Republic of Mauritius
Prime Minister's Office

Department for Continental Shelf, Maritime Zones Administration & Exploration

Mauritius Underwater Cultural Heritage Project

Reconnaissance Study of the Victoire Shipwreck
Pointe aux Canonniers

25-27 July 2022

September 2022

ACKNOWLEDGEMENTS

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DISCLAIMER

CITATION

Manfio[1] S., von Arnim[2] Y., Runghen[3] H., Motah[3] B. A., Bhunjun[3] D., and Mamode[3] S. (2022). Reconnaissance Study of the Victoire Shipwreck, Pointe aux Canonniers. Mauritius Underwater Cultural Heritage Project. Department for Continental Shelf, Maritime Zones Administration & Exploration. Report, September 2022, pp 37.

[1] Stanford University

[2] Mauritius Marine Conservation Society

[3] Department for Continental Shelf, Maritime Zones Administration & Exploration

COVER PHOTO

Reconnaissance study of *Victoire* Shipwreck (Date 25 July 2022), Hugues Vitry, MSDA

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ACRONYMS

CTD	Conductivity, Temperature, and Depth
CSMZAE	Department for Continental Shelf, Maritime Zones Administration & Exploration
DEM	Digital Elevation Model
DGPS	Differential Global Positioning System
DSM	Direct Survey Measurement
EEZ	Exclusive Economic Zone
GIS	Geographical Information System
GPS	Global Positioning System
IHO	International Hydrographic Organization
MHS	Mauritius Hydrographic Service
MMCS	Mauritius Marine Conservation Society
MSDA	Mauritius Scuba Diving Association
MUCH	Mauritius Underwater Cultural Heritage
NAM	National Archives of Mauritius
NCG	National Coast Guard
NGO	Non-Governmental Organisation
RDO/SRDO	Research Development Officer / Senior Research Development Officer
RMSE	Root Mean Square Error
ROV	Remotely Operated Vehicle
SBES	Single-beam Echo Sounder
SDG	Sustainable Development Goal
UCH	Underwater Cultural Heritage
UN	United Nations
WGS84	World Geodetic System 1984

About the Department for Continental Shelf, Maritime zones Administration & Exploration (CSMZAE)

The Department for Continental Shelf, Maritime Zones Administration & Exploration operates under the *aegis* of the Prime Minister's Office (Rodrigues, Outer Islands and Territorial Integrity). Its mission is primarily to ensure the effective management of the maritime zones of the Republic of Mauritius and to delineate and establish its maritime zones in accordance with international laws and conventions. The CSMZAE is responsible for the formulation of policies in ocean affairs and for the establishment of legal and regulatory frameworks governing the sustainable management of the non-living resources in the maritime zones.

Its main objectives are, *inter alia*, to ensure orderly, safe and rational management of non-living ocean resources including the seabed area and the underlying sub-soil; ascertain sovereign rights for the purpose of exploring and exploiting our non-living ocean resources; carry out the delimitation of our maritime boundary as provided for, under international conventions; develop regulatory and operational framework to enable exploration and exploitation activities in our maritime zones and oversee upstream activities of any petroleum sector; rationalise and harmonise all ocean-resources related matters; regulate marine scientific research; and contribute to energy security and maritime safety. CSMZAE also has the responsibility of preparing the submissions for Extended Continental Shelf and a Marine Spatial Plan for the Republic of Mauritius.

In December 2016, the Government of the Republic of Mauritius agreed for CSMZAE to elaborate a Marine Spatial Plan for the Exclusive Economic Zone (EEZ) of the Republic of Mauritius in view of the increasing demand for marine space in the EEZ for various purposes, particularly, fisheries and aquaculture, tourism, and leisure. The main purpose of marine spatial planning is to identify the utilisation of marine space for different sea uses in accordance with national policies and legislation, while taking into consideration the preservation, protection, and improvement of marine environment, including resilience to climate change impacts. It will also contribute to the effective management of marine activities and the sustainable use of marine and coastal resources through the creation of a framework for consistent, transparent, sustainable, and evidence-based decision making. The elaboration of the Marine Spatial Plan is in line with the implementation of the 2030 UN Agenda for Sustainable Development and the Sustainable Development Goals (SDGs).

For more information see:

https://csmzae.govmu.org/SitePages/Index.aspx

INTRODUCTION

In line with the activities of the Memorandum of Understanding (MoU) between the Department for Continental Shelf, Maritime Zones Administration & Exploration (CSMZAE), and the Board of Trustees of the Leland Stanford Junior University (Stanford University), a reconnaissance study of the *Victoire* shipwreck at Pointe aux Canonniers was carried out from 25 to 27 July 2022.

This report gives a description of the activities carried out within the context of the reconnaissance study and includes the bathymetry survey which was conducted on 14 and 15 July 2022 by the Mauritius Hydrographic Service (MHS) and results from historical research carried out at the National Archives of Mauritius (NAM). The report concludes with recommendations made during a debriefing meeting organized on 05 August 2022 on future works on the *Victoire* shipwreck and activities to enhance research/surveys within the context of the Mauritius Underwater Cultural Heritage (MUCH) Project.

Background

The "Mauritius Underwater Cultural Heritage Project" (MUCH Project) was initiated by CSMZAE in response to the need for identification, preservation, protection, and awareness of underwater cultural heritage (UCH) in the maritime zones of the Republic of Mauritius. The project has as main objectives: (a) to provide capacity building in UCH; (b) to identify and document the marine archaeological resources in the maritime zones of Mauritius on a GIS platform; (c) to ensure the integrity of the UCH identified through management plans; (d) to investigate means to develop a sustainable UCH tourism; and (e) to create awareness on marine archaeological resources. Similar training programs have been carried out on UCH in March 2019[1] and November 2021[2].

The wreck site of the *Victoire* is located in shallow waters and was thus an ideal site to develop local capacity through training in maritime archaeology methods. The study complemented previous training programs carried out under the *aegis* of the MUCH project and provided additional technical expertise and confidence to relevant stakeholders to undertake studies of shipwrecks.

Aim and Objectives

The aim of the reconnaissance study was to enhance the capacity of local stakeholders in the documentation of UCH. The main objectives of the reconnaissance study were to use non-intrusive techniques to:

(i) Undertake capacity building exercises using geophysical techniques and underwater operations to study UCH;

(ii) Produce a structured record of field observations on and around the wreck site of the *Victoire*; and

(iii) Describe the natural environment surrounding the *Victoire* shipwreck.

With a length of approximately 80 m and a width of 50 m, the study area included the *Victoire* shipwreck and its immediate surroundings (Table 1 and Figure 1). The reconnaissance study used non-intrusive techniques to survey the extent of the shipwreck, identifying the visible physical remains, and state of the wreck site. During this non-intrusive study, the team used marine geophysical techniques (bathymetry) and carried underwater documentation using a Remotely Operated Vehicle (ROV) and through diving operations (three-dimensional (3-D) trilateration and photogrammetry). Geospatial information collected during the study have been compiled on a Geographical Information System (GIS) and uploaded on the Mauritius Ocean Observatory E-platform, an online geospatial database. A bathymetric surface model of the wreck site was produced using data collected by the Mauritius Hydrographic Service (MHS). The analysis of the information will be used to determine the state of the wreck and its

[1] CSMZAE (2019). The Shipwreck of HMS Sirius. Geophysical Survey – Phase I, 6-7 March 2019. Mauritius Underwater Cultural Heritage, Department for Continental Shelf, Maritime Zones Administration & Exploration. Report, pp. 53.

[2] CSMZAE (2021). Training workshop on 'Underwater Cultural Heritage – Database of Shipwrecks and Underwater Survey', 24-26 November 2021. Mauritius Underwater Cultural Heritage, Department for Continental Shelf, Maritime Zones Administration & Exploration. Report, pp. 27.

surrounding natural environment. The reconnaissance study will also guide the conduct of further investigations in the designated area.

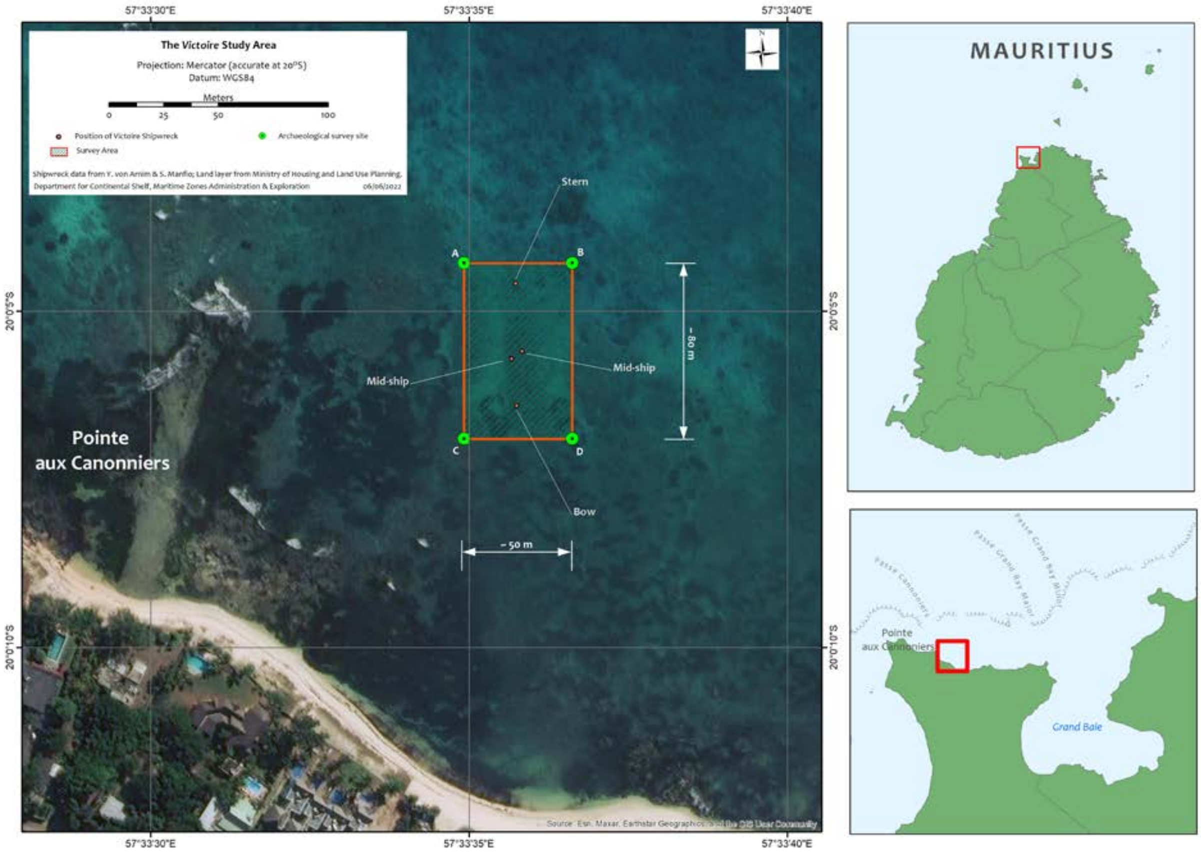

Figure 1: Location of the *Victoire* shipwreck at Pointe aux Canonniers

Table 1: List of the points (in WGS84) delimiting the study area for the wreck site of the *Victoire*

Description	Latitude	Longitude
Stern	20° 00'4.59"S	57°33'35.73"E
Bow	20° 00'6.41"S	57°33'35.75"E
Mid-ship (West)	20° 00'5.71"S	57°33'35.67"E
Mid-ship (East)	20° 00'5.60"S	57°33'35.83"E
A	20° 00'4.29"S	57°33'34.92"E
B	20° 00'4.29"S	57°33'36.62"E
C	20° 00'6.90"S	57°33'34.92"E
D	20° 00'6.90"S	57°33'36.62"E

Historical Background

The *Victoire* was a 220-tonnage French ship. In 1804, Captain Jacques Genève[3] led the *Victoire* on its last voyage from Madagascar to Port Louis. Its cargo consisted of enslaved people from Madagascar, gunpowder, and glassware along with cattle and rice. Chased by the British ships HMS *Tremendous*, HMS *Phaeton* and HMS *Terpsichore*, the ship hit the reef at Pointe aux Canonniers and lost its rudder. Unable to navigate, the ship was finally stranded inside the reef, near the artillery battery of Pointe aux Canonniers. The crew disembarked the enslaved people and threw the cattle overboard so they could reach the mainland. As a heavily armed longboat with British sailors approached the *Victoire*, Captain Genève set fire to both ends of the ship. Soon after the entire crew had reached the shore, the stern of the *Victoire* exploded, killing several British sailors[4].

Discovery and Previous Studies

The *Victoire* was discovered by a scientific team of the Mauritius Marine Conservation Society (MMCS) in 1988. Initially, the site was identified as the *Meduse* shipwreck (1733), but further archival studies and findings have confirmed the wreck to be the *Victoire*.

Preliminary archaeological studies were conducted in April-December 1988 and February 1991 by the MMCS. The studies revealed elements of the hull such as pieces of wood, some iron fittings, copper bolt, copper sheathing nails and copper sheathing, while from the cargo emerged various fragments of glassware. Samples of artefacts recovered during these studies were showcased in the permanent exhibition on glassware from Mauritian shipwrecks at the Mauritius Glass Gallery.

Archival Research

In July 2022, archival research on the *Victoire* and its wreckage in 1804 was carried out at the NAM to compile information on the historical background of the ship and its cargo.

The consulted documents were in group *G* (Gouvernement Imperial, 1766-1825), group *I* (Slavery) and *Les Petites Affiches de l'Isle de France* as classified by the NAM. Relevant documents were in the folders:

- GB 40: *Amirauté (Tribunal de Première Instance) Registre des déclarations d'arrivées et autres*; and
- GB 75: *Bureau du Port États des vaisseaux entrés et sortis*.

Based on the research, the *Victoire* arrived in Mauritius on 11 November 1803[5] from Lorient, captained by Lamy. The *Victoire* then started trading in the Indian Ocean by making voyages to Madagascar under Captain Jacques Genève[6].

The *Victoire* left Mauritius on 12 July 1804 for the island of Madagascar and arrived in Tamatave on the twenty-seventh day of the same month. Goods, such as enslaved people, heifers, bullocks and rice, were loaded on the ship on behalf of various consignees. On 1 August 1804, the *Victoire* left the port to return to Mauritius.

The course of the incident is documented under the *Déclaration du sinistre du navire La Victoire du Capitaine Genève*[7] of 30 August 1804. The exact date of the sinking is not certain, as the date reported is that of the minutes. However, Captain Genève claimed that it took longer than usual to return to Mauritius due to unfavourable winds and that he did not report the incident immediately as he had to execute higher orders. It could therefore be assumed that the incident occurred in the second half of August 1804.

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[3] Baron d'Unienville (1838) Statistique de l'île Maurice et ses dépendances, Tome 2, p262-263; Adrien d'Epinay (1890) Renseignements pour servir à l'histoire de l'île de France jusqu'à l'année 1810, inclusivement p487; Pitot (1899) L'île de France. Esquisses Historiques 1715-1810, p262

[4] National Archives of Mauritius, GB40 Fol30 No 51 & GB40 Fol32 No 53

[5] National Archives of Mauritius, GB75 p19 I006 & GB40 Fol13 No10.

[6] National Archives of Mauritius, GB75 p49 I004.

[7] National Archives of Mauritius, GB40 Fol30 No 51.

Further archival research is envisaged (e.g., in archives of France) to better understand:

- What kind of ship was the *Victoire*? (Period/Year of creation/building)
- Why the *Victoire* was transporting numerous glassware?
- Whether the *Victoire* had already sailed to Mauritius with a different name (Toussaint[8] reported the ship as *Ile de France*)?

Figure 2: Deployment during the reconnaissance study

[8] Toussaint, A. (1967). La Route des îles: Contribution à l'histoire maritime des Mascareignes, p298.

Planning

The study included bathymetry mapping of the wreck site with a single-beam echo sounder (SBES) on the 14 and 15 July 2022 and diving operations from 25 to 27 July 2022 to provide underwater survey training on setting markers for geographical positions, measurement techniques (trilateration), and photogrammetry survey. The training also included the use of a Remotely Operated Vehicle (ROV) to visualise the wreck site. The planning for the reconnaissance study is listed in Table 2. The equipment used during the study are listed in Table 3, Table 4 and Table 5.

Table 2: Planning for the study of the *Victoire* wreck site.

14 & 15 July 2022	
Geophysical Techniques Bathymetry mapping of wreck site	
DAY 1 - 25 July 2022	
1030 - 1200	Team 1 & 2 • Examination of site • Site documentation – photos & videos • Setting markers
1300 - 1500	Team 3 & 4 • Examination of site • Site documentation – photos & videos • Setting markers
DAY 2 - 26 July 2022	
1030 - 1100	Team 1 - Remotely Operated Vehicle • Examination of site • Site documentation – photos & videos
1100 - 1200	Team 2 • Measurements - trilateration
1300 - 1500	Team 3 & 4 • Measurements - trilateration
DAY 3 - 27 July 2022	
1030 - 1200	Team 1 - 4 • Photogrammetry & Trilateration • Closing of site

Table 3: Equipment for the trilateration technique

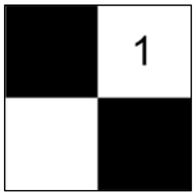
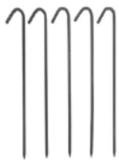
Quantity	Items	Details
3	Diving slate to report the measurements underwater	
3	Graphite pencil for writing on diving slate	
2	Long fiberglass tape	
2	Mesh dive bag	
13	Markers with numbers (Size 10 cm x 10 cm) Marker pegs	 
	Dive computer to record estimates of artefacts depths	

Table 4: Equipment for underwater documentation / photogrammetry technique

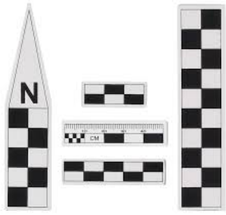
Quantity	Items	Details
2	Scale (yellow and black)	 
2	Underwater Camera	
1	ROV	

Table 5: Demarcation of wreck site

Quantity	Items	Details
1	Hand held GPS	
2	Buoys + Ropes	
1	Inflatable buoy	delimitation / geographical position using GPS

PARTICIPANTS

The reconnaissance study gathered participants from the MHS, the Mauritius Scuba Diving Association (MSDA), the National Coast Guard (NCG), the National Heritage Fund (NHF), Reef Conservation, and CSMZAE (**Figure 3**). **Table 6** provides a list of participants during the reconnaissance study, including those actively involved in planning and discussions following the study.

Table 6: List of participants

Name	Position/Designation	Ministry/Organisation
Commander Praveen Thomas	Officer-in-Charge	MHS
Mr D Madhow	Principal Surveyor	MHS
Mr R Ansari	MCPO II (HY)	MHS
Mr R. Kumar	MCPO II (HY)	MHS
Mr S. Seeboruth	Surveyor	MHS
Mr H. Vitry	President of Technical Committee	MSDA
Insp O. Pokhot	Inspector of Police - NCG Commando	NCG
PC 1797 Nursimloo	Diving Instructor - NCG Commando	NCG
PC 28 Adebiro	Diver - NCG Commando	NCG
PC 9088 Bothe	Diver - NCG Commando	NCG
PC 908 Elise	Diver - NCG Commando	NCG
PC 9889 Habib Moussa	Diver - NCG Commando	NCG
PC 10729 Mudhoo	Diver - NCG Commando	NCG
PC 2888 Nahanoo	Diver - NCG Commando	NCG
PC 10273 Ramessur	Diver - NCG Commando	NCG
PC 6765 Sonoo	Diver - NCG Commando	NCG
PC 11268 Beeharry	NCG Trou aux Biches	NCG
PC 10502 Tegally	NCG Trou aux Biches	NCG
PC 8894 Aldin	NCG Grand Bay	NCG
PC 2211 Taucoory	NCG Grand Bay	NCG
PC 6972 Gunga	NCG Grand Bay	NCG
PC 8686 Beeharry	NCG Grand Bay	NCG
Mr S. Dowlutrao	Officer-in-charge	NHF
Mrs J. Mungur-Medhi	Manager Technical Section	NHF
Dr O. Pasnin	Senior Research Coordinator	Reef Conservation
Dr R. Badal	Director General	CSMZAE
Dr D. Bissessur	Director, Physical Oceanography/ Marine Geoscience Unit	CSMZAE
Dr H. Runghen	Director, Ocean Mapping/ Marine Information System Unit	CSMZAE
Dr B. A. Motah	Director, Hydrocarbon/Mineral Production Unit	CSMZAE

Name	Position/Designation	Ministry/Organisation
Ms S. Mamode	RDO/SRDO	CSMZAE
Mr D. Bhunjun	RDO/SRDO	CSMZAE
Mr K. Sauba	RDO/SRDO	CSMZAE
Ms P. Coopen	RDO/SRDO	CSMZAE
Ms Y.Oozeeraully	RDO/SRDO	CSMZAE
Ms N. Leelodharry	RDO/SRDO	CSMZAE
Ms S. Munnaroo	RDO/SRDO	CSMZAE

Trainers

The training workshop was facilitated by trainers from Stanford University and MMCS, namely:

1. Dr Krish Seetah, Professor, Stanford University
   Email: kseetah@stanford.edu

Dr Krish Seetah is an environmental archaeologist with a particular focus on the period of European expansion. He has a background in biology, health and ecology, with a research emphasis on colonization and colonialism. He has directed the Mauritian Archaeology and Cultural Heritage Project since 2008. This project seeks to gather scientific data on human impacts in the Indian Ocean; the transition from slavery to indentured labour following abolition, the extent and diversity of trade in the region, and the environmental consequences of intensive monocrop agriculture. His work has been funded by international grants from the British Council, British Academy, Australian National University and Slovenian Research Agency. A recent grant from the National Geographic Society has supported ongoing research on the impressive maritime heritage of Mauritius. He is a member of the Joint Working Group set up under the framework of the MoU between CSMZAE and Stanford University.

2. Ms Stefania Manfio, Maritime Archaeology, Stanford University
   Email: smanfio@stanford.edu

Ms Stefania Manfio is a Maritime Archaeologist and current PhD candidate in the Department of Anthropology, Stanford University. She completed her Bachelor's and Master's degrees at the University of Ca' Foscari, Venice. During her training in maritime and underwater archaeology, she had the opportunity to participate in numerous underwater excavations, in Veneto, Sicily, Pugila, Calabria, and Croatia. She has also worked with an industry partner allowing her to learn new 3D visualizations, based on gaming technology, as a tool for the valorisation and dissemination of maritime heritage. She is a member of the Joint Working Group set up under the framework of the MoU between CSMZAE and Stanford University.

3. Mr Yann von Arnim, Underwater Archaeology, MMCS
   Email: arnim@intnet.mu

Mr Yann von Arnim is a professional diver with vast experience on shipwrecks in the maritime zones of Mauritius. He has managed several underwater archaeological surveys of shipwrecks including the slave ship "*Le Coureur*" and the British frigate "*Sirius*". He has published a number of articles regarding shipwrecks around Mauritius and he is currently working on a shipwreck database. He has an MSc in Oceanography and an MASc in Coastal Resources Management with expertise in marine biodiversity and aquaculture. Mr von Arnim is the President of the Mauritius Historical Society, Vice-President of the Mauritius Marine Conservation Society and a co-opted member of the Project Steering Committee of the Mauritius Museums Council. He is also a member of the technical Coordinating Committee working on the Mauritius Underwater Cultural Heritage (MUCH) project and the Joint Working Group set up under the framework of the MoU between CSMZAE and Stanford University.

Figure 3: Participants during the reconnaissance study.

BATHYMETRY MAPPING

Bathymetry provides an overview of the depth and seafloor topography of the immediate area of the wreck site. This section describes the hydrographic survey and processing carried out by the MHS to acquire bathymetric data in the study area and the GIS processing used to produce a bathymetric surface model to characterise the depth of the wreck site.

Bathymetry Data Acquisition

MHS Survey 2022

On 14 and 15 July 2022, the MHS carried out a hydrographic survey (MHS Survey 2022) to ascertain the bathymetry of the *Victoire* wreck site (**Figure 1**). The survey was carried out at a scale of 1:1000 as per Order-1b in accordance with International Hydrographic Organisation (IHO) standards for hydrographic Surveys[9]. A detailed description of the survey and associated processing is provided in a separate report[10] produced by MHS.

The survey was carried out using a boat-mounted single-beam echo-sounder (SBES) linked to a differential global positioning system (DGPS). Bathymetric depths were measured using an Atlas Deso 30 SBES with a 210 kHz frequency and the position during the survey was obtained using a Hemisphere R-330 DGPS configured to receive Atlas correction signals via L-Band satellites. In order to minimize error resulting from offsets, the GPS antenna and the echo sounder transducer were mounted in-line vertically. Sound velocity in the survey area was observed using a CTD48M Sound Velocity Probe and applied during post processing. **Figure 4** shows some photos taken during data collection.

HYPACK 2019 software was used to plan the survey lines and log the raw bathymetry data. Processing was carried out using CARIS HIPS version 11.3.17. Tidal corrections were applied to reduce the bathymetry data to chart datum. Sounding errors due to varying density gradients in the water column were corrected using the observed sound velocity measurements[11]. Automatic and manual quality control ensured that any systematic and random errors in the data were removed. Approximately 1 M of sounding was acquired during the survey which consisted of 5716 depth soundings ranging between -0.99 m and -4.12 m (soundings of green colour in **Figure 5(a)**). Soundings outside the delimited wreck site were retained to create the bathymetric surface model.

Horizontal accuracy better than 5m + 5 % of depth has been achieved in accordance with IHO S-44 (6th edition). The Posterior vertical uncertainty is well within Order-1b of S-44 IHO Standards for Hydrographic Surveys[9].

Archive Data - MHS Survey 2017

Additional bathymetry data archived by the MHS was retrieved for the region of interest. Between 18 July 2016 and 19 May 2017, the MHS carried out Phase III of the project Survey of Navigable Passes[12] which included the survey of Grand Major Pass at Pointe aux Canonniers (MHS Survey 2017). The aim of the survey was to delineate passes, to delineate safe waters for vessels operating in these waters and to update existing charts with latest data. The survey area of Grand Major Pass coincides with the *Victoire* wreck site (soundings of yellow colour in **Figure 5(a)**).

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[9] IHO (2020). Standards for Hydrographic Surveys; Publication S-44. 6th ed., Monaco, International Hydrographic Organization, pp 51. Online: https://iho.int/uploads/user/pubs/standards/s-44/S-44_Edition_6.0.0_EN.pdf [Accessed: 29/08/2022]

[10] Mauritius Hydrographic Service (2022). Bathymetric survey of shipwreck area at Pointe aux Canonniers from 14 - 15 July 2022. Report, Mauritius Hydrographic Service, Ministry of Housing and Land Use Planning, pp 26.

[11] IHO (2005). Manual on Hydrography; Publication C-13, 1st ed., Monaco, IHO International Hydrographic Organization, pp 548. Online: https://iho.int/uploads/user/pubs/cb/c-13/english/C-13_Chapter_1_and_contents.pdf [Accessed: 29/08/2022]

[12] Mauritius Hydrographic Service (2021). Compendium of the Survey of Navigable Passes. Report, Mauritius Hydrographic Service, Ministry of Housing and Land Use Planning, pp 41.

Depth measurements for the survey were collected using SBESs RESON's NaviSound 215 sounder and the Precision Depth Recorder (PDR) 601 while accurate positioning was ensured using a DGPS Hemisphere R-131 with Satellite Based Augmentation System (SBAS) Mode. The survey was carried out at a scale of 1:5000 as per Order-1b (SP-55) in accordance with IHO Standards for Hydrographic Surveys. All soundings were reduced to chart datum.

Figure 4: (a) Setting up the SBES transducer; (b) the GPS antenna and SBES transducer mounted in-line vertically; (c) the SBES logging system; (d) Casting CTD to observe the Sound Velocity Profile.

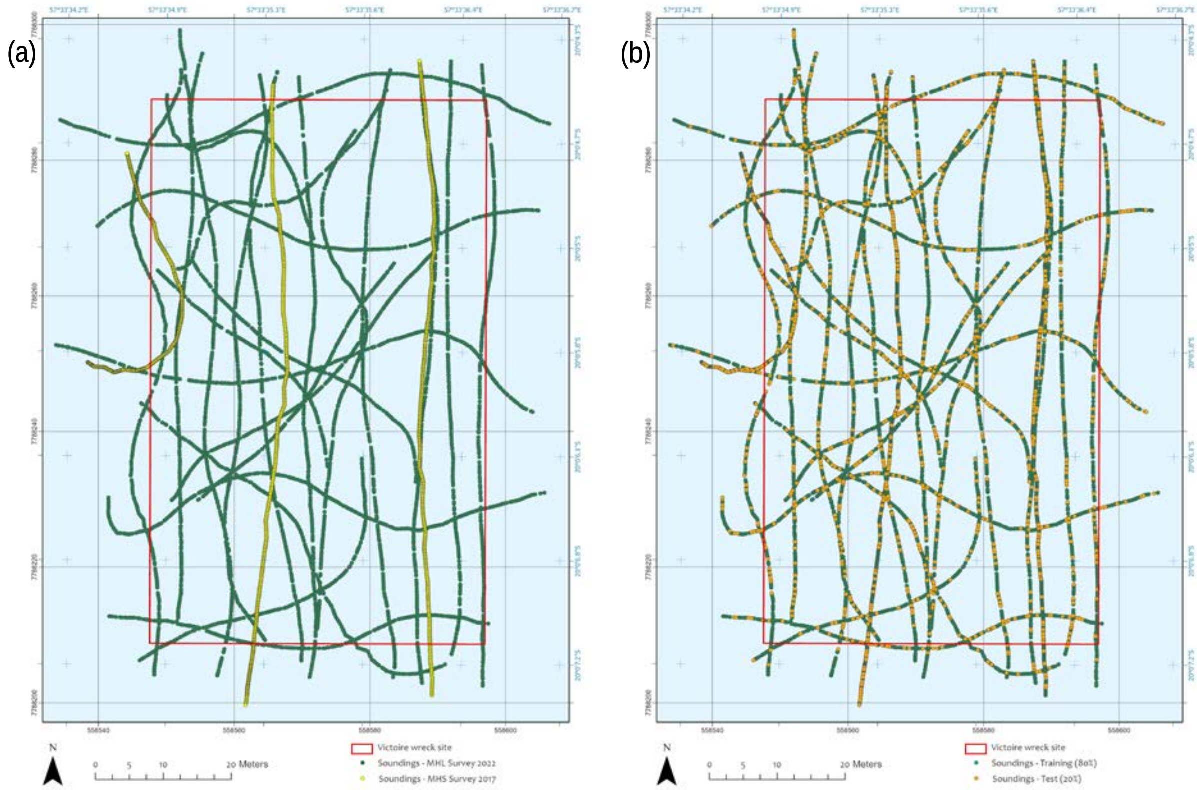


Figure 5: (a) Soundings from MHS survey 2017 (yellow) and 2022 (green); (b) Training (green) and Test (yellow) dataset.

Table 7: Statistics of bathymetry data within the *Victoire* wreck site

Data	Count	Min (m)	Max (m)	Mean (m)
MHS Survey 2017	1,737	-3.72	-1.74	-2.81
MHS Survey 2022	5,716	-4.12	-0.99	-2.93
Training Data (80%)	5,962	-4.12	-0.99	-2.90
Test Data (20%)	1,491	-4.11	-1.14	-2.91

Bathymetric Surface Model

A bathymetric surface model is "a digital elevation model which represents the seafloor in a regular grid structure"[13]. Soundings from MHS surveys of 2017 and 2022 located within the *Victoire* wreck site were used to produce a bathymetric surface model.

The Geographical Information System (GIS) software ArcGIS Pro version 2.8 was used to process the corrected bathymetric data points to the bathymetric surface model. The soundings were converted to point shapefiles and randomly split[14] into two subsets: Training (80%) and Test (20%) (**Figure 5(b)**). **Table 7** contains some statistics of the sounding datasets.

[13] IHO (2005). Bathymetric surface product specification; Publication S-102, 2.10 ed., Monaco, IHO International Hydrographic Organization, pp 89. Online: https://iho.int/uploads/user/Services%20and%20Standards/HSSC/HSSC14/HSSC14_2022_05.1D_Rev1_S102_PS_draft_2_1_0_clean_PrimarEdits_6May2022.pdf]

[14] Amante C. J. and Eakins B. W. (2016). Accuracy of Interpolated Bathymetry in Digital Elevation Models. Journal of Coastal Research 76 (sp1), 123-133, https://doi.org/10.2112/SI76-011.

The training dataset was gridded using the ordinary kriging interpolation technique available in the Spatial Analyst Tools extension.

The output cell size for the bathymetric surface model was taken as 0.2 m to fit[15] a map of scale 1:400. The test dataset was then used to evaluate the accuracy of the bathymetric surface model by calculating the root mean square error (RMSE) (Equation (1)).

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(Z_i - Z(x)_i)^2} \quad (1)$$

where n is the number of soundings in the test dataset, Z_i is the observed sounding value at point i and $Z(x_i)$ is the corresponding estimated value by using the ordinary kriging interpolation at the same point.

The resulting bathymetric surface model has a low RMSE value of 0.0795 m. Figure 6 and Figure 7 show the interpolated surface model in 3D and 2D respectively.

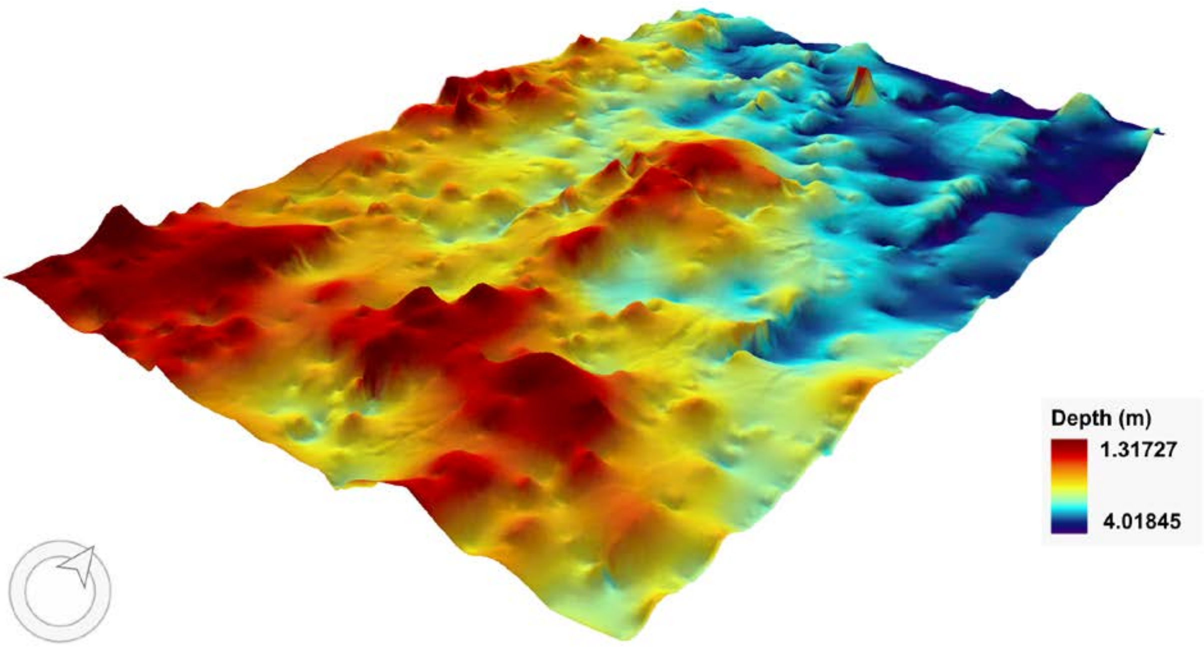


Figure 6: 3D representation of the bathymetric surface model.

The Bathymetry grid surface model will be uploaded on the Mauritius Ocean Observatory E-platform[16].

[15] Tobler, W. (1987). Measuring Spatial Resolution. Proceedings, Land Resources Information Systems Conference, Beijing, pp. 12-16.

[16] Access the Mauritius Ocean Observatory E-platform using the link: http://gococeanobservatory.govmu.org/ [Accessed 15 September 2022]

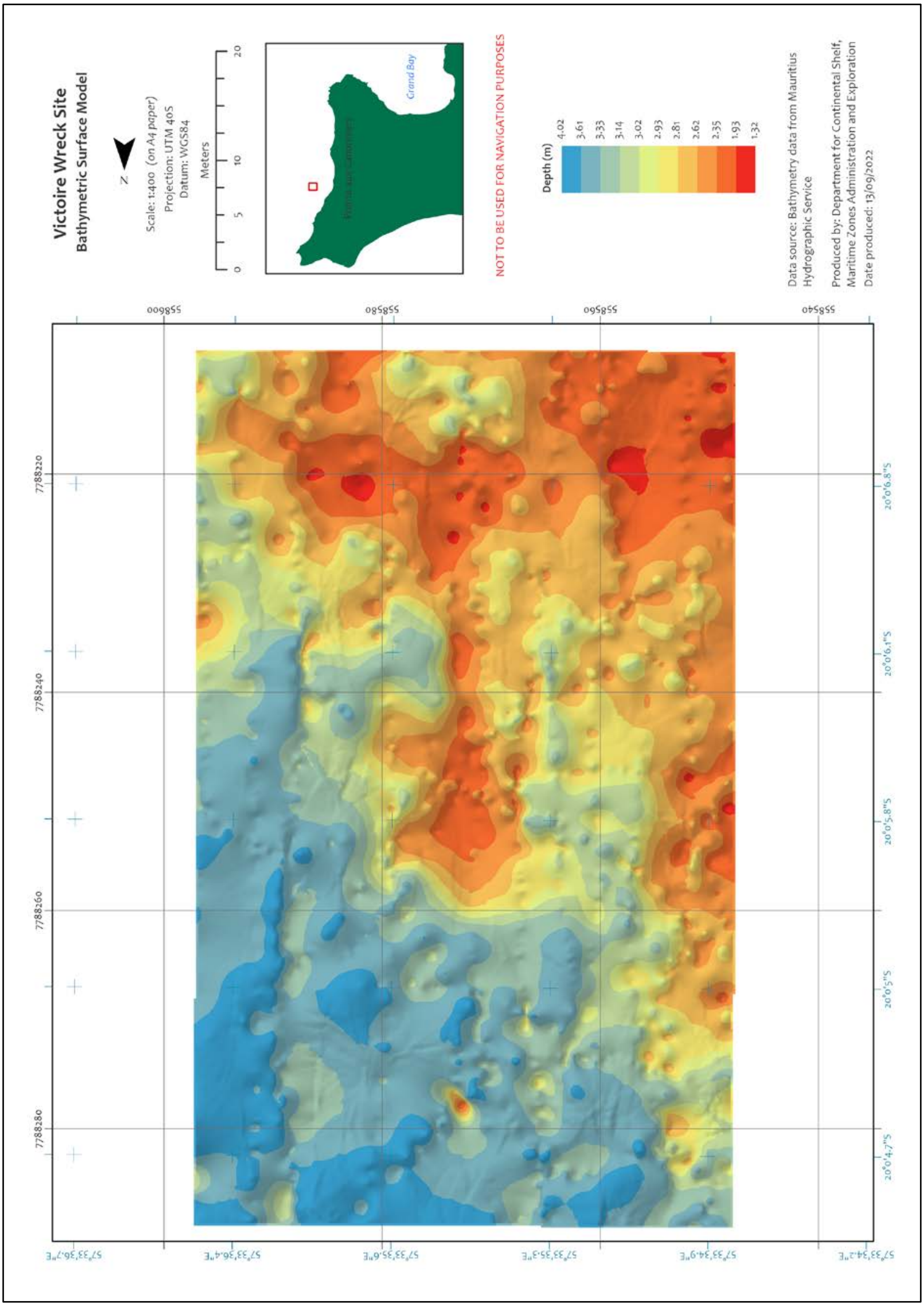


Figure 7: Bathymetric Surface model using ordinary kriging interpolation technique.

TRILATERATION

Three-dimensional (3-D) trilateration[17] (or DSM 'direct survey measurement' (Figure 10)) uses direct distance and depth measurements to position features on a site. Three-dimensional trilateration requires a network of control points to be established around and inside the site. Once this network of points has been fixed, the measurement of distance from each artefact can be recorded. Each artefact should be measured from at least three control points. This triangle can then be described on paper, thus allowing a precise record of the position of each artefact.

Figure 8: 3D trilateration operations: (a) setting markers; (b) measuring distance between markers; (c) measuring depth of the markers; (d) recording the measurements.

Data Acquisition

The survey operations were undertaken on 25 and 26 July 2022, while the last day (27 July 2022) was dedicated to carrying out final checks on some measurements and closing the site.

The first operation executed was the positioning of 13 markers around the wreck and some in the centre of the wreck site (Figure 8(a)). Distances between one marker to another were limited to 6 - 7 m to avoid distortion of the measurements and to ensure the next marker was visible.

With the *Victoire* lying in shallow waters, the site was subject to strong current and wave motion which caused the measuring tape to bend and the measurement exercise quite a challenge.

Since the study included a capacity-building component, during the trilateration operations, the teams consisted of 3 divers with 2 in charge of measuring the distance between two markers (Figure 8(b)) and a third person to record the measurements on a diving slate (Figure 8(d)) and ensure that the tape was well taut.

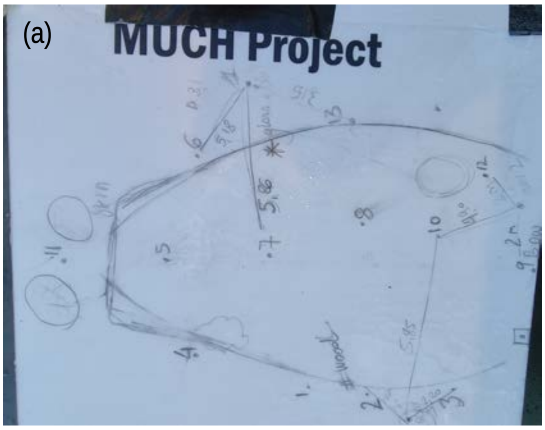
Another important step in acquiring the three-dimensionality of the site was to record the depth of the markers. This procedure was accomplished by registering the depth of the markers using a dive computer (Figure 8(c)) including

[17] Bowens, A. (2011) 'Underwater surveys', in Underwater archaeology: the NAS guide to principles and practice. John Wiley & Sons.

the time of acquisition which was then used to adjust the tidal variation. All measurements were taken using the same dive computer. A sketch the site and the positioning of the markers were drawn on one side of the slate to help guide the divers during the measurements (Figure 9 (a)).

Data Processing

As soon as the dive was completed and the measurements recorded, a picture of the diving slate was taken to avoid any data loss (Figure 9 (b)). These measurements (Table 8) were used with *Site Recorder 4*[18] (SR4), a GIS and image management software, to correctly scale and position the markers.



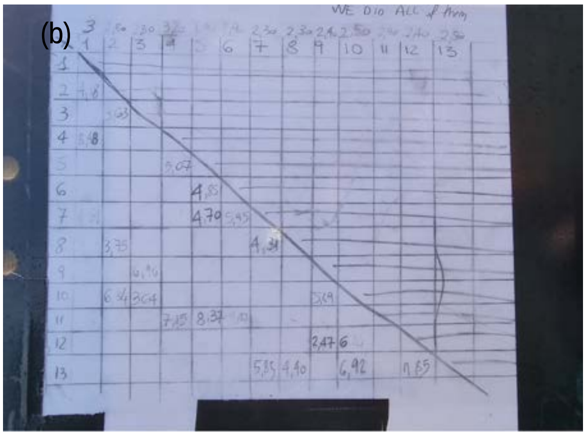


Figure 9: (a) sketch of the site; (b) measurements chart.

The SR4 software highlighted a 1 m discrepancy between markers 9 and 12 (see the purple line in Figure 10). During the underwater measurements, distance between markers 9 and 12 was marked as 2.47 m while the software estimated 3.47 m (Table 8). This error could probably be attributed to confusion when reading measurements underwater. This information was accordingly rectified for the 3D modelling.

Table 8: Trilateration - Distance between targets and depth.

Depth	3	2.80	2.80	3.20	1.90	2.90	2.30	2.30	2.40	2.50	2.90	2.40	2.50
	1	2	3	4	5	6	7	8	9	10	11	12	13
1													
2	4.18												
3		3.63											
4	8.48												
5				5.07									
6					4.85								
7	4.61				4.7	5.95							
8		3.75											
9			6.96										
10		6.34	3.64					5.67	5.89				
11				7.15	8.37	9.47							
12									*3.47**	6.14			
13							5.85	4.40		6.92		11.85	

* This data has been modified from 2.47 m to 3.47m following the calculations made by the SR4 Software.

[18] http://www.3hconsulting.com/ProductsRecorderMain.html [Accessed 15 September 2022]

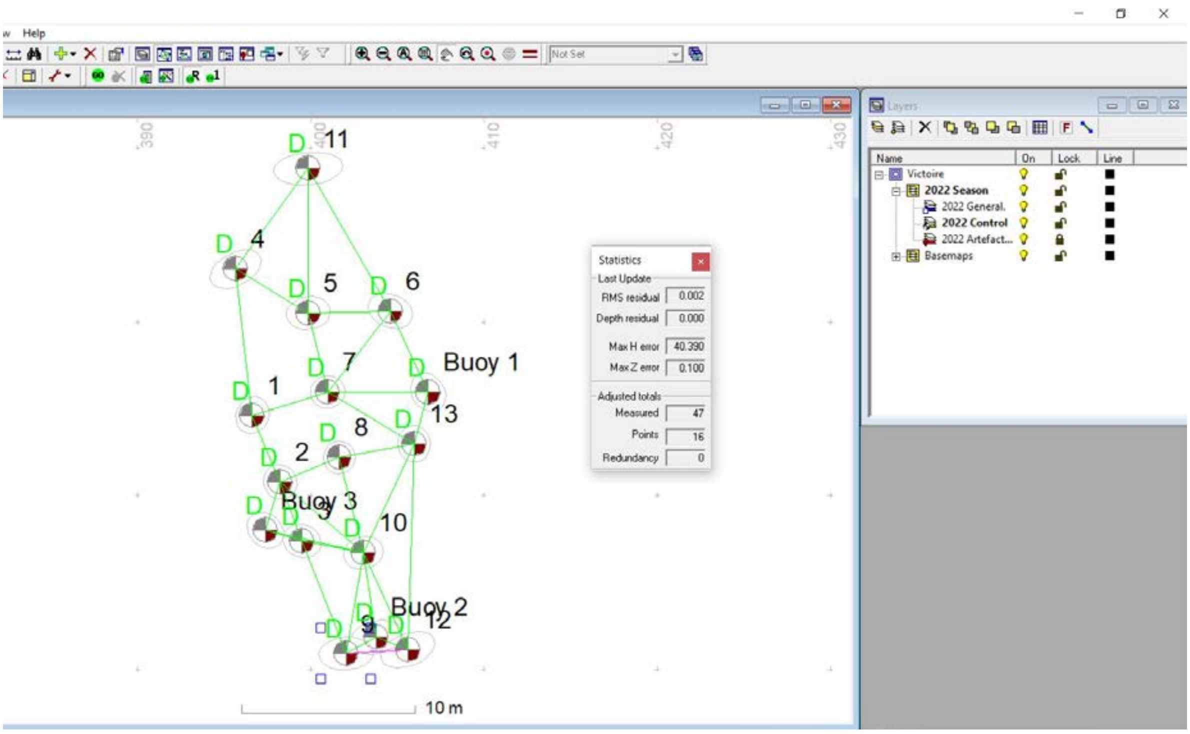


Figure 10: DSM ‘direct survey measurement’. Purple line showing discrepancy in measurements.

Figure 11: Underwater photos enhanced using Adobe Lightroom

PHOTOGRAMMETRY

Underwater photogrammetry consists of the acquisition of photographic strips of the entire site, allowing for the visualisation of the study area and reconstruction of underwater artefacts in 3D. As in aerial photogrammetry, the underwater artefacts are photographed in the nadir, orthogonally to the sea bottom.

Data Acquisition

Underwater photogrammetry was carried out on the second day (26 July 2022). The GoPro 10 camera was used for the exercise. Approximately 170 photos were acquired during the first photogrammetric swipe. However, the site was not entirely covered.

On the third day (27 July 2022), the GoPro 10 camera was set to *time-lapse > photos every 1s*. A total of 646 photos were taken along the north-south direction of the wreck. Another photogrammetric swipe was performed at the end of the day and 544 photos were taken in a transverse direction from west to east of the wreck. Some pictures were also taken at 45 degrees.

In addition to the 3D trilateration and visualisation, photogrammetry must be supported by a GPS survey to georeference the acquired pictures and derived model into a known coordinate system[19]. An inflatable buoy was attached to the markers and the geographical coordinates of these markers were recorded using a handheld GPS (Figure 12). The survey was carried out during calm sea condition to reduce error margins as much as possible.

Figure 12: Recording geographical coordinates of markers

Data Processing

The images collected were enhanced by editing the colour balance, the contrast, and the brightness properties of the photos (Figure 11) using *Adobe Lightroom mobile app*[20].

The *Agisoft Metashape*[21] software was then used to make a 3D reconstruction of the wreck site. The following workflow was used:

- Align the photos (Figure 13(a));
- Build Dense Cloud;

[19] Semaan, L. and Salama, M.S. (2019) 'Underwater Photogrammetric Recording at the Site of Anfeh, Lebanon', in *3D Recording and Interpretation for Maritime Archaeology*. Cham: Springer International Publishing (Coastal Research Library). Available at: http://link.springer.com/10.1007/978-3-030-03635-5 (Accessed: 6 October 2022); Balletti, C. *et al.* (2015) 'Underwater photogrammetry and 3D reconstruction of marble cargos shipwreck', in *Proceedings of the International Archives of the Photogrammetry*. *Remote Sensing and Spatial Information Sciences (ISPRS)*, Piano di Sorrento, Italy. Available at: https://doi.org/10.5194/isprsarchives-XL-5-W5-7-2015.

[20] https://www.adobe.com/products/photoshop-lightroom/mobile.html

[21] https://www.agisoft.com/

- Build Mesh (**Figure** 13(b));
- Build Texture;
- Build DEM (**Figure** 13(c)); and
- Build Orthomosaic

Markers were created to scale and position the model on the reference geographic coordinates (**Figure** 13(d)). The final product is an accurate reconstruction of the site which may allow further study and analysis of the wreck without diving (**Figure** 14).

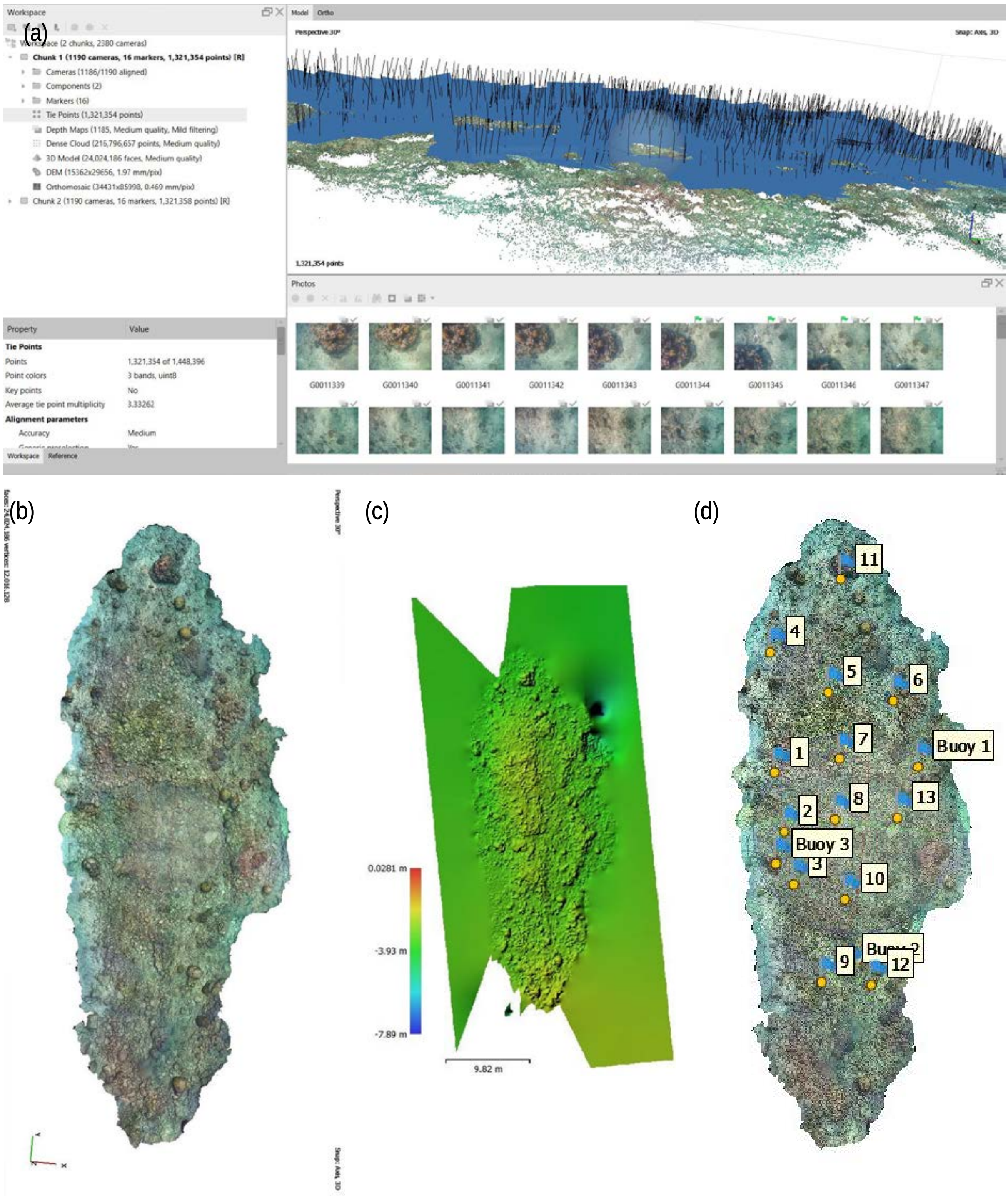


Figure 13: (a) Photo alignment; (b) Mesh; (c) DEM; and (d) positioning of the markers and scale combined with the DSM data

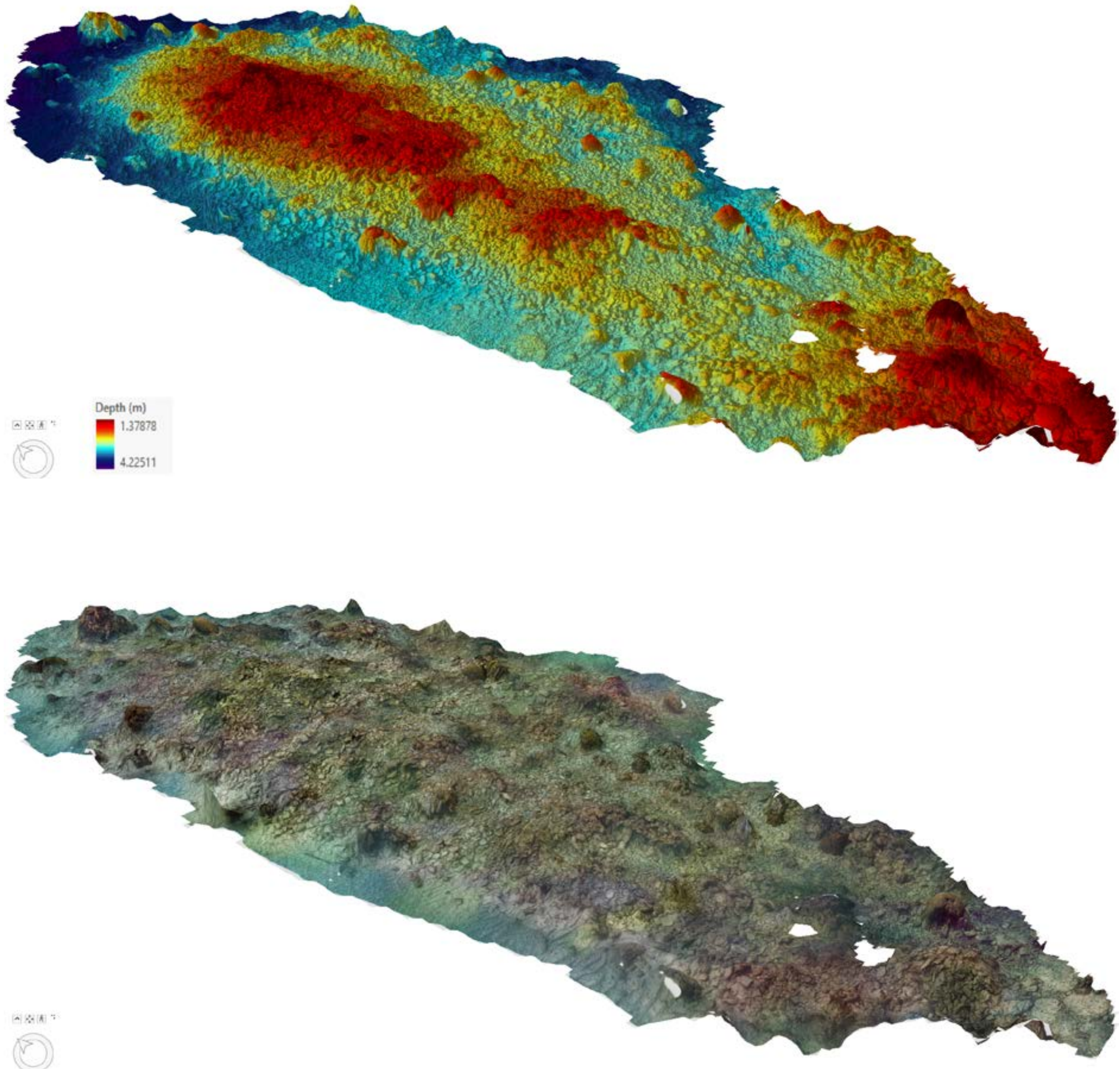


Figure 14: 3D scene of the DEM and orthomosaic of the *Victoire* wreck site

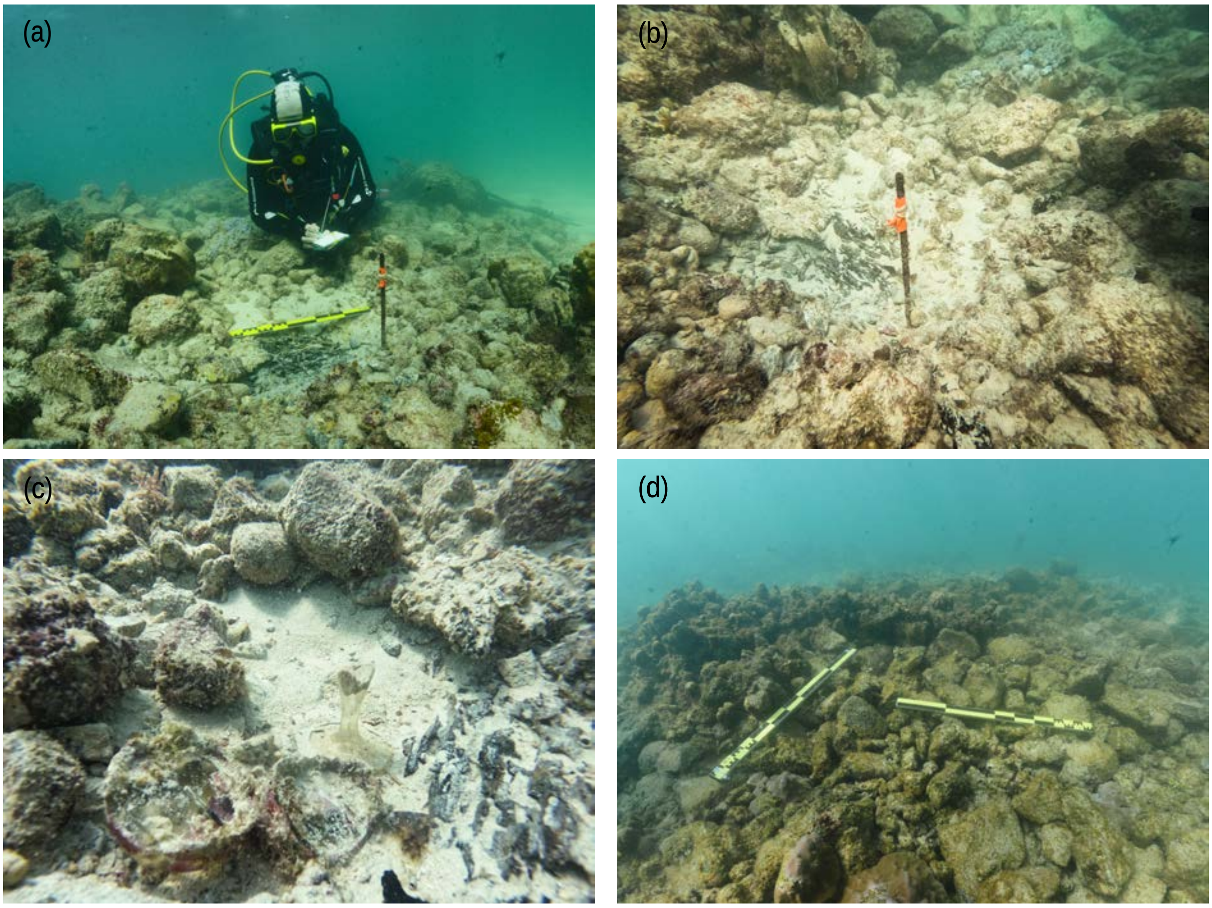
The DEM and Orthomosaic layers will be uploaded on the Mauritius Ocean Observatory E-platform[22].

[22] Access the Mauritius Ocean Observatory E-platform using the link: http://gococeanobservatory.govmu.org/ [Accessed 15 September 2022]]

UNDERWATER DOCUMENTATION

Documentation of the wreck site was carried out using an underwater camera and a ROV. The wreck is completely covered with ballast rocks. The ballast stones are either small oval shaped shingles ranging between 5 cm to 15 cm or irregular shaped rocks ranging between 15 cm and 40 cm. From the starboard side, part of a wooden structure that continues under the ballast was spotted (Figure 15 (a) & (b)). This wooden structure has been identified as possibly forming part of the hull and has been preserved by the ballast rocks. Additionally, numerous pieces of glass were observed and documented (Figure 15 (c)) during the study. These pieces of glassware which were part of the cargo of the *Victoire* during its last voyage are at risk of being lost due to wave motion. Although the documents concerning the *Victoire* which were retrieved during the archival research do not give much detail, the use of glassware and bottles for trade of slaves and goods is well documented[23].

An ecological assessment of the *Victoire* shipwreck was carried out using visual exploration and linear transect techniques. The depth of the area varies from 1.3 m to 4.0 m. The whole zone is subject to current in the wave propagation direction, resulting in a back-and-forth motion at the bottom. The site is characterized by a sandy bottom partly covered with ballast stones from the *Victoire*, coral assemblages and isolated basaltic rocks. The coral areas are mainly colonized by massive hard corals of the genus *Porites* and by arborescent soft corals of the genus *Litophyton*. In addition, the sandy area to the south of the site is partly covered with seagrass of the genus *Cymodocea*. The shipwreck is partially overgrown with algae assemblages (6% of the surface) and coral (7% of the surface) (see transect in ANNEX 2). The biodiversity is low, and corals are in relatively poor condition (see biocenosis in ANNEX 3). Figure 15 shows some pictures of the wreck site.



[23] Huetz de Lemps, A (2001). Boissons et civilisations en Afrique. Presses Universitaires de Bordeaux, « Grappes & Millésimes », 658 p. (ISBN 2-86781-181-8), pg 432 ; National Archives of Mauritius, E 166 on "Le navire hambourgeois La Susanne (1798)"


(e)
(f)
(g)
(h)
(i)
(j)
(k)
(l)

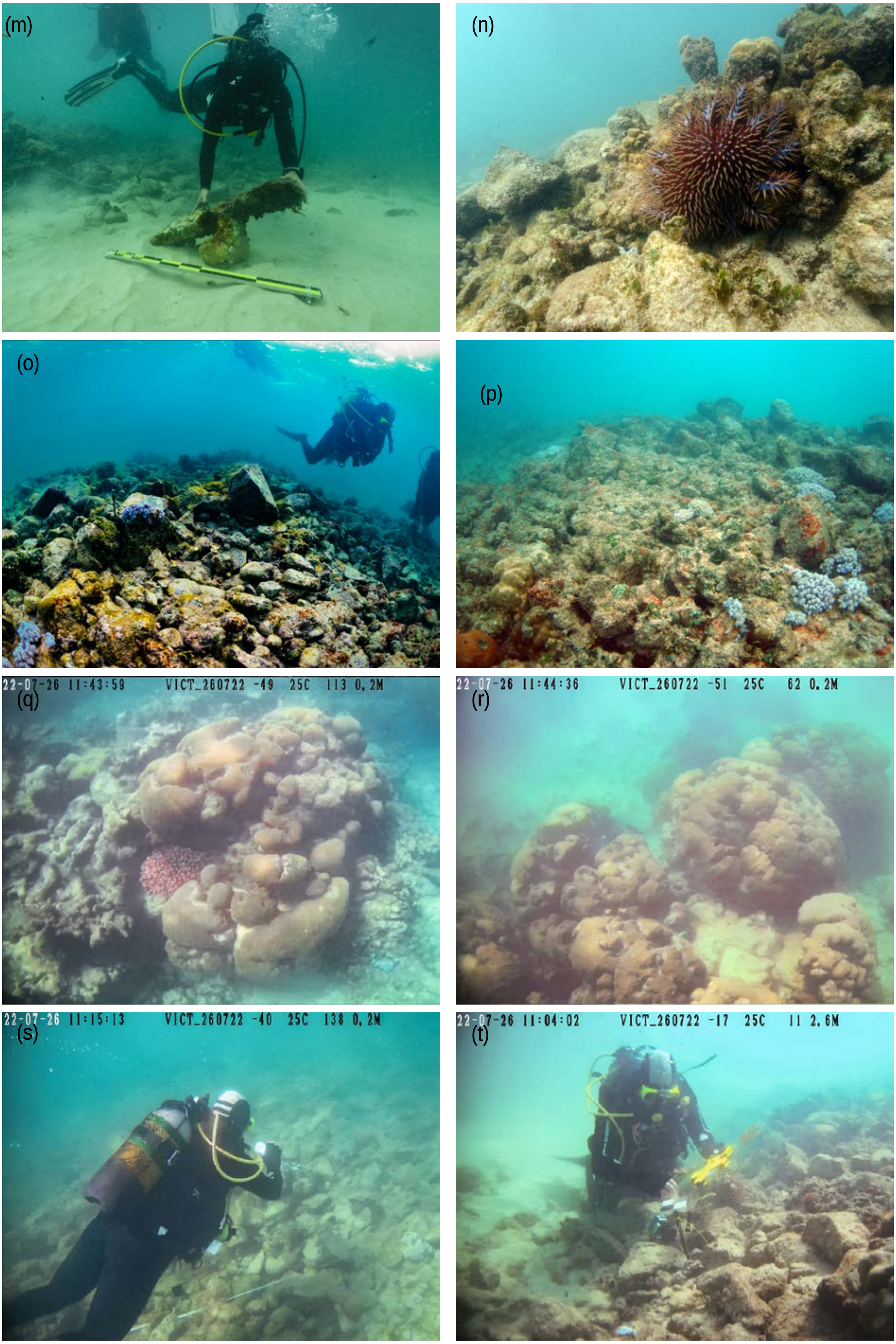


Figure 15: Documentation of the *Victoire* wreck site

GENERAL CHARACTERISTICS OF THE SITE

TYPE	Shipwreck

Location and extent

COORDINATES	GEOGRAPHICAL COORDINATES		
PROJECTION: UTM 40S	DATUM: WGS84		
X: 558573.461	Latitude: 20° 00' 05.980" S		
Y: 7788236.974	Longitude: 057° 33' 35.808" E		
Z: 2.18 (Chart Datum)	Depth 2.18 (Chart Datum)		
MAX. EXTENT OF SITE (Estimate in meters)	Width	Length	Height
	50	80	4

Exposure	No visible parts	ACCESS	By boat

DESCRIPTION	AREA	MARITIME ZONE
	Lagoon Close to coast	Internal waters

WATER	WATER FEATURES	DEPTH IN METERS	
	Moved (strong current and wave motion)	Maximum	4.0
		Minimum	1.3

SITE IMMERSION	Continuous	VISIBILITY	Partial

SEA-BOTTOM SURFACE COMPOSITION/STRATIGRAPHIE				
Gravel	Pebbles	Rock	Coral	Sand

RECOMMENDATIONS

A debriefing session was organised on 05 August 2022 among participants of the field exercises and recommendations were made on possible improvements and future field exercises.

Members were encouraged to:

- carry out further capacity building on studies directed at UCH;
- procure equipment for accurate positioning and georeferencing;
- procure software for photogrammetry and the processing of underwater images and videos;
- undertake additional archival research in Mauritius and seek possibility to carry out research in France and the UK;
- conduct further research to:
  - investigate the extent of *Victoire* wreck site and discover what lies underneath ballast stones;
  - enable preservation of any wooden structure that will otherwise be degraded;
- compile information on artefacts currently displayed at the Mauritius Glass Gallery and that may have been preserved at the National History Museum.

ANNEX 1 - ROV SPECIFICATION

Table 9: Deep Trekker DTG3[24] remotely operated vehicle features and specifications

1. MAIN FEATURES	
Depth rating	200m
Weight	Maximum 10 kg
Operating temperature	0 to 50 Degrees Celsius
2. TETHER	
Tether length	75m
Minimum Breaking Strength	90 kg
Tether reel	Heavy duty
3. POWER SUPPLY	
Battery Run Time	Minimum 4 hours
Rechargeable Battery	
4. INTEGRATED SENSORS	
Video	UHD 4K
	Minimum 30FPS
Range of view	Minimum 270° rotational
Picture	JPG 8mp
5. CONTROLLER	
Screen	LCD screen
Controller	Splash resistant
Connectivity	USB, SD, HDMI and Ethernet
6. PACKAGING	
Pelican case 3 kg	

Figure 16: Remotely Operated Vehicle (ROV) Deep Trekker DTG3.

[24] https://www.deeptrekker.com/resources/dtg3-spec-sheet [Accessed 15 September 2015]

ANNEX 2 - TRANSECT *VICTOIRE* SHIPWRECK - POINTE AUX CANONNIERS - BALLAST

Mauritius Marine Conservation Society

Date: 27-July-2022 (*Victoire* shipwreck from North to South along a distance of 28.5m)

Photos: File ECO-V1 : DSC09043 à DSC09113 (70 photos)

Position: GPS Beginning: 20°00'05.30"S / 57°33'35.73"E

GPS End: 20°00'06.41"S / 57°33'35.75"E

Characteristics: Depth varying from 1.3 m to 4.0 m. Zone is subject to current in the wave propagation direction, resulting in a back-and-forth motion at the bottom.

Transect - Assessment

Dead Coral	2.6 %
Living Coral	5.7 %
Soft Coral	1.4 %
Sponge	0.2 %
Algae	6.2 %
Sediments	1.4 %
Rubble	0.0 %
Ballast Stones	82.5 %

Transect - Detailed Assessment

Algal Assemblage	AA	140 cm	4.9 %
Coralline Algae	AC	33 cm	1.2 %
Seaweed	AD	3 cm	0.1 %
Digital Coral	CD	61 cm	2.1 %
Encrusting Coral	CE	9 cm	0.3 %
Free Coral	CE	0 cm	0.0 %
Massive or Sub-massive Coral	CM	92 cm	3.2 %
Soft Coral	CMO	41 cm	1.4 %
Dead Coral	CX	74 cm	2.6 %
Rubble	DEB	0 cm	0.0 %
Sponge	EP	7 cm	0.2 %
Ballast Stones	P	2350 cm	82.5 %
Sediments / Sand	S	40 cm	1.4 %
TOTAL		2850 cm	100.0%

Transect Record Sheet SITE: *Victoire* Shipwreck

Transition (cm)		Transition (cm)	Section (cm)	Categories (codes)	Type	Specification & Notes (genus/species)	Picture
0	-	10	10	CM	Massive Porites	*Porites sp.*	9043
10	-	30	20	Stone	Ballast Stones	Ballast of *Victoire*	
30	-	60	30	S	Sand and Gravel		9044
60	-	90	30	Stone	Ballast Stones	Ballast of *Victoire*	
90	-	100	10	AA	Algal assemblage		
100	-	103	3	CM	Massive Porites (young specimen)	*Porites sp.*	9045
103	-	128	25	Stone	Ballast Stones	Ballast of *Victoire*	
128	-	130	2	AA	Algal assemblage		9046
130	-	166	36	Stone	Ballast Stones	Ballast of *Victoire*	
166	-	175	9	CM	Massive Porites	*Porites sp.*	
175	-	229	54	Stone	Ballast Stones	Ballast of *Victoire*	9047
229	-	232	3	AA	Green Algae	*Halimeda sp.*	9048
232	-	238	6	Stone	Ballast Stones	Ballast of *Victoire*	
238	-	241	3	AA	Red algae		
241	-	253	12	AC	Coralline Algae, encrusting	*Peyssonnelia sp.* or similar	
253	-	290	37	Stone	Ballast Stones	Ballast of *Victoire*	9049
290	-	294	4	AC	Coralline Algae, encrusting	*Peyssonnelia sp.* or similar	
294	-	301	7	Stone	Ballast Stones	Ballast of *Victoire*	
301	-	302	1	AA	Green Algae	*Halimeda sp.*	
302	-	305	3	AA	Algal Assemblage		
305	-	309	4	Stone	Ballast Stones	Ballast of *Victoire*	
309	-	314	5	CM	Massive Porites young	*Porites sp.*	
314	-	327	13	Stone	Ballast Stones	Ballast of *Victoire*	

Transition (cm)		Transition (cm)	Section (cm)	Categories (codes)	Type	Specification & Notes (genus/species)	Picture
327	-	332	5	CM	Brain Coral young		9050
332	-	338	6	Stone	Ballast Stones	Ballast of *Victoire*	
338	-	344	6	CE	Encrusting Corals	Sort of encrusting *Acropora*	
344	-	346	2	Stone	Ballast Stones	Ballast of *Victoire*	
346	-	349	3	AA	Brown Algae	*Padina sp.*	
349	-	377	28	Stone	Ballast Stones	Ballast of *Victoire*	9051
377	-	383	6	AA	Brown Algae		
383	-	392	9	Stone	Ballast Stones	Ballast of *Victoire*	
392	-	394	2	AA	Brown Algae		
394	-	418	24	Stone	Ballast Stones	Ballast of *Victoire*	
418	-	420	2	AA	Brown Algae	*Padina sp.*	9052
420	-	447	27	Stone	Ballast Stones	Ballast of *Victoire*	
447	-	452	5	CM	Massive Porites	*Favites complata*	9053
452	-	506	54	CD	Birdsnest Coral	*Seriatopora hystrix* (in bad state)	9955
506	-	519	13	Stone	Ballast Stones	Ballast of *Victoire*	
519	-	521	2	CM	Massive Porites (young specimen)	*Porites sp.*	9056
521	-	569	48	Stone	Ballast Stones	Ballast of *Victoire*	
569	-	571	2	AA	Brown Algae		9057
571	-	584	13	Stone	Ballast Stones	Ballast of *Victoire*	
584	-	585	1	AA	Brown Algae	*Padina sp.*	
585	-	635	50	Stone	Ballast Stones	Ballast of *Victoire*	9058
635	-	642	7	AA	Brown Algae		9059
642	-	652	10	AA	Green Algae		
652	-	654	2	CM	Massive Porites (young specimen)	*Porites sp.*	
654	-	671	17	Stone	Ballast Stones	Ballast of *Victoire*	

Transition (cm)		Transition (cm)	Section (cm)	Categories (codes)	Type	Specification & Notes (genus/species)	Picture
671	-	673	2	AA	Green Algae		
673	-	689	16	Stone	Ballast Stones	Ballast of *Victoire*	
689	-	693	4	CM	Massive Porites (young specimen)	*Porites sp.*	9061
693	-	696	3	Stone	Ballast Stones	Ballast of *Victoire*	
696	-	698	2	CMO	Branching Soft Coral	*Litophyton sp.* (*L. arboreum*)	
698	-	728	30	Stone	Ballast Stones	Ballast of *Victoire*	
728	-	731	3	AA	Brown Algae		9062
731	-	751	20	Stone	Ballast Stones	Ballast of *Victoire*	
751	-	754	3	AA	Brown Algae		9063
754	-	809	55	Stone	Ballast Stones	Ballast of *Victoire*	9065
809	-	812	3	CM	Massive Porites	*Porites sp.*	9065
812	-	826	14	CX	Dead Coral		
826	-	828	2	CM	Massive Porites	*Porites sp.*	
828	-	831	3	CX	Dead Coral		
831	-	833	2	CM	Massive Porites	*Porites sp.*	
833	-	838	5	CX	Dead Coral		9067
838	-	841	3	CM	Massive Porites	*Porites sp.*	
841	-	888	47	CX	Dead Coral		
888	-	906	18	Stone	Ballast Stones	Ballast *of Victoire*	9068
906	-	912	6	CM	Massive Porites	*Porites sp.*	
912	-	925	13	Stone	Ballast Stones	Ballast *of Victoire*	
925	-	930	5	CX	Dead Coral		
930	-	959	29	Stone	Ballast Stones	Ballast *of Victoire*	
959	-	961	2	AA	Brown Algae	*Padina sp.*	
961	-	1084	123	Stone	Ballast Stones	Ballast *of Victoire*	

Transition (cm)		Transition (cm)	Section (cm)	Categories (codes)	Type	Specification & Notes (genus/species)	Picture
1084	-	1089	5	AA	Brown Algae	*Padina sp.*	9074
1089	-	1155	66	Stone	Ballast Stones	Ballast *of Victoire*	
1155	-	1157	2	AA	Green Algae	*Halimeda sp.*	9077
1157	-	1332	175	Stone	Ballast Stones	Ballast *of Victoire*	9081
1332	-	1339	7	CMO	Branching Soft Coral	*Litophyton sp.* (*L. arboreum*)	9082
1339	-	1344	5	Stone	Ballast Stones	Ballast *of Victoire*	
1344	-	1348	4	CMO	Branching Soft Coral	*Litophyton sp.* (*L. arboreum*)	
1348	-	1480	132	Stone	Ballast Stones	Ballast *of Victoire*	9087
1480	-	1495	15	CMO	Branching Soft Coral	*Litophyton sp.* (*L. arboreum*)	
1495	-	1706	211	Stone	Ballast Stones	Ballast *of Victoire*	
1706	-	1709	3	AD	Brown Algae (Seaweed)		9096
1709	-	1720	11	Stone	Ballast Stones	Ballast *of Victoire*	
1720	-	1728	8	CMO	Branching Soft Coral	*Litophyton sp.* (*L. arboreum*)	9097
1728	-	1740	12	Stone	Ballast Stones	Ballast *of Victoire*	9098
1740	-	1743	3	AC	Red Coralline, encrusting	*Peyssonnelia sp.* or similar	
1743	-	1749	6	Stone	Ballast Stones	Ballast *of Victoire*	
1749	-	1753	4	AC	Red Coralline, encrusting	*Peyssonnelia sp.* or similar	
1753	-	1787	34	Stone	Ballast Stones	Ballast *of Victoire*	
1787	-	1790	3	AC	Red Coralline, encrusting	*Peyssonnelia sp.* or similar	
1790	-	1794	4	Stone	Ballast Stones	Ballast *of Victoire*	9099
1794	-	1797	3	AA	Algal assemblage		
1797	-	1850	53	Stone	Ballast Stones	Ballast *of Victoire*	
1850	-	1858	8	AA	Green Algae	*Halimeda sp.*	9101
1858	-	1868	10	Stone	Ballast Stones	Ballast *of Victoire*	
1868	-	1872	4	AA	Brown Algae		9102

Transition (cm)		Transition (cm)	Section (cm)	Categories (codes)	Type	Specification & Notes (genus/species)	Picture
1872	-	1991	119	Stone	Ballast Stones	Ballast *of Victoire*	9106
1991	-	1994	3	AA	Green Algae	*Halimeda sp.*	
1994	-	2017	23	Stone	Ballast Stones	Ballast *of Victoire*	
2017	-	2021	4	AA	Green Algae	*Halimeda sp.*	9108
2021	-	2069	48	Stone	Ballast Stones	Ballast *of Victoire*	
2069	-	2071	2	AA	Green Algae	*Halimeda sp.*	
2071	-	2093	22	Stone	Ballast Stones	Ballast *of Victoire*	
2093	-	2100	7	AC	Red Coralline, encrusting	*Peyssonnelia sp.* or similar	9110
2100	-	2140	40	Stone	Ballast Stones	Ballast *of Victoire*	
2140	-	2142	2	CMO	Branching Soft Coral	*Litophyton sp.* (*L. arboreum*)	9111
2142	-	2155	13	Stone	Ballast Stones	Ballast *of Victoire*	
2155	-	2157	2	AA	Green Algae	*Halimeda sp.*	
2157	-	2167	10	Stone	Ballast Stones	Ballast *of Victoire*	
2167	-	2169	2	AA	Green Algae	*Halimeda sp.*	
2169	-	2206	37	Stone	Ballast Stones	Ballast *of Victoire*	
2206	-	2209	3	AA	Brown Algae	*Padina sp.*	9112
2209	-	2220	11	Stone	Ballast Stones	Ballast *of Victoire*	
2220	-	2223	3	AA	Red Algae		
2223	-	2242	19	Stone	Ballast Stones	Ballast *of Victoire*	
2242	-	2244	2	AA	Red Algae		
2244	-	2276	32	Stone	Ballast Stones	Ballast *of Victoire*	
2276	-	2278	2	CD	Birdsnest Coral	*Seriatopora hystrix* (in bad state)	9114
2278	-	2337	59	Stone	Ballast Stones	Ballast *of Victoire*	
2337	-	2340	3	AA	Green Algal Assemblage		9116
2340	-	2349	9	CM	Massive Coral (young)	*Porites sp.*	

Transition (cm)		Transition (cm)	Section (cm)	Categories (codes)	Type	Specification & Notes (genus/species)	Picture
2349	-	2396	47	Stone	Ballast Stones	Ballast *of Victoire*	
2396	-	2399	3	CE	Encrusting Coral	Unidentified	
2399	-	2408	9	AA	Green Algal assemblage		9120
2408	-	2416	8	Stone	Ballast Stones	Ballast *of Victoire*	
2416	-	2419	3	CMO	Soft Coral	*Tubipora musica*	
2419	-	2437	18	Stone	Ballast Stones	Ballast *of Victoire*	
2437	-	2440	3	AA	Green Algae	*Halimeda sp.*	
2240	-	2448	8	Stone	Ballast Stones	Ballast *of Victoire*	
2446	-	2452	4	AA	Algal Assemblage		9121
2452	-	2459	7	CM	Massive coral young	*Porites sp.*	
2459	-	2466	7	Stone	Ballast Stones	Ballast *of Victoire*	
2466	-	2470	4	AA	Green Algae	*Halimeda sp.*	
2470	-	2484	14	Stone	Ballast Stones	Ballast *of Victoire*	
2484	-	2496	12	CM	Massive Coral (young)	*Porites sp.*	9122
9496	-	2536	40	Stone	Ballast Stones	Ballast *of Victoire*	
2536	-	2540	4	AA	Green Algae	*Halimeda sp.*	9123
2540	-	2547	7	Stone	Ballast Stones	Ballast *of Victoire*	
2547	-	2554	7	EP	Sponge	Eponge dressé non-identifiée	9124
2554	-	2557	3	Stone	Ballast Stones	Ballast *of Victoire*	
2257	-	2559	2	AA	Red Algae		
2559	-	2583	24	Stone	Ballast Stones	Ballast *of Victoire*	9125
2583	-	2586	3	CM	Massive Coral (young)	*Porites sp.*	
2586	-	2610	24	Stone	Ballast Stones	Ballast *of Victoire*	
2610	-	2615	5	CD	Digital Coral (young)	*Acropora sp.*	
2615	-	2748	133	Stone	Ballast Stones	Ballast *of Victoire*	

Transition (cm)		Transition (cm)	Section (cm)	Categories (codes)	Type	Specification & Notes (genus/species)	Picture
2748	-	2754	6	S	Sand		9130
2754	-	2786	32	Stone	Ballast Stones	Ballast *of Victoire*	
2786	-	2789	3	AA	Brown Algae	*Padina sp.*	9131
2789	-	2837	48	Stone	Ballast Stones	Ballast *of Victoire*	9133
2837	-	2841	4	S	Sand		
2841	-	2850	9	Stone	Ballast Stones	Ballast *of Victoire*	9133

ANNEX 3 - BIOCENOSIS *VICTOIRE* SHIPWRECK

Mauritius Marine Conservation Society

Date: 25, 26 & 27-July-2022 (*Victoire* shipwreck)

Photos: File ECO-V2 / DSC8424 à DSC9010 & IMG7663 à IMG7930 (823 photos)

Position: GPS Beginning: 20°00'05.30"S / 57°33'35.73"E

GPS End: 20°00'06.41"S / 57°33'35.75"E

Characteristics: Depth varying from 1.3 m to 4.0 m. Zone is subject to current in the wave propagation direction, resulting in a back-and-forth motion at the bottom.

Description: Sandy bottom partly covered with ballast stones from the *Victoire*, coral assemblages and isolated basaltic rocks. The coral areas are mainly colonized by massive hard corals of the genus *Porites* and by arborescent soft corals of the genus *Litophyton*. In addition, the sandy area to the south of the site is partly covered with seagrass of the genus *Cymodocea*. The shipwreck is partially overgrown with algae assemblages (6% of the surface) and coral (7% of the surface). The biodiversity is low and corals are in rather poor condition

Biocenosis:

Common Name	Scientific Name	Type	Code	Frequency Observation	Notes	Photo Nº
Seagrass & Algae						
Serrated ribbon seagrass	*Cymodocea serrulata*	Cymodoceaceae		Common		8584/8577+
Algae Assemblage	Unidentified	Phaeophyceae	AA	Frequent		8338
Peacock's tail	*Padina sp.*	Phaeophyceae	AG	Common		8338/8429+
Branched brown seaweed	Unidentified	Phaeophyceae	AD	Common		8338/8387+
Erect brown seaweed	Unidentified	Phaeophyceae	AD	Occasional	6 specimens	8607/8736+ 7916/9006+
Brown cottony algae	Unidentified	Phaeophyceae	AG	Occasional		8344
Brown seaweed with lamified thallus	*Chnoospora minima*	Phaeophyceae	AG	Common		8387
Turbinaria algae	*Turbinaria sp. (T. conoides* or *T. ornata)*	Phaeophyceae	AG	Uncommon	1 specimen	7840

Common Name	Scientific Name	Type	Code	Frequency Observation	Notes	Photo Nº
Halimeda	*Halimeda sp.*	Chlorophyceae	AG	Common		8338/8346+
Grass like green algae	Unidentified	Chlorophyceae	AG	Occasional		
Dictyosphaeria	*Dictyosphaeria verluysii*	Chlorophyceae	AG	Uncommon	1 specimen	8460
Red branched seaweed	Unidentified	Rhodophyceae	AG	Occasional	5 specimens	8387/8436
Blue algae	Unidentified	Cyanophyceae	AG	Occasional		8440/8450+
Invertebrates						
Orange shaped sponge	*Tethya sp.*	Sponge	EP		2 specimens	8348
Digitate soft coral	*Sarcophyton sp.*	Cnidaria	CMO	Common	3 specimens	8348/8367+
Pedunculate soft coral	*Sarcophyton sp.*	Cnidaria	CMO	Occasional	1 specimen	8361
Arborescent soft coral	*Litophyton sp. (L. arboreum)*	Cnidaria	CMO	Frequent (Dominant species)	Upright violet species	8338/8346+ 8621/
Massive Porites	*Porites lutea*	Coral	CM	Frequent (Dominant species)		8338/8347+
Massive Porites	*Porites australiensis*	Coral	CM	Frequent (Dominant species)		8348/8354+
Sub-massive Favites	*Favites pentagona*	Coral	CM	Uncommon	2 specimens	8449/8598
Massive Favites	*Favites complanta*	Coral	CSM	Uncommon	3 specimens	8364/8458+ 8672
Encrusting Favites	*Favites halicora*	Coral	CE	Uncommon	1 specimen	8593
Branching Acropora	*Acropora sp.*	Coral	CB	Uncommon	1 specimen	8693
Massive Goniopora	*Goniopora tenuidens*	Coral	CM	Uncommon	1 specimen	8699
Encrusting Montipora	*Montipora mollis*	Coral	CE	Uncommon	1 specimen	8408
Birdsnest coral	*Seriatopora hysterix*	Coral	CB	Uncommon	1 specimen (dying)	8482
Massive brain coral	*Platygyra crosslandi*	Coral	CM	Uncommon	4 specimens	8364/8460/ 8662/7819
Coral Pavona	*Pavona venosa*	Coral	CSM	Uncommon	1 specimen	7821
Digitate Pocillopora	*Pocillopora eydouxi*	Coral	CB	Uncommon	1 specimen	8827

Common Name	Scientific Name	Type	Code	Frequency Observation	Notes	Photo Nº
Massive Plesiastrea	*Plesiastrea sp.* (*P. devantieri*)	Coral	CM	Occasional	4 specimens	8356/7766+
Orange seastar	*Fromia elegans*	Echinoderm	ET	Uncommon	1 specimen	8346
Crown of thorns	*Acanthaster planci*	Echinoderm	AP	Uncommon	1 specimen	8908
Black urchin	*Stomopneustes variolaris*	Echinoderm	OU	Uncommon	1 specimen	8737
Vertebrates						
Brown surgeon fish	*Acanthurus nigrofuscus*	Fish	FA	Occasional	8 specimens	8496/8552+
Convict surgeon fish	*Acanthurus triostegus*	Fish	FA	Uncommon	1 specimen	8813
Long-barbel goatfish	*Parupeneus forsskali* or *Parupeneus macronema*	Fish	FDP	Uncommon	2 specimens	8706/8724
Doublebar goatfish	*Parupeneus bifasciatus*	Fish	FDP	Uncommon	1 specimen	8723
Tiger damselfish	*Chrysiptera annulata*	Fish	FDD	Uncommon	1 specimen	8743
False-eye sergeant	*Abudefduf sproides*	Fish	FD	Occasional	2 specimens	8392/8394
Dusky farmerfish	*Stegastes nigricans*	Fish	FD	Uncommon	2 specimens	8440/8717
Moorish idol	*Zanclus cornutus*	Fish	FC	Occasional	3 specimens	8348/8707+
Valentin's sharpnose puffer	*Canthigaster valentini*	Fish	FB	Uncommon	1 specimen	
Tripletail wrasse	*Cheilinus trilobatus*	Fish	FP	Uncommon	2 specimens	7724/7899
Vagabond butterflyfish	*Chaetodon vagabundus*	Fish	FC	Uncommon	1 specimen	8549
Melon butterflyfish	*Chaetodon trifasciatus*	Fish	FC	Uncommon	2 specimens	8493/8494
Sunburst butterflyfish	*Chaetodon kleinii*	Fish	FC	Uncommon	1 specimen	8706
Honeycomb grouper	*Epinephelus merra*	Fish	FP	Uncommon	2 specimens	8576/8812
Red-cheek wrasse	*Thalassoma genivittatum*	Fish	FDP	Uncommon	1 specimen	8753

NOTES: Rate of observation - Uncommon to 3 specimens, Occasional: 4 to 10 specimens, Common: 11 to 30, Frequent: more than 30 specimens

(+) Several photos done; If a species is in parentheses such as (*L. arboreum*) it is probably this or a similar species.