilization and monitoring strategies for the site

In order to plan better mitigation and monitoring strategies suitable for the site, it was crucial to understand the relation between different environmental and human threats for *in situ* preservation. The exposed hull of the *Nossa Senhora da Consolação* (IDM-003) requires extensive preservation work to re-establish the stability of the site. These attempts have been conducted from 2016 till the present.

Thus, intending, an experimental strategy was developed using geotextile to mitigate the deterioration rate of site. This strategy seems to be working fairly well in some parts of the wreck. However, constant monitoring using visual inspection and photogrammetry over time, will inform if this methodology can ensure long-term preservation for the site. There may be a need to perform other mitigation strategies as described in chapter 6. The study conducted in this dissertation discussed some of the basic elements that can be utilised to develop a Management Plan for the site over the next 5 years. The Plan should focus on improving institutional cooperation and better set the role of local community in the protection and preservation of the UCH at Mozambique Island.

7.4. Additional impacts of the study

In the second chapter of this dissertation, it was shown that the Mozambique Island community played a big role in fighting treasure hunting since they realized that their underwater heritage was being destroyed. The work carried out over the last four years has had incredible support from the local community at Mozambique Island. Since the beginning of the study on the *Nossa Senhora da Consolação* wreck in 2016 (with SWP support), the community has been involved and trained in SCUBA diving and some basic survey methods. Part of this training took place at the *Nossa Senhora da Consolação* due to its relatively easy access (see Chapter 3).

As a result, representatives of the Mozambique Island community presented a talk at a UNESCO meeting which took place on Mozambique Island in 2016. The meeting was intended to consult the local community on the safeguarding of UCH, within the framework of the UNESCO 2001 Convention. At the meeting, the community expressed its satisfaction at taking part in the study and addressed the need for more training to develop local skills in site protection and the sustainable of UCH. Therefore, through the SWP more training is being provided to more community members, with the aim of establishing a more ambitious and solid group of local divers who will be known as *Community Monitors.* Part of the responsibility of this group will be the monitoring of the shipwrecks around Mozambique Island, but they will also play a role in wider social, cultural and economic activities related to the heritage of Mozambique Island and its sustainability.

Figure 45. Community monitors initiative. Photo: Ricardo Duarte, 2016

The development of this study on the *Nossa Senhora da Consolação* wreck was a test case in which the *Community Monitors* idea was applied. Most of the operational team, from skippers to divers, consisted of Mozambique Island community members. The involvement of the community in this study (but also in the larger SWP) created positive feedback, not only on the island but also in the country. The work drew media attention and a local television channel approached the working team to gather more information about the importance of UCH and the involvement of the community in heritage protection. Mozambican society is still not well informed about archaeology, particularly underwater archaeology and there is still the notion that underwater lies bigger *treasure ships.* Here, media can play a role educating society through the dissemination of the results of actual work carried out by professional archaeologists.

Some of the results obtained in this study and the imagery produced from the *Nossa Senhora da Consolação* wreck were present in two exhibitions organized by the SWP. One in the *Maputo Fortress* and the other in *São Sebastião Fortress* at Mozambique Island. These exhibitions were a major step in capturing the public imagination and providing a visual experience of the underwater world for those who cannot dive and access shipwrecks.

In the academic field, the combination of the survey methods which resulted in the imagery of the *Nossa Senhora da Consolação* wreck were presented and discussed in the ICOMOS-ICAHM sub-Saharan Africa and international conference which took place in Bagamoyo in Tanzania in 2017. This conference was also a moment for regional maritime archaeologists to discuss research projects carried out in their respective countries and the need for regional collaboration. As a result of this discussion, *Maritime and Underwater Cultural Heritage Management on the Historic and Arabian Trade Routes* was recently published, to which I contributed an article resulting from the work carried out at the *Nossa Senhora da Consolação* (Mahumane 2020).

Figure 46. Exhibition and seminar presentation of the study. Photo: Cezar Mahumane 2017

7.5. Way forward

Archaeologists are always excited with the idea of identifying and investigating sites to interpret past ways of life and envision the future. Therefore, we get so focused in developing methodologies and interpretation models that can be used as milestones in present and future studies. However, as Boshoff (2018) mentioned, we often do not realize the impacts that research projects have on the public. Jopela (2010) and Macamo and Ekblom (2018) have developed a larger discussion on how important it is to include the public in archaeological research and address its impact. This study focused essentially on *in situ* preservation and on finding strategies for the preservation of the *Nossa Senhora da Consolação.* It ended up achieving the main research purposes, but it also produced considerable impacts on the Mozambique Island community.

Thus, in the field of underwater archaeology in Mozambique, this study was an initial local effort discussing a range of themes including: the impacts of treasure hunting on underwater heritage at Mozambique Island; the re-interpretation of the *Nossa Senhora da Consolação* wreck history and her artefactual collection; and the development of an *in situ* preservation methodology that can be applied to other wreck sites in Mozambique. The development of this study and its results was an important step forward in underwater archaeology in Mozambique, considering that the country still has a small community of underwater archaeologists and a long coastline rich in submerged heritage. This study proved that locally trained underwater archaeologist are able to develop and apply scientifically valid methodologies to interpret sites and, at the same time, develop strategies to encourage local community involvement. The principles behind this study should be used and improved in future projects.

Mozambique Island is particularly rich in UCH from different pre-colonial and post-colonial periods which demands further archaeological research. Essentially, the pre-colonial period of the island needs to be better investigated as it is still largely unknown. This body of knowledge will help illuminate the role played by this island before the Portuguese presence. I expect that this sort of research will have a positive impact on the local community, either through integration with research groups, the development of exhibitions with local material content, or through the development of socially and economically sustainable ways of protecting UCH. From the academic perspective, the study of Mozambique Island's pre-colonial history will also enlarge the body of knowledge of this area from the maritime archaeology perspective. Regardless the period being researched, however, underwater archaeology projects at Mozambique Island need to have strong community impacts.

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APPENDICES

Appendix 1: List of archaeological sites located and intervened by AWW/PI

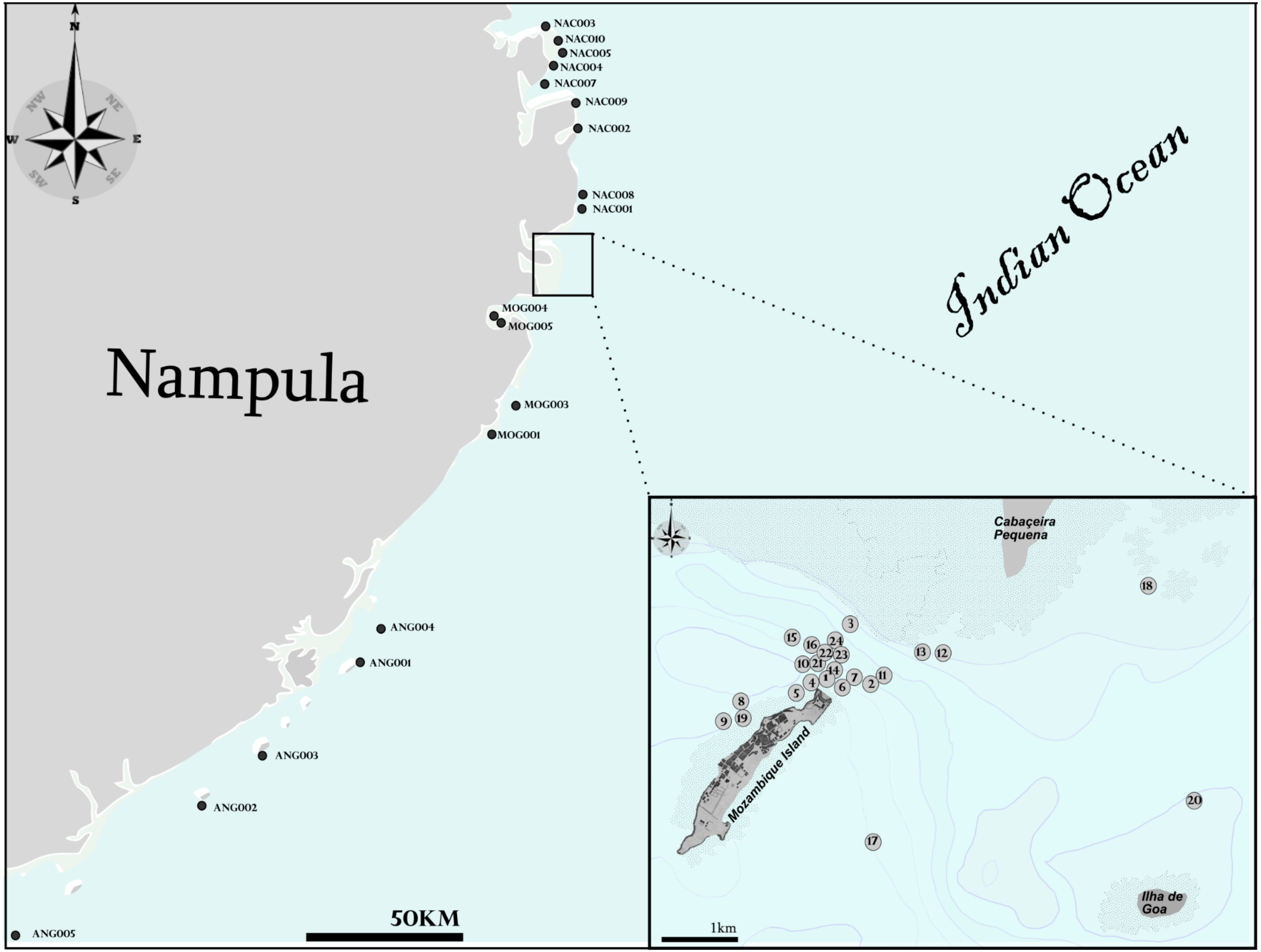
Site Code	Ship Name	Date Sunken	Date Found	Position	Description of relevant finds	Remarks
ANG-001		1900	20 September 2003	Mafamede Island	Steel wreck circa 1900s	Observation only
ANG-002	*Nossa Senhora da Guia*	1721	27 September 2003	Moma Island	1 bronze cannon, 5 anchors and 18 iron cannons. Gold and silver coins recovered	Observance and pre-disturbance survey
ANG-003		1550	01 November 2003	Caldeira Island	6 anchors, several pieces of lead, boat shaped lead ingots, copper ingots	Observation and pre-disturbance survey
ANG-004	*São António*	1512	01 November 2003	São António Shoal	2 ancient anchors and a scattering of ballast stones	Observation and pre-disturbance survey
ANG-005	*Bredenhof*	1753	17 November 2003	Silva Shoal	15 iron cannons, 5 anchors, lead rolls and ingots, iron bars, copper coins (VOC 1752)	Observation and pre-disturbance survey
CAD-001	*Nossa Senhora do Populo*	1619	11 November 2004	Vadiazi Shoal	13 iron cannons, several cannon balls, lead shot, lead sheathing and ballast stones	Observation only
IDM-001		1600	15 May 2001	Mozambique Island	Stone ballast pile in a sandy bottom, some wood structure	Observation and pre-disturbance survey
IDM-002	***Espadarte***	**1558**	**30 May 2001**	**Mozambique Island**	**2 bronze cannons, ballast stones and a cargo of Chinese porcelain recovered**	**Total excavation of defined area(s)**
IDM-003	***Nossa Senhora da Consolação***	**1608**	**03 July 2001**	**Mozambique Island**	**Stone ballast pile, lead ingots, silver coins and olive jars, large wood structure remaining**	**Total excavation of defined area(s)**
IDM-004		1600	04 July 2001	Mozambique Island	Small ballast pile and some wood remains	Observation only
IDM-005		1600	04 July 2001	Mozambique Island	Small ballast pile	Observation only
IDM-006		1600	06 July 2001	Mozambique Island	Small stones ballast pile, no other sign of wreckage	Observation only

Site Code	Ship Name	Date Sunken	Date Found	Position	Description of relevant finds	Remarks
IDM-007		**1600**	**24 February 2002**	**Mozambique Island**	**3 concentrations of ballast stones in an area of 10,000 m2, 14 kg, of gold recovered**	**Limited area excavation and detailed survey**
IDM-008		1550	30 April 2002	Mozambique Island	Small round ballast in a low flat pile	Observation and pre-disturbance survey
IDM-009		1850	30 April 2002	Mozambique Island	Clipper ship, possible from end of 18th century	Observation only
IDM-010		**1850**	**18 July 2002**	**Mozambique Island**	**20th century ship with a cargo of gin bottles, charcoal and various good**	**Total excavation of defined area(s)**
IDM-011		1850	05 September 2003	Mozambique Island	Scattered ballast. Green glass bottles (ca. end of 1700s)	Observation and pre-disturbance survey
IDM-012	*Nossa Senhora do Livramento*	1773	26 March 2004	Mozambique Island	3 groups of medium to big size ballast stones, some scattering in an area of 80x40 cm	Observation and pre-disturbance survey
IDM-013		1600	04 April 2004	Mozambique Island	Ballast stones, wood structure, olive jar fragments, lead shot, lead sheating	Observation and pre-disturbance survey
IDM-014		1600	13 April 2004	Mozambique Island	Ballast stones, wood structure, iron rudder pindle, lead sheathing	Observation and pre-disturbance survey
IDM-015		1900	29 April 2004	Mozambique Island	20th century ship, no archaeological interest	Observation only
IDM-016		1800	31 April 2004	Mozambique Island	Wood structure, 2 iron grapnels	Observation only
IDM-017	*Santa Teresa*	1622	07 Jun 2004	Mozambique Island	10 iron cannons, ballast stones, hull structure, coarse ceramic shards	Observance and pre-disturbance survey
IDM-018		1600	28 Jun 2004	Mozambique Island	5 iron cannons, ballast stones scattering	Observation only
IDM-019		1600	19 May 2007	Mozambique Island	Small anchor lying over medium size ballast stones. Covered by a 0.5 m layer of mud, sand and seashells, at a water depth of 6 m in medium tide	Observation only

Site Code	Ship Name	Date Sunken	Date Found	Position	Description of relevant finds	Remarks
IDM-020	*São Bento*	1642	20 May 2008	Mozambique Island	One large anchor, ballast stones, lead sheathing, lead shot and various pieces of iron scattered in the area. 10 silver coins recovered in reconnaissance	Observance and pre-disturbance survey
IDM-021		1750	05 August 2009	Mozambique Island	Wood structure, copper nails, bricks as ballast, no ballast stones	Observation only
IDM-022		1650	14 August 2009	Mozambique Island	Scattering of artefacts on the seabed, ballast stones. 1 silver coin. Martaban fragments, one sword	Observation only
IDM-023		1700	01 December 2012	Mozambique Island	One anchor, iron jars, ceramic, gin ceramic bottle, glass bottles, organic remains	Observation only
IDM-024		1750	04 January 2013	Mozambique Island	Wood structure with bricks, iron frames, iron ingots, copper nails	Observation only
MOG-001	*Nossa Senhora Madre de Deus e São José*	1802	09 July 2002	Mongicual Shoal	100 iron cannons, copper pins, 44 gold coins recovered during limited excavations	Observation only
MOG-002		1600	01 December 2003	Infuse Shoal	1 anchor, 1 iron cannon.	Observance and pre-disturbance survey
MOG-003	***São José***	**1622**	**01 October 2004**	**Infuse Shoal**	**4 bronze cannons, 5 iron cannons and 8 anchors. Approximately 25,000 silver coins recovered during excavation**	**Limited area excavation and detailed survey**
MOG-004		1900	07 August 2007	Lunga Bay	Steel wreck in a muddy bottom at 16 m depth, near the beach, extensively plundered, ca. 1900s	Observation only
MOG-005		1600	07 August 2007	Lunga Bay	Wide scattering of smallish ballast stones in the area of app. 300 m right on the beach. More survey needed, mainly with magnetometer	Observation only

Site Code	Ship Name	Date Sunken	Date Found	Position	Description of relevant finds	Remarks
NAC-001	*São Antônio e Almas*	1789	09 December 2003	Crusse Island	2 iron cannons and ballast stones mound	Observation and pre-disturbance survey
NAC-002	*Thert*	1622	13 October 2004	Quissimajulo Bay	Ballast stones mound. Fragments of coarse pottery and many bricks, wood structure	Observation and pre-disturbance survey
NAC-003		1600	18 October 2004	Pinda Reef	1 iron cannon, 1 anchor, ballast stones pile, fragments of martaban jars and ceramic	Observation only
NAC-004	*São João Baptista*	1826	19 October 2004	Pinda Reef	Ballast stones. Bottoms and necks of green glass bottles	Observation only
NAC-005		1600	19 October 2004	Pinda Reef	3 piles of ballast stones. Bottoms and necks of green glass bottles	Observation only
NAC-006		1600	19 October 2004	Pinda Reef	Large scattering of massive amount of ballast stones	Observation only
NAC-007		1600	20 October 2004	Pinda Reef	A ballast stones mound underneath a modern steel wreck	Observation only
NAC-008		1600	09 April 2012	Quitangonha Island	One large arrow anchor, 2 Iron cannons, scattering of ballast stones	Observation only
NAC-009	***São Miguel e Almas***	**1771**	**02 May 2012**	**Fernão Veloso**	**13 cannons, 1 anchor, Chinese Porcelain, trading beads, ballast stones**	**Observation and trial excavation**
NAC-010		1600	13 May 2012	Pinda Reef	Iron cannon, several concretion, copper handle, ballast stones.	Observation only

*Entries in bold are sites that have been excavated. Source used to collect this information were www.arq-publications.com and Duarte 2012. Below it was also illustrated the map with the location of all the sites.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Appendix 2: List of artefact collection collected by AWW/PI at IDM-003 excavation

Site code	Artefact No. given	Year collected	Description*	Present Location	Remarks
IDM-003	133.000	2001	3 boat-shaped lead ingots with marks	Unknown	Objects sold
IDM-003	2005.000	2003	Small olive jar, rounded, attached to small fragment of wood		
IDM-003	2006.000	2003	Small olive jar, rounded, with small hole in the side		
IDM-003	2007.000	2003	Fragments (6) of a martaban with rests of tar in the surface. Typically decorated	MUSIM store room	
IDM-003	2008.000	2003	Pewter jar with wide mouth and flat base, the mouth is misshaped and the handle missing		
IDM-003	2009.000	2003	Small delicated ceramic flask (crude pottery) with some decoration. Looks like Indian manufacture		
IDM-003	2012.000	2003	Medium size pendant representing a hand closed fist (Mano Fico) or ´fig-hand´. Depression in the back, possibly for a stone.	MUSIM store room	
IDM-003	2013.000	2003	Small pendant representing a hand closed as a fist (Mano Fico) or ´Fig-hand´. Rectangular base.	MUSIM store room	
IDM-003	2017.000	2003	Ceramic dispenser (for salt or pepper) with 4 reinforcing rings in the body		
IDM-003	2019.000	2003	4 bowls of ceramic, different sizes. Found as a stack, the bigger containing the smaller.		
IDM-003	2020.000	2003	Small olive jar, Tap in situ, rounded.	MUSIM store room	
IDM-003	2023.000	2003	Olive jar, small, rounded.		
IDM-003	2024.000	2003	Olive jar, small, rounded.		
IDM-003	2025.000	2003	Olive jar, small, rounded.	MUSIM store room	
IDM-003	2026.000	2003	8 silver coins in two clumps (one of 5 coins and the other with 3).	MUSIM store room	
IDM-003	15000.000	2005	Group of three animal tooth. One elephant tusk and two hippopotamus fangs.		
IDM-003	15001.000	2005	Olive jar.	MUSIM store room	
IDM-003	15002.000	2005	2 fragments necks of glass bottles. Fine glass decorated with strips.	MUSIM store room	
IDM-003	15003.000	2005	Pitcher jar, wide mouth, flat base and handle.		
IDM-003	15004.000	2005	Olive jar		

Site code	Artefact No. given	Year collected	Description*	Present Location	Remarks
IDM-003	15005.000	2005	Olive jar	MUSIM store room	
IDM-003	15005.001	2005	Elephant tusk, small		
IDM-003	15006.000	2005	Olive jar	MUSIM store room	
IDM-003	15007.000	2005	Fragment of glass bottle, transparent ornamented glass	MUSIM store room	
IDM-003	15009.000	2005	Elephant tusk		
IDM-003	15010.000	2005	Elephant tusk		
IDM-003	15011.000	2005	Pewter lid in a concretion. After cleaning seems to be part of art. No 2008		
IDM-003	15012.000	2005	Metallic object, with handles in an iron concretion	MUSIM store room	
IDM-003	15013.000	2005	Metallic solid flattened cone		
IDM-003	15014.000	2005	Intact ceramic lid depressed in the centre	MUSIM store room	
IDM-003	15015.000	2005	Broken side of an olive jar with handle	MUSIM store room	
IDM-003	15016.000	2005	Broken copper handle	MUSIM store room	
IDM-003	15017.000	2005	Neck of broken martaban with handle	MUSIM store room	
IDM-003	15018.000	2005	Clump of 4 silver coins. After treatment in the lab there were 5 eroded coins	MUSIM store room	
IDM-003	15019.000	2005	Copper jar handle	MUSIM store room	
IDM-003	15020.000	2005	Clump of silver coins. After treatment there were only 10 eroded coins. Some of them minted in Mexico, the other no recognizable mint.	MUSIM store room	
IDM-003	15021.000	2005	Copper jar handle	MUSIM store room	
IDM-003	15023.000	2005	Silver coin. After treatment in the lab there were 5 gr of washer.	MUSIM store room	
IDM-003	15024.000	2005	Black bead, ornamented with floral motifs and diagonal lines forming a rectangular frame	MUSIM store room	
IDM-003	15025.000	2005	Black bead, ornamented with floral motifs and diagonal lines forming a rectangular frame		
IDM-003	15027.000	2005	Broken glazed ceramic lid. Reconstructed in the lab	MUSIM store room	
IDM-003	15028.000	2005	Copper alloy block		

Site code	Artefact No. given	Year collected	Description*	Present Location	Remarks
IDM-003	15030.000	2005	Little clump of silver coins. After treatment in the lab there were 1 eroded coins and 2 gr of washer	MUSIM store room	
IDM-003	15032.000	2005	Silver coin in the concretion with lead	MUSIM store room	
IDM-003	15033.000	2005	Ceramic jar with handle	MUSIM store room	
IDM-003	15034.000	2005	Silver coin. After treatment in the lab there were 2 gr of washer		
IDM-003	15035.000	2005	Olive jar		
IDM-003	15036.000	2005	Olive jar		
IDM-003	15037.000	2005	Olive jar		
IDM-003	15038.000	2005	Olive jar		
IDM-003	15039.000	2005	Olive jar		
IDM-003	15040.000	2005	Olive jar	MUSIM store room	
IDM-003	15041.000	2005	Olive jar		
IDM-003	15042.000	2005	Olive jar	MUSIM store room	
IDM-003	15043.000	2005	Olive jar		
IDM-003	15044.000	2005	Olive jar		
IDM-003	15045.000	2005	Olive jar		
IDM-003	15046.000	2005	Olive jar		
IDM-003	15047.000	2005	Olive jar		
IDM-003	15048.000	2005	Olive jar	MUSIM store room	
IDM-003	15049.000	2005	Olive jar (deformed body)	MUSIM store room	
IDM-003	15050.000	2005	Olive jar (neck broken, reconstructed in the lab)	MUSIM store room	
IDM-003	15051.000	2005	Olive jar		
IDM-003	15052.000	2005	Olive jar	MUSIM store room	
IDM-003	15053.000	2005	Olive jar		
IDM-003	15054.000	2005	Olive jar, completely misshaped from the origin		
IDM-003	15055.000	2005	Lead seal depicting the Portuguese ´Esfera Amilar´	MUSIM store room	
IDM-003	15056.000	2005	Lead seal with coat of arms	MUSIM store room	
IDM-003	15057.000	2005	Olive jar	MUSIM store room	

Site code	Artefact No. given	Year collected	Description*	Present Location	Remarks
IDM-003	15058.000	2005	Silver coin. After cleaning in the lab no coins we found inside, just concretion.		
IDM-003	15059.000	2005	A copper alloy lid	MUSIM store room	
IDM-003	15060.000	2005	Lead roll. Probably modern contamination	MUSIM store room	
IDM-003	15061.000	2005	Olive jar		
IDM-003	15064.000	2005	Black bead, ornamented with floral motifs and diagonal lines forming a rectangular frame		
IDM-003	15065.000	2005	Wooden handle		
IDM-003	15066.000	2005	Metallic object (part of an ornament)	MUSIM store room	
IDM-003	15068.000	2005	Ceramic jar, neck missing	MUSIM store room	
IDM-003	15069.000	2005	Olive jar	MUSIM store room	
IDM-003	15070.000	2005	Copper alloy lid with attaching holes	MUSIM store room	
IDM-003	15071.000	2005	Olive jar	MUSIM store room	
IDM-003	15072.000	2005	Olive jar	MUSIM store room	
IDM-003	15073.000	2005	Olive jar		
IDM-003	15074.000	2005	Olive jar	MUSIM store room	
IDM-003	15075.000	2005	Round ornamented flask, stern missing		
IDM-003	15076.000	2005	Ceramic lid, apparently from an olive jar	MUSIM store room	
IDM-003	15077.000	2005	Decorated ceramic flask with handles		
IDM-003	15078.000	2005	Copper alloy sheet with rounded edges like a lid	MUSIM store room	
IDM-003	15079.000	2005	Olive jar	MUSIM store room	
IDM-003	15080.000	2005	Decorated ceramic pot in the concretion. Apparently of African manufacture	MUSIM store room	
IDM-003	15081.000	2005	Decorated ceramic jar with one handle	MUSIM store room	
IDM-003	15082.000	2005	Ceramic lid in the iron concretion with fragments of coarse ceramic	MUSIM store room	
IDM-003	15082.001	2005	Elephant tusk, small		
IDM-003	15083.000	2005	Ceramic lid, apparently from an olive jar	MUSIM store room	
IDM-003	15084.000	2005	Ceramic lid, apparently from an olive jar	MUSIM store room	

Site code	Artefact No. given	Year collected	Description*	Present Location	Remarks
IDM-003	15085.000	2005	Porcelain ewer. Kendi made of white porcelain with blue cobalt decoration under the glaze, showing a circular bulge, long straight Stern and very prominent spout,. It is decorated with a scroll of stylized lotus around the bulge as well as curled and straight leafs around the stern. The base is showing a mark depicting a white hare in front of a blue rock.	Exposed in the MUSIM exhibition	
IDM-003	15086.000	2005	Olive jar	MUSIM store room	
IDM-003	15087.000	2005	Ceramic lid, apparently from an olive jar	MUSIM store room	
IDM-003	15088.000	2005	Neck of martaban	MUSIM store room	
IDM-003	15089.000	2005	Neck of martaban	MUSIM store room	
IDM-003	15090.000	2005	4 fragments of glass bottle		
IDM-003	15091.000	2005	Intact green drinking glass		
IDM-003	15092.000	2005	Martaban jar	MUSIM store room	
IDM-003	15093.000	2005	Olive jar	MUSIM store room	
IDM-003	15094.000	2005	Metallic statue of Jesus Christ		
IDM-003	15095.000	2005	Olive jar	MUSIM store room	
IDM-003	15096.000	2005	Olive jar	MUSIM store room	
IDM-003	15097.000	2005	Metallic stopper	MUSIM store room	
IDM-003	15098.000	2005	Olive jar	MUSIM store room	
IDM-003	15099.000	2005	Copper alloy handle (as for a bucket)	MUSIM store room	
IDM-003	15100.000	2005	Copper alloy circle with attaching holes	MUSIM store room	
IDM-003	15101.000	2005	Intact plate	MUSIM store room	
IDM-003	15102.000	2005	Earthenware pot, apparently of African manufacture	MUSIM store room	
IDM-003	15103.000	2005	A pewter plate, partially cracked and concreted	MUSIM store room	
IDM-003	15103.001	2005	Ceramic lid		
IDM-003	15104.000	2005	Olive jar		
IDM-003	15105.000	2005	Olive jar	MUSIM store room	
IDM-003	15106.000	2005	Plate, or possible a frying pan	MUSIM store room	
IDM-003	15107.000	2005	Porcelain plate (Fragmented but reconstructed in the lab)		

Site code	Artefact No. given	Year collected	Description*	Present Location	Remarks
IDM-003	15108.000	2005	A set of dividers, badly corroded		
IDM-003	15109.000	2005	A copper alloy object into a concretion		
IDM-003	15110.000	2005	One hand navigation divider. Perfect condition	MUSIM store room	
IDM-003	15111.000	2005	Ceramic lid	MUSIM store room	
IDM-003	15113.000	2005	Ceramic lid	MUSIM store room	
IDM-003	15115.000	2005	Olive jar		
IDM-003	15116.000	2005	Little ceramic cup, rim broken		
IDM-003	15117.000	2005	Olive jar		
IDM-003	15118.000	2005	Olive jar		
IDM-003	15119.000	2005	Olive jar		
IDM-003	15120.000	2005	Pewter bottle tap	MUSIM store room	
IDM-003	15121.000	2005	Pewter bottle tap in a concretion		
IDM-003	15122.000	2005	Olive jar		
IDM-003	15123.000	2005	Metallic object concreted		
IDM-003	15124.000	2005	Pewter bottle tap	MUSIM store room	
IDM-003	15125.000	2005	Pewter bottle tap		
IDM-003	15126.000	2005	A piece of decorated ceramic. Floral motifs and Swastika on relieve		
IDM-003	15127.000	2005	Metal stick with wooden ball on top		
IDM-003	15128.000	2005	Copper alloy sheet with rounded edges		
IDM-003	15129.000	2005	Measurement instrument with scales in both sides, apparently to measure angular distances or arcs.	MUSIM store room	
IDM-003	15130.000	2005	Straight pattern navigation divider in perfect condition	MUSIM store room	
IDM-003	15131.000	2005	Ceramic lid with a handle on top, rim chipped	MUSIM store room	
IDM-003	15132.000	2005	Olive jar		
IDM-003	15133.000	2005	Table game piece, possible checkers		
IDM-003	15134.000	2005	Pewter hinge as for a buckle		
IDM-003	15135.000	2005	Lead seal		
IDM-003	15136.000	2005	Ceramic lid		
IDM-003	15137.000	2005	Copper alloy pins in a concretion	MUSIM store room	

Site code	Artefact No. given	Year collected	Description*	Present Location	Remarks
IDM-003	15138.000	2005	One hand navigation divider. Perfect condition		
IDM-003	15139.000	2005	Coil of wire		
IDM-003	15140.000	2005	One hand navigation divider. Perfect condition		
IDM-003	15141.000	2005	Ceramic bowl		
IDM-003	15142.000	2005	Lower section of a glazed ceramic bowl	MUSIM store room	
IDM-003	15144.000	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.001	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.002	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.003	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.004	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.005	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.006	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.007	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.008	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.009	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.010	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.011	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.012	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.013	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.014	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.015	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.016	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.017	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.018	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.019	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.020	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.021	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.022	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.023	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold

Site code	Artefact No. given	Year collected	Description*	Present Location	Remarks
IDM-003	15144.024	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.025	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.026	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.027	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.028	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.029	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.030	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.031	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.032	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.033	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.034	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.035	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15144.036	2006	A lead ingot, part of a group of 37 lead ingots found	Unknown	Objects sold
IDM-003	15145.000	2006	Small oil dispenser of blue glass	Exposed in the MUSIM exhibition	
IDM-003	15146.000	2006	A little lead seal		
IDM-003	15147.000	2006	One lead ingot, part of a group of 5 lead ingots found	Unknown	Objects sold
IDM-003	15147.001	2006	One lead ingot, part of a group of 5 lead ingots found	Unknown	Objects sold
IDM-003	15147.002	2006	One lead ingot, part of a group of 5 lead ingots found	Unknown	Objects sold
IDM-003	15147.003	2006	One lead ingot, part of a group of 5 lead ingots found	Unknown	Objects sold
IDM-003	15147.004	2006	One lead ingot, part of a group of 5 lead ingots found	Unknown	Objects sold
IDM-003	15148.000	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.001	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.002	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.003	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.004	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.005	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.006	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.007	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold

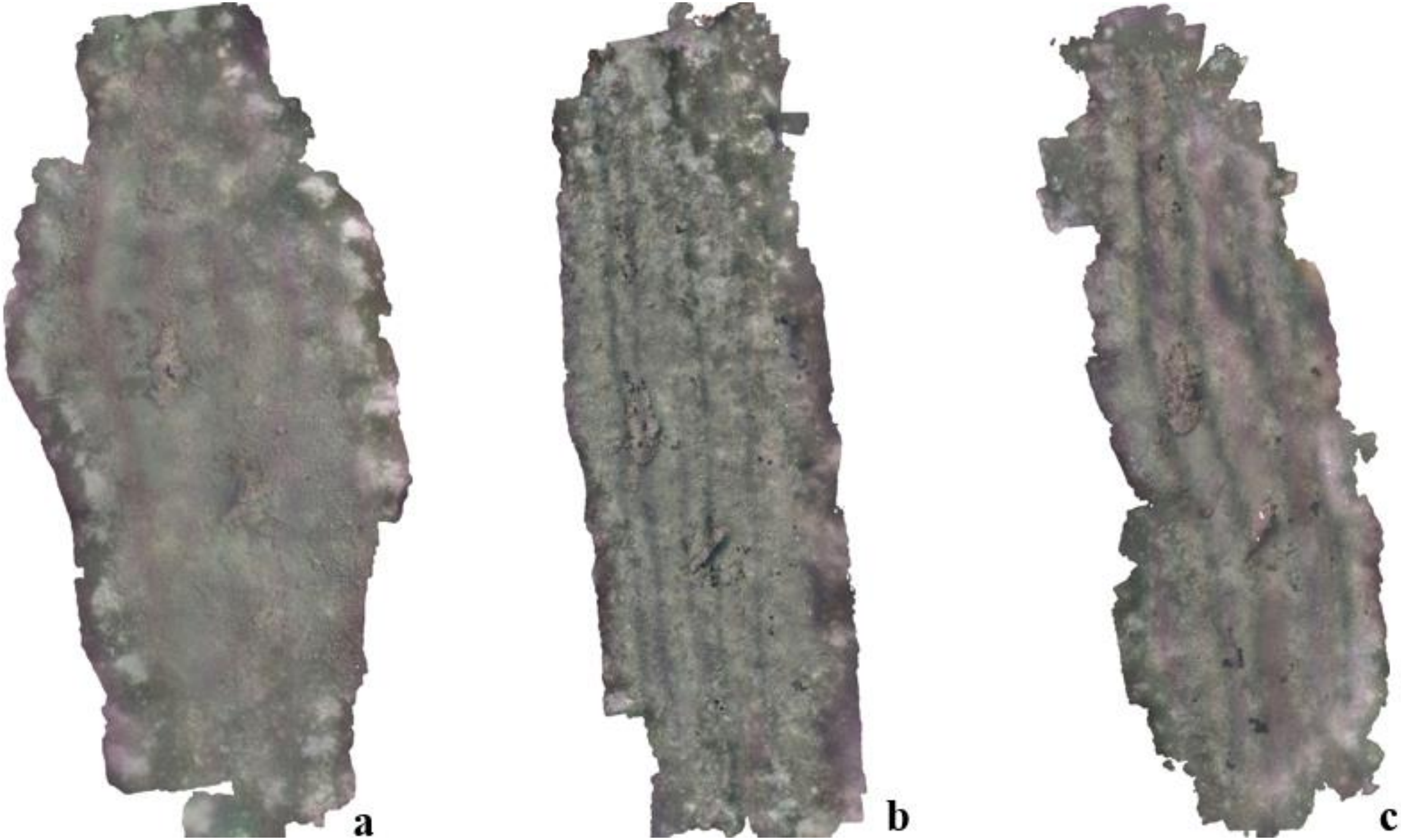
Site code	Artefact No. given	Year collected	Description*	Present Location	Remarks
IDM-003	15148.008	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.009	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.010	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.011	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.012	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.013	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.014	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.015	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.016	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.017	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.018	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.019	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.020	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.021	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.022	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.023	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.024	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.025	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.026	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.027	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.028	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.029	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.030	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.031	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.032	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15148.033	2006	One lead ingot, part of a group of 34 lead ingots found	Unknown	Objects sold
IDM-003	15149.000	2006	One lead ingot, part of a group of 11 lead ingots found	Unknown	Objects sold
IDM-003	15149.001	2006	One lead ingot, part of a group of 11 lead ingots found	Unknown	Objects sold
IDM-003	15149.002	2006	One lead ingot, part of a group of 11 lead ingots found	Unknown	Objects sold

Site code	Artefact No. given	Year collected	Description*	Present Location	Remarks
IDM-003	15149.003	2006	One lead ingot, part of a group of 11 lead ingots found	Unknown	Objects sold
IDM-003	15149.004	2006	One lead ingot, part of a group of 11 lead ingots found	Unknown	Objects sold
IDM-003	15149.005	2006	One lead ingot, part of a group of 11 lead ingots found	Unknown	Objects sold
IDM-003	15149.006	2006	One lead ingot, part of a group of 11 lead ingots found	Unknown	Objects sold
IDM-003	15149.007	2006	One lead ingot, part of a group of 11 lead ingots found	Unknown	Objects sold
IDM-003	15149.008	2006	One lead ingot, part of a group of 11 lead ingots found	Unknown	Objects sold
IDM-003	15149.009	2006	One lead ingot, part of a group of 11 lead ingots found	Unknown	Objects sold
IDM-003	15149.010	2006	One lead ingot, part of a group of 11 lead ingots found	Unknown	Objects sold
IDM-003	15150.000	2006	One lead ingot, part of a group of 18 lead ingots found	Unknown	Objects sold
IDM-003	15150.001	2006	One lead ingot, part of a group of 18 lead ingots found	Unknown	Objects sold
IDM-003	15150.002	2006	One lead ingot, part of a group of 18 lead ingots found	Unknown	Objects sold
IDM-003	15150.003	2006	One lead ingot, part of a group of 18 lead ingots found	Unknown	Objects sold
IDM-003	15150.004	2006	One lead ingot, part of a group of 18 lead ingots found	Unknown	Objects sold
IDM-003	15150.005	2006	One lead ingot, part of a group of 18 lead ingots found	Unknown	Objects sold
IDM-003	15150.006	2006	One lead ingot, part of a group of 18 lead ingots found	Unknown	Objects sold
IDM-003	15150.007	2006	One lead ingot, part of a group of 18 lead ingots found	Unknown	Objects sold
IDM-003	15150.008	2006	One lead ingot, part of a group of 18 lead ingots found	Unknown	Objects sold
IDM-003	15150.009	2006	One lead ingot, part of a group of 18 lead ingots found	Unknown	Objects sold
IDM-003	15150.010	2006	One lead ingot, part of a group of 18 lead ingots found	Unknown	Objects sold
IDM-003	15150.011	2006	One lead ingot, part of a group of 18 lead ingots found	Unknown	Objects sold
IDM-003	15150.012	2006	One lead ingot, part of a group of 18 lead ingots found	Unknown	Objects sold
IDM-003	15150.013	2006	One lead ingot, part of a group of 18 lead ingots found	Unknown	Objects sold
IDM-003	15150.014	2006	One lead ingot, part of a group of 18 lead ingots found	Unknown	Objects sold
IDM-003	15150.015	2006	One lead ingot, part of a group of 18 lead ingots found	Unknown	Objects sold
IDM-003	15150.016	2006	One lead ingot, part of a group of 18 lead ingots found	Unknown	Objects sold
IDM-003	15150.017	2006	One lead ingot, part of a group of 18 lead ingots found	Unknown	Objects sold
IDM-003	15152.000	2006	Olive jar		
IDM-003	15153.000	2006	A little piece of copper alloy, apparently part of an instrument	MUSIM store room	
IDM-003	15154.000	2006	5 copper alloy pieces, apparently part of an instrument	MUSIM store room	

Site code	Artefact No. given	Year collected	Description*	Present Location	Remarks
IDM-003	15155.000	2006	Ceramic lid	MUSIM store room	
IDM-003	15156.000	2006	12 copper alloy pieces	MUSIM store room	
IDM-003	15157.000	2006	Lead seal	MUSIM store room	
IDM-003	15158.000	2006	Lead seal	MUSIM store room	
IDM-003	15159.000	2006	Lead seal		
IDM-003	15161.000	2006	Copper alloy piece	MUSIM store room	
IDM-003	15163.000	2006	Group of 6 lead seals	MUSIM store room	
IDM-003	15164.000	2006	Lead seal	MUSIM store room	
IDM-003	15165.000	2006	4 lead seals		
IDM-003	15166.000	2006	Copper alloy wing nut		
IDM-003	15167.000	2006	Lead seal	MUSIM store room	
IDM-003	15168.000	2006	10 lead seals		
IDM-003	15169.000	2006	Ceramic lid	MUSIM store room	
IDM-003	15170.000	2006	A group of 6 lead seals		
IDM-003	15171.000	2006	2 silver coins. After treatment in the lab were only concretion		
IDM-003	15172.000	2006	A group of 6 silver coins. After treatment in the lab there were 6 eroded coins	MUSIM store room	
IDM-003	15173.000	2006	A group of 8 lead seals	MUSIM store room	
IDM-003	15174.000	2006	6 copper alloy pieces	MUSIM store room	
IDM-003	15176.000	2006	Lead seal		
IDM-003	15178.000	2006	A group of 49 elephant and hippo tusks	MUSIM store room	
IDM-003	15179.000	2006	A group of 8 silver coins. After treatment it was only concretion		
IDM-003	15180.000	2006	A group of 4 lead seals	MUSIM store room	
IDM-003	15181.000	2006	A metal piece (as an ornament)	MUSIM store room	
IDM-003	15182.000	2006	A metal piece (as part of an ornament)		
IDM-003	15183.000	2006	Lead seal		

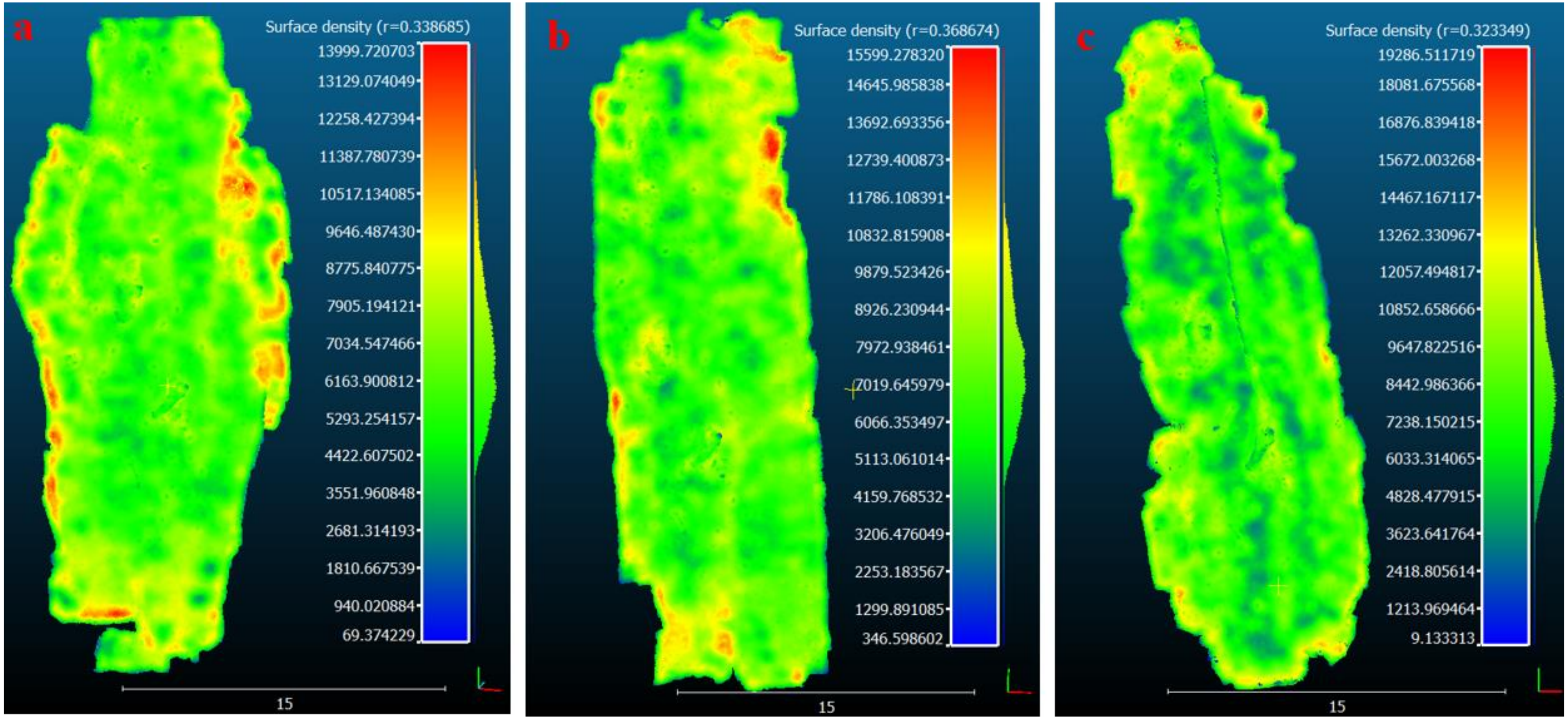
***Description followed the AWW/PI designations**

Appendix 3: photogrammetry data processed on Agisoft PhotoScan



Photogrammetry data from IDM-003, (a) 2016; (b) 2017; (c) 2019

Appendix 4: Cloud compare data



Cloud compare data showing the different stages of the IDM-003, (a) 2016; (b) 2017; (c) 2019

Appendix 5: Map of all the sampling area at IDM-003 or *Nossa Senhora da Consolação*