

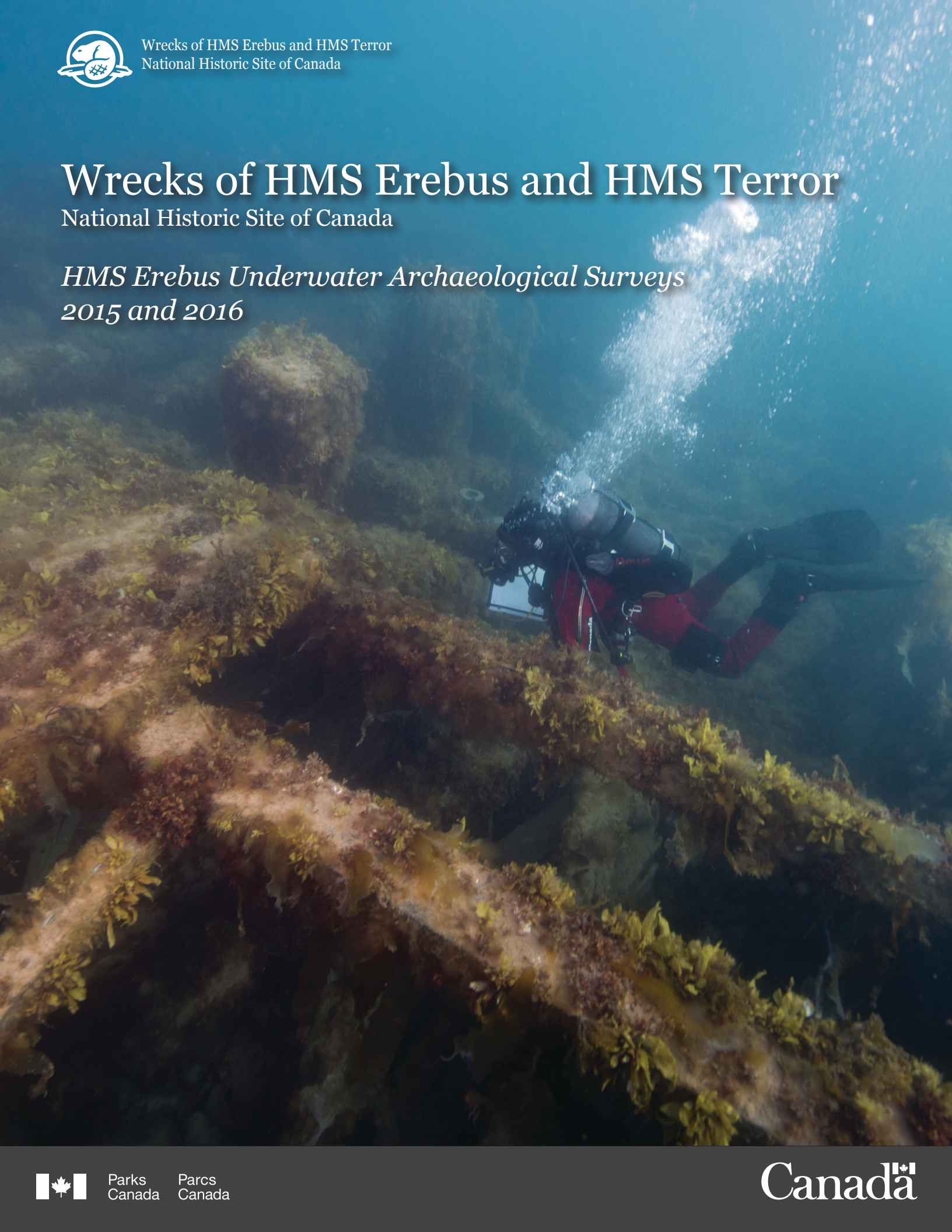


Wrecks of HMS Erebus and HMS Terror
National Historic Site of Canada

Wrecks of HMS Erebus and HMS Terror

National Historic Site of Canada

*HMS Erebus Underwater Archaeological Surveys
2015 and 2016*



Parks
Canada

Parcs
Canada

Canada

Front cover: A Parks Canada underwater archaeologist examines the upper deck structure of HMS *Erebus* in 2016 (Photo: T. Boyer, Parks Canada; 89M008452EF).

Back cover: DeepTrekker remotely-operated vehicle inside the stern cabin of HMS *Erebus* in 2016 (Photo: T. Boyer, Parks Canada; 89M008811EF).

WRECKS OF HMS EREBUS AND HMS TERROR

NATIONAL HISTORIC SITE OF CANADA

HMS EREBUS UNDERWATER ARCHAEOLOGICAL SURVEYS 2015 AND 2016

Jonathan Moore
Charles Dagneau
Marc-André Bernier
Ryan Harris
Thierry Boyer
Filippo Ronca
Brandy Lockhart
Joe Boucher

UAT Project: 89M

UAT Report: 2017-01

Parks Canada Research and Collection Permits: 2015-19820, 2016-22580

December 2017

UNDERWATER ARCHAEOLOGY TEAM
ARCHAEOLOGY AND HISTORY BRANCH
PARKS CANADA

UNDERWATER ARCHAEOLOGY TEAM
PARKS CANADA
1800 WALKLEY ROAD, OTTAWA
ONTARIO K1H 8K3
TEL.: 613-993-2125

Summary	iii
Sommaire	iv
ᑭᐱᓂ ᕿᐅᔨᒪᓯᑦ ᐅᓂᑲᑕᐱᑦ	v
Acknowledgements	vi
List of Abbreviations	ix
1. Project Description	1
1.1 Introduction	1
1.2 Definition of the Study Area	3
1.3 Objectives	5
1.4 Provenience System	6
2. Historical and Archaeological Background	11
2.1 The 1845 Franklin Expedition	11
2.2 The 2014 Discovery of HMS <i>Erebus</i>	20
3. Methodology	23
3.1 Fieldwork Description 2015-2016	23
3.2 Diving	31
3.3 Marine Biology Pilot Study and Kelp Removal	35
3.4 Site Positioning and Mapping	36
3.5 Photo and Video Documentation	41
3.6 Artefact Retrieval and Recording	43
3.7 Site Mapping Software	45
3.8 CHS Water Level Recorder and ArcticNet Current Profiler	45
3.9 Multi-Beam Echosounder	46
3.10 Remotely-operated Vehicle	47
4. Site Environment Description	49
4.1 Weather	49
4.2 Bathymetry, Hydrology and Ice Conditions	49
4.3 Seafloor Composition and Sedimentation	52
4.4 Marine Biology	53
5. In Situ Archaeological Description	55
5.1 Hull Exterior	55
5.2 Upper Deck	60
5.3 Lower Deck	67
5.4 Orlop Deck	75
5.5 Debris Field	78

6. Artefact Description	89
6.1 Food Preparation and Service	89
6.2 Rigging	93
6.3 Clothing and Uniforms	95
6.4 Health and Hygiene	99
6.5 Ordnance	102
6.6 Edged Weapons, Firearms and Ammunition	105
6.7 Heating	107
6.8 Lighting Devices	107
6.9 Steering	110
6.10 Ship's Fittings	111
6.11 Navigation, Surveying and Science	112
6.12 Furniture and Furnishing Hardware	114
6.13 Ship's Architecture	115
6.14 Communication	116
6.15 Unknown Function	118
6.16 Artefact Distribution	118
7. Conclusions and Recommendations	123
7.1 Site Environment	123
7.2 Hull Integrity	125
7.3 Archaeological and Site Formation Inferences	126
7.4 Artefact Potential	129
7.5 Future Steps and Recommendations	131
References Cited	137

SUMMARY

This report presents the results of fieldwork and research undertaken by Parks Canada's Underwater Archaeology Team (UAT) and its partners between 2015 and 2016 on the wreck of HMS *Erebus*. This work carried forward an initial episode of fieldwork at the site immediately following the wreck's discovery in September 2014.

Three episodes of fieldwork took place at the site in 2015-2016: the first in April 2015 was staged from an ice camp as part of Operation Nunavut; the second and longest episode unfolded through August-September 2015 and was staged from the MV *Martin Bergmann*; and lastly several site visits in August-September 2016 were based from the CCGS *Sir Wilfrid Laurier*.

The main objective of the 2015-2016 archaeological fieldwork and associated research on HMS *Erebus* has been to complete a site assessment that encompasses the wreck's hull, visible artefacts and debris field, including: a general archaeological potential evaluation; a preliminary assessment of the hull's structural integrity; an examination of the debris field extents and depth; a visual reconnaissance of interior spaces; and a baseline study of the site's marine environment. This assessment has been completed chiefly in order to better plan and initiate long-term, full-scale archaeological study of the site, including excavation. The assessment in turn aims to provide valuable information for the actual management of both natural and cultural resources within the Wrecks of HMS *Erebus* and HMS *Terror* National Historic Site of Canada.

The assessment was undertaken primarily using non-destructive means of investigation, such as video and photo recording (allowing for

photogrammetric modelling), detailed measurement of selected underwater features, biological sampling, as well as a multi-beam echosounder survey. In 2015 a significant portion of underwater work time had to be devoted to kelp clearing before any detailed recording and archaeological mapping and recovery of a sample of accessible artefacts. No excavation took place on site in 2015-2016.

This site assessment has confirmed without a doubt not only the remarkable archaeological potential of the site first witnessed in 2014 but also environmental threats to its integrity. HMS *Erebus* represents a largely intact vessel within which are multiple and well-preserved enclosed areas that provide great promise for the interpretation of in-context artefacts. The study of this shipwreck site provides a unique opportunity to learn more about cutting-edge mid-nineteenth century technologies deployed on Sir John Franklin's 1845 expedition (and expeditions both before and after it), its impact on regional Inuit cultures and trading networks and indeed the lives of the crewmen who served aboard the ship. New insights into all of these elements have also been garnered through original historical, material culture, and analytical research presented herein.

The preliminary analysis and interpretation of the wreck included in this report has already yielded interesting and promising results. It is believed that the future study and excavation of HMS *Erebus*, not to mention planned complementary work at the wreck of HMS *Terror*, will shed new light on the Franklin expedition, and possibly totally rewrite chapters in the history of this remarkable expedition.

SOMMAIRE

Ce rapport présente le résultat des travaux archéologiques effectués par l'Équipe d'archéologie subaquatique de Parcs Canada (EAS) et ses partenaires sur l'épave du HMS *Erebus* en 2015 et 2016. Ce projet s'inscrit dans la poursuite des travaux préliminaires réalisés après la découverte de l'épave en septembre 2014. Les recherches ont été effectuées lors de trois périodes distinctes : la première dans le cadre de l'Opération Nunavut, déployée sur la glace en avril 2015; la seconde – aussi la plus longue – en août et septembre 2015 à partir du MV *Martin Bergmann*; enfin la dernière en septembre 2016 à partir du NGCC *Sir Wilfrid Laurier*.

L'objectif principal des travaux archéologiques de 2015 et 2016 sur *Erebus* était d'effectuer une évaluation complète du site, c'est-à-dire de l'épave et des artefacts qui y sont associés, ainsi que du champ de débris. L'étude comprend les éléments suivants : une évaluation du potentiel archéologique du site en général, mais aussi de l'intégrité architecturale du navire, de la nature et de l'étendue du champ de débris; une inspection visuelle des espaces intérieurs; ainsi que l'établissement de données environnementales de base. La présente évaluation archéologique a été réalisée principalement dans le but de planifier l'étude et la fouille archéologique exhaustive du site à long terme. Elle visait également à informer la gestion des ressources culturelles et naturelles au sein du nouveau Lieu historique national des Épaves-du-HMS *Erebus*-et-du-HMS *Terror*.

Les travaux archéologiques ont été réalisés principalement par le biais de méthodes non-destructives, comme l'enregistrement vidéo et photo (permettant une modélisation photogrammétrique 3D), des observations et mesures directes d'éléments précis sur l'épave, le prélèvement d'échantillons biologiques marins, de même que des relevés au sondeur multifaisceaux. En 2015,

une part significative des travaux en plongée a été employée à couper les laminaires couvrant l'épave, avant de pouvoir procéder à la réalisation de plans archéologiques et au prélèvement de quelques artefacts directement accessibles. Il n'y a pas eu de travaux d'excavation proprement dit sur le site en 2015 et 2016.

L'évaluation confirme hors de tout doute le potentiel archéologique remarquable du site noté lors de la découverte en 2014. Il met également en lumière quelques menaces réelles ou potentielles à son intégrité. HMS *Erebus* constitue une épave quasi intacte au sein de laquelle sont conservés de multiples espaces qui promettent de livrer des groupes cohérents d'objets scellés en contexte. L'étude de cette épave représente donc une opportunité unique pour mettre en lumière la technologie de pointe employée pour l'expédition de Sir John Franklin en 1845 (par extension, aussi celles de ses contemporains); d'évaluer l'impact de cette expédition sur la culture et les réseaux d'échange inuit régionaux; en permettant aussi d'approfondir notre connaissance de la vie à bord des navires du milieu du XIX^e siècle. L'information archéologique présentée dans les pages qui suivent et touchant à ces grands thèmes est étayée de données issues de recherches récentes en archives, d'études en culture matérielle, ainsi que de différentes analyses scientifiques spécialisées.

L'étude et l'interprétation préliminaire de l'épave inclue dans ce rapport ont déjà livré des résultats intéressants et prometteurs pour l'avenir. La fouille et l'analyse de l'épave du HMS *Erebus* – sans parler des travaux complémentaires à prévoir pour HMS *Terror* – jettera certainement un éclairage nouveau sur l'expédition Franklin et permettra possiblement de réécrire des chapitres entiers de l'histoire de cette expédition hors du commun.

ACKNOWLEDGEMENTS

Marc-André Bernier

As this report covers three separate episodes of complex fieldwork, the list of people who played a role in making these efforts a success is obviously quite long and it would be impossible to thank every person. As much as we would like to name everyone individually, we hope that these acknowledgements are able to cover, at least institutionally, all the dedicated and passionate individuals who took part in these three incredible adventures.

The April 2015 Breaking the Ice fieldwork took place within an annual Canadian Armed Forces exercise called Operation Nunavut. To be part of such a deployment makes one appreciate not only the number of people needed to make it happen but also the expertise to do so efficiently and safely. First, our gratitude goes to the Canadian Joint Operation Command, Joint Task Forces North and Atlantic, specifically Major-General Christopher J. Coates and Lieutenant-Colonel John St. Dennis in command of Operation Nunavut, and to Rear-Admiral John Newton who supported the integration of the UAT with Royal Canadian Navy (RCN) Clearance Divers. On the operational level within Joint Task Force North, we also extend special thanks to Lieutenant-Colonel John Cowen and Captain Simon Rocheleau.

The 2015 April fieldwork saw the integration of two dive teams with normally very divergent purposes: Parks Canada's Underwater Archaeology Team (UAT) and the RCN's Fleet Diving Units (Atlantic and Pacific)(FDU). The training and preparation of the FDU's participation were coordinated by FDU (Atlantic). Special acknowledgements go to Major Stéphane Briand who approved the final integration, to Lieutenant Greg Oickle for his leadership throughout the training and the deployment, and to Operations Chief Larry Lyver who made all the pieces of the puzzle fit together to get us on the ice. Larry and the UAT's Dive Officer Filippo Ronca did a great job to mesh each respective team's diving procedures. A huge thank you must be extended to Aaron Griffin, Director of the Underwater Skills Program, Seneca College, and the other instructors, notably Riccardo Ronca, for teaching old dogs new tricks and preparing the UAT to operate with surface supply diving equipment under

the ice. John French of Cavanaugh Construction Ltd. (Kanata, Ontario) kindly made Jinkinson's Quarry available to the UAT for diving training.

Special acknowledgements for the April fieldwork are also due the Canadian Armed Forces personnel who were on the ice with us. Every person on site had a crucial role to ensure the safe running of the operation and everyone delivered with flying colours. In particular, we would like to recognize the FDU team with whom we shared one of the most amazing experiences in the annals of Canadian Arctic diving. The integration of both dive teams was remarkable and is due to the professionalism of all involved on both sides. The interest, passion and open-mindedness of all team members made it possible to dive as an integrated team, to deliver amazing archaeological results in the brief time available and, most importantly, to bring everyone back home safely. We would also like to recognize the eleven team members who could not make it to the site after the initial deployment plan changed due to logistical challenges and who had to be sent home from Yellowknife on April 7, 2015.

Thanks are also in order for the 1st Canadian Ranger Patrol Group members who arrived first on site and left last: Jackie Ameralik, Johannisie (Angel) Ukuqtunnuaq and Trevor Tularialik from Gjoa Haven, and Bruce Takolik, Henry Lyall, George Aklah and Andy Aklah from Taloyoak. As well, we acknowledge the 109th Air Lift Wing, New York Air National Guard of the United States Air Force who worked tirelessly to prepare a landing strip to expedite our return home.

For the Live Dive broadcast, special thanks go to Fiona Currie (New Media Specialist, Parks Canada) and Bengt Neatherly (at the Royal Ontario Museum) and Simon Gray (on the ice) both of whom represented iSi Live. A tap on the back goes to Al Tremblay of Defence Research and Development Canada for cutting ice holes and for 'MacGyvering' batteries for the Live Dive. The Canadian Hydrographic Service kindly loaned a water level recorder for deployment to the site, a loan arranged by Hydrographer Scott Youngblut. Terese Herron, Supervisor Tides, Currents and Water Levels of the Canadian Hydrographic Service (Central and Arctic Region) kindly processed the 2015 water level data.

The August–September 2015 Mission *Erebus* and *Terror* 2015 fieldwork was really two separate operations that were integrated under one umbrella, encompassing fieldwork at the wreck of HMS *Erebus* and the search for HMS *Terror*; acknowledgements for the latter will appear in a separate report.

All 2015 fieldwork on HMS *Erebus* was staged from the Arctic Research Foundation’s (ARF) vessel *Martin Bergmann*, and we would like to extend sincere thanks to Jim Balsillie and Tim MacDonald of ARF for their support. At the operational level, a big thank you to Adrian Schimnowski, Operation Manager, who coordinated the logistics and preparations for ARF under challenging conditions. Thank you to the crew of the *Bergmann*: Captains David McIsaac and Gerry Chidley and Bridge Watchmen Clyde Bursey and Daniel McIsaac for their high spirits and interest in the archaeology of the site. The *Bergmann*’s core crew was completed by RCN staff; thanks to Master Seaman Randy Flynn for his amazing cooking skills and Petty Officer 2nd Class Kurt Eason (Engineer). Leading Seaman Dan Bard was also aboard for the second leg of the fieldwork as an Image Technician.

Thank you to Parks Canada’s Theoran Kopak for joining the team at the outset of the August–September 2015 fieldwork and for bringing his unique perspective and humour to our adventure. The UAT was also joined by Conservator Flora Davidson of Parks Canada’s Collections, Curatorial and Conservation Branch who took care care of the recovered artefacts aboard the *Martin Bergmann*. Aaron Griffin, Director of the Underwater Skills Program, Seneca College, also took part in summer fieldwork as UAT’s Advanced Dive Medic and a member of the dive team.

August 2015 saw the addition of a marine biology study to the site assessment of HMS *Erebus*. This pilot project was made possible through the support of the W. Garfield Weston Foundation. Thanks to Geordie Dalglish for his leadership and to Laurel Atkinson for her support. The study was also supported by ArcticNet, and we would like to thank Dr. Louis Fortier (Québec–Océan/ Université Laval) Scientific Director of ArcticNet and Dr. Philippe Archambault of the Benthic Ecology Laboratory at the Université du Québec à Rimouski (UQAR), as well as biologists Lisa Treau de Coeli (UQAR) and Nadia Ménard (Parks Canada, Saguenay–St. Lawrence National Marine Park) who took part in the field operations. Thanks

also to Caroline Bouchard (Québec–Océan/ Université Laval) and Shawn Meredyk (Université Laval/ArcticNet) for their help and guidance in the deployment of a current meter.

Thank you to the Parks Canada Nunavut Field Unit: Superintendent Jenna Boon for her support and insight, Brandi Larochelle for her help in getting Theoran Kopak on staff, and Jane Chisholm for her guidance through the permitting process. Thanks also to Davin St. Pierre of the Nunavut Impact Review Board for his assistance.

Heather Dewar of the Canadian High Arctic Research Station in Cambridge Bay kindly arranged for vehicle loans in September 2015.

During August–September 2016 fieldwork at HMS *Erebus* was based from CCGS *Sir Wilfrid Laurier*. The UAT extends its thanks to Captain Bill Noon, Chief Officer Rich Marriott and the rest of the ship’s company. The UAT is also grateful for the support and 2016 field participation of Sediment Scientist Dr. Hans Biberhofer of Environment Canada (EC).

Former Parks Canada material culture researchers Charles Bradley and Phil Dunning kindly provided information and advice on selected recovered artefacts. Researcher Christian Roy also kindly provided information on ceramic artefacts.

Ongoing historical research has been assisted by students Pascale Couturier and Phoebe Mannell, both of whom were supervised by Parks Canada Historian Meryl Oliver. In addition, a team of volunteers from the Nautical Archaeology Society’s Maritime Research Group carried out directed research at the National Archives of the United Kingdom; the UAT is grateful to their enthusiasm and assistance. This team was comprised of Ian Oxley, Sheilah Openshaw, Ian Barefoot, Faye Homsí and Chris Ohlsson.

The following members of Parks Canada’s Collections, Curatorial and Conservation Branch have provided direct assistance and support for the project: Hugues–Frédéric Brouillette, Mike Steinhauer, Kenza Dufourmantelle, Flora Davidson, Mélanie Hugron, Jayson Drew Oliver, Shelley Rowan, Louis Laflèche, Despoina Kavousanaki, Marni Wilson, Amanda Thomas and Meaghan O’Connor. Curator Heather Maiklejohn of Parks Canada provided information on a recovered textile sample and boot. The ongoing

efforts of all of these team members are greatly appreciated. Michael Eisen very kindly machined mounting brackets for multi-beam echosounder equipment on very short notice.

Parks Canada extends its sincere thanks to the hamlets of Gjoa Haven and Cambridge Bay for their collaboration in the project and to the Kitikmeot Inuit Association and in particular Fred Peterson for his support. The UAT is grateful to Dr. Doug Stenton, Director of Heritage, Government of Nunavut for his ongoing collaboration on research on the Franklin Expedition.

Special thanks go to some of the Parks Canada team who worked closely with us to make the 2015-2016 exploration, study and presentation of HMS *Erebus* happen: Alan Latourelle, Jeff Anderson, George Green, Marty Magne, Jarred Picher, Ellen Bertrand, Meryl Oliver, Francesco Manganiello, Tamara Tarasoff, Leanna Ellsworth, Bronwyn Pavey, the communications and web teams, and so many others.

Dr. Matthew Betts, creator of the *Building HMS Terror* website kindly reviewed the report and provided many insightful comments and corrections.

UAT underwater archaeologists Alexandre Poudret-Barré and Thierry Boyer carried out the report's page-setting. The maps and plans were prepared by UAT underwater archaeologists Brandy Lockhart and Charles Dagneau. Carol Pillar painstakingly drew the outstanding artefact and site plan illustrations. Enterprise Geomatics Specialist Geordan Harvey (Parks Canada) prepared Figures 1.2.1 and 2.1.1. Monika Templin, Geomatics Technician (Parks Canada) prepared Figure 1.2.2.

To anyone who is not mentioned in these acknowledgements but who supported these three field-work episodes, we extend our gratitude. The following is a list of Parks Canada's 2015-2016 HMS *Erebus* project partners (in alphabetical order):

- 1st Canadian Ranger Patrol Group
- 2G Robotics
- ArcticNet

- Arctic Research Foundation
- Canadian Coast Guard
- Canadian Hydrographic Service
- Canadian Ice Service
- Canadian Space Agency
- Deep Trekker, Inc.
- Defence Research and Development Canada
- Department of National Defence
- Fleet Diving Units (Atlantic and Pacific)
- W. Garfield Weston Foundation
- Government of Nunavut
- Hamlet of Cambridge Bay
- Hamlet of Gjoa Haven
- Inuit Heritage Trust
- Joint Task Force (North)
- Kitikmeot Inuit Association
- Nautical Archaeology Society Maritime Research Group
- New York Air National Guard
- One Ocean Expeditions
- Québec Océan
- Royal Canadian Navy
- Royal Ontario Museum
- Seneca College
- Université du Québec à Rimouski

LIST OF ABBREVIATIONS

ANG	Air National Guard
ARD	Parks Canada’s Archaeological Resource Database
ARF	Arctic Research Foundation
CHS	Canadian Hydrographic Service
CCG	Canadian Coast Guard
CCGS	Canadian Coast Guard Ship
CIS	Canadian Ice Service
CSA	Canadian Standards Association
CSL	Canadian Survey Launch
CSRS 98	Canadian Spatial Reference System 1998
DCIEM	Defence and Civil Institute of Environmental Medicine
DFO	Fisheries and Oceans Canada
DGPS	Differential global positioning system
DND	Department of National Defence
DRDC	Defence Research and Development Canada
DSM	Direct survey method
EC	Environment Canada
FDU(A)	Fleet Diving Unit (Atlantic), Royal Canadian Navy
GN	Government of Nunavut
GIS	Geographic information system
GNWT	Government of the Northwest Territories
GPS	Global positioning system
HMS	Her Majesty’s Ship
HSMBC	Historic Sites and Monuments Board of Canada
LWSS	Light weight surface supply
MBES	Multi-beam echo sounder system

MDT	Mountain Daylight Time
MV	Motor vessel
NAD 83	North American Datum 1983
NAVAIDS	Aids to navigation
NHS	National Historic Site
NMM	National Maritime Museum
NORAD	North American Aerospace Defense Command
NTCL	Northern Transportation Company Ltd.
PO1	Petty Officer first class
POV	Point-of-view
RCGS	Royal Canadian Geographical Society
RCN	Royal Canadian Navy
RHIB	Rigid-hulled inflatable boat
ROM	Royal Ontario Museum
ROV	Remotely operated vehicle
RV	Research vessel
SAR	Search and rescue
SBAS	Satellite-based augmentation system
SCUBA	Self-contained underwater breathing apparatus
UAT	Underwater Archaeology Team
UNESCO	United Nations Educational, Scientific and Cultural Organization
UQAR	Université du Québec à Rimouski
UTC	Universal Time Coordinated
UTM	Universal Transverse Mercator
VAC	Volts alternating current
VDC	Volts direct current
WAAS	Wide Area Augmentation System
WGS 84	World Geodetic System 1984

cm	Centimetre(s)
cm/s	Centimetre(s) per second
in.	Inch
ft.	Feet
hp	Horsepower (1 hp = 746 Watts)
kW	Kilowatt
lb.	pound
m	Metre(s)

1. PROJECT DESCRIPTION

1.1 INTRODUCTION

Marc-André Bernier

Once the euphoria of the discovery of HMS *Erebus* in September 2014 had subsided, the on-site archaeological tasks at hand quickly became obvious to UAT underwater archaeologists. The wreck rests on a shallow seabed in a state of preservation that exceeded prior expectations, although other historic wreck examples found in Arctic waters made this a reasonable preservation scenario. The three-dimensional hull was remarkably intact and rose above the seabed up to the upper deck in most places. Its interior was presumed to be in excellent condition with the exception of parts of the lower deck living spaces either crushed or exposed to the elements in places where the upper deck had collapsed or had been ripped open. Artefacts seemingly in pristine condition were observed on top, inside and around the wreck, raising hopes for the discovery of ground-breaking information to unlock some of the perennial mysteries surrounding the Franklin expedition.

The immediate questions facing UAT archaeologists were: “What information can we realistically hope to extract from this site?” and “How do we tackle this three-dimensional puzzle located in an environment that only provides a limited annual window(s) of opportunity to access the promised information?”

In reality, these two particular questions are not novel to UAT underwater archaeologists. Indeed, they are part of a linear process that follows any discovery and their gist is embedded in the Annex of the United Nations Educational, Scientific and Cultural Organization’s (UNESCO) 2001 Convention on the Protection of the Underwater Cultural Heritage, under Part III (Preliminary work), Rules 14 and 15:

Rule 14. The preliminary work referred to in Rule 10 (a) shall include an assessment that evaluates the significance and vulnerability of the underwater cultural heritage and the surrounding natural

environment to damage by the proposed project, and the potential to obtain data that would meet the project objectives.

Rule 15. The assessment shall also include background studies of available historical and archaeological evidence, the archaeological and environmental characteristics of the site, and the consequences of any potential intrusion for the long-term stability of the underwater cultural heritage affected by the activities (UNESCO 2001).

Upon the discovery of *Erebus* it was self-evident that the largely intact wreck was extremely promising archaeologically. Yet it would be simplistic to infer that since the wreck has rested on the seabed in this location for almost 170 years that it had achieved a state of equilibrium with its environment and that it was entirely stable, especially given new environmental and climatic dynamics at play in the Arctic.

An assessment of the *Erebus* site in order to prepare for any future archaeological work became the UAT’s priority: the very first dives following the 2014 discovery, conducted with a remotely operated vehicle (ROV) and shortly thereafter by UAT underwater archaeologists, actually started this structured process which was also guided by Parks Canada’s Cultural Resource Management Policy (Parks Canada 2013). The three subsequent fieldwork campaigns that took place in April 2015 (Figure 1.1.1), August-September 2015 and August-September 2016 (Figure 1.1.2) were entirely dedicated to assessing the:

- extent and the state of preservation of the wreck;
- site’s potential to enlighten our knowledge of the history of the Franklin expedition and the areas of the wreck site most likely to deliver this knowledge;
- stability of the wreck structure;
- preferred *modus operandi* to access the wreck’s unique information; and



Figure 1.1.1: Ice diving operations underway at the *Erebus* site in April 2015 (Photo: J. Boucher, Parks Canada; 89Mo1829EF).

- environmental risks to the wreck and any urgency to conduct intrusive archaeological work and excavation.

The site assessment, embodied by this report on 2015 and 2016 archaeological activities will help guide future research and will be fundamental in shaping Parks Canada's privileged archaeological study of a truly remarkable shipwreck site.

This report's Section 1 provides an introduction to the project, the study area and provenience system. Section two presents historical and archaeological background. Section 3 outlines field and research methodologies, during the novel ice diving in April 2015 of Operation Nunavut as well as open water diving in August-September 2015 and 2016. Section 4 is a preliminary description of the site environment, including an outline of findings from a marine biological inventory of the site. Section 5, the heart of this report, provides an in situ description of the wreck. Section 6 is a description of recovered artefacts with identification, analytical and material culture research contextual information. The concluding Section 7 sums-up the results of the site assessment.

This report provides as complete an assessment of the wreck site of *Erebus* as the UAT could possibly present given its limited time on site and the limited fieldwork opportunities. This assessment sets out new, interesting and varied archaeological findings – from the debris field, hull construction, hull interior, to recovered artefacts. It also provides enough baseline information to show



Figure 1.1.2: UAT underwater archaeologist examines the wreck's upper deck structure in September 2016 (Photo: T. Boyer, Parks Canada; 89Mo8448EF).

the way forward for archaeological work and indeed lays the foundation for a comprehensive and forthcoming research design for the wreck of *Erebus*.

1.2 DEFINITION OF THE STUDY AREA

Jonathan Moore

The 2015-2016 study area corresponded to the boundaries of the Wrecks of HMS *Erebus* and HMS *Terror* National Historic Site of Canada situated in Wilmot and Crampton Bay at the eastern end of Queen Maud Gulf, within the Kitikmeot Region (Qitikmiut) of Nunavut, Canada. The site is approximately 125 km from Gjoa Haven and 275 km from Cambridge Bay, the two nearest communities in Nunavut (Figures 1.2.1 and 1.2.2). The historic site is a 10 km by 10 km zone that

encompasses the wreck of *Erebus* and that is situated amongst an archipelago west of the Adelaide Peninsula and north of O'Reilly Island. It was created on April 8, 2015 by way of an Order Amending the National Historic Sites of Canada under the Canada National Parks Act and comprises "... the seabed and water column above the seabed ... EXCEPTING all islands and foreshore lying above the ordinary low-water mark ..." (Government of Canada 2015). The area covers approximately 83.6 km² taking into account the islands' collective area. As a result of the creation of this zone, the wreck of *Erebus* was afforded the protections of the Canada National Parks Act and the National Historic Parks General Regulations. The 10 islands or parts thereof within the zone that are above the low-water mark are under the jurisdiction of the Government of Nunavut (GN).

All underwater archaeological activities in 2015 and 2016 took place within a 200-m radius of the hull of the wreck, and encompassed parts of its surrounding seabed debris field. Following the

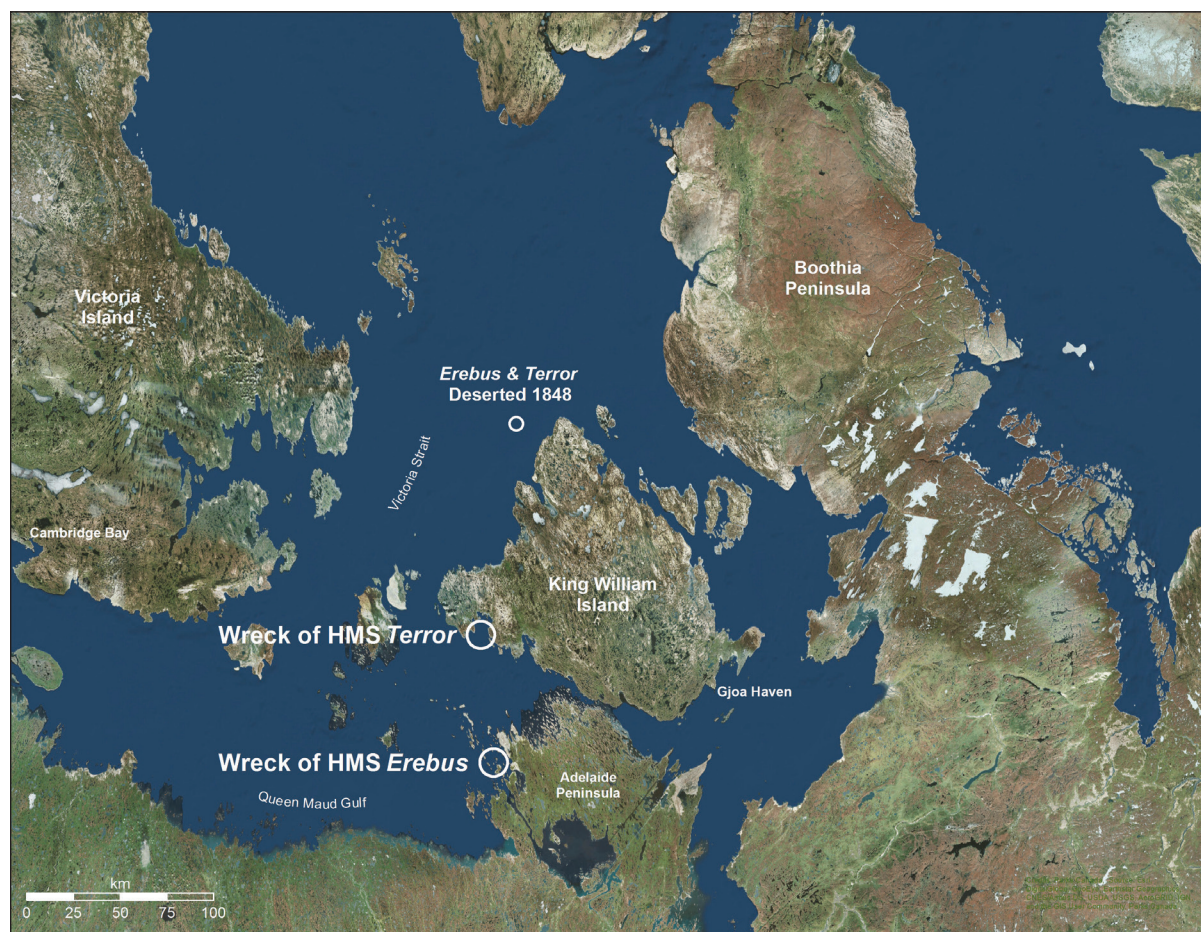


Figure 1.2.1: Locations of the wrecks of HMS *Erebus* and HMS *Terror*, Kitikmeot Region, Nunavut (Map: G. Harvey, Parks Canada).

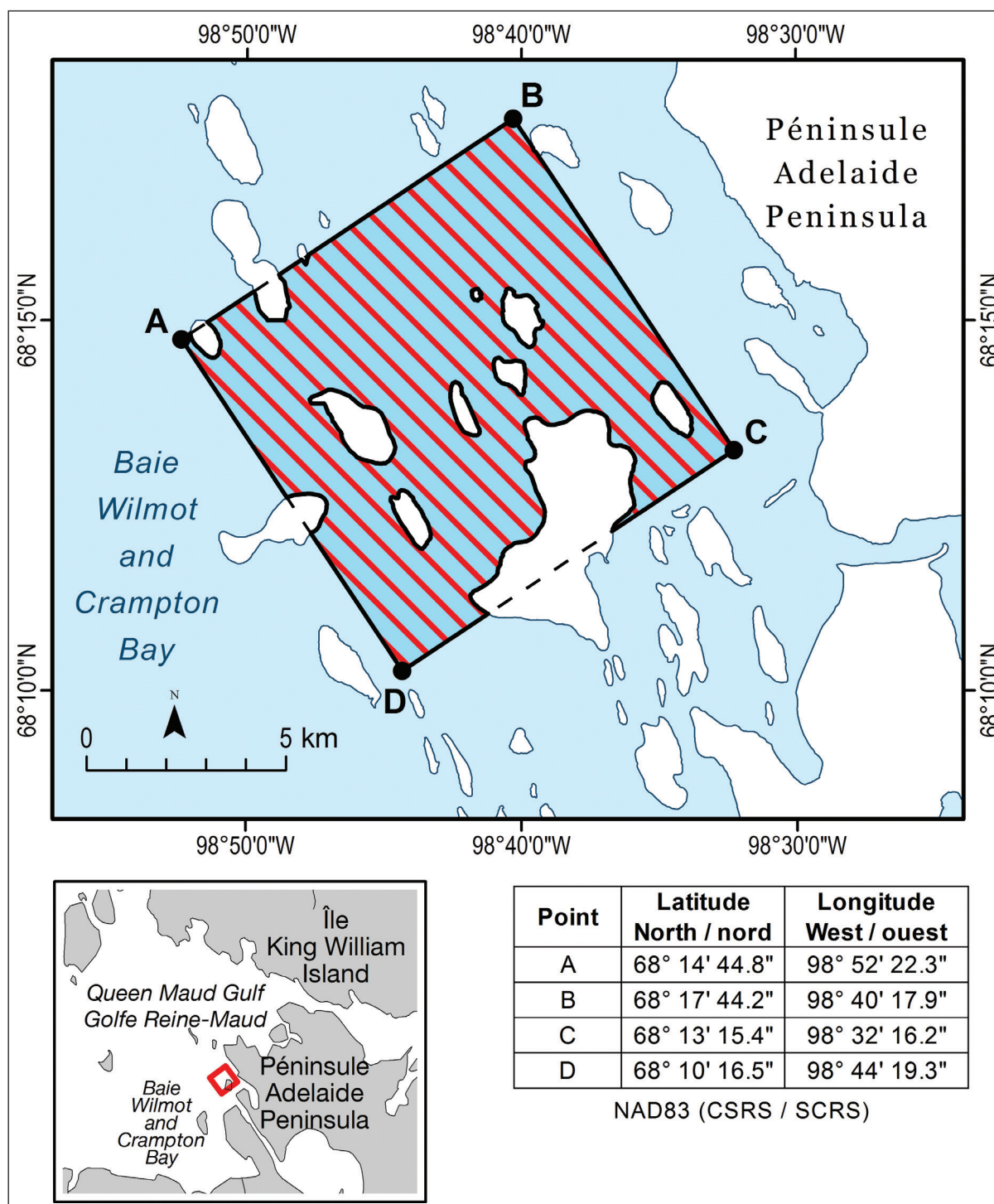


Figure 1.2.2: Wrecks of HMS *Erebus* and HMS *Terror* National Historic Site of Canada showing the 10 km by 10 km protected area for the wreck of HMS *Erebus* (Map: M. Templin, Parks Canada).

2014 discovery of *Erebus*, Parks Canada and the GN agreed that the precise site location would not be disclosed; for this reason no absolute site location information is provided in this report, although archaeological data is presented within a relative geomatic backdrop. Given that the UAT will approach study of the wreck with an inclusive

maritime archaeological approach, it is anticipated that future archaeological activities directed at *Erebus* could spread geographically beyond the wreck itself, to include for example remote sensing surveys and collaboration with terrestrial archaeological work on nearby islands and the Adelaide Peninsula.

1.3 OBJECTIVES

Marc-André Bernier, Ryan Harris and Jonathan Moore

The overriding objective for 2015 and 2016 fieldwork at *Erebus* was to complete the archaeological assessment phase of the project, within a planned multi-year project window of 2015-2020. Not all objectives within any given fieldwork episode were completed however and actual results are described in Sections 3 through 7.

The first episode of fieldwork in April 2015 was called Breaking the Ice: HMS *Erebus* Revealed and took place under the umbrella of Operation Nunavut 2015, an annual Canadian Forces military exercise directed by Joint Task Force (North) based in Yellowknife, Northwest Territories. Archaeological objectives for this episode included:

- Installation of primary reference points for site surveying;
- Systematic removal of overlying kelp from the wreck;
- Extensive video and photo documentation of the site including 3D photogrammetric modelling;
- Exploration of interior spaces using inspection cameras inserted through various ruptures in the upper deck;
- Selected test excavation(s) with a water induction dredge and aluminum grid reference system;
- 3D underwater laser scanning of the upper deck, stern structure, and/or accessible between-deck space;
- Possible recovery of the two 6-pounder brass cannon located off the stern;
- Underwater video filming in support of a proposed documentary film production and a Live Dive from the wreck site; and
- Deploy a Canadian Hydrographic Service tide gauge to the seabed at the site.

The objectives for the August-September 2015 episode of fieldwork, entitled “Mission *Erebus* and *Terror* 2015”, followed on from the April 2015 work, and included:

- Continuation of site recording, the evaluation of site condition, and in-depth investigations of the periphery and interior of the wreck site;
- Continuation of 3D photogrammetric modelling;
- Test excavation(s) in the debris field at the stern;
- Recovery of selected diagnostic and representative artefacts (surface collection) necessary to help reconstruct the story of the Franklin expedition;
- A marine biology component to characterize the benthic communities (fauna and flora) found on the wreck in order to better understand Arctic marine biodiversity, the factors limiting or enabling the development of benthic communities in Arctic regions and the impact of these communities on the wreck;
- Deploy a current profiler to the seabed at the site and recover the Canadian Hydrographic Service tide gauge;
- Clear kelp from the upper deck, starboard side and stern;
- Photo and video coverage of the wreck and its debris field;
- Locate, map and record diagnostic features and visible in situ artefacts within a gridded provenience system;
- Scout potential future excavation areas and potential entry points for future interior site penetration dives;
- Interior photo and video through visible hull openings;
- Collect wood species samples of selected features; and

- Explore the debris field beyond 5 m out from the hull perimeter, including a multibeam echo-sounder survey of this zone.

The objectives for the August-September 2016 episode of fieldwork, entitled *Mission Erebus and Terror 2016*, were limited due to time constraints, and included:

- Site inspection to check on the condition of the wreck and to detect any change to the site since September 2015;
- Photo and video documentation;
- Complete the initial phase of 3D photogrammetric recording;
- Recover a current profiler deployed in September 2015 and its redeploy it elsewhere in Wilmot and Crampton Bay;
- Multi-beam echosounder survey of the site and the surrounding debris field;
- Interior video using a DeepTrekker ROV; and
- Meet and escort members of the Franklin Advisory Committee to the site.

1.4 PROVENIENCE SYSTEM

Jonathan Moore

Parks Canada employs an alphanumeric coding system to categorize, identify and reference archaeological data. This hierarchical provenience classification system is outlined in the Parks Canada Archaeological Recording Manual: Excavations and Surveys (2005). In September 2014, upon the discovery of the wreck that later proved to be *Erebus*, the UAT assigned the Parks Canada site number 89M to the wreck (Table 1.4.1). All field data and site records linked to the wreck collected from September 2014 onwards have been classified under this provenience designation. At the time of writing this report, and with the prior agreement of Dr. Doug Stenton of the Department of Culture of the GN, the wreck site has not been registered and assigned a Borden number, as this could lead to the unwanted dissemination of its exact position.

Provenience number example:

89M - 40N - 100 - 1
Site - sub-operation - lot - artefact number

Lot number ranges for distinct surfaces:

1-99	Seabed / debris field
100-199	Upper deck and hull exterior
200-299	Lower deck
300-399	Orlop deck
400-499	Hold

Artefacts September 2014 - April 2015:

89M99X1-1 to 89M99X1-15

Artefacts on seabed outside of grid:

89M-100A1

Table 1.4.1. Summary of *Erebus* provenience number classification system.

In early 2015, the UAT began to further develop the site provenience system, adopting a proven method of spatial control applied during previous survey and excavation work on historic shipwrecks in Canada. An alphanumeric site reference grid of 2-m-by-2-m squares was aligned to the longitudinal axis of the hull, which conveniently runs almost perfectly due east-west, with the bow pointing 272 degrees relative to true north (Figures 1.4.1 and 1.4.2; see Table 1.4.1). Within this system lateral columns of 2-m wide squares are numbered “operations”. Longitudinal rows of 2-m wide squares are “sub-operations” and have a letter designation, with the letters “O” and “I” omitted to avoid confusion with the numbers zero and one. An individual grid square thereby has an alphanumeric identifier formed by combining its operation and sub-operation designations. For example, the bow is found in square 20L and the stern in square 54L; in common practice these designations are called “units”, “squares” or “sub-ops”. Furthermore, the vertical dividing lines between two columns of operations take the number immediately to the left, and the horizontal dividing line between two rows of sub-operations takes the letter immediately above it.

In a departure from previous UAT practice, the longitudinal axis of the grid is not centered on or follow a straight line from endpost to endpost. Rather, the grid and the X-axis of the primary sub-operation row “L” straddles the centerline running between the hull’s end-posts. This grid positioning approach was adopted for a range of practical reasons:

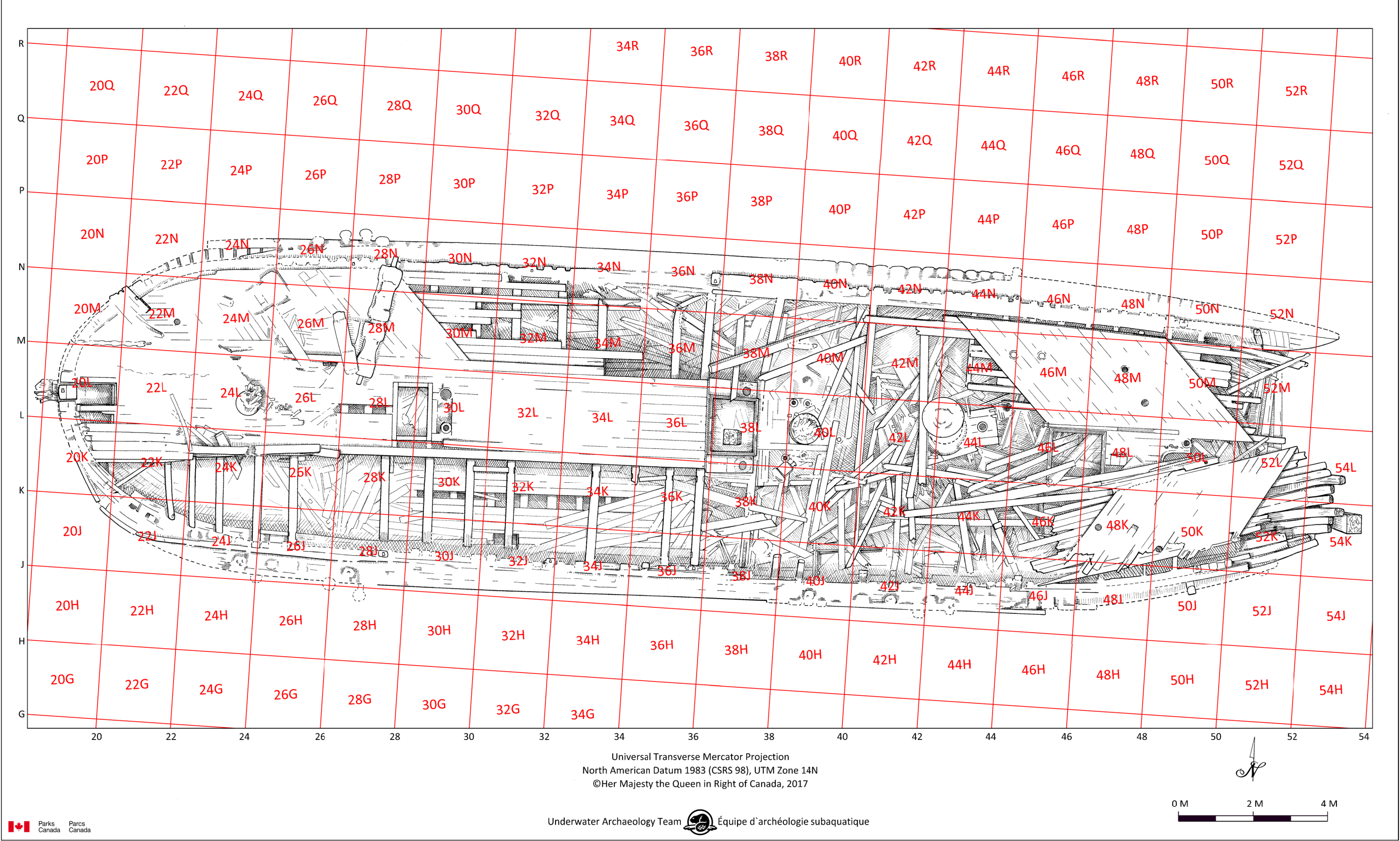


Figure 1.4.1: Site provenience grid superimposed over the upper deck site plan of *Erebus* (Drawing: C. Pillar, Parks Canada; 89M-2017-101-1. Image: B. Lockhart, Parks Canada).

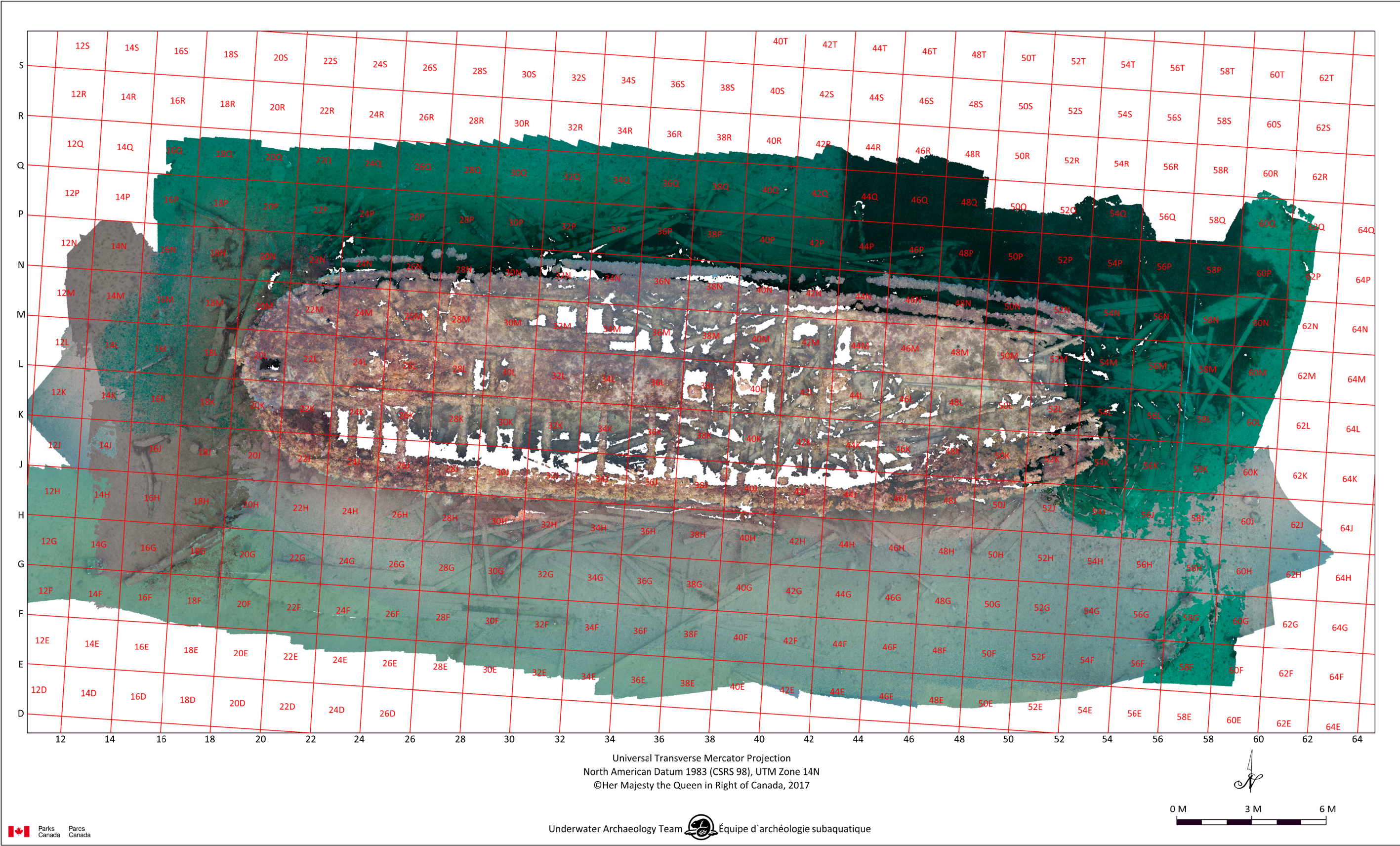


Figure 1.4.2: Site provenience grid superimposed over a photogrammetric point cloud model of *Erebus* upper deck and debris field (Image: T. Boyer and B. Lockhart, Parks Canada).

- It best accommodates the 3-dimensionality of the wreck and the marked elevation differences between the upper deck and seabed;
- Features projecting upwards from the upper deck would have interfered with a centerline baseline alignment thereby rendering it impractical underwater;
- Line K could be physically tied to distinctive longitudinal structural features underwater;
- Five 2-m wide grid squares taken together approximate the breadth of the hull at the upper deck level and centering this odd number of units across the width of the hull maximizes the number of grid units wholly over the upper deck or wholly over the seabed, a mapping convenience;
- Lines H and N run along the port and starboard sides of the hull respectively, another convenience for mapping both the outer margins of the upper deck and the debris field below; and
- It creates a balanced distribution of squares on the upper deck.

For vertical provenience control, Parks Canada standard practice was again adopted, but with some adaptation. Within each 2-m-by-2-m sub-op, stratigraphic layers (also known as ‘lots’) were assigned a sequential number, beginning with the uppermost surface layer. To take into account the fact that there are five intact and discrete ‘surfaces’ at the site, namely the seabed and the four respective decks of the ship, unique number ranges for lots at each surface were assigned (see Table 1.4.1). It is assumed that no given sub-op will have more than 99 stratigraphic or arbitrary lots, and that someday excavation or collection might take place lower down in the hull.

A final identifier in the provenience numbering scheme is a sequential number assigned to artefacts or samples within a given lot, assigned in

order of discovery or recovery. This provenience number is also the artefact’s ‘catalogue number’. It is important to note that all artefacts raised to date from the wreck can be considered surface collection, given that no excavation has taken place. Thus, catalogue number 89M40N100-1 is a belaying pin found on the surface of the upper deck in sub-op 40N and catalogue number 89M30K200-1 refers to a dinner plate from the first surface lot on the lower deck, in sub-op 30K. It is also important to note that prior to the imposition of the provenience system in mid-2015, one artefact raised in September 2014 (89M99X1-1) and fourteen in April 2015 (89M99X1-2 through 89M99X1-15) were assigned catalogue numbers based on the 99X sub-op number that denotes missing provenience control (see Table 1.4.1). This is not to say that the finds were not mapped or position-fixed, but rather that they could not at the time be tied into a grid. Artefacts that are located on the seabed outside the provenience grid are assigned to sub-operation and lot 100A1, for example the ship’s wheel fragment 89M100A1-1.

In order to represent or forge a contextual link between artefacts that transcend lots and/or sub-operations, ‘feature’ numbers are also used to identify a distinct assemblage or physical grouping of artefacts. Four feature numbers were assigned in 2015 for artefact groupings on the lower deck near the galley. Two more were assigned to group containers and their contents, for example, feature six which comprises a pharmaceutical bottle (89M99X1-8) that contained one buck shot (89M28K200-1) and 18 bird shot (89M28K200-2).

In addition to artefacts, all field records, photographs, video, geomatic data, drawings, collections and conservation records are coded and archived using the provenience system and artefact catalogue numbers. The most common number that will appear in this report are photo catalogue numbers, comprising the site code 89M followed by a five digit sequential number and suffix “EF” denoting “electronic file” or digital image.

2. HISTORICAL AND ARCHAEOLOGICAL BACKGROUND

2.1 THE 1845 FRANKLIN EXPEDITION

Jonathan Moore and Ryan Harris

On May 19, 1845 the Royal Navy ships HMS *Erebus* and HMS *Terror* departed Greenhithe, England on a much-heralded Arctic expedition in search of a Northwest Passage. Under the command of Sir John Franklin, with Francis Rawdon Moira Crozier second in command, the expedition's two ships set out with a total complement of 134 officers and men.

Terror was launched at Topsham, England in 1813 as a *Vesuvius*-class bomb vessel of 325 tons burthen. *Terror* saw action on the American eastern seaboard during the War of 1812, including the infamous bombardment of Fort McHenry during the Battle of Baltimore in September 1814. Like other bombs in a period of renewed Royal Navy Arctic exploration after the Napoleonic Wars, *Terror* was refit as a polar discovery ship. This took place in late 1835 and early 1836 prior to an aborted rescue mission in search of trapped whaling ships, and Captain George Back's Northwest Passage expedition of 1836-1837.

Erebus was launched in 1826 at Pembroke Dockyard in Wales as a *Hecla*-class bomb vessel, slightly larger than *Terror* at 372 tons burthen. *Erebus* was similarly refit as a polar discovery ship in 1839 prior to a successful 1839-1843 voyage with *Terror* to the Antarctic under the command of Captain James Clark Ross. A final refit for both of these Barque-rigged ships took place in early 1845 prior to Franklin's voyage. Both ships had already been heavily reinforced for operation in the ice and in 1845 were equipped with novel auxiliary-steam screw propulsion systems fitted expressly for the expedition, and lavishly provisioned for a voyage of up to three years expected duration (Battersby and Carney 2011; Cyriax 1939, 28ff). Contemporary documentation of both ships includes paintings, sketches, voyage journals, logbooks, and dockyard records.

Sir John Franklin's orders were to traverse the passage and return to England without delay via the Pacific (Cyriax 1939). After clearing the Thames, *Erebus*, *Terror*, a transport called *Baretto Junior* and their tows headed up England's North Sea coast (Figure 2.1.1). This part of the voyage is well-depicted by contemporary artwork, and ship details are very clearly illustrated, which accord well with contemporary sets of ship plans and a block

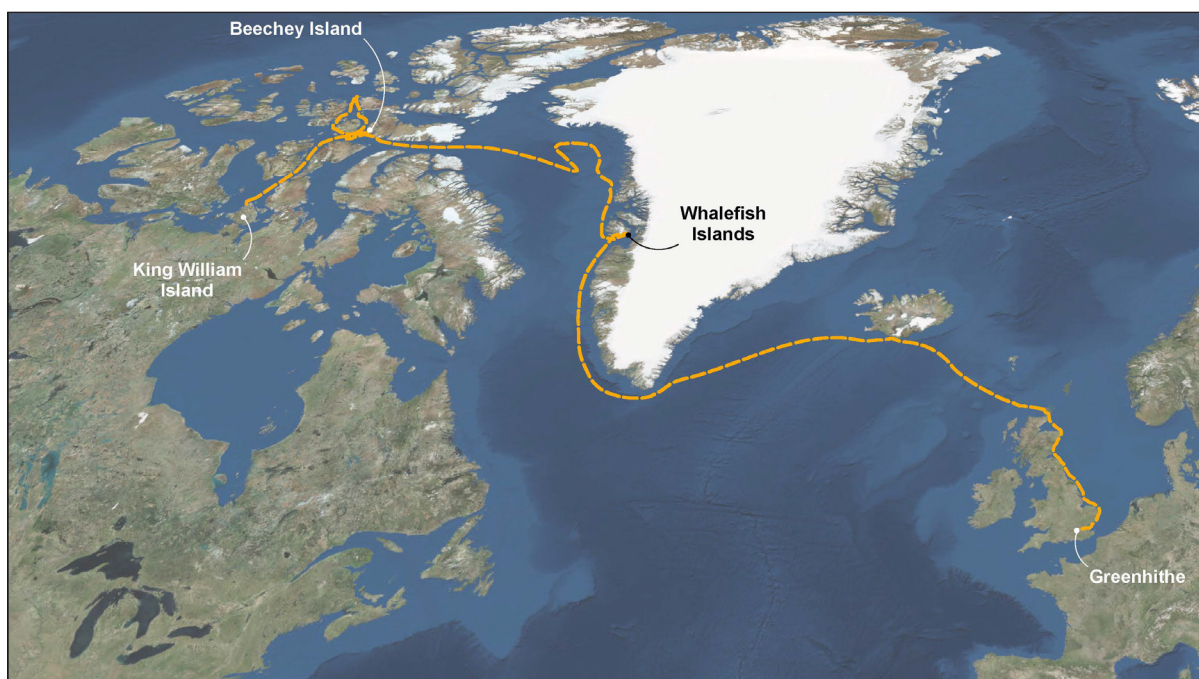


Figure 2.1.1: Map showing reconstructed route of *Erebus* and *Terror*, 1845-1848 (Map: G. Harvey, Parks Canada).

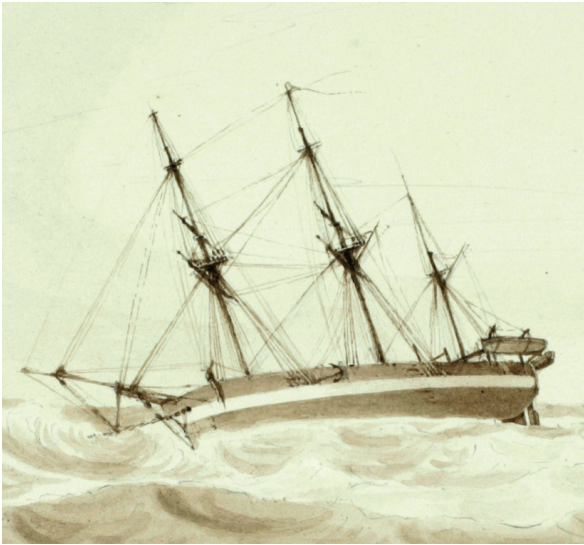


Figure 2.1.2: Detail of “H.M.S. *Erebus* May 22nd 1845 3 AM Off Aldborough”, by Lieutenant Graham Gore (Courtesy: Scott Polar Research Institute, N1533).

model of *Erebus* (Figures 2.1.2-2.1.9, Table 2.1.1 and Figure 5.1.5). It is important to note that while the illustrations from 1845 show the ships as fitted for the 1845 voyage, the invaluable ship plans themselves paint an incomplete picture of the 1845 modifications and fittings, necessitating a certain degree of interpretation and extrapolation. Given their overlapping subject matter, both the ship plans of *Erebus* and those of *Terror* must be considered in concert: for example the *Terror*

plans show 1836, 1839 and 1845 refit details, including the extensive 1845 modifications to the stern for the addition of steam propulsion. As well, whereas the *Erebus* plans represent primarily this ship, they also depict added fittings and modified features on the *Terror* (as the titles of the plans suggest with the inclusion of the name *Terror*).

The three ships parted company with their tows HMS *Blazer* and HMS *Rattler* off the northwest coast of Scotland (see Figure 2.1.3). They crossed the Atlantic to the Whalefish Islands on the west coast of Greenland where *Erebus* and *Terror* took on board extra provisions from the *Barretto Junior*, which returned to England. Surviving letters sent home by expedition officers on the ships during the first leg of their voyage. The two now very heavily-laden discovery ships, with about three-years' worth of provisions and 129 men on board were last seen afloat by Europeans in late July while crossing Baffin Bay en route to Lancaster Sound, the eastern entrance to the Northwest Passage.

It was at this juncture that a mystery enveloped the Franklin expedition. From the European perspective, nothing whatsoever was heard from the ships by 1847, and they were earnestly expected to emerge from the western end of the passage at any moment. Concern mounted that year: the British



Figure 2.1.3: HMS *Erebus* and HMS *Terror* part company with HMS *Blazer* and HMS *Rattler*, June 1845 (Courtesy: Scott Polar Research Institute, N972).

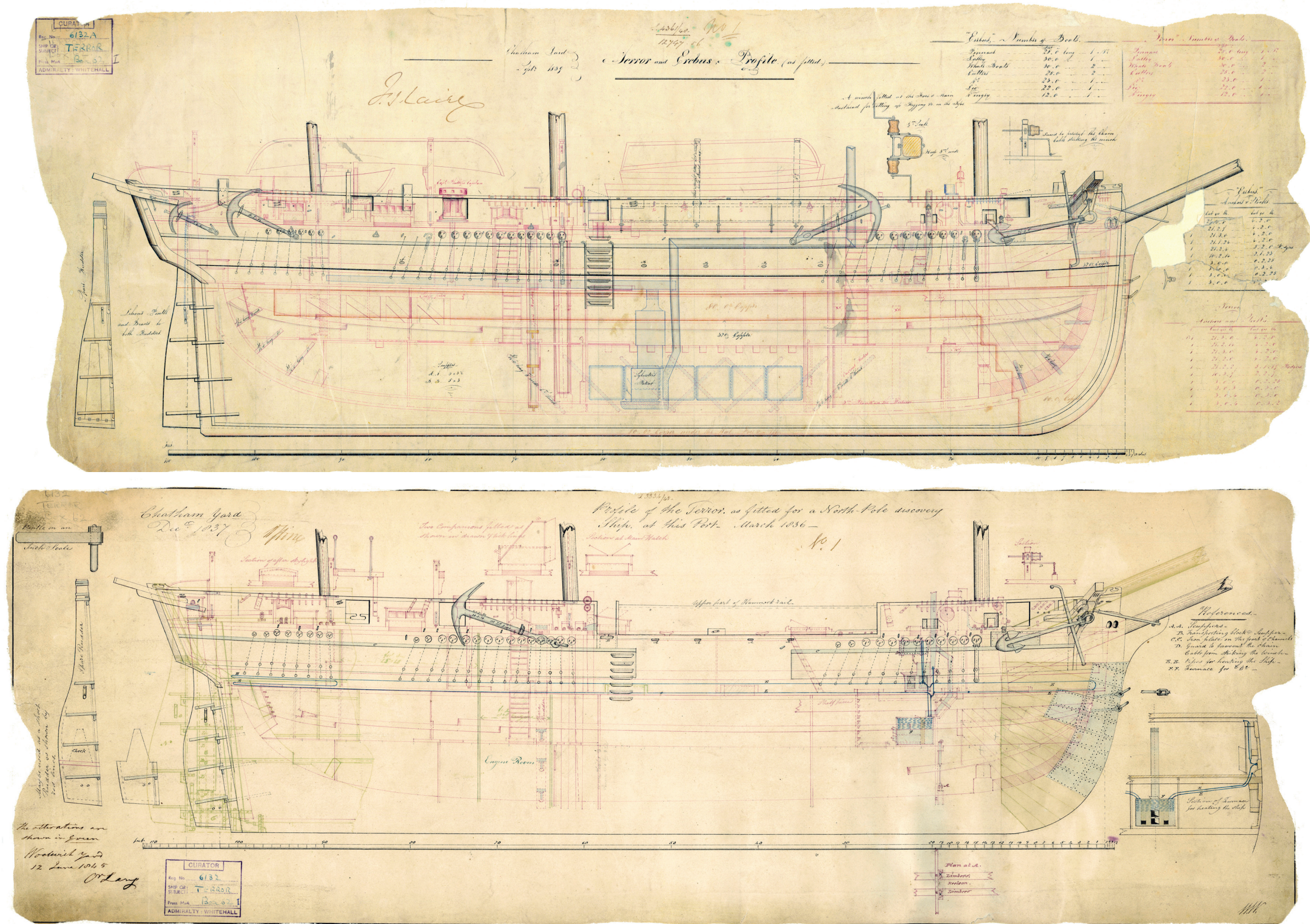


Figure 2.1.4: Ship profile plan comparison of HMS *Erebus*, 1839 and HMS *Terror*, 1837/1845 respectively (Courtesy: National Maritime Museum, Greenwich, London; ZAZ5673, J1407; ZAZ5672, J1406).

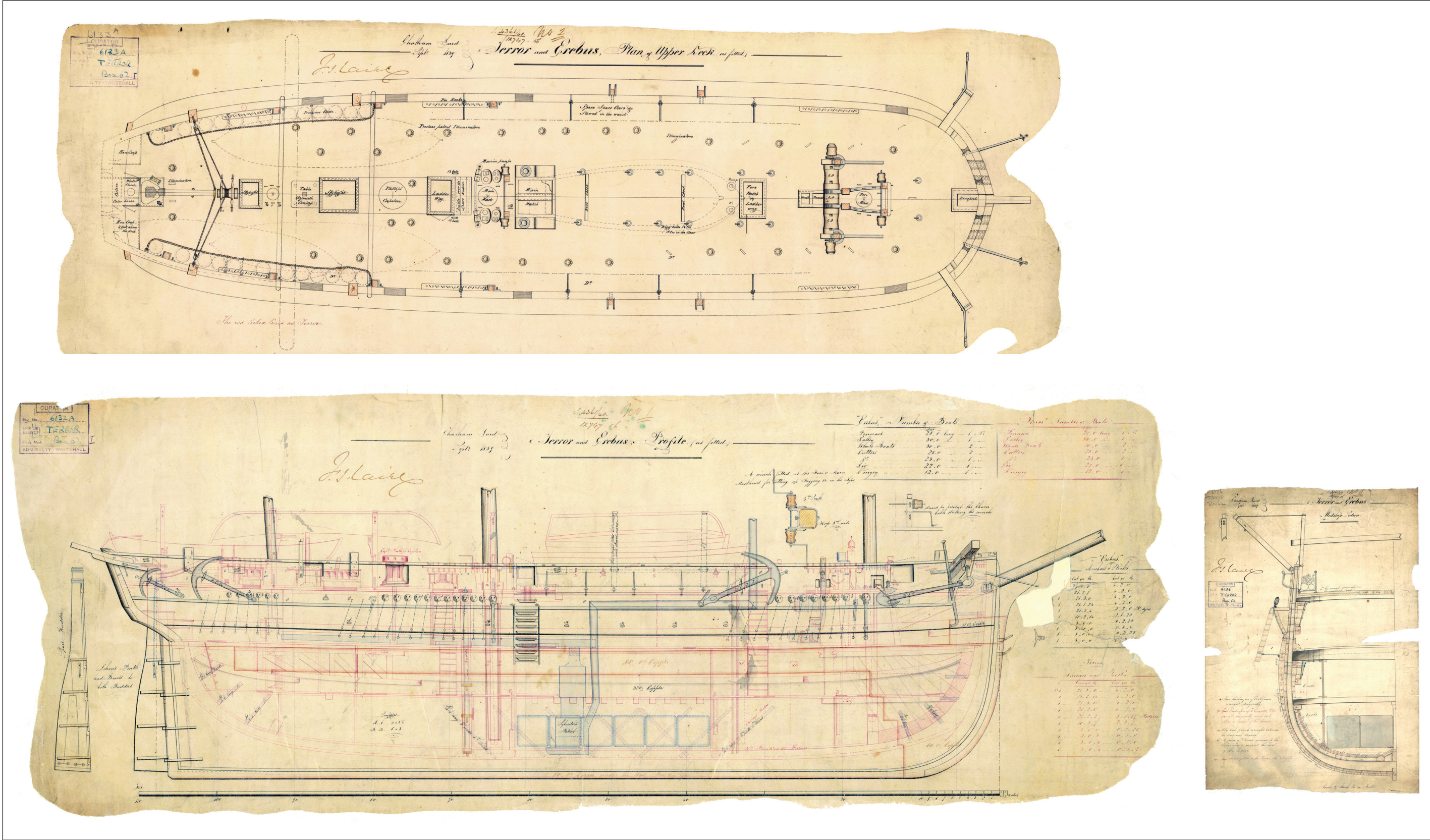


Figure 2.1.5: Ship plan compilation of HMS Erebus, 1839: upper deck (top), profile (bottom), midship section (right) (1:150) (Courtesy: National Maritime Museum, Greenwich, London; ZAZ5675, J1409; ZAZ5673, J1407; ZAZ5678, J1412).

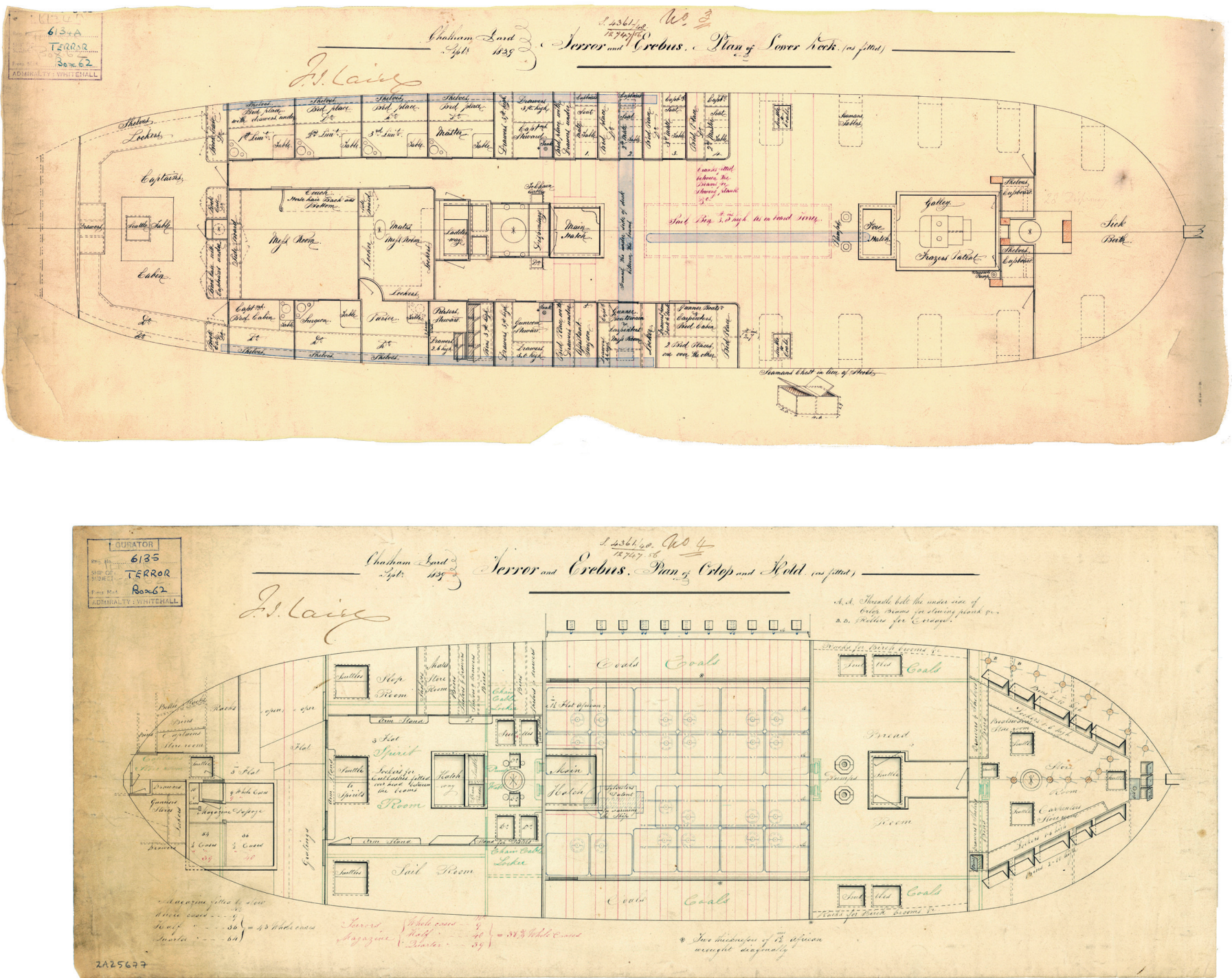


Figure 2.1.6: Ship plan compilation of HMS Erebus, 1839: lower deck (top), and orlop and hold (Courtesy: National Maritime Museum, Greenwich, London; NPC3125, J8650; ZAZ5675, J1411).

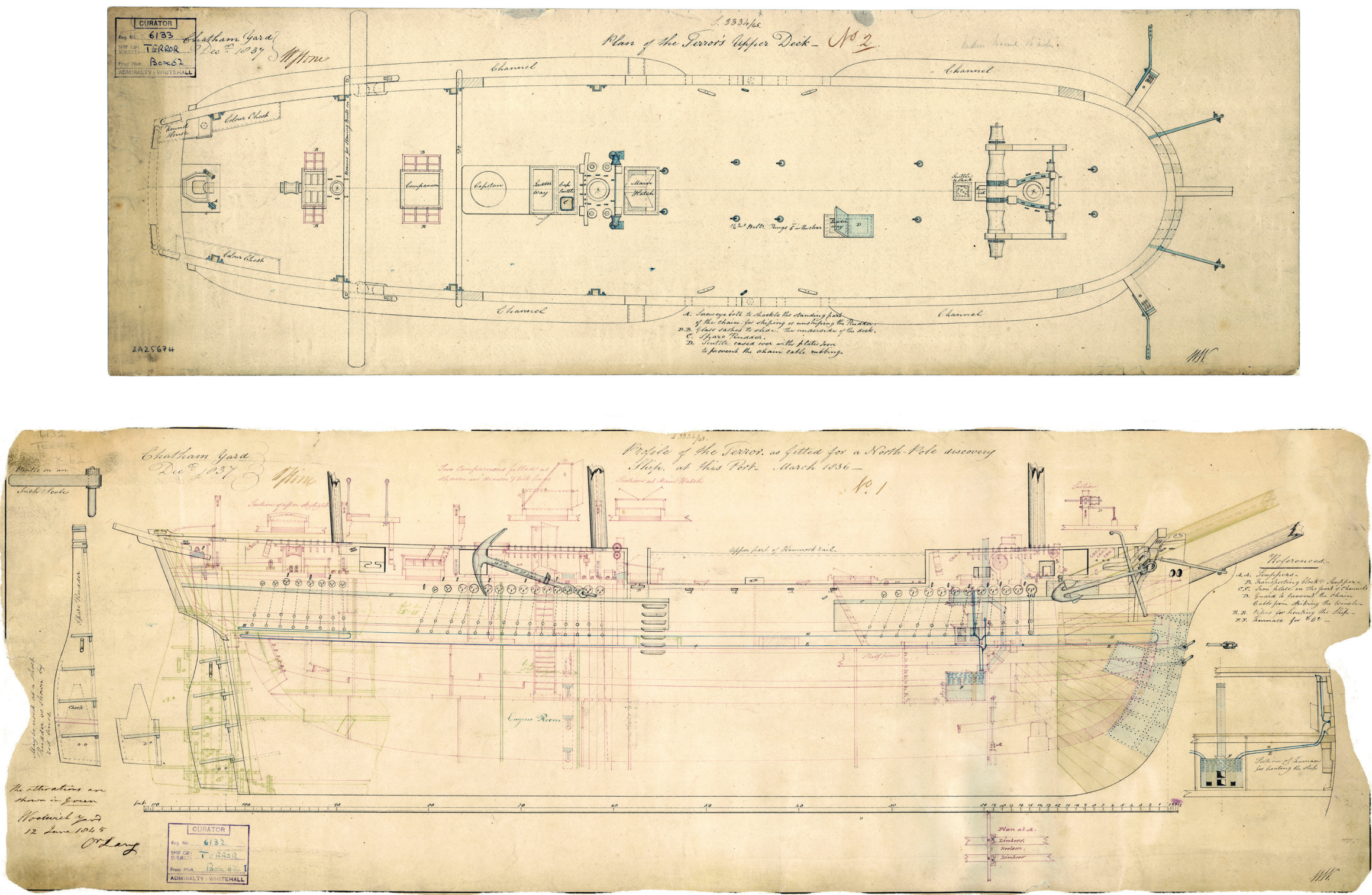


Figure 2.1.7: Ship plan compilation of HMS Terror: upper deck (top), 1837, and profile, 1836/1845 (1:150) (Courtesy: National Maritime Museum, Greenwich, London; ZAZ5674, J1408; ZAZ5672, J1406).

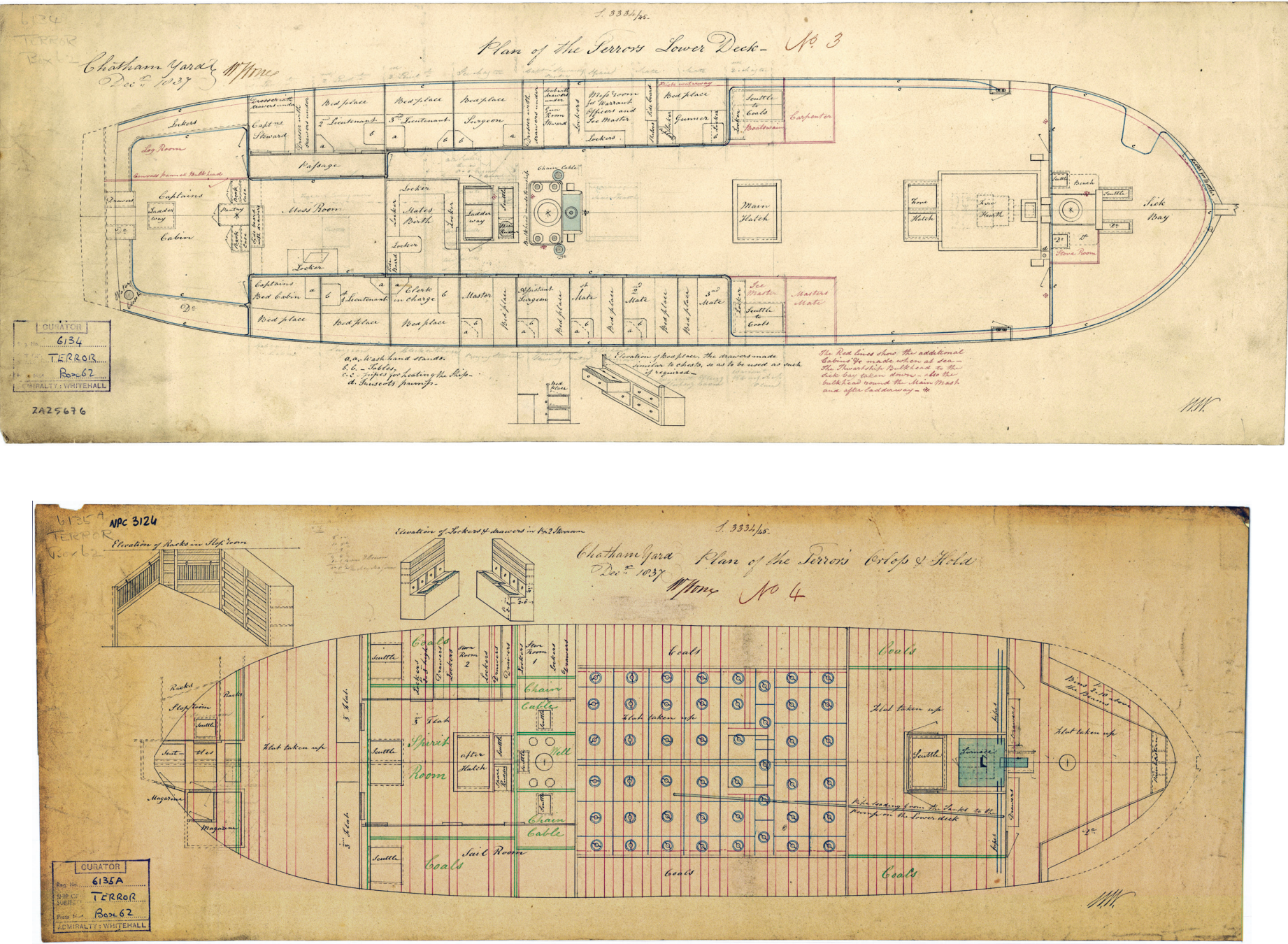


Figure 2.1.8: Ship plan compilation of HMS Terror: lower deck (top), and orlop and hold (Courtesy: National Maritime Museum, Greenwich, London; ZAZ5676, J1410; NPC3124, J8649).



Figure 2.1.9: Compilation of photographs of the 1839 full block model of HMS *Erebus* (SLR0715) and 1845 stern block model of *Erebus* (SLR2253) (bottom right) in the collections of the National Maritime Museum, Greenwich (Photos: J. Moore, Parks Canada).

Plan #	Scan #	Date(s)	Title
ZAZ5672	J1406	December 1837 June 12, 1845	Profile of the <i>Terror</i> . As fitted for a North-Pole discovery Ship, at this Port. March 1836
ZAZ5673	J1407	September 1839	<i>Terror</i> and <i>Erebus</i> , Profile. (as fitted.)
ZAZ5674	J1408	December 1837	Plan of the <i>Terror</i> 's Upper Deck.
ZAZ5675	J1409	September 1839	<i>Terror</i> and <i>Erebus</i> , Plan of Upper Deck. (as fitted.)
ZAZ5676	J1410	December 1837 1845	Plan of the <i>Terrors</i> Lower Deck.
ZAZ5677	J1411	September 1839	<i>Terror</i> and <i>Erebus</i> , Plan of Orlop and Hold. (as fitted).
ZAZ5678	J1412	September 1839	<i>Terror</i> and <i>Erebus</i> . Midship Section.
ZAZ5683	J1529	March 17, 1845	Drawings,- representing the after part of the " <i>Erebus</i> " Arctic ship; [...]
NPC3124	J8649	December 1837	Plan of the <i>Terror</i> 's Orlop & Hold
NPC3125	J8649	September 1839	<i>Terror</i> and <i>Erebus</i> , Plan of Lower Deck. (as fitted)

Table 2.1.1: List of selected ship plans of *Erebus* and *Terror* held by the National Maritime Museum, Greenwich, England. Note that plans ZAZ5673 and ZAZ5676 show 1845 steam plant, propeller and bow sheathing modifications on the profile of *Terror*, changes that would have been applied to *Erebus* as well. The remainder of the plans, despite their titles, depict *Erebus*.

government offered sizeable financial rewards for news and assistance rendered and search expeditions soon began (Ross 2002). A vital clue was later found in 1859 on King William Island by the McClintock expedition of 1857-1859. This clue, a standard form message with marginal additions had been deposited near Victory Point in April 1848 by Captain Crozier and Commander James Fitzjames. It stated that after crossing from the Whalefish Islands into Lancaster Sound, the ships circumnavigated Cornwallis Island and then spent their first winter (1845-1846) at Beechey Island on Barrow Strait. The next navigation season, following the summer melting and break-up of sea ice, Franklin's ships headed south, presumably descending the uncharted Peel Sound and Franklin Strait and then became beset in ice north of King William Island on September 12, 1846. There the ships remained trapped though slowly drifting southwestwards from Larsen Sound and into Victoria Strait, locked in the unyielding embrace of the ice floes for a full year and a half. At least one party of men carried out exploration on shore in May of 1847, the situation reported as "all well". Soon things took a turn for the worse according to a marginal note added by Crozier and Fitzjames around an earlier May 1847 entry. Franklin died on June 11, 1847 and on April 22, 1848 the surviving 105 crewmembers to that point, under the command of Crozier, abandoned the ships off the northwest flank of King William Island, presumably having been confronted by dwindling supplies and health, and with no foreseeable hope of

extrication on the horizon. Making landfall on the island the combined crews headed south towards the Great Fish (modern Back) River on the North American mainland, dragging boats on sledges over the still frozen sea and land. This terse yet invaluable record is more or less the only written document of the ships' proceedings after their departure from the Whalefish Islands (McClintock 1860; Cyriax 1939).

A succession of 37 Royal Navy and private search, supply and relief expeditions took place from 1847-1859 and failed to find any surviving members of Franklin's lost expedition or either of its missing ships (Cyriax 1939:71-99; Ross 2002). Explorers John Rae, James Anderson and James Stewart, Francis Leopold McClintock, Charles Francis Hall, and Frederick Schwatka searched for traces of the Franklin Expedition and its records in 1854, 1855, 1857-1859, 1864-1869 and 1878-1880 respectively, chiefly on and in the vicinity of King William Island. In doing so they and their search companions made first hand discoveries of perished expedition members, their retreat materiel and even examples of their personal possessions. Moreover, they (as well as subsequent explorers and researchers into the early twentieth century) also recorded Inuit firsthand observations and oral histories about the fate of Franklin's men and their ships (Barr 1999; Barr 1987; Gilder 1880; Hall 1879; Klutschak 1881; McClintock 1860; Rae 2014; Schwatka 1899; Stackpole 1965). These contemporary explorers' accounts and their

associated records of Inuit oral histories have been further interpreted and articulated by more recent researchers, including David Woodman (1991, 2001, 2003), Darren Keith and Louie Kamookak (1999) and Dorothy Eber (2008).

It is currently held, based on contemporary Inuit histories and antiquarian and archaeological fieldwork, that all 1845 Franklin expedition members perished on the southward retreat, some of whom reached as far south as Starvation Cove on the Adelaide Peninsula, with further traces of the expedition found farther south and east, notably on Montreal Island. The fate of the vessels themselves was, until 2014, far less clear (Cyriax 1939, 182–94).

Inuit oral histories recount that one of Franklin's two ships was crushed in the ice west of King William Island while the other made its way as far south as Adelaide Peninsula where it finally sank in the waters of Ugjulik (spelled variously Utjulik, Ook-joo-lik, Ootjoolik etc.). The fact that Inuit witnesses to the event left tangible evidence as to the possible disposition of the Ugjulik vessel, having reportedly seen it firsthand, was a key element in the discovery of *Erebus* in 2014. While the accounts do not wholly agree in their precise details, the corroborating reports of a wreck sunk off the western shore of the Adelaide Peninsula in one location or another at least provided an approximate starting point for systematic searches that began in the 1960s in the expansive area corresponding to Ugjulik.

2.2 THE 2014 DISCOVERY OF HMS *EREBUS*

Ryan Harris and Jonathan Moore

The wreck of what later proved to be HMS *Erebus* was discovered on September 2, 2014 by members of the UAT on the Parks Canada survey and diving boat RV *Investigator*, during a towed side-scan sonar survey for the Ugjulik wreck (Figure 2.2.1). This discovery was the culmination of a renewed search for the *Erebus* and *Terror* launched by the Government of Canada and partners in August 2008. At the time of discovery, RV *Investigator* was deployed from the CCGS *Sir Wilfrid Laurier* along with Canadian Hydrographic Service (CHS) survey launches *Gannet* and *Kinglett*.

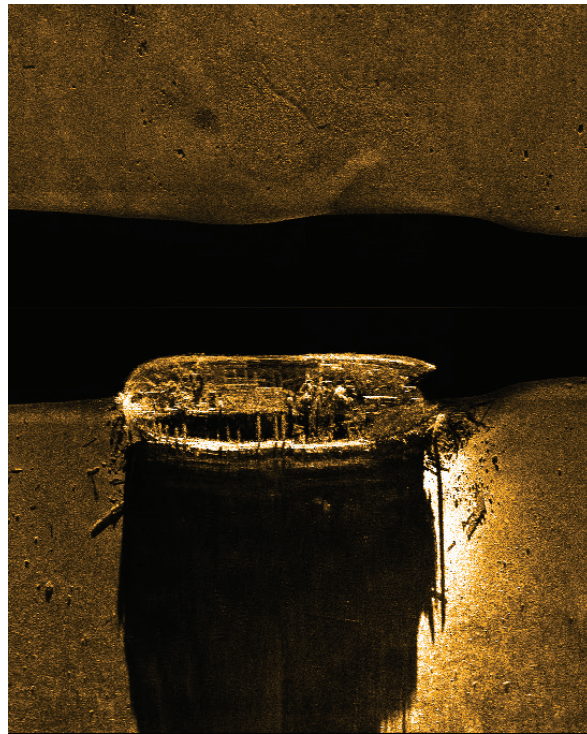


Figure 2.2.1: Side-scan sonogram of the wreck of *Erebus*, 2014. North is at top and the bow at left (Sonogram at 37 m range, 445 kHz, Parks Canada).

As well, a terrestrial archaeology team from the Government of Nunavut was operating from the CCGS *Sir Wilfrid Laurier*, which had arrived in the southern search area on September 1, 2014. The Arctic Research Foundation's (ARF) MV *Martin Bergmann* was also searching in the southern search area, having completed a first leg of searching from August 19–21, 2014 and had resumed searching during a second leg on August 26. In addition to the above-mentioned platforms, the *One Ocean Voyager* was also operating farther to the north in Victoria Strait with a team from Defence Research and Development Canada deploying its *Arctic Explorer* autonomous underwater vehicle.

On September 1, 2014 RV *Investigator* surveyed in provenience zone 51M45 northeast of O'Reilly Island, south of where the MV *Martin Bergmann* was searching. The same day, a shore party was deployed by helicopter from the CCGS *Sir Wilfrid Laurier* to an island in the search zone and discovered two artefacts, tentatively identified later that day as a davit pintle (marked with two broad arrows) and a deck hawse scuttle cover. Immediately, both objects were believed to have come from one

of Franklin's ships, the Ugiulik wreck that in all likelihood was located in the near vicinity of their find spot (Harris, Moore, and Bernier 2015).

The next day, September 2, 2014 RV *Investigator* completed survey activities in provenience block 51M45 and then moved to a new block closer to the terrestrial findspot of September 1. Soon the wreck was located upright at a depth of 11 m, with only a moderate amount of apparent damage having been sustained presumably by ice occasionally grounding on the wreck structure since its sinking. Following initial target detection, a series of imaging passes were made with the side-scan at various ranges and aspects to the target in order to optimize the imagery obtained for diagnostic purposes. This coverage was focused on the immediate vicinity of the wreck, and did not seek to systematically survey for possible outlying debris. The first visuals of the *Erebus* were returned by the UAT ROV on September 7, 2014 and confirmed the wreck beyond a shadow of a doubt as one of Franklin's ships. The UAT returned to the site on September 17-18, 2014 and completed a series of seven two-person inspection dives on the wreck totalling 12 hours of bottom time. This preliminary site evaluation focused on observing and recording diagnostic features and on assessing structural integrity and overall artefact potential. The ship's cast bronze bell (89M99X1-1), bearing an embossed British government broad arrow mark and the date 1845, was also found and

recovered. Between dives on September 18, the CHS took the opportunity to image the wreck with multi-beam echosounder sonar, yielding an accurate three-dimensional model of the hull situated in a precise geo-referenced bathymetric context. In late September 2014 the multi-beam model of the wreck (and the hull shape and dimensions it yielded) was compared with 1839 plans of *Erebus* and *Terror*, yielding a positive identification of the wreck as *Erebus*. The archaeological results of the multi-beam echosounder survey and first series of archaeological dives on the wreck are described in Harris, Moore and Bernier (2015).

It is worth noting that over the course of search years beginning in 2008, Parks Canada and GN team members gathered reported wreck and wreckage location information from local community members, chiefly from Gjoa Haven. Importantly, in 2013, information was received at Gjoa Haven of a potential wreck in *Terror* Bay resting in the shallow waters of the eastern flank of the bay. This lead was followed-up by helicopter reconnaissance by Dr. Doug Stenton and in subsequent years *Terror* Bay was identified as a potential secondary or tertiary search zone.

The wreck of HMS *Terror* was discovered by the crew of the MV *Martin Bergmann* of the ARF on September 3, 2016 as a result of information received from Gjoa Haven resident Sammy Kogvik.

3. METHODOLOGY

Given the archaeological, technical and logistical complexity of fieldwork at the wreck of *Erebus* in 2015 and 2016, this section provides a detailed description of the project's methodology. Since the study of the site is nascent and that many of the technologies and methods employed are rapidly evolving, this section is intended to be comprehensive rather than cursory.

3.1 FIELDWORK DESCRIPTION 2015-2016

Jonathan Moore and Marc-André Bernier

Two episodes of fieldwork took place at the wreck of *Erebus* in 2015 and one in 2016. The first 2015 project, entitled *Breaking the Ice: HMS Erebus Revealed* unfolded between April 1-21. The second was called *Mission Erebus and Terror 2015* and took place between August 14 and September 21. The latter unfolded in parallel with a search for *Terror*, reported separately in Harris and Boyer (2016). An abbreviated period of fieldwork took place at the wreck in August-September 2016 as part of *Mission Erebus and Terror 2016*, which also encompassed searching for *Terror*, which again will be reported separately. This section will outline key dates and movements, partners, personnel, and transport for all periods of fieldwork at *Erebus* in 2015 and 2016.

APRIL 2015

In the days leading up to the launch of *Breaking the Ice: HMS Erebus Revealed*, UAT members Ryan Harris and Thierry Boyer travelled from Ottawa to Yellowknife on April 1, 2015 and joined Operation Nunavut. Six other UAT members traveled by road from Ottawa to Canadian Forces Base Trenton, Ontario on April 3, 2015 and transferred equipment to cargo handling staff preparatory to a CC-130J Hercules flight the following day. On the morning of April 4 the six UAT staff embarked the CC-130J flight to Halifax, Nova Scotia. On April 5 both the UAT and members of FDU(A) embarked the CC-130J and flew to Yellowknife via Iqaluit, Nunavut, where the combined team was installed at a military accommodation facility.

Meanwhile at the *Erebus* site a team of both Canadian Rangers from 1 Canadian Ranger Patrol Group and the 109th Air Lift Wing of the New York Air National Guard (ANG) established an ice camp. In addition, they had begun to prepare an ice landing ski-way for ski-equipped LC-130H Hercules aircraft to land at the site. This ski-way, 6,000 feet long and 200 feet wide, was later completed on April 14.

On April 7, while the combined UAT-FDU(A) team awaited flights north to Cambridge Bay, FDU(A) learned that transport constraints necessitated a 40% reduction in ice-camp diving equipment and a 20% reduction in its diving complement. At this time, Operation Nunavut was experiencing reduced limitations in its air transport capacity. For this reason FDU(A) trimmed 11 FDU(A)



Figure 3.1.1: *Erebus* ice diving camp, April 2015 (Photo: F. Currie, Parks Canada).

personnel destined for the ice-camp, including its Electronic Diving Systems team; no Parks Canada staff were affected. Archaeological objectives were reassessed and prioritized; plans for the deployment of ROV at the site were shelved by necessity. Furthermore, the delay in deployment to the site ultimately caused a loss of three diving days, from eight to five.

On April 8, UAT staff members Ryan Harris, Jonathan Moore and Thierry Boyer joined a CC-177 Globemaster III flight to Cambridge Bay and spent the night at the Operation Nunavliut headquarters established at the North American Aerospace Defense Command (NORAD) Cambridge Bay North Warning System facility. From Cambridge Bay, ski-equipped CC-138 Twin Otters from 440 Transport Squadron had been ferrying gear to the growing ice camp (Figure 3.1.1). On April 9, Harris and Moore flew on separate flights to the ice camp where Harris position-fixed the bow and stern of the wreck of *Erebus* (see below Section 3.4) and marked two pre-planned ice diving holes locations. Among other camp personnel, Al Tremblay of Defence Research and Development Canada (DRDC) arrived with a hot water ice-drill. By the end of the day an auger hole for a port side hole was drilled and the hole's position relative to the wreck confirmed by underwater video from a pole-mounted Panasonic HMR10 video camera (in a Gates housing) that was lowered down through the hole. Underwater visibility was at least 11 m as the seafloor was clearly visible. Meanwhile the balance of the UAT members arrived at Cambridge Bay by CC-177.

On April 10 two ice holes were completed and heated tents erected atop each. The primary hole was off the port side amidships of the wreck with the secondary hole at the starboard quarter (Figure 3.1.5). UAT staff members Thierry Boyer and Filippo Ronca arrived at the site. The growing camp complement spent April 11 setting-up the camp and installing diving gear in the two dive tents. At the joint FDU(A)-UAT camp atop the wreck there were two modular dive tents, three modular accommodations tents, a modular operations and cooking tent and an enclave of small sleeping tents occupied by Rangers, with a total of 25 persons at this camp. The ANG camp was separate, but nearby, and was occupied by seven, yielding a total of 32 persons on the ice on April 11.

No flights arrived on April 11-12 due to strong winds, thereby delaying the arrival of equipment and personnel as well pushing back the commencement of diving operations. Flights resumed on April 13 however, when diving preparations were completed and the balance of UAT staff members (Marc-André Bernier, Charles Dagneau, Joe Boucher and Aimie Néron) arrived on site via Twin Otter by April 13. The first project dive began at 19:15 MDT (UTC -6 hours) and improvements and additions to the diving equipment set-up continued apace.

On April 14 a CH-149 Cormorant helicopter arrived with Flora Davidson (Parks Canada conservator), Fiona Currie (Parks Canada video specialist) and a video production consultant. In the afternoon the UAT recorded, in both English and French, a video tour of the wreck, as a back-up to a planned "Live Dive" video tour of the wreck scheduled for April 16. An ANG LC-130H Hercules successfully completed a trial landing and take-off at the landing strip. Underwater activities on April 14-15 included kelp clearing from the port side of the hull and parts of the upper deck, photo and video recording, measurement of selected underwater features, installation of a baseline along the port side debris field, installation of artificial lighting on the underside of the ice, and trials of a 2G Robotics ULS-500 laser scanning system.

On April 16, CH-149 Cormorant flights brought site visitors, including Rear Admiral John Newton (Joint Task Force Atlantic), Jim Balsillie (ARF), and other military staff and support personnel for the "Live Dive". The "Live Dive" itself started at 11:00 MDT and resulted in a successful live video broadcast of an underwater tour of the wreck that was transmitted via satellite uplink to an

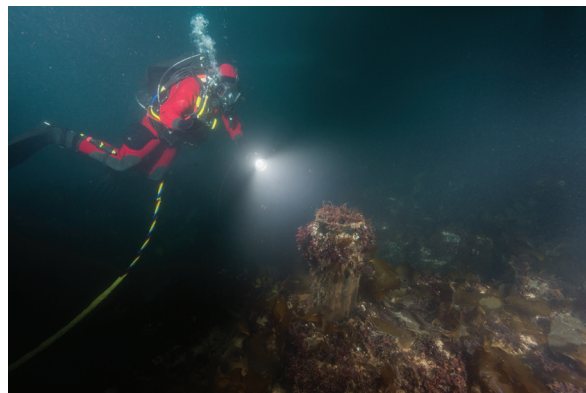


Figure 3.1.2: UAT underwater archaeologist diving under the ice hovers over the wreck of *Erebus* (Photo: T. Boyer, Parks Canada; 89Mo2839EF).

auditorium of school-aged children at the Royal Ontario Museum (ROM), Toronto. Following the “Live Dive”, further work on baseline installation took place, as well as kelp clearing, photo and video recording, and recording of hull interior video images with a pole-mounted GoPro camera; the latter was directed down into the lower and orlop decks (Figure 3.1.2).

On April 17 underwater archaeological activities included photo and video recording, site mapping, kelp clearing, position-fixing mapping of artefacts earmarked for recovery (including a cannon), artefact recovery itself, hull interior photo and video imaging, trials of a 2G Robotics ULS-200 laser scanner, preparations to lift at least one of the 6-pounder cannon from the stern of the wreck, and removal of some underwater lights. The interior video work revealed the presence of a small copper-alloy cannon under the collapsed stern deck. Another CH-149 Cormorant flight brought in a small group of reporters to view the diving operation.

On April 18, the last day of diving, the principal activity was the raising of a 6-pounder cannon to the ice surface (Figure 3.1.3). Other activities included selected artefact retrieval, equipment recovery, site photos, and installation of a Canadian Hydrographic Service water level recorder. The last dive of this fieldwork episode ended at 16:22 MDT on April 18. Soon break-down and packing of selected camp tents and equipment began, and some Parks Canada staff departed the site. April 19 was devoted to demobilizing and packing gear for a planned LC-130 Hercules flight from the ski-way. The LC-130H arrived at 11:00 and the balance of all UAT staff (and the UAT gear and collected artefacts) flew from the site, arriving at Yellowknife, Northwest Territories, at 15:00 MDT. UAT staff spent April 20 at Yellowknife, sorting gear and preparing for the return to Ottawa. On April 21 UAT members flew from Yellowknife to Ottawa, via Calgary on a commercial carrier with some of the collected artefacts, arriving in Ottawa on the morning of April 22. Parks Canada conservator Flora Davidson remained in Yellowknife to care for some of the larger artefacts, including the cannon, until military air transport to Trenton on April 28. The ice atop and near the wreck of *Erebus* was later cleared of equipment and personnel.



Figure 3.1.3: Team members watch the raising of a cannon from the wreck in April 2015 (Photo: J. Moore, Parks Canada; 89Mo3o73EF)

AUGUST-SEPTEMBER 2015

The *Erebus* element of the Mission *Erebus* and *Terror* 2015 project was staged from Cambridge Bay, Nunavut. UAT team members travelled to Cambridge Bay where they began to arrive on August 14. The vessel platform for this period of fieldwork was the ARF's MV *Martin Bergmann*, with three planned sorties to the site anticipated over the course of five weeks. The crew would travel to the site and reside in the MV *Martin Bergmann* with actual diving taking place from two inflatable boats deployed from the *Bergmann*'s boat deck.

On August 15 the MV *Martin Bergmann* arrived at Cambridge Bay from a research trip to Bathurst Inlet, and preparations immediately began for the first sortie to *Erebus* for a planned Marine Biology Pilot Project sponsored by the W. Garfield Weston Foundation and ArcticNet. For Leg 1, biologists Nadia Ménard (Parks Canada Saguenay-St. Lawrence National Marine Park) and Lisa Treau de Coeli (Université du Québec à Rimouski, UQAR) joined the MV *Martin Bergmann*. As well, Theoran Kopak (Parks Canada) joined as a field assistant for Legs 1 and 2. Another invited team member was Aaron Griffin (Seneca College) who joined as a Diver Medic for Legs 1, 2 and 3.

Preparations at Cambridge Bay included assembly of the UAT's Zodiac FC530 inflatable boat (which would be the primary diving platform), fabrication of a boat cradle for the FC530, preparation of conservation equipment and storage, transshipment of diving equipment from the airport to the MV *Martin Bergmann*, and provisioning. On August 18 the MV *Martin Bergmann* took aboard a Zodiac Hurricane 473 rigid hull inflatable boat shipped from Victoria via the CCGS *Sir Wilfrid*

Laurier, which at the time was anchored at Cambridge Bay. This second boat would serve as a safety boat and operate in conjunction with the FC530; it too was housed on the boat deck. The MV *Martin Bergmann* departed Cambridge Bay on August 18 at 17:40 MDT en route to *Erebus*, motoring through the night. Twenty-four hours later the MV *Martin Bergmann* reached an island just outside the NHS boundary colloquially called Muskox Island but named Igluvigaqturvik (“place where they make iglus”) in Keith and Kamookak (1999, Appendix II). There the MV *Martin Bergmann* anchored in a shallow but sheltered cove for the night of August 19 and team members completed a compass calibration for a submersible current profiler.

Mid-afternoon the following day, August 20, the final set-up of diving equipment and the boats took place at Igluvigaqturvik Island (Figure 3.1.4). Later the MV *Martin Bergmann* entered the boundary of The Wrecks of HMS *Erebus* and HMS *Terror* NHS and anchored approximately 2.5 km from the wreck. UAT archaeologists, using the FC530, relocated the wreck with a Trimble Yuma 2 GPSmap unit with ESRI ArcPad software; a surface marker buoy was positioned on the site. Diving operations commenced that day and began with the installation of a mooring 20 m off the port

quarter of the wreck at a depth of 9 m. Prior to the installation of the mooring its planned location was inspected and found to be free of artefacts and features. The mooring consisted of a folding-stock Admiralty-pattern anchor with attached rope and mooring buoy. Underwater visibility during this first day of diving was 15 m horizontal, the best observed to date; a temporary tape baseline along the wreck’s centerline was also installed. Marine biology sampling commenced following the mooring installation and continued until midday on August 23. Sampling was carried out on the upper deck, hull sides and near-wreck debris field, and entailed sample and site photo and video recording.

On August 22 three visitors arrived via helicopter: Louie Kamookak and Jacob Keanik of Gjoa Haven accompanied by Ellen Bertrand (Parks Canada). During the visit, Kamookak and Keanik were taken to the wreck site by boat where they made a ceremonial offering.

Following the conclusion of fieldwork for Leg 1, the mooring buoy was removed, the mooring line was sunk and the MV *Martin Bergmann* departed the site of *Erebus* midday on August 23, en route to Cambridge Bay. At the time of departure crew members took Thierry Boyer to nearby “Northeast Island” where he transferred to the CCGS *Sir Wilfrid Laurier*’s helicopter, which was engaged in terrestrial archaeological work with Dr. Doug Stenton and Dr. Bob Park. In summary, Leg 1 of Mission *Erebus* and *Terror* 2015 achieved the following results over the course of three diving days:

- A preliminary inventory of marine life on and around *Erebus* and the collection of marine biological samples from the site; and
- Photo and video documentation of marine life, marine life sampling in progress and of archaeological features on the wreck and its debris field.

The MV *Martin Bergmann* arrived at Cambridge Bay in the early afternoon of August 24. Biologists Nadia Ménard and Lisa Treau de Coeli soon departed Cambridge Bay and Leading Seaman and Imagery Technician Dan Bard of the RCN joined the MV *Martin Bergmann* as a photographer/videographer.



Figure 3.1.4: Parks Canada, ARF, RCN and Seneca College personnel prepare the MV *Martin Bergmann* prior to departure to the site (Photo: T. Boyer, Parks Canada; 89M03397EF).

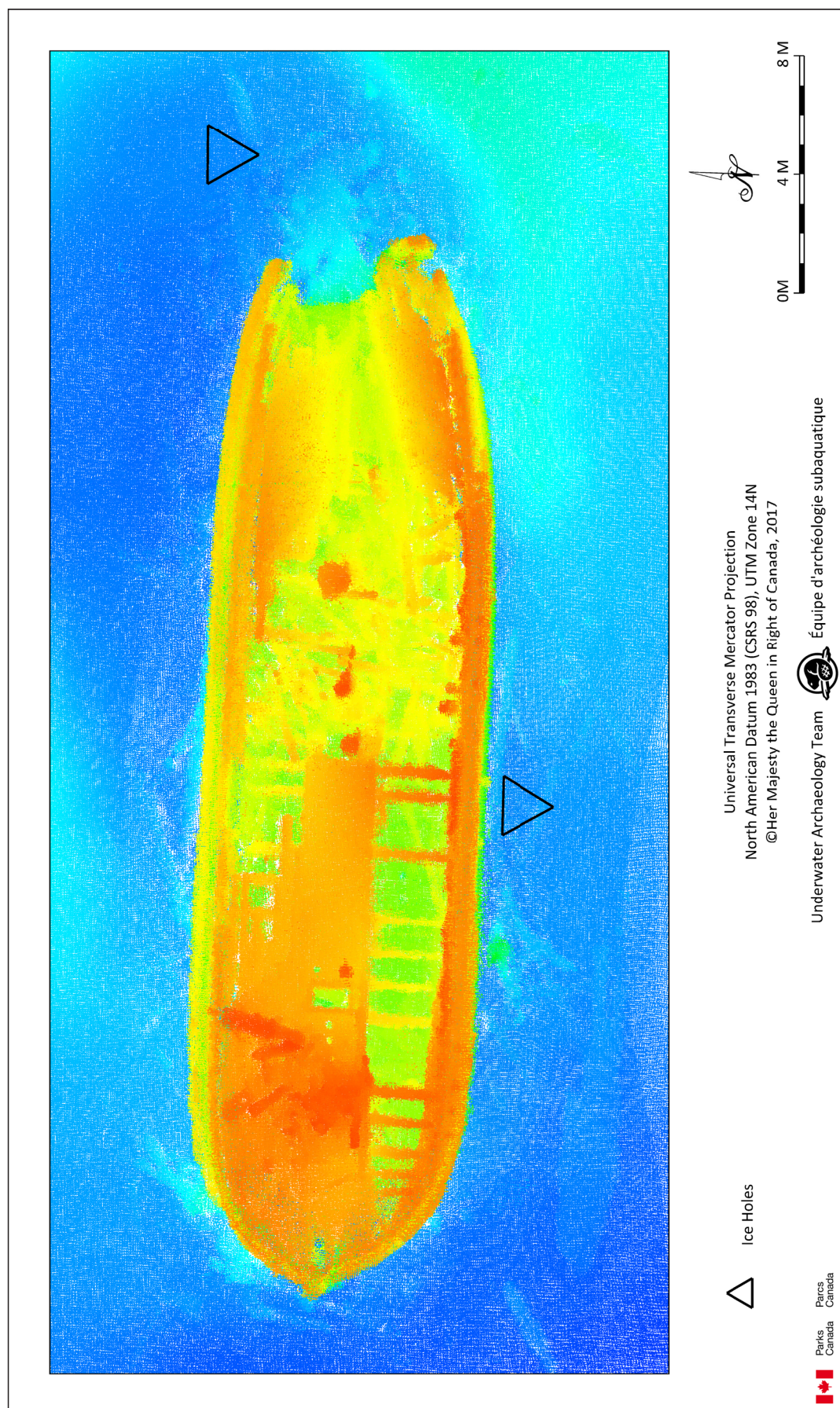


Figure 3.1.5: April 2015 ice hole positions relative to 2014 multi-beam echosounder imagery of the wreck (Image: B. Lockhart, Parks Canada; Data CHS).

The MV *Martin Bergmann* departed Cambridge Bay on Leg 2 of the project in the early evening of August 26, arriving back at the wreck of *Erebus* approximately 24 hours later on August 27, under ideal weather conditions. Leg 2 was devoted solely to meeting archaeological objectives, and for the balance of the episode weather conditions were exemplary, with warm temperatures, sunny skies, and light winds, or periods of no wind at all. As well, given the still water conditions and excellent light levels, underwater visibility was also excellent, often in excess of 15 m horizontal. The seafloor was often clearly visible 15 m or more below from boats on the surface. The MV *Martin Bergmann* anchored approximately 500 m from the wreck (Figures 3.1.6 and 3.1.7).

Diving resumed in the morning of August 28, with kelp clearing and photogrammetry. Kelp clearing was the predominant underwater activity for the next six days until September 2 and revealed a range of interesting features and artefacts. Primary reference point installation on the upper deck and top timbers began on September 1 and both the installation and surveying of the network were completed on September 4. Position-fixing mapping of artefacts and features began in earnest on September 4 and continued through to September 7. Photo recording of in situ artefacts took place in parallel with site mapping, photogrammetry, photography and detailed inspection tours of the wreck and recording of structural features on the upper deck. On September 7 the team deployed an ArcticNet current profiler on the seafloor 15 m due west of the bow, then began to make preparations for the return trip to Cambridge Bay.

While Leg 1 of the *Erebus* element of Mission *Erebus* and *Terror* 2015 focused on the marine biology of the site, Leg 2 saw the beginning of archaeological work in the summer season. The objective was to continue the documentation of the wreck in order to understand the shipwreck itself and its surrounding debris field. Although Parks Canada archaeologists had carried out archaeological work on the wreck on two previous occasions (September 2014 and April 2015), these opportunities had yielded only seven days of diving. During Leg 2 the team was able to dive on the wreck on each of the 11 days on site. In summary, the following tasks were completed during Leg 2:

- Clearance of kelp from the upper deck, starboard side and stern;
- Photo and video coverage of all sides of the hull and the debris field adjacent to the hull;
- Re-installation of the primary seafloor site datum line, installation of primary reference points on the upper deck, and installation of a transverse datum line on the seafloor at the stern;
- Search of the upper deck to locate features and artefacts;
- Detailed recording and mapping of selected features, including: fore hatch, bowsprit partner, main hatch, capstan, 6-pounder brass cannon, gun carriage, tiller, propeller in debris field, in part to correlate them to existing remote sensing data (i.e. 2014 multi-beam echosounder data);



Figure 3.1.6: MV *Martin Bergmann* at anchor with Zodiac FC530 on its starboard side (Photo: D. McIsaac, Arctic Research Foundation; 89Mo7106EF).



Figure 3.1.7: UAT underwater archaeologists prepare to dive on *Erebus* from Zodiac FC530 (Photo: D. Bard, Royal Canadian Navy; 89Mo7167EF).

- Mapping and photographic recording of visible in situ artefacts;
- Video imaging of the hull interior (Figure 3.1.8);
- Scouting of future excavation area(s) and potential access points for future interior penetration diving;
- Deployment of ArcticNet current profiler; and
- Visual search of the debris field more than 5 m from the hull for features and artefacts.

Upon the conclusion of fieldwork for Leg 2, the MV *Martin Bergmann* departed the site midday on September 7 and arrived back at Cambridge Bay in the evening of September 8, following a rough passage with 30 knots easterly winds. Meanwhile, Parks Canada conservator Flora Davidson had arrived at Cambridge Bay in advance of Leg 3. September 9 was devoted to provisioning and equipment preparations for the third and final leg.

The departure for Leg 3 was delayed from September 10 until September 15 due to a major low pressure weather system that entered the region. This resulted in a strong gale with winds in the order of 45 knots (see Section 4.1). Whereas several days of on-site time were lost due to the weather system, the team profitably used time in Cambridge Bay to plan for a series of public and school presentations scheduled to take place after the return from Leg 3. In addition to the changes to the project imposed by weather, a change to a shipping date meant that there would not be an opportunity to deploy the RV *Investigator* to the site during Leg 3, meaning that a planned multi-beam echosounder survey of *Erebus* and its debris field, as well as a ROV inspection of the hull interior, would not be possible.

The MV *Martin Bergmann* departed Cambridge Bay in the morning of September 15, arriving back at *Erebus* the morning of September 16. Diving operations resumed that day with, as expected, a marked decrease in underwater visibility from 15 m to 0.5 m on account of the storm. The chief objective of Leg 3 was artefact recovery, and the first dive back at the site revealed significant movement of artefacts and timbers, especially noticeable in the lower deck assemblage in



Figure 3.1.8: UAT technician introduces the point of view video camera into an opening in the upper deck at the stern, September 2015 (Photo: M.-A. Bernier, Parks Canada; 89Mo6653EF).

sub-operations 24J/K to 36J/K. As well, the in situ section of upper deck at the bow was observed to bounce up and down due to a ground swell at the site. Some artefacts slated for recovery, such as a sextant, could not be recovered as they had become trapped as a result of the movement of surrounding timbers on the lower deck. Aboard the MV *Martin Bergmann*, team members carried out initial artefact processing, including the completion of inventory forms, measurements, photographs, packaging and storage of recovered artefacts.

The last dive of Leg 3, and of 2015, took place in the morning of September 18 when team members recovered the Canadian Hydrographic Service (CHS) water level recorder placed on the site on April 18. The following archaeological objectives were achieved during the Leg 3 over the course of three days of diving:

- Recovery and initial processing of 42 artefacts; and
- Recovery of the CHS water level recorder.

With equipment and artefact packing and stowing completed, the MV *Martin Bergmann* departed the site at 10:15 MDT on September 18, arriving at Cambridge Bay about 11:00 MDT the following morning on September 19. Further equipment and artefact packing and shipping preparations took place September 19-20, and September 21 was devoted primarily to presentations at the two Cambridge Bay schools and an evening event at the community centre which entailed public presentations, the display of selected recovered artefacts and equipment, and question and answer sessions.

UAT manager Marc-André Bernier and conservator Flora Davidson travelled to Gjoa Haven to give a series of school and public presentations on September 21. All other Parks Canada staff members and Aaron Griffin departed Cambridge Bay en route to Ottawa on September 22.

AUGUST-SEPTEMBER 2016

The final episode of fieldwork encompassed by this report, Mission *Erebus* and *Terror* 2016, commenced on August 15, 2016 when UAT members Ryan Harris, Filippo Ronca, Thierry Boyer and Joe Boucher embarked the CCGS *Sir Wilfrid Laurier* at Cambridge Bay. In preparation for this episode of fieldwork, Parks Canada's RV *Investigator* had been transported to Victoria, British Columbia and transferred to the CCGS *Sir Wilfrid Laurier* prior to its departure for its 2016 Arctic patrol.

Once in the Arctic and aboard the CCGS *Sir Wilfrid Laurier*, this first Parks Canada team prepared the RV *Investigator* for both multi-beam echosounder surveying as well as diving operations. On August 19, UAT members travelled in RV *Investigator* south from the CCGS *Sir Wilfrid Laurier* in Simpson Strait to the *Erebus* site with the intention of carrying out a multi-beam echosounder survey of navigation corridors in the vicinity of the site. Whereas the team was able to install a temporary DGPS reference station on a nearby island, engine problems ruled-out surveying and the team made its way back to the CCGS *Sir Wilfrid Laurier*. A planned return trip to the site in the following days to undertake the multi-beam surveying did not materialize.

A week later UAT members Jonathan Moore, Charles Dagneau, Alexandre Poudret-Barré and Brandy Lockhart, as well as Hans Biberhofer, a Sediment Scientist with Environment Canada attached to the team, arrived aboard the CCGS *Sir Wilfrid Laurier* on August 30, 2016, at which time the ship was at anchor off Gladman Point, Simpson Strait. On the morning of August 31 UAT members departed on RV *Investigator* from the CCGS *Sir Wilfrid Laurier* (northeast of Kirkwall Island) and travelled to the *Erebus*. Upon arrival, one dive was completed to raise the site mooring and to attach a line to the ArcticNet current profiler. The afternoon was devoted to meeting Franklin Interim Advisory Committee members on a nearby island and escorting some of them to the site on RV *Investigator* and recovering the current profiler. The following day, September 1, the team returned to the site and conducted two dives and carried out an ultra-high resolution multi-beam echosounder survey of the wreck and the adjacent debris field. On September 7 RV *Investigator* was transferred at Taloyoak, Nunavut to the cargo ship *Mitiq* for transport back south. Consequently a final episode of diving on the wreck on September 11 was carried out from the *Sir Wilfrid Laurier*'s boat rigid-hulled inflatable boat *Laurier One*. The following archaeological objectives were achieved in 2016:

- Site inspection dives that did not reveal any radical change to the condition of the site (Figure 3.1.9);
- Photo and video documentation, including 3D photogrammetry;
- Recovery and redeployment of ArcticNet current profiler;



Figure 3.1.9: UAT underwater archaeologist examines the ship's upper deck structure, September 2016 (Photo: T. Boyer, Parks Canada; 89Mo8457EF).



Figure 3.1.10: UAT underwater archaeologist with Deep Trekker ROV above *Erebus*, September 2016 (Photo: T. Boyer, Parks Canada; 89Mo8760EF).

- Ultra-high resolution multi-beam echosounder survey of the wreck and the surrounding debris field; and
- Interior video trial using DeepTrekker ROV (Figure 3.1.10).

3.2 DIVING

Filippo Ronca

This sub-section summarizes the diving methodology employed during three episodes of fieldwork at *Erebus* in April 2015, August-September 2015 and most recently August-September 2016. It outlines background on UAT Arctic diving operations to date, equipment and approaches employed, safety procedures, and future considerations. Statistics for the 2014, 2015 and 2016 diving operations at *Erebus* are provided in Table 3.2.1.

BACKGROUND

Diving in the Arctic poses significant logistical and safety challenges, due to its remoteness, relative inaccessibility, invariably cold-water temperatures, highly variable seasonal weather and high costs for shipping, accommodation, storage and transport. The military adage “If you have one you have none” must be taken to heart as equipment redundancy in the Arctic is an absolute necessity. To overcome these challenges a considerable amount of pre-planning is required, for instance, to select, pack, ship and stage equipment well in advance. Support from project partners such as the Canadian Coast Guard (CCG), RCN, Seneca College, ARF, UAT’s diving and hyperbaric medical specialist Dr. George Harpur and countless

others within Parks Canada have contributed to meet these challenges and ensure safe and the successful diving operations at the *Erebus* site.

Looking back, the initial dives on *Erebus* over the course of two days in September 2014 were undertaken with only a limited amount of equipment and preparation time, yet with essential support from the CCGS *Sir Wilfrid Laurier*. Diving hazards, such as the absence of a hyperbaric recompression chamber in the region, were mitigated through the UAT’s own training, equipment and procedures not to mention the safety net provided by the CCGS *Sir Wilfrid Laurier*. These reconnaissance dives proved to be a success and immediately following the UAT’s return to Ottawa, the team began planning for its return to the site and the next series of dives in April 2015; Parks Canada’s senior management requested that the UAT make their return as quickly as possible, and avoid having to wait an entire year before open water conditions returned in August 2015. Indeed, the significance of the discovery of *Erebus* dictated that all options for an April 2015 return be considered. The obvious and natural partner was the RCN, specifically its FDU that had been performing diving operations in the Canadian Arctic for years and are adept at working on and under the ice. The UAT already had a relationship with the FDU going back several years, including collaboration on a 2008 ROV survey of the wrecks of USS *Hamilton* and USS *Scourge* (Lake Ontario), the search for *Erebus* and *Terror* (2013-2014) and ROV operations at the wreck of the *Breadalbane* (Beechey Island, Nunavut) in 2014. An opportunity to return to the *Erebus* during Operation Nunavut in April 2015 and dive through the ice side-by-side with the FDU teams soon presented itself.

Date	Days	Divers	Dives	Hours
September 2014	2	7	14	12.1
April 2015	5	20	88	75.0
August-September 2015	18	7	147	143.3
August-September 2016	3	6	14	9.8
Totals	28	22	263	240.2

Table 3.2.1: Diving statistics for fieldwork at the wreck of HMS *Erebus*, 2014-2016. The average dive time for this period was 55 minutes. A total of 22 individuals have dived on the wreck to date, with UAT members having dived multiple years.

SURFACE-SUPPLY DIVING TRAINING

Planning and training for the April diving operations were intense and took place over the course of only six months from start to finish. The archaeological potential of the *Erebus* required that this phase of diving operations be on an ambitious scale and necessitated a departure from the UAT's traditional use of open-circuit scuba diving and a shift to surface-supply diving.

In the over 50 years of the UAT's existence it has accumulated tens of thousands of hours of diving experience in remote areas of Canada under adverse and cold-water conditions. This corporate knowledge has been diligently passed down over the years. Team strengths that have been forged are standardization of dive training and equipment, a strict adherence to diving safety procedures and training, internal consistency, adaptability and overall, a conservative approach to diving. The UAT's long-term, team-based approach to scientific diving has also fostered a cohesive diving unit that has built-in redundancy and interchangeability among its personnel, traits not unlike those found in military units. In the several years preceding the discovery of *Erebus*, the UAT gained recent Arctic diving experience, notably during the underwater archaeological survey of the wreck of HMS *Investigator* (Mercy Bay, Banks Island, Northwest Territories) in 2011. This was preceded by a course on remote diving safety given by Dr. George Harpur. In August 2012 UAT archaeologists also carried out a day-long diving operation in James Ross Strait, Nunavut, based from the CCGS *Sir Wilfrid Laurier*, which introduced the team to regional diving conditions.

Diving through ice and more traditional diving in ice-free summer conditions each offers their own pluses and minuses. Diving in open water in August-September in Queen Maud Gulf is logistically less challenging as the area is generally more accessible, diving equipment is more easily transported to the site, the weather is traditionally better and diving can be carried out with simpler open-circuit scuba gear. Nevertheless, it is not without its difficulties, as ice floes can be present and poor weather conditions including high winds and poor sea state can constrain or temporarily rule out diving operations. As well windy conditions can greatly reduce underwater visibility which negatively affects archaeological work. On the other hand through-ice diving is more difficult and it is very costly to establish and maintain a

diving ice camp. Nevertheless, it can eliminate any day-to-day problem accessing a site due to weather conditions, for example, as project personnel reside at the site. As well, given that the water column and seabed are not subject to disturbance for wind-generated waves, underwater visibility can be consistently good. Importantly, surface-supply diving actually improves diving safety as divers are tethered to an immobile surface, have a theoretically unlimited breathing gas supply, and enjoy clearer underwater communications. Besides increasing diving safety, surface-supply diving allows for the use of hot-water diving suits (which boost comfort, efficiency and dive durations) and a greater suite of underwater power tools. As well, this method allows for the future penetration and excavation inside the wreck itself by UAT divers.

So while the prospect of an April 2015 project presented its own unique challenges, they were not insurmountable given UAT's prior experience and procedures and the logistical support on offer via Operation Nunavut and the FDU. Since the current generation of UAT staff had limited experience with surface-supply diving (except for several members), a comprehensive training regime was required so the UAT could actually dive through the ice with the FDU.



Figure 3.2.1: UAT underwater archaeologists during surface supply diving training at Jinkinson's Quarry (Photo: J. Moore, Parks Canada; 89M-2014-1325).

With a steep learning curve ahead, in November 2014 the UAT contracted Seneca College to Ottawa to give an introduction to surface-supply diving in order for UAT to confirm its feasibility in the context of archaeological work at *Erebus*. This trial was deemed a success and in January of 2015, six UAT members began an intensive nine-week surface-supply diving course. This training was overseen by Aaron Griffin, Underwater Skills Program coordinator at Seneca College. During this training he was supported by fellow instructors Ian White, John Buckle, Riccardo Ronca and Mike Boreen. The training was carried out in accordance with the Canadian Standards Association (CSA) Competency Standard for Diving, Hyperbaric Chamber, and ROV Operations and Occupational Diver Training (Canadian Standards Association 2013, 2015, 2017). All diving was done in accordance with the Occupational Safety Code for Diving Operations (Government of Canada 1986), as well as Parks Canada's Directive on Diving Safety (Parks Canada 2002) and the Canada Labour Code (Government of Canada 1985).

To simulate diving conditions in the Arctic, the majority of the diving training was done outdoors at a local quarry provided by John French of Cavanaugh Construction Ltd. (Kanata, Ontario) (Figure 3.2.1). The UAT set-up a tent on the ice for shelter, rented a heated trailer on shore for dive support, and used UAT's truck to house the breathing gas supply, communications equipment and diving support gear. With temperatures often dipping to -30°C during a particularly frigid January-February 2015 in Ottawa, conditions were ideal for training and mimicked the weather conditions to be experienced in April in the Arctic. During the course, the UAT trained on the following equipment: Kirby Morgan KM27 diving helmets; Kirby Morgan 37 diving helmets; Interspiro Divator "AGA" full face masks; Dräger full-face masks; hot-water suits; and various diving panels and K-cylinder air banks. With UAT training well underway, the focus in the third week of February switched to the integration of the UAT and FDU dive teams. Shared objectives between the UAT and FDU were cross-training in diving and scientific operations, with Parks Canada training FDU team members on archaeological work and the FDU provided a crash course and practical drills on navy diving procedures. The UAT and FDU carried out in-water and in-class training together for one week at Canadian Forces Base Shearwater (Dartmouth, Nova Scotia) in February 2015 and for another week at the Naval Reserve Headquarters

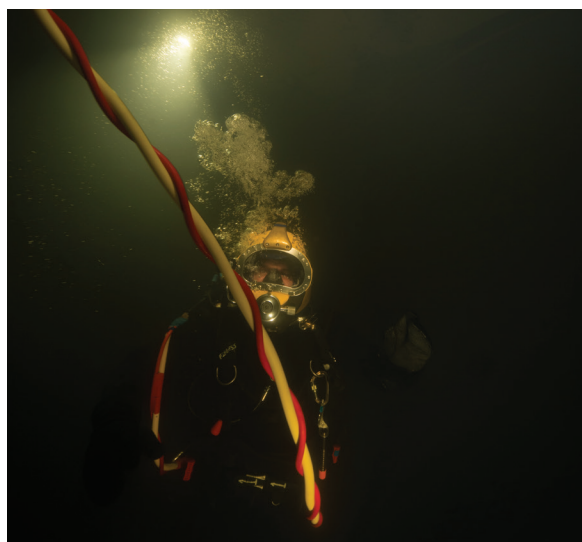


Figure 3.2.2 : Fleet Diving Unit (Atlantic) diver during training at the Pointe-à-Carcy Naval Complex (Photo: T. Boyer, Parks Canada; UAT-2015-0862EF)

at the Pointe-à-Carcy Naval Complex in Québec City (Québec) in March 2015 (Figure 3.2.2). With the cross training complete, the UAT were the first civilian divers to be approved to dive with the FDU and the remainder of March was devoted to completing the Seneca College training.

APRIL 2015

Once at the site of *Erebus* in April 2015, all diving logistics were under the control of the FDU, including the diving tent set-up, the cutting of two ice holes, and the interior "dive spread". Diving safety was also overseen by the FDU's dive supervisor with support from UAT's dive officer. Safety hazards were mitigated through the joint training and established procedures and the overall safety umbrella provided by Operation Nunavut. To quickly deal with medical emergencies, FDU had its diving and emergency room physician at the ice camp and the UAT had Dr. Harpur on-call. If necessary, an injured diver could be evacuated to Cambridge Bay where the FDU's transportable 2-person Dräger Duocom hyperbaric recompression chamber had been set-up. All dives were carried out in accordance with the RCN's diving procedures and the use of the Defence and Civil Institute of Environmental Medicine (DCIEM) Air Decompression Procedures and Tables.

The majority of dives employed the FDU's light-weight surface supply (LWSS) equipment with two divers in the water at a time; UAT archaeologists used their individual dry-suits and diving



Figure 3.2.3 : Preparations for the Live Dive underway in the *Erebus* diving tent (Photo: J. Boucher, Parks Canada; 89M01840EF).

accessories. These dive pairings normally consisted of one FDU diver (“red diver”) paired with one Parks Canada diver (“yellow diver”) although UAT divers fulfilled both functions during video recording of the “Live Dive”. These colour name designations and the actual colouring of the two diving umbilicals streamlined communications. The FDU divers were always the lead divers although UAT personnel coordinated and directed all archaeological work underwater. On occasion these two divers were joined by a third diver (“blue diver”) on tethered scuba to take photos and record video. For each dive a FDU standby diver equipped with tethered scuba gear was at the ready. Each diver used the following equipment: LWSS 2-person panel; OTS Aquacom MK2 surface communications box; AGA full-face mask with integrated OTS hardwired communications system and AXSUB video camera and dive lights; buoyancy compensator; and an 80 cubic foot bail-out compressed air cylinder with regulator. Each four-element umbilical comprised a communications line, air hose, pneumofathometer hose and a video/light cable. Unfortunately the umbilicals were negatively (versus neutrally buoyant) so regularly they made minor contact with the wreck despite careful tending. Surface-supplied compressed breathing air was stored in a series of 80-cubic-foot cylinders that were filled daily using a high-pressure compressor. Each dive team comprised a minimum of 11 persons, including a: FDU dive supervisor; FDU panel operator; FDU video reviewer/recorder; FDU red diver; FDU red tender 1; FDU red tender 2, UAT yellow diver; UAT yellow tender 1; UAT yellow tender 2; FDU standby diver; and the FDU emergency room physician.

Two 2-m triangular openings were cut through the ice and tent shelters assembled atop each. All diving was conducted through a hole cut at the port side of the wreck yet a light bronze 6-pounder cannon was raised through a hole at the stern. With the camp directly atop the wreck and with the diving taking place in an a more or less controlled site environment, each dive day could be 12 to 14 hours long. Dives averaged about one hour in duration and from four to six dives were completed per day (Figure 3.2.3).

AUGUST-SEPTEMBER 2015

Control of logistical and diving arrangements for the August-September 2015 fieldwork at *Erebus* reverted to the UAT. This work was staged from the ARF’s MV *Martin Bergmann* which was used to transport equipment and personnel from Cambridge Bay to the site, and to provide the dive station, accommodations, and field lab. UAT dive officer Filippo Ronca took overall responsibility for diving safety and was supported by Aaron Griffin of Seneca College, who served as the on-site dive medical technician as well as undertaking some diving activities. In addition, Dr. George Harpur was on call. An in-depth job hazard analysis was also undertaken prior to project deployment and evacuation protocols were established with all involved.

In order to avoid anchor damage in the debris field the MV *Martin Bergmann* was stationed off site and the UAT’s Zodiac FC 530 inflatable boat served as the actual main diving platform and although cramped and exposed to the elements, it proved functional. The UAT dive team motored between the site and the MV *Martin Bergmann* before and after dives, to swap out divers and compressed air tanks, which were filled using a UAT high-pressure compressor set-up on the MV *Martin Bergmann*. As an added safety feature, the UAT’s Zodiac Hurricane 472 rigid-hull inflatable boat was also used to ferry divers and equipment the short distance to and from the dive site and it served as a chase boat and back-up to the FC 530 Zodiac.

All dives during this fieldwork were carried out using scuba equipment and in accordance with the Parks Canada Directive on Diving Safety (Parks Canada 2002), the Canada Labour Code (R.S.C., 1985, c. L-2) and the DCIEM air tables. Diving hazards were mitigated through training,

safety procedures and on-site safety equipment, with special care taken to bring an ample supply of pure oxygen in the event of a diving emergency.

Each dive team comprised a minimum of four persons, including: two (sometimes three) free-swimming divers working in tandem; a dive supervisor; a boat operator; and a stand-by diver. All diving was done on a rotational basis and multiple dives were performed on any given day. Only no-decompression dives were performed and dive times adhered to the DCIEM tables. Importantly, diving operations were restricted to daylight hours. The basic dive kit included a Cressi Sub full-face mask and Apeks regulator; buoyancy compensator and backpack; 100 or 119 cubic foot compressed air tank (with 27 cubic foot bail-out tank with regulator); and a drysuit. Divers were in contact with the surface and with each other using Orcatron single-side band wireless underwater headsets with microphones set into the Cressi Sub full face masks. Overall the diving set-up worked very well, especially given the very favorable weather conditions during Leg 1 and Leg 2.

AUGUST-SEPTEMBER 2016

There was a marked change in the diving arrangements between 2015 and 2016, with the latter episode comprising only three days of diving, all of which was staged from the CCGS *Sir Wilfrid Laurier*. The actual diving took place from Parks Canada's diving and survey boat RV *Investigator* (Figure 3.2.4) and the ship's Zodiac Hurricane 753 Fast Response Craft (FRC) named *Laurier One*. Each were deployed from the ship that was stationed some 10 km to the west of the site in an access corridor. The diving equipment configuration was unchanged from August-September 2015, except for the adoption of Dräger full-face masks and OTS through-water communications equipment.

In conclusion, during the course of diving field-work at *Erebus* in 2014-2016, the UAT has experienced the pros and cons of the two types of diving operations, namely open water scuba diving and through-ice surface-supply diving. The UAT has gained valuable practical experience, skills and knowledge for planning and executing future diving at the wreck site and this has in turn informed and influenced the project research design and methodological options. Indeed, the acquisition of the former CCGS *Arrow Post*, the forthcoming



Figure 3.2.4: UAT underwater archaeologist prepares to enter the water at *Erebus*, September 2016 (Photo: T. Boyer, Parks Canada; 89Mo8137EF).

construction of a purpose-built diving support barge (to mount containers and UAT's recompression chamber) and investments in additional surface-supply diving equipment promise to greatly augment diving hours, underwater efficiency and in turn archaeological results in years to come.

3.3 MARINE BIOLOGY PILOT STUDY AND KELP REMOVAL

Jonathan Moore

Leg 1 of the field project was devoted the marine biology study entitled “Characterization of Benthic Communities on and Around the HMS *Erebus* Wreck Site: 2015 Pilot Study”. This project was allied to a wider “Queen Maud Gulf-Victoria Strait Marine Ecosystem Study”. The objectives of the former were as follows (Ménard et al. 2015:2):

- Identify the benthic communities living on vertical and horizontal substrates of the ship;
- Explore the colonisation time and process of benthic species;
- Identify potential non-native benthic species; and

- Assess the impact of biological fouling on the preservation of the vessel and surfaces. As well, a fifth objective was the installation of an ArcticNet current profiler on the seafloor adjacent to the wreck.

The field methodology for this study is outlined in Ménard et al. (2015:3-5) and was carefully recorded in UAT field notes. This underwater work entailed the collection of “Macroalgae, epifauna (invertebrates living on the outside surfaces of the wreck and surrounding debris), and infauna (invertebrates living in sediments around the wreck)” on the upper deck, hull sides, and seafloor (Figure 3.3.1). UAT archaeologists collected a total of 16 macroalgae and epifauna samples from 0.5 m by 0.5 m sample quadrants as well as other random samples from throughout the wreck site (Ménard et al. 2015:4). UAT archaeologists collected a total of five infauna samples using 10 cm diameter cores. The sampling was accompanied by photo and video recording. A total of 22.6 hours of marine biology sampling diving took place during Leg 1. Following the completion of the pilot study, UAT archaeologists continued the removal of vegetation, and by the middle of Leg 2 the bulk of the kelp had been removed from the hull (Figure 3.3.2).

Vegetation clearing took place in both April 2015 and August-September 2015, principally of what has been identified as brown algae or kelp (*Laminaria saccharina*) (see Section 4.5). This was accomplished using sharp pruning shears to cut the kelp stalks at their base(s), then bagging the cut fronts for transport away from the hull. In April 2015 the bagged kelp cut from the port side and upper deck was swum by divers off the port side and deposited in open areas of the debris

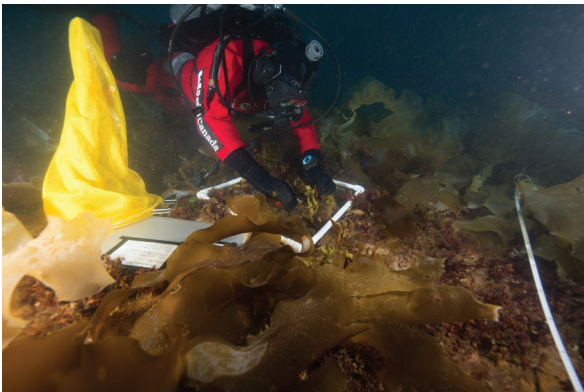


Figure 3.3.1: Biological sampling on the upper deck by a UAT underwater archeologist, 2015 (Photo: T. Boyer, Parks Canada; 89Mo3510EF).



Figure 3.3.2: UAT underwater archaeologist clears kelp on the port side of the upper deck, 2015 (Photo: M.- A. Bernier, Parks Canada; 89Mo4312EF)

field. In August-September 2015 the mesh bags were hoisted to the surface to the 472 Hurricane then motored several hundred metres off site then dumped overboard.

3.4 SITE POSITIONING AND MAPPING

Charles Dagneau

SURFACE POSITIONING

Surface positioning for site relocation, navigation, and selected artefact mapping were achieved using two different systems. For positioning the UAT most commonly uses a Novatel Propak-V3-VBS GPS receiver (WAAS enabled) in conjunction with survey navigation softwares SonarWiz 5.0 or Hypack Max 6.2 installed on Panasonic Toughbook computers. Indeed, this configuration was used for the survey operations leading to the discovery of *Erebus*. A similar configuration was used on the ice in April 2015 to position-fix the bow and stern of *Erebus*, as well as two ice holes, relative to a multi-beam echosounder bathymetric model of the wreck site produced by the CHS in September 2014; this model is a georeferenced 3D representation of the wreck with absolute accuracy of 2.5 cm in the x, y, and z axes (Figure 3.4.1).

For August-September 2015 fieldwork operations mounted from relatively small inflatable boats, a more compact Trimble Yuma 2 GPSmap tablet (WAAS enabled) with ESRI ArcPad software was used for site relocation and for plotting isolated artefacts found on the debris field around *Erebus*.



Figure 3.4.1: UAT underwater archaeologist determines an ice hole position at the outset of the April 2015 dives (Photo: P. Reed, Royal Canadian Navy).

The Yuma 2 system also used the CHS multi-beam bathymetric model as a basemap. Satellite-based augmentation (SBAS) for differential corrections was achieved through North American Wide Area Augmentation System (WAAS) for both system configurations. Recorded GPS positions and all relevant geomatic information were assembled into the project geographic information system (GIS) using ArcGIS software using the Universal Transverse Mercator (UTM, zone 14N) projection system and Canadian Spatial Reference System 1998 (CSRS 98) datum, which is derived from North American Datum 1983 (NAD 83).

UNDERWATER MAPPING REFERENCE SYSTEM

Many wooden-hulled historic shipwreck sites found in salt water consist of a collapsed hull structure that is largely flattened and buried through time as a result of natural site formation processes. The level of preservation of *Erebus*' hull structure is certainly exceptional in that regard, as it is largely intact and stands upright on the seafloor. The three-dimensionality of the structure, although holding great promise for finding in-context material culture inside the vessel, nevertheless presents a challenge in terms of site mapping, interior penetration and future excavation.

To cope with this site challenge, two different reference mapping systems have been applied to the site to allow effective positioning of artefacts on the seafloor as well as on and within the hull. To map artefacts located on the relatively flat seafloor around the hull (including the hull itself at the seafloor level) a primary baseline was established parallel to the vessel, approximately 4 m

off its port side, in order to take standard offset measurements. A custom-made datum support using counter-weights was used to stretch a fiberglass surveyor's rope horizontally, 0.5 m off the bottom (Figure 3.4.2). This primary baseline runs West-East (bow to stern) from the 15 m to 57 m marks respectively (Figure 3.4.3). On the site provenience grid, this line corresponds to the limit line between sub-operation rows F and G. Small brass datum tags were used to pinpoint the location of this baseline on different wooden hull sections on the seafloor: tag 910 at 15.0 m, tag 911 at 22.0 m, and 912 at 57.0 m. These are meant to serve as references for installing this baseline at the beginning of every episode of fieldwork, and to verify its position regularly, as the tape may dis-tend through time.

A second baseline was installed perpendicular to the first, approximately 4 m off the stern of the vessel (see Figure 3.4.3). This second baseline crosses the main baseline at the 56 m mark, and runs South-North for a distance of 24 m. It follows the line limit between operation columns 56 and 58 on the provenience grid. Reference point no. 20 marks its start (0 m), and reference point no. 21 marks its end (24 m). To complete this offset positioning system in future, two similar baselines should be installed to the starboard side (North) and at the bow (West) of the hull.

A second reference system using the direct survey method (DSM) was installed directly on the shipwreck itself in order to allow artefact mapping in three dimensions (Figures 3.4.3 and 3.4.4). This system replaced a temporary tape baseline that was established down the centerline of the wreck for general orientation and quick referencing

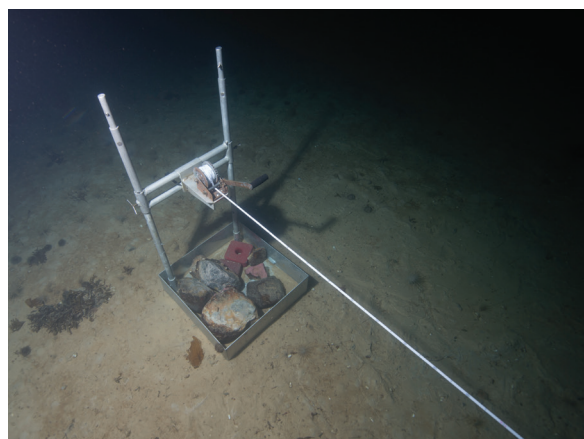


Figure 3.4.2: One of two datum line supports used for the primary baseline (Photo: T. Boyer, Parks Canada; 89Mo2679EF)

during Legs 1 and 2 of the 2015 programme. A network of 18 reference points (REF1 to 18) was established and it traces the hull outline at the upper deck level. Each point was installed on solid and secure timbers, such as frame heads and other sizeable wooden structural features. Each reference point is marked by an 8 cm-long stainless steel lag bolt and an orange, numbered plastic polyvinyl chloride (PVC) cattle ear tag. The lag bolt heads have a diameter of 1.1 cm, a size well suited to fit in the loop ends of fibreglass measuring tapes. Their hexagonal heads also provide an easy reference point for elevation measurements. 3H Consulting's Site Surveyor 4 software was used in order to accurately plot each point in space using a web of trilateration measurements, in conjunction with absolute depth values derived from the 2014 multi-beam echosounder model created by the CHS. This system proved to be extremely accurate, with a calculated root-mean-square (RMS) residual value of 0.009.

The principal DSM reference points are REF1 and REF8. REF1 is located in the middle of the inner stem post and REF8 is located on a massive vertical timber protruding from the main hatch (possibly a bitt post), in the middle of the site; given its central location REF8 has been designated as the principal site depth datum. Taken together both points define the central longitudinal axis of *Erebus*, although that axis does not correspond to any grid line on the provenience grid. Whereas this network of reference points atop the wreck is demonstrably accurate, it will be advisable in future to establish another independent network of permanent datum stakes driven into the seafloor around the hull perimeter, in the event that the hull structure becomes unstable with time, and as archaeological work progresses.

At present this DSM network allows for efficient 2-dimensional (2D) or three-dimensional (3D) mapping of artefacts and features on the upper deck, and artefacts resting on this deck were mapped by 2D trilateration in September 2015 using these reference points. As well, the network can be expanded and extended for working below the upper deck when that time comes. In fact, in September 2015 the DSM network was also used to establish temporary baselines on the lower deck during mapping of artefacts in a discrete location where most objects were recovered in 2015. In this instance, secondary reference points REF11 and REF12 were added on a deck plank, on the edge of the upper deck opening, to transfer temporary

baselines below the upper deck. Selected vessel structures on the upper deck were also mapped in 2015 using a mix of survey methods. Measured sketches of the bowsprit partner and main hatch areas on the upper deck were also completed.

The DSM model has been georeferenced to the NAD83 (CSRS98) spatial reference system (UTM zone 14N) in relation to the CHS multi-beam echosounder data from 2014. The DSM network has in turn been used to georeference (not georectify) a highly-accurate 3D photogrammetric textured model and resulting point cloud data set created using Agisoft PhotoScan software (see Section 3.5). This was instrumental in creating not only a georeferenced site map for the study of the vessel structure, but also for plotting artefacts and features. Ultimately, these data sets will be further validated and improved geomatically with the processing of the 2016 multi-beam echosounder data of the wreck that employed the UAT's R2Sonic multi-beam echosounder.

Given the highly 3D nature of the wreck and the limited time available for underwater recording, laser scanning was identified as a promising method to expediently map the site, in conjunction with other methods. Indeed, since 2011 the UAT has tested underwater laser scanners manufactured by 2G Robotics of Waterloo, Ontario, on a range of sites, including the wreck of HMS *Investigator*. In April 2015 the UAT deployed its 2G Robotics ULS-500 scanner through the ice to the seafloor on the port side of the *Erebus* and attempted scans of the hull's side. As well, trial scans of the lower deck in sub-operations 28J, 28K, 30J and 30K were made with a smaller 2G Robotics ULS-200 scanner. This scanning yielded promising preliminary results; this said, further trials and use of the technology need to take place in order to realize its full potential.

DEBRIS FIELD AND ISOLATED FINDS MAPPING

Mapping of the seafloor debris field around the wreck is incomplete and nascent. A wide perimeter zone was surveyed by side-scan sonar and multi-beam echosounder in 2014, with little ground-truthing of many observed targets or features, for example, planking and debris. This said, UAT archaeologists and crewmembers from the MV *Martin Bergmann* conducted multiple visual inspections of the seafloor debris field from

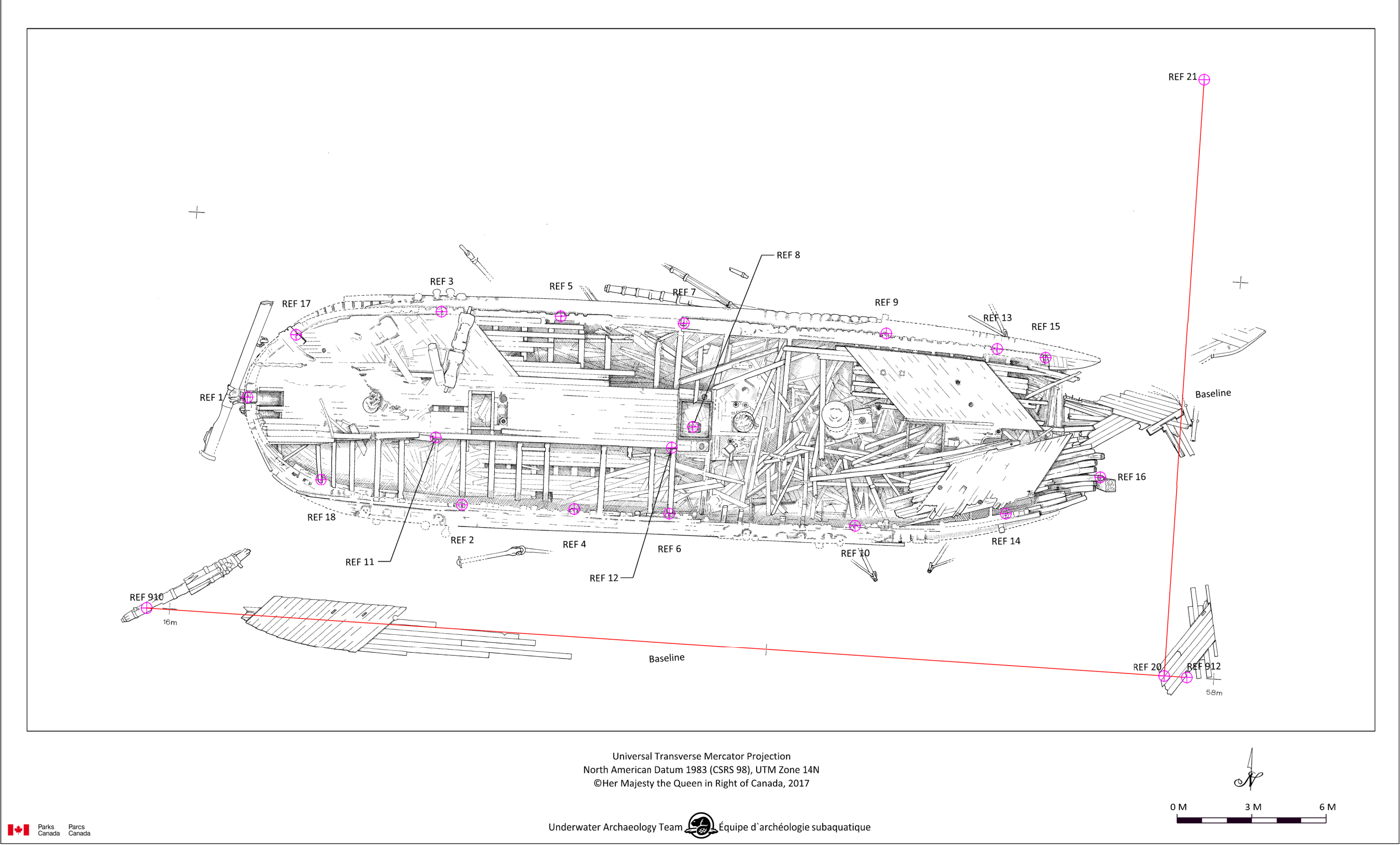


Figure 3.4.3: Baseline and DSM reference tag positions on the wreck of *Erebus*. Tag 911 is not shown as it was obscured during recording (Drawing: C. Pillar, Parks Canada; 89M-2017-101-3; Image: B. Lockhart, Parks Canada).

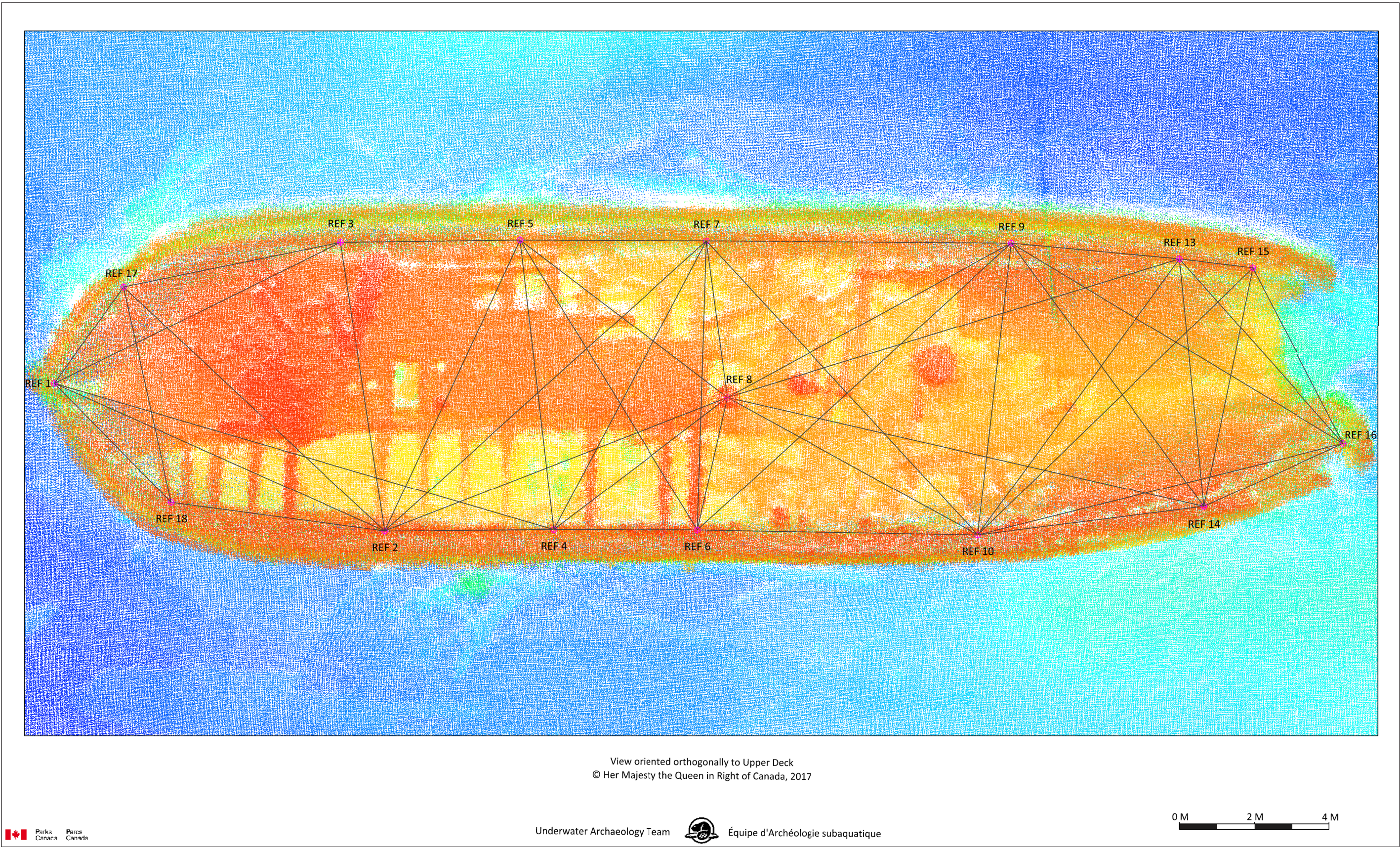


Figure 3.4.4: DSM reference points and measurements recorded between points (shown by gray lines), superimposed over 2014 multi-beam echosounder imagery (Image: B. Lockhart, Parks Canada).



Figure 3.4.5: Parks Canada team member uses an improvised bathyscope to look at the wreck of *Erebus* (Photo: D. Bard, Royal Canadian Navy; 89Mo7166EF).

the vantage point of the Hurricane 472 in particular during Legs 1 and 2 in August-September 2015. Given the relatively shallow seafloor depth and excellent visibility, combined with periods of flat-calm surface conditions coinciding with sunny days, it was possible to locate large debris items and artefacts on the seafloor both with the naked eye and with bathyscopes (Figure 3.4.5). This simple survey method was surprisingly successful and led to the discovery of a second propeller (89M100A1-1) with some nearby finds, 43 m north of *Erebus*' bow, and part of the ship's wheel (89M100A1-1), 29 m to the south of the bow. In both instances, these isolated finds were plotted using a Trimble Yuma 2 GPSmap unit. The propeller and nearby finds were also photographed from the surface. Closer in to the hull, out to a distance of 8-10 m, the site has been recorded in geomatic terms by photogrammetry, side-scan sonar and multi-beam echosounder. Both in situ artefacts and artefacts raised from the seafloor debris field were positioned using perpendicular offsets from the primary baseline. The locations of some debris field features have been sketch mapped by UAT archaeologist within fieldnotes pending more formal mapping.

3.5 PHOTO AND VIDEO DOCUMENTATION

Thierry Boyer and Marc-André Bernier

The UAT used a combination of still photo and video cameras for its image documentation of the wreck of *Erebus* in 2015. For still photography, the principal camera system was a Nikon

D4 with a 14-24 mm lens, and the spare system was a Nikon D300s with a fixed 14 mm lens. Both cameras were used in Aquatica housings, each of which was equipped with a glass dome and two Ikelite DS161 strobes for artificial lighting (Figure 3.5.1). For high definition video, the primary camera was a Sony PMW-F55 UHD camera, with Raw 4K recorder, a Duclos 11-16 mm PL-mount lens in a Gates housing, and four Keldan Luna-4X lights (6,000 lumens each). This camera system is of professional film production quality, with complete manual controls, and allows for simultaneous recording in Raw 4K (ideal for colour correction and film production) at the same time as compressed HD (advantageous for both simple review and export to the Web). The UAT also used a Panasonic HVX-200p video camera in a Gates housing with two Keldan Luna-8 lights (6,000 lumens each). In April 2015, surface powered Orcalight Seawolf underwater lights were installed to serve as a chandelier (using ice-screws the fix them under the ice) to illuminate the wreck site, given that natural light was partially blocked by the thick ice and tents above. Whereas this chandelier system generated about 88,000 lumens in total, there was seldom more than 2.5 m horizontal underwater visibility, thereby reducing the number of high-quality photographs that could be used to generate completely satisfactory photogrammetric models.

For some specific recording, notably filming interior video through small hull and deck openings as well as small-scale video tasks, the UAT employed GoPro Hero3 and Hero4 cameras in GoPro underwater housings, as well as a Panasonic HMR10 Point of View (POV) video camera (in a Gates housing). For shooting interior images, in both cases the cameras were mounted on extendable



Figure 3.5.1: UAT underwater archaeologist takes photographs under the upper deck (Video Still: R. Harris, Parks Canada; 89M2016R003_2114).

painter's poles and inserted into the hull opening by one operator; typically a light was also inserted into the opening, or a nearby opening, by either the camera operator or an assistant. Whereas the operator shot blind with the GoPro system in the pole-mount configuration, the POV system allowed the operator to view a colour video monitor, given the camera is linked to the monitor by a 3-m cable. This latter system can yield better video as the videographer can see what he or she is filming in real time, as opposed to reviewing on the surface after the dive, and can make adjustments based on interior obstacles. Both systems however yielded excellent interior wreck images.

During both the April and the August-September 2015 projects, the bulk of the photo documentation and recording efforts were dedicated to the creation of photogrammetric 3D models of the shipwreck. Single point photogrammetry is a process that allows one to create a 3D model from a collection of photos taken from different locations around an object or structure. When loaded into photogrammetry software, in this case Agisoft Photoscan Standard Edition Version 1.2.4, the photographs are correlated through the detection of identical points on different images and the subsequent calculation of the point of origin of the photograph. By calculating the locations or points of origins of the camera, the software is able to generate a 3D model for all the features that appear on overlapping photos. The generated model can later be spatially corrected and geo-rectified by entering measurements and the positions of multiple points. This allows the photogrammetric images to be useful not only as public outreach and education products, but also as powerful and highly accurate archaeological documentation and research tools.

For any two adjacent photographs to be useful in the generation of a model, they both need to display part of the same feature. Therefore the meshing of the photographs can only work efficiently on fixed structures and not on moving features such as vegetation. For this reason, in both April and August-September 2015 the image acquisition for the 3D models took place only after kelp removal from the shipwreck (or from specific wreck surfaces). Raw photos of a hull side, the upper deck or of one side of the debris field could be completed during a single dive, with an overlap of at least 50%, but often of 75%. After both the April and August-September 2015 projects, all of the wreck except for the starboard side had

been documented with photogrammetry. A total of 2,200 photos were taken for and used in 3D photogrammetric models.

During the 2015 fieldwork (for both the April and August-September projects), over 6,600 digital photographs were taken underwater and on the surface, including artefacts, photogrammetry images, and the daily activities of project team members. More than 13 hours of digital video were also captured both topside and underwater.

LIVE LINK

An important component of the April 2015 project was the “Live Dive”, a live audio-video link between the site in Queen Maud Gulf and the ROM in Toronto, Ontario (Figure 3.5.2). The original intent was to have a three-way link between an archaeologist diving on *Erebus*, another archaeologist on the ice's surface and a school group of seventh-grade students in an auditorium in the ROM. The full three-way live link could not be completed as planned because of ice-camp tent positioning and the technology available. Whereas the students could not talk directly to the archaeologist underwater, they were still able to hear and see the live tour of the shipwreck from Ryan Harris. Questions were answered by Marc-André Bernier located in a tent a few meters from the dive tent.

In order to generate the link (as undertaken) between the underwater archaeologist diving on the shipwreck and the museum in Toronto, a number of complementary technologies had to be used in concert. First, the audio from the speaking archaeologist underwater had to be mixed to the video, and to do so, an audio line was run from



Figure 3.5.2: Live Dive broadcast underway in April 2015 (Photo: P. Reed, Royal Canadian Navy).

the microphone in the diver's full-face mask to the camera underwater. To send this now mixed audio-video feed to the surface, a fibre optic cable was chosen for its reliability and quality. To achieve this, an HD-SDI-to-fibre-optic converter was installed in the Sony F55 Gates housing and a 152-m (500 ft.) fibre-optic cable was coiled into the videographer's (Thierry Boyer) umbilical to link the camera to the surface. In the ice camp, the signal was converted back into a HD-SDI signal and run into a video editing station, where it could be either mixed with or used in parallel with a surface image of Marc-André Bernier narrating the images while the diver and camera operator were changing stations. The selected or mixed signal was then converted into an Ethernet signal using a Teradek Cube converter and transmitted via the Internet using a Galaxy Scout satellite antenna and a Skydata system.

3.6 ARTEFACT RETRIEVAL AND RECORDING

Charles Dagneau

The archaeological work conducted on *Erebus* in April 2015 was conceived as a preliminary survey of the site and not a full excavation per se. As a consequence, only 14 selected artefacts in fairly good condition, free of sediment and easily recoverable were selected for recovery (not including the ship's bell raised in 2014). Later lab excavation at Parks Canada's facility at 1800 Walkley Road added 23 artefacts to this April total (including a batch of 18 small bird shot, three cannon shot, one buck shot and a window glass fragment) yielding a total of 20 records for 37 individual objects. Most of these objects (28 out of 37) were found together and recovered from the lower deck, between deck beams 100 and 101, in sub-operations 28J-K and 30J-K. Nine objects were recovered from the debris field directly adjacent to the hull.

Artefact positioning on the seafloor was achieved using the primary baseline established to the south of the site. For artefacts on the lower deck inside the vessel, positioning was achieved relative to upper deck beams and deck planking and other discrete features (Figure 3.6.1). For a few obscured artefacts at the stern, namely the two cannon and a furniture leg, both the baseline offset method and DSM were employed relative to



Figure 3.6.1: UAT underwater archaeologist records a plate and other artefacts on the lower deck (Photo: M.- A. Bernier, Parks Canada; 89M06611EF).

discrete elements of the stern structure used as temporary reference points. Most artefacts were then raised to the surface and through the ice hole using standard practice, after being wrapped in thick bandages and inserted in either rigid plastic containers or closable plastic bags. Some artefacts were secured with bandages to Coroplast splints. Basic surface recording and inventory is discussed in the following section.

The raising of a light 6-pounder cannon (89M99X1-6) is worth describing in detail, since it required a high level of preparation and coordination, given its size and weight. Two bronze cannon were found in 2014 at the stern of *Erebus* lying one atop the other; raising one or both of the cannon was set as a 2015 objective. After close underwater examination in April 2015, it was deemed possible to raise the uppermost cannon. A plastic bag was tied in place over the cannon muzzle to capture and contain any and all material within the cannon that might be dislodged during raising. The muzzle end was rigged and then raised to a slightly increased angle relative to the breech using one 500 lb. lifting bag. It was then possible to re-rig the cannon with one strap around the trunnions, and one strap around the breech end. These straps were rigged to a single pick point and two 500 lb. lift bags, one fully inflated and one as a feather bag, allowing the cannon to be lifted from the seafloor to the underside of the ice at the secondary ice hole directly atop the cannon's in situ location (Figure 3.6.2). From there the cannon was attached to a chain hoist mounted on a derrick, in turn mounted on two military man-haul sleds. This hoisting method had been used earlier to remove heavy blocks of ice from the two ice holes as they were cut. The cannon was hoisted up through

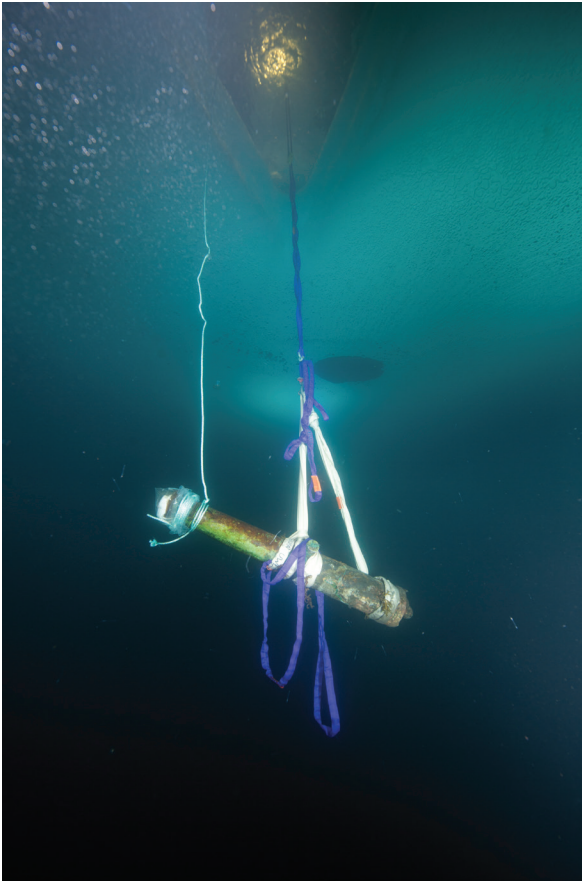


Figure 3.6.2: The 6-pounder cannon (89M99X1-6) is raised to the ice surface, April 2015 (Photo: T. Boyer, Parks Canada; 89Mo3059EF).

the ice hole, deposited on a cradle, examined and photographed, prepared for transportation and placed in a custom crate fabricated by FDU personnel. Parks Canada was able to take advantage of the partnership with the FDU and benefit from the unique opportunity of having a U.S. Air Force ski-equipped Hercules available. This aircraft was used to transport the cannon, other artefacts and most of UAT gear from the remote site of the wreck of *Erebus* directly to Yellowknife.

The archaeological work in August-September 2015 continued the vegetation clearing and preliminary survey of the site that aimed to achieve an overall understanding of the wreck rather than study it through the lens of a provenience grid or specific sub-operations. Again, no excavation per se was possible due to time and logistical limitations. The artefact recovery strategy followed the same pattern as in April 2015, and focused on objects readily available throughout the upper deck, and also from the artefact-rich zone on the port-forward part of the lower deck. All artefacts recovered in September 2015 were relatively small

however; they were raised to the surface according to standard practice, after being wrapped in thick bandages and placed in either hard plastic containers or reclosable plastic bags. This work was done under very poor visibility conditions.

For the August-September 2015 operation, 85 artefacts were recovered representing 46 archaeological records (including a concretion holding approximately 40 percussion caps within one artefact record). Like the previous operation in April, most artefacts were recovered from the lower deck in the port forward section of the vessel (sub-operations 26J/K and 36J/K). Again the number of records grew as lab excavation and conservation treatment continued at 1800 Walkley Road. Following the conclusion of lab excavation in April 2016, the *Erebus* artefact collection had grown to a total of 66 records representing 122 individual objects (including the 40 percussion caps and a batch of 18 lead bird shot).

Once on the surface aboard the MV *Martin Bergmann* and in its lab space, each artefact was first catalogued and sketched using inventory paper forms, then photographed. Data entry of catalogue information into a Microsoft Access “HMS *Erebus* Artefact Database” was initiated in the field. In Ottawa, controlled laboratory excavation, conservation treatment and specific material culture research revealed more information about many objects within the collection, and this data was inserted to update and expand artefact records in the database. This work continues at the time of report writing.

The *Erebus* Artefact Database was designed for both the recording of archaeological objects in the field and the interpretation of the collection in archaeological terms. It follows Parks Canada’s Archaeology Recording Manual (2005) and is designed to allow easy data import into Parks Canada’s Archaeological Resource Database (ARD), an archaeology and collections management tool first created by Parks Canada’s Ontario regional office. The *Erebus* Artefact Database includes unique fields and functions however that are not present in ARD that are required for the interpretation of present and future *Erebus* artefacts and excavation material. For example, 3D coordinates (XYZ) for each artefact are to be stored in NAD83-CSRS98 UTM format, to allow future 3D spatial distribution analysis with the database.

3.7 SITE MAPPING SOFTWARE

Brandy Lockhart

As noted above, three-dimensional point clouds consisting of millions of points with specific RGB values and XYZ coordinates relative to one another were created using the photogrammetric software Agisoft PhotScan. The resulting point clouds were rendered dimensionally accurate by scaling them to the direct survey method (DSM) survey although they lacked inherent positioning data. This was corrected by registering the 2015 photogrammetric point clouds to the CHS's 2014 multi-beam echosounder (MBES) point cloud using CloudCompare Version 2.6.2 software. The resulting registered photogrammetric point clouds were then compared to the 2014 MBES point cloud to determine areas of deviation. The major source of deviation between the 2014 and 2015 data sets was vegetation that was removed prior to data collection in August-September 2015. Overall however, there was excellent spatial agreement between the two. The raising of the cannon in April of 2015 created local variation on account of this event but this was readily detectable in the comparison.

The photogrammetric point clouds were then imported into Bentley Descartes V8i, Select Series 6 software for archaeological analysis. This software will be the primary platform for processing three-dimensional mapping data for the wreck of *Erebus*, for example for any future laser, acoustic, photogrammetric data and divers' measurements and drawings. The ability to import MBES point clouds into Descartes allows for the selection of the highest quality data from each cloud without creating data gaps. The position of the point clouds was inspected in Descartes using its sections tool to compare several site features between clouds and slight corrections were made as required to ensure the best alignment of the clouds. Additional data imported into Descartes to date includes the 1839 ship plans of the *Erebus*, which were geo-rectified to point clouds in three dimensions and the 2015 DSM survey data. Thus far the point cloud data has been used to measure wreck and feature dimensions, depths, depth of burial as well as to create scale plans and drawings.

3.8 CHS WATER LEVEL RECORDER AND ARCTICNET CURRENT PROFILER

Joe Boucher and Jonathan Moore

On April 18, 2015 the UAT deployed a CHS Aanderaa WLR7 Submersible Water Level Recorder at *Erebus*. This precision instrument measures water depth change over time, and by extension the tidal range and cycle for the period the instrument is on the seafloor. The unit was placed on the bottom approximately 15 m off the starboard bow of *Erebus* and at a depth of 11.4 m. After having been initially lowered to the seafloor through the ice hole, the recorder was swum by diver to the installation location with the aid of a lifting bag. On April 19, 2015 the UAT placed an accompanying barometer on high ground on a nearby island. The barometer was recovered on September 17, 2015 and the submersible recorder itself on September 18, 2015.

On September 7, 2015 the UAT installed ArcticNet's Teledyne RD Systems Sentinel V Acoustic Doppler Current Profiler (ADCP) in support of the marine biology study and to gain a better understanding of site conditions (Figure 3.8.1). This precision instrument measures current velocity and water temperature, among other sensor data. Prior to the deployment of the current profiler, Parks Canada's UAT assembled the various components on the unit's stand, completed a compass calibration, and logged into the meter wirelessly to ensure it was recording properly. The current profiler was installed during a collaborative dive involving

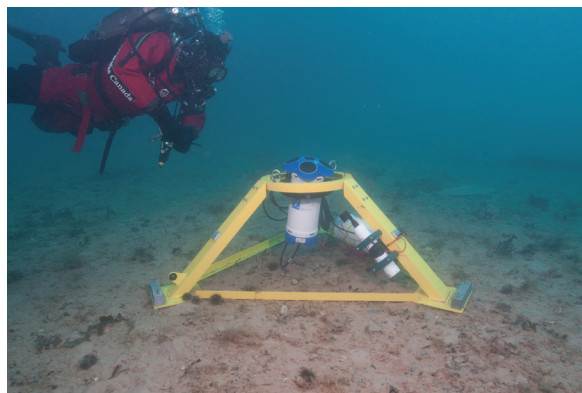


Figure 3.8.1: ArcticNet's Teledyne RD Systems Sentinel V Acoustic Doppler Current Profiler (ADCP) on the seafloor (Photo: J. Moore, Parks Canada; 89Mo6478EF).

both a Parks Canada UAT diver Joe Boucher and Seneca College diving instructor Aaron Griffin. The current profiler was rigged to two 100 lb. lift bags. Using the lift bags and a line, it was lowered from the Zodiac Hurricane 472 to the seafloor on the starboard side of the wreck, inside the debris field but clear of any visible wreckage. The current profiler was then transported by the two divers with aid of the lift bags to a predetermined position 15 m directly forward (due West) from the bow. Once carefully placed on the seafloor, the lifting bags and rigging were removed. The profiler was later photographed in situ.

On August 31, 2016 the UAT recovered the current profiler and downloaded the collected data with the assistance of Hans Biberhofer. The unit was redeployed on September 11, 2016 approximately 11 km northwest of the wreck of *Erebus*.

3.9 MULTI-BEAM ECHOSOUNDER

Ryan Harris

A multi-beam echosounder (MBES) efficiently plots a swath of high density bottom soundings along a surface vessel's survey track, providing detailed 3D imagery of seafloor topography.

A pole-mounted R2Sonic (MBES) system, model 2024 was deployed from RV *Investigator* in 2016 (Figure 3.9.1). This MBES system offers variable 200-400 kHz frequency selection, with a high resolution imaging capacity at 700 kHz. Indeed, all MBES surveying was conducted at 700 kHz. Correction for localised variations in the ambient speed of sound in water was achieved by an AML Micro.X direct measurement sound velocity probe that was secured to the faring of the multi-beam head. Sound velocity profiles characterising the full depth of the water column were also periodically collected by periodic deployment of an AML MinosX direct measurement sound velocity profiler. Bathymetry was also corrected for diurnal tide fluctuation and differential positioning using a Novatel Propak-V3-VBS shore-based GPS reference station situated on a nearby island.

At the time of writing, MBES field data is being post-processed to provide both a very accurate and updated 3D point cloud dataset of *Erebus*, as well as a DBM digital bathymetry models of an area of seafloor around *Erebus*. This new survey will provide a much more detailed 3D point cloud model than the one produced from 2014 CHS data. It will also potentially help to quantify any large scale dynamics affecting the site, otherwise hard to apprehend with standard archaeological recording techniques while diving.



Figure 3.9.1: RV *Investigator* approaches *Erebus* during the 2016 MBES survey (Photo: D. Stenton, Government of Nunavut; 89Mo8853EF).

3.10 REMOTELY-OPERATED VEHICLE

Brandy Lockhart

In September 2016 a ROV was used to collect video from the interior of the wreck of *Erebus*. The ROV was a customized DeepTrekker DTG2 equipped with an internal high-definition Sony 4K Actioncam with a 330-degree field of view. Customizations to the ROV included vertical thrusters and inertial motion. The ROV measured 32.5 cm wide, 25.8 cm high and 27.9 cm long; this small size allowed for the ROV to maneuver into the lower deck and orlop decks of the wreck. The ROV was piloted from a small surface control unit via a lightweight and neutrally buoyant umbilical cable which transmitted a realtime video feed back

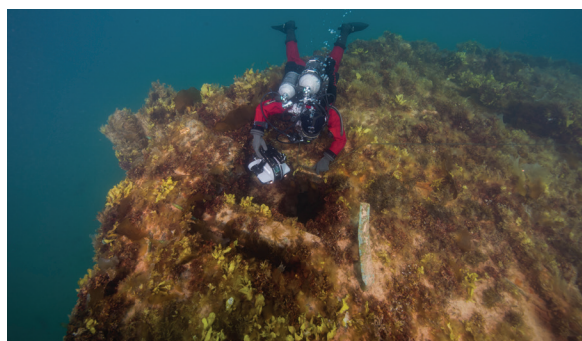


Figure 3.10.1: UAT underwater archaeologist inserts the Deep Trekker ROV into the bowsprit partner opening at the bow (Photo: T. Boyer, Parks Canada; 89Mo3059EF).

to the surface. The umbilical cable was tended at upper deck level by a diver to eliminate umbilical drag in the water column and to direct the ROV into desired hull openings (Figure 3.10.1).

4. SITE ENVIRONMENT DESCRIPTION

Jonathan Moore

This section provides a preliminary description of the site environment of the *Erebus*. As diving and research at the site progress, it is anticipated that additional quantitative and qualitative site environment data will be collected. This section therefore presents a snapshot of currently available information.

4.1 WEATHER

The wreck site of *Erebus* undergoes dramatic seasonal variation in weather conditions (Table 4.1.1). UAT staff have begun to garner a better understanding of temperature, wind speed, wind direction and surface visibility as they relate to project logistics, on-site working conditions and ultimately site preservation.

Weather conditions were generally favourable during April 2015 fieldwork and conditions were recorded daily at the ice camp, although this section cites weather data from station CWIL at Hat Island, Nunavut, approximately 60 km to the west of *Erebus*. Air temperature and wind speed ranges from April 9-19, 2015 (the first and last days UAT staff were on site) are shown in Table 4.1.1, not including wind chill. Winds and reduced visibility at the site curtailed Twin Otter flights to the site on April 11 and ruled out flights altogether on April 12. Reportedly, visibility of three miles was required in order for Twin Otters to be permitted to land at the site.

Fieldwork during Legs 1 and 2 in August and September 2015 experienced generally sunny, fair and warm conditions, with variable winds yet

some flat calm periods. Air temperatures and wind speed ranges are shown in Table 4.1.1. Following Leg 2 however, a strong gale from September 11 to 15, 2015 adversely affected the project, delaying the departure of the MV *Martin Bergmann* from Cambridge Bay for Leg 3. Hat Island recorded sustained winds of 76 kph (41 knots) and 80 kph (43 knots) on September 12 and 13 respectively, with gusts to 84 kph (45 knots) on both days (The Weather Company 2015). This gale evidently generated significant waves that adversely affected the wreck site and moved timbers and artefacts. Afterwards during Leg 3, on-site conditions were generally favourable but windier on average than the preceding two legs, with winds observed on-site perpetually 15 to 20 knots (estimated) from the south or southeast. After the departure of the MV *Martin Bergmann* from the site, on September 25 and 26 another (albeit shorter) low pressure system with winds of 80 kph (gusts to 84 and 89 kph respectively or 45 and 48 knots) took place. Wind direction recorded at Gjoa Haven at this time was north-northeast.

4.2 BATHYMETRY, HYDROLOGY AND ICE CONDITIONS

The bathymetry of the *Erebus* wreck site and its immediate surroundings were surveyed by CSL *Kinglett* of the CHS in September 2014 and on September 2, 2016 from Parks Canada's RV *Investigator*. The *Kinglett* employed a 200-400 kHz R2Sonic 2022 multi-beam echosounder while the latter used a 200-400 and 700 kHz ultra-high frequency R2Sonic 2024 multi-beam echosounder. The initial side-scan sonar coverage of the wreck on September 2, 2014, the day of its discovery also provided useful bathymetry data.

Date	Air Temperature (°C)	Wind Speed (kph)
April 2015	Low -31 to -19 High -23 to -14	High 19 to 42
August-September 2015	Low 0 to +6 High +4 to +10	High 14 to 84
August-September 2016	Low +1 High +4	High 18-26

Table 4.1.1. Summary of selected air temperature and wind speed ranges for three episodes of fieldwork at the wreck of *Erebus*, 2015-2016 (Data: CWIL at Hat Island, Nunavut, The Weather Company 2015).

As well, visual observations from boats and echosounder displays from the MV *Martin Bergmann* gave additional contextual knowledge.

Based on available data, the *Erebus* is flanked on its north and east sides by shoals (Figure 4.2.1). The nearest shoal is due north from the wreck at a distance of approximately 100 m. In general the seafloor at the wreck slopes from northeast (shallower) to southwest (deeper) (Figures 4.2.1 and 4.2.2). The exception to this trend is a sizable and irregular-shaped scour pocket off the stern that extends forward along the port side and also wraps around the starboard quarter; this pocket is up to 20 m wide and as much as 1.5 m deeper than the flanking seafloor. The stern scour pocket is clearly discernible underwater by divers under good visibility conditions, especially given that it has a steeply sloping edge in places. As well, there is noticeable scouring along the turn of the bilge of both sides of the hull.

The minimum depth recorded at the site in 2014 was 4.5 m atop debris on the foredeck and the depths to the seafloor at the bow and stern were



Figure 4.2.1: *Erebus* from the air facing west, August 2015. The stern is in the foreground (Photo: T. Boyer, Parks Canada; 89Mo3937EF).

Tide Description	Level (m)
Higher High Water Large Tide (HHWLT)	1.04
Lower Low Water Large Tide (LLWLT)	0.0
Highest Astronomic Tide (HAT)	1.07
Lowest Astronomic Tide (LAT)	0.02
Higher High Water Mean Tide (HHWMT)	0.77
Lower Low Water Mean Tide (LLWMT)	0.26
Astronomic Tide Range	1.09
Large Tide Range	1.03
Large Mean Tide Range	0.509
Mean Tide Range	0.381

Table 4.2.1. Tide and water level data for the *Erebus* site as processed by the Canadian Hydrographic Service, Fisheries and Oceans Canada, Burlington, Ontario.

recorded as 10.7 m and 10.2 m respectively. The wreck was recorded as standing 5.2 m off the seafloor.

Many areas in the Canadian Arctic lack quantitative water level and tidal data, and this was certainly the case for the *Erebus* site prior to 2015. The situation changed in 2015 when an Aanderaa WLR7 Submersible Water Level Recorder loaned from the CHS was deployed on site at a depth of 15.4 m, for a total of 154 days from April 18 to September 18. This has yielded the water level data for the site in Table 4.2.1, which shows a modest Astronomic Tide Range of 1.096 m. This maximum tidal range of one metre was confirmed by the ArcticNet current profiler (Meredyk 2016:pers. com.).

The UAT has experienced modest tidal currents both on the water's surface and underwater at the site, which sometimes made swimming against it more difficult but never impossible. The ArcticNet current profiler deployed in September 2015 provided the following results (Meredyk 2016: pers. com.):

The current speeds are low from a[n] oceanographic perspective, though for a dive team it might seem substantial. Currents range from 5 cm/s to 18 cm/s [0.1 to 0.35 knots] in the high current pulsing events of the mid summer to early winter period (5 months in total).

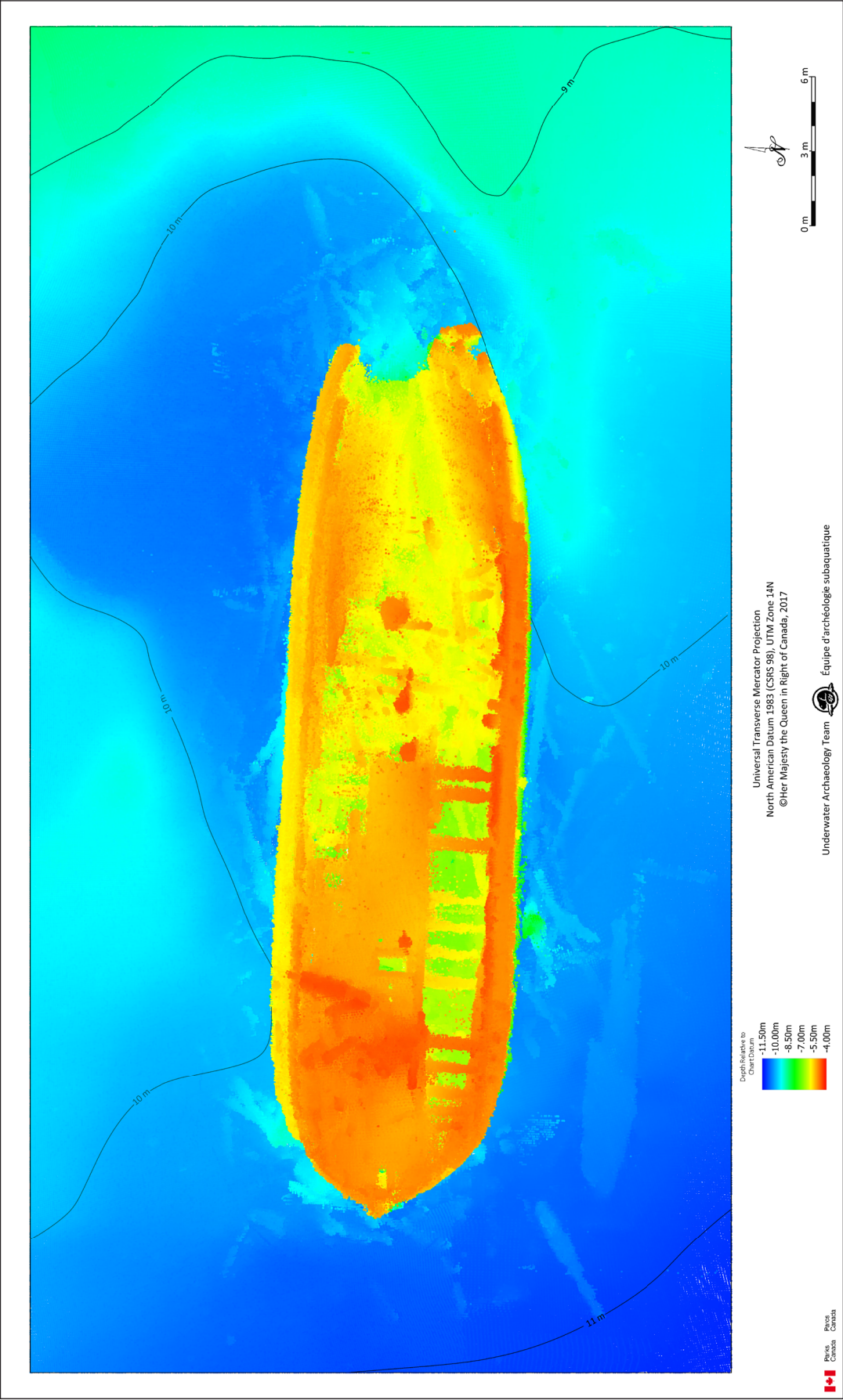


Figure 4.2.2: Bathymetric model of the *Erebus* (orthogonal view) showing selected contours, based on 2014 data (Image: B. Lockhart, Parks Canada; Data: CHS).

Date	Temperature (°C)
April 2015	-1 and -2
August-September 2015	+3 to +6
Late October 2015-June 2016*	Hovered at -1.5
September 2016	+4
July 2016-September 2016* with Early October 2015	Maximum +3 (Average 0)

Table 4.2.2: Recorded water temperatures at the wreck of *Erebus*, 2015-2016. Entries marked by an asterisk were recorded by the ArcticNet current profiler (Data: UAT and Meredyk 2016:pers. com.).

Based on qualitative observations alone, underwater visibility at the site varied significantly in 2015 and 2016. In April 2015 visibility was fair, in excess of 11 m, but given the ice cover, ambient light was reduced and the site therefore perpetually sombre. The latter was offset marginally with the installation of an artificial lighting system. Excellent visibility in excess of 15 m was observed during Legs 1 and 2 in August-September 2015, but during Leg 3 it fell dramatically to 0.5 m on account of the abovementioned storm. Visibility at the site in 2016 was approximately 5-10 m.

UAT team members used Suunto *Vyper* depth and temperature gauges to record underwater temperatures on the wreck in 2015 and 2016. As well, water temperatures were recorded by the ArcticNet current profiler (Table 4.2.2).

In April 2015 ice thickness at the site was measured at 1.8 m and it was measured as approximately 3.5 m during the winter of 2015-2016, cover which was attended by the low current speed of 5 cm/s (Meredyk 2016:pers. com.).

4.3 SEAFLOOR COMPOSITION AND SEDIMENTATION

No formal study of the seafloor composition and sedimentation at the site has taken place, but some general observations can be made based on diving survey and photographic recording. Some general conclusions about the seafloor composition were also drawn in Harris, Moore and Bernier (2015: 41-42) following the wreck's discovery.

The surrounding seafloor consists of hard-packed flat cobblestone with intermixed gravel and sand. Given the firm substrate that this represents, the wreck's hull has not become deeply embedded. There is however a scour pocket around the footprint of the hull where it makes contact with the

seafloor. The most prominent scouring is found along the run of the hull, where quantities of detached wreck debris have become entrapped.

While no evidence of ice scouring of the seafloor has been observed to date, historically ice could have had significant contact with the upper portions of the wreck's structure, especially at the stern where there has been significant collapse.

Some additional information on seafloor composition has come from 2015 fieldwork. Indeed, orthogonal photogrammetric models of the wreck and the surrounding seafloor show spatial variation in bottom materials. The underlying stratigraphic unit or substrate, exposed in places, is small rounded boulders, cobble and gravel consistent in appearance with glacial till. It appears to not only support the hull of *Erebus* substantially proud of the seafloor, as noted above, but equally the majority of detached timbers, deck sections and artefacts alike. The exceptions are very heavy objects, notably the anchors, which have penetrated a little deeper into this substrate. No exposed bedrock has been observed near to the hull of *Erebus* or in the immediately adjacent debris field.

An accretion of fine-grained sediments is generally found as the upper stratigraphic layer both on the upper deck, seafloor and atop detached structural elements and artefacts in the debris field. The net accumulation of this sediment has not been so great as to bury or obscure timber edges and seams, although fasteners and surfaces are often indistinct. The depth and deposition/erosion regime of this upper unit appears to vary across the site however and it is not fully understood at this time; it could be that there is intermittent deposition and re-suspension of current-borne sediments. Clearly however there is little net sediment accumulation on much of the debris field immediately adjacent to the hull, inasmuch as there has been little accumulation relative to sizeable timbers and features. There are however

zones of deeper sediment deposition at the site, for example the northern side of the site north of the scour pocket. Here archaeologists have encountered more than a metre of fairly loose mixed silty sand, small stones and clay.

A 2016 comparison of the 1839 longitudinal profile of *Erebus* (*Terror and Erebus, Profile (as Fitted)* 1839) co-registered with both multi-beam echosounder and photogrammetry point-cloud data has yielded quantifiable measurements of the depth of burial of the wreck. The bow is embedded 1.3 m and the stern 2.5 m where the hull intersects the lowest points of the scour line at both the bow and stern. Given that the hull has little or no pitch fore and aft, the 1 m variation in the depth of burial reflects the topographic slope of the seafloor from shallower at the east (stern) to deeper in the west (bow).

There appears to be more scouring on the seafloor directly aft of the stern post and off the port quarter, where there is an exposed bank forming the edge of the scour pocket and apparent winnowing around the exposed glacial till substrate. There appears to be deeper deposition of the uppermost stratigraphic of finer grained material further forward both along the port and starboard sides, and at the bow, possibly due to current effects. For example, the detached deck section off the port bow is covered with a layer of finer grained sediments. The upper deck exhibits significant variation in sediment deposition, ranging from a dusting to approximately 1-2 cm in places where timber seams and fasteners are obscured, quite aside from the presence of vegetation. Parts of the lower deck under which the upper deck planking is absent exhibit little or no net sediment deposition, whereas more sheltered zones have more blanketing sediment cover.

4.4 MARINE BIOLOGY

Leg 1 of Mission *Erebus* and *Terror* 2015 field-work at the wreck of *Erebus* was devoted to the marine biology pilot project outlined in Section 3.3. Preliminary field results are presented in (Ménard et al. 2015:5):

Numerous species were identified in situ in the macroalgae and epifauna sampled on and around *Erebus* (Tables 1 and 2). In order of importance: macroalgae

(*Laminaria saccharina*, *Phyllophora* sp.), sponges (*Geodia* sp.), molluscs (*Hiatella arctica*, *Musculus discors*), tunicates (*Ascidia* sp., *Styela rustica*), bryozoa, and the polychaetes (*Nereis zonata*) were identified in situ. As for the infauna, the invertebrates identified were molluscs (*Macoma* sp. and *Astarte* sp.) and the polychaete *Nereis zonata*. The species found in epifauna and infauna were different except for *Nereis zonata*.

No evidence of invasive species was found during the field work accomplished during the first leg of Mission *Erebus* and *Terror* 2015.

All told, 20 algae species and 71 invertebrate species were identified (Ménard et al. 2015), bearing in mind that a study of the interior-dwelling species has not yet been completed (Figures 4.4.1 and 4.4.2). As well, UAT archaeologists observed several as yet formally unidentified fish species on the site, including small cod (*Gadidae*). Individual bearded seals (*Erignathus barbatus*) regularly visited the site. At the time of writing work continues on the study of the marine biology of the *Erebus* site.

The marine biology of the site has a direct bearing on the archaeology of *Erebus*. A salient affect is the obscuring of features, structures and artefacts from view. In this regard, the prolific *Laminaria saccharina* and *Phyllophora* sp. obscured most of the upper works and hull sides upon its discovery in 2014, with the former having to be carefully removed in order for detailed archaeological work to proceed in 2015 (and by extension 2016). The density and size of the *Laminaria saccharina*



Figure 4.4.1: UAT underwater archaeologist collects biological samples on the upper deck of *Erebus* (Photo: T. Boyer, Parks Canada; 89M03501EF).

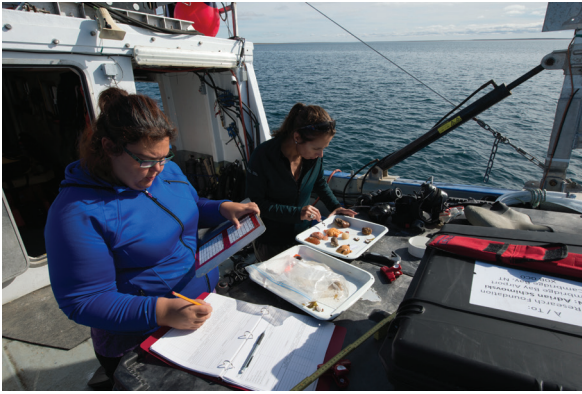


Figure 4.4.2: Lisa Treau de Coeli (left) and Nadia Ménard examine marine biological samples on the stern deck of MV *Martin Bergmann* (Photo: T. Boyer, Parks Canada; 89M03922EF).

in particular varies spatially, with most prolific growth attached to the upper deck, shallower portions of the hull sides and the hull ends.

The surrounding seabed and debris field initially exhibited markedly less overall algae cover with timbers relatively free of marine growth of any kind. As well, as the 2014 fieldwork revealed, there is little or no kelp growth under intact and contiguous sections of the upper deck (Harris, Moore, and Bernier 2015:42). The exception is the stern debris area and scour pocket that was in part blanketed with algae, predominantly *Fucus vesiculosus*. Most of this algae in the scour pocket has

not been removed to date. As well, the physically more diminutive *Phyllophora* sp. has not generally been removed from the wreck to date, given the time required for removal, and it still significantly obscures timber surfaces, timber edges and artefacts. Indeed, marine growth significantly obscures most wreck surfaces, affecting recording from 3D photogrammetry to hand mapping, and efforts will continue in future to selectively remove it in the course of archaeological recording and excavation. In August 2015 UAT archaeologists determined that there was no perceivable regrowth of *Laminaria saccharina* on the port side of the hull after it had been removed in April 2015. Molluscs also obscure wreck surfaces and these are observed to be particularly prevalent on vertical surfaces and hard substrates, such as the stern post. The mollusc species *Hiatella arctica* and *Musculus discors* have been identified at the site. Coralline algae covers selected features and appears to have a preference for ferrous substrates.

Interior imagery of enclosed spaces shows the presence of marine growth, but to a lesser extent that exposed exterior surfaces of the upper deck and parts of the lower deck open to above. This said, molluscs are abundant in semi-closed environments, such as under the upper deck amidships, both on deck beams and under the deck planking. Further research will be required to inventory the marine life of the hull interior.

5. IN SITU ARCHAEOLOGICAL DESCRIPTION

The following section provides an archaeological description of the wreck, divided into subsections for each of the *Erebus*' decks and the debris field. In considering the in situ remains, it is worth referencing contemporary construction evidence for *Erebus* which was also used in the preparation of this report section. As noted in Section 2, *Erebus* was a three-masted ship launched in 1826 as a Hecla-class bomb vessel of 372 tons burthen. While the original *Hecla*-class architectural ship plans survive at the National Maritime Museum, Greenwich, England, of particular interest are the plans in the collection that capture the results of its two refits in 1839 and 1845 for service as a polar discovery ship (see Section 2.1). Contemporary ship models, artwork and documents supplement the ship plans. Furthermore, ship plans of other polar contemporaries of *Erebus*, most obviously *Terror* but also, for example, HMS *Investigator* also provide useful comparative information and depictions of features not always shown on the *Erebus* plans.

The ship is fortified externally by solid chock channels, the spaces between the channels being similarly fitted, tapering at the extremities, so as to form an easy curvature in a fore and aft direction.

On the wreck itself, amidships they project out from the hull 0.32 m, are 1.0 m in height and their upper surfaces are 0.54 m wide. As well, they reduce in dimensions as they fair into the bow and stern. Photogrammetric and multi-beam echosounder recording confirms the hull's cross sectional shape amidships and above the sediment line which agrees with the 1839 midship section of the ship and captured the gentle tumblehome just below the ice channels (see Figures 2.1.5 and 2.1.9; Figure 5.1.3).

The hull's outer layer of planking, or "doubling", is visible on both sides of the hull. Twenty-one strakes are visible on the port side from the seabed to the top of the preserved hull. Of these 21, the top four are part of the ice channel. There are multiple scarfs in each of the planking strakes and

5.1 HULL EXTERIOR

Thierry Boyer

The hull exterior of *Erebus* has only been partially studied but the its sides, stern and bow have been recorded by photography and photogrammetry (Figures 5.1.1-5.1.3). Observations reported herein were also made during diving inspections, but most of the information comes from photogrammetric models. Recently, a port-side profile drawing and hull midship cross section drawing have been completed (based on photogrammetry and MBES data) both of which are shown in Figure 5.1.4 with the upper deck site plan.

The hull rests upright on the seabed with a heel of 6.18 degrees to starboard but with no discernible pitch either to the bow or stern. It is generally intact up to the level of the upper deck, with the ice channels on both sides preserved and coherent albeit damaged along their lengths. These distinctive features, a polar modification, are described in "Appendix I, Memorandum of the Fittings of H.M. Ship *Erebus*, by Mr. Rice, of Chatham Dockyard" in Ross (1847:327):



Figure 5.1.1: Port side of the *Erebus*' hull showing outer (doubled) planking (Photo: T. Boyer, Parks Canada; 89Mo1964EF).

along the waterline the strakes are made of wider planks, in order to compensate for the bulging of the hull. According to the 1839 midship section of *Erebus*, the ship had 41 strakes from the keel (garboard strake) to the strake at upper deck level just atop the ice channels. The uppermost outer planks were “Oak”, the mid-body “English Elm” and the lowermost section were “Canada Elm” (*Terror and Erebus. Midship Section 1839*). To date no wood species samples have been taken to confirm these identifications. The outer planks are fastened to the interior plank layer and the ship’s frames using a mix of treenails and copper alloy bolts or nails; this fastening system has not been recorded in detail.

The bow is plated in iron sheathing, in the manner shown in 1845 to a profile ship plan of *Terror* (*Profile of the Terror 1837*) (see Figure 2.1.7). On *Erebus* the top of this plating starts below the fifth strake and extends down below the level of the seabed. It is believed that the iron plating covers the hull down to the heel of the stem. The plating, having a different density and composition versus wooden hull planking, has created an easily discernible and distinct zone of more dense marine growth. It extends approximately 6.0 m aft from the stem and approximately 3.0 m above the seabed; its thickness has not been measured.

The *Erebus* was not sheathed in copper for its 1845 voyage as its suit of copper was removed while in dry-dock between March 6 and April 29, 1845 (Moore et al. 2014). Evidence of its prior copper sheathing is still present however in the form of the shanks of many copper tacks in the doubling. The heads of the tacks are missing, suggesting that the sheathing was simply ripped off in 1845, taking the heads with it. Any projecting shanks might have been hammered in, as removing them entirely would have been more trouble than it was worth (see Figure 5.1.1). However the nailing pattern of the copper sheathing is still clearly visible from the in situ tack shanks. Tacks were spaced very closely around the perimeter of every sheet, and to affix the central part of each sheet were eleven equally-spaced transverse sets of three tacks. Immediately above the port-side iron plating at the bow, the top half the draft mark “XX” (Roman numerals for 20) is visible having been partly covered by the iron sheathing added overtop in 1845. Another partial and illegible mark is still attached to the hull approximately 30 cm higher.



Figure 5.1.2: UAT underwater archaeologist inspects the propeller well of *Erebus*, including one of the tracks that guided the propeller into position (Photo: T. Boyer, Parks Canada; 89Moo437EF).

The lower part of the stern planking is of lighter colour than the rest of the hull evidently due to different marine life colonizing that part of the hull. The reason behind this is unclear at present but it could result from plating of some kind (possibly iron) or different wood species, or less exposure to natural light in that area due to the overhanging structure above. There is no available evidence in any of the ship plans for *Erebus* and *Terror*, or contemporary descriptions of the ships, for any iron plating or a different type of wood sheathing in this zone. Nevertheless, scrutinizing photos of this area, the copper sheathing nailing pattern can still be observed under the attached marine life.

Along the hull on the port side are at least two lead scuppers tubes that project out from the hull through the ice channel. The 1839 profile plan of *Erebus* shows six of these scuppers (at least for the starboard side) which probably ran diagonally down from the upper deck and out through the hull side. They are shown as two sizes, presumably in inches: “A.A. 6 x 3½ B.B. 5 x 3” (*Terror and Erebus. Midship Section 1839*) (see Figure

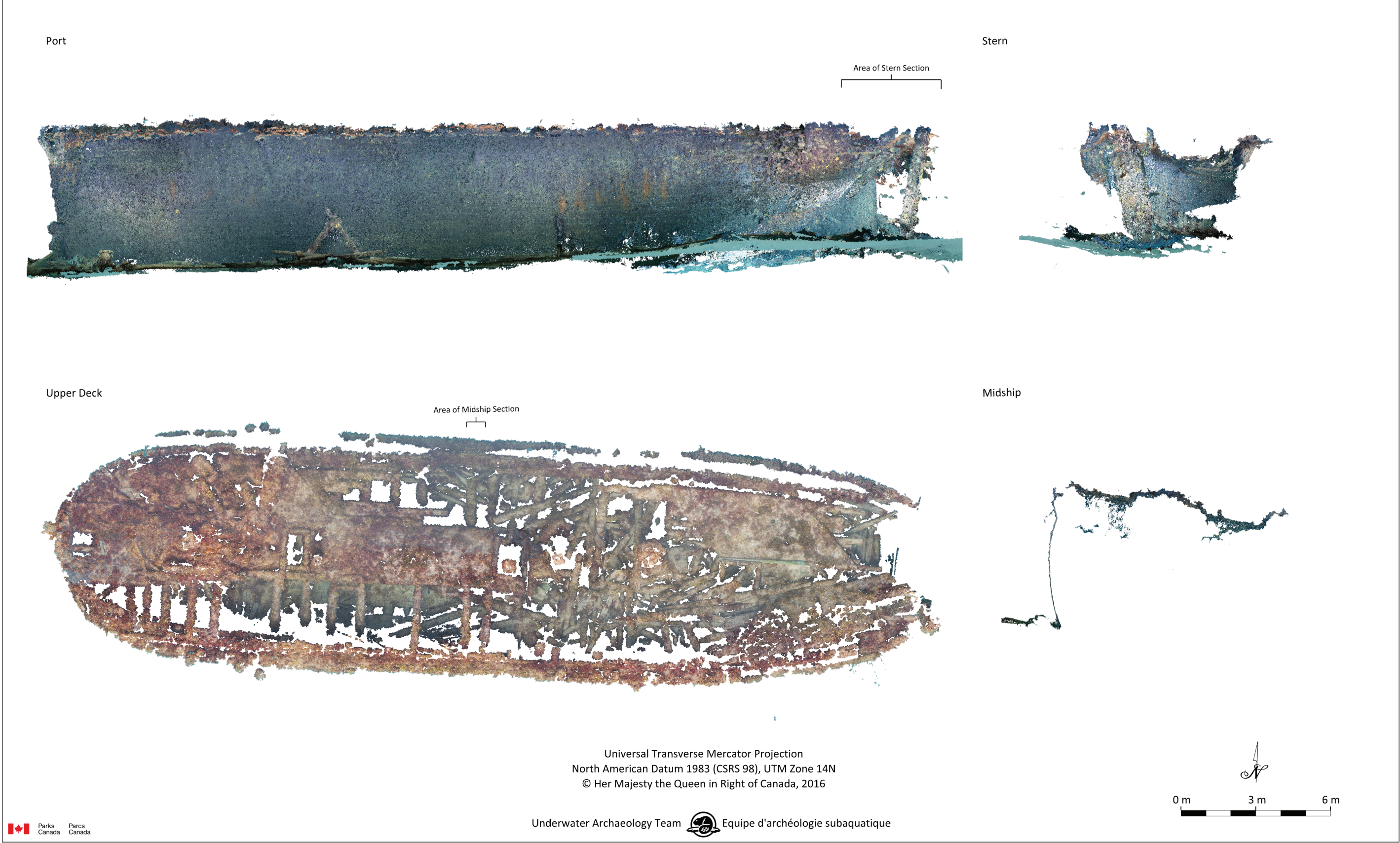


Figure 5.1.3: Photogrammetric models of the wreck of *Erebus*: port-side profile (top), upper deck (bottom), stern facing forward (top right) and midship section facing forward (bottom right) (Image: T. Boyer and B. Lockhart, Parks Canada).

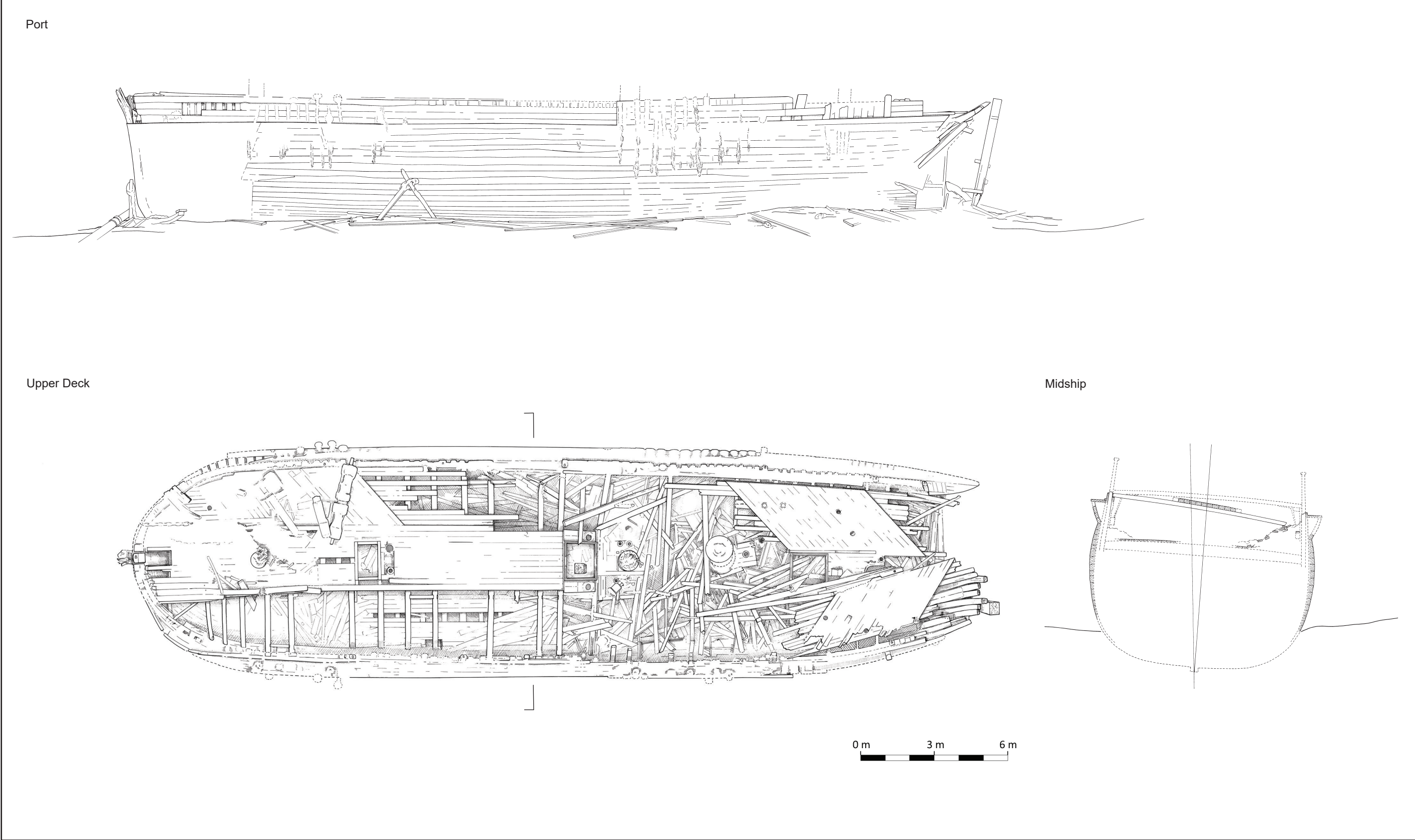


Figure 5.1.4: Preliminary compilation of *Erebus* site plans: upper deck plan (bottom), port-side profile (top) and midship hull cross section facing forward (right) (Drawings: C. Pillar, Parks Canada; 89M-2017-101-1, 89M-2017-101-4, and 89M-2017-101-5; Image: J. Moore, Parks Canada).

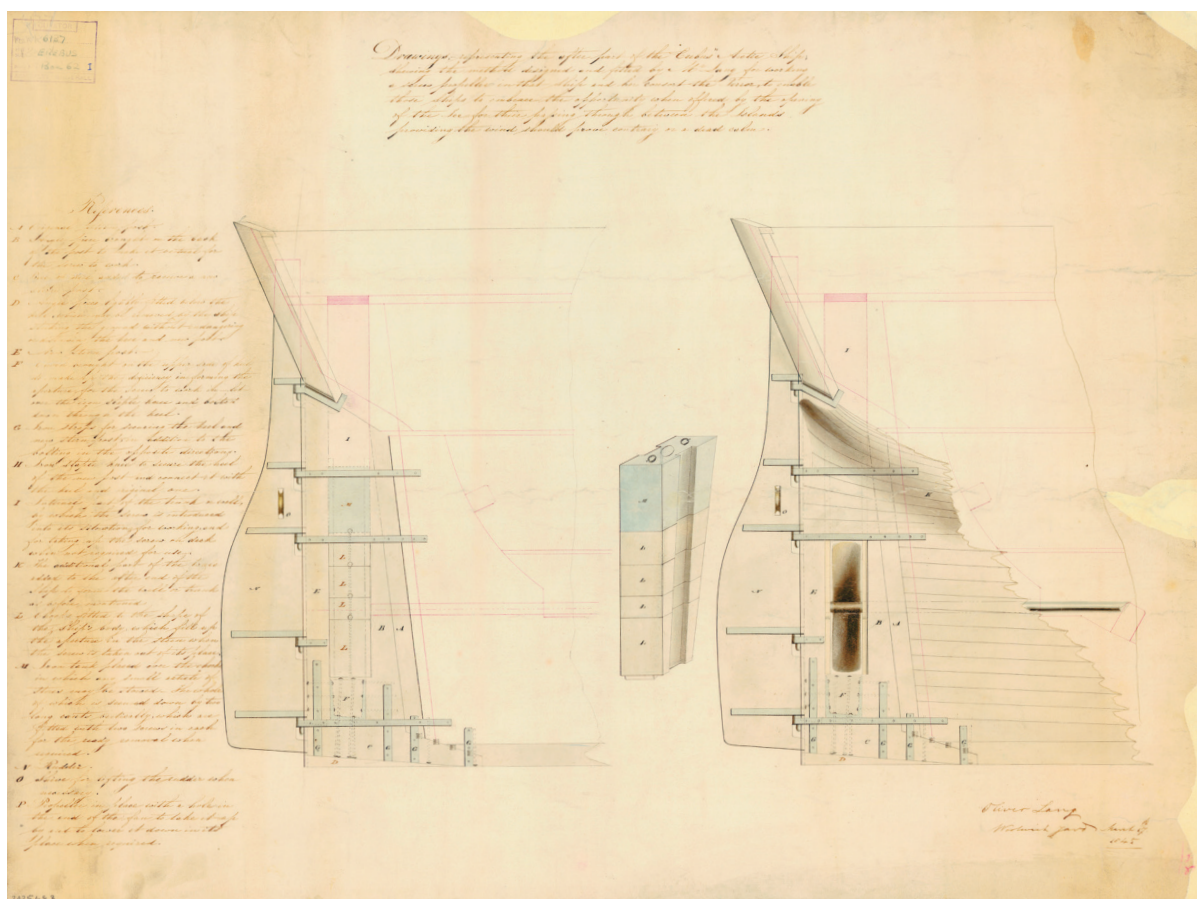


Figure 5.1.5: Ship plan showing modifications to the sterns of HMS *Erebus* and HMS *Terror*, 1845 (Courtesy: National Maritime Museum, Greenwich, London; ZAZ5683, J1529).

2.1.5). The nails holding their outer flanges to the hull gave way when the tubes were pushed from the inside out.

Vertical iron corrosion marks along both the port and starboard sides of the hull embody traces of the chainplates (see Figures 5.1.1 and 5.1.4). The 1839 profile of *Erebus* reveals 12, 15, and 8 chainplates (per side) for the fore, main and mizzen mast shroud assemblies respectively (*Terror and Erebus, Profile (as Fitted) 1839*) (see Figure 2.1.5). We can infer that when the masts and shrouds were toppled, the chainplates split from the shrouds and fell down on the hull; the fastening point of each one to the hull, just below the ice channels, would have acted as a pivot point. On the port side, seven vertical chainplate corrosion marks are visible astern of the main mast, but those forward of it are not as clearly discernible.

As described in Harris, Moore and Bernier (2015:46) elements of the stern post assembly and propeller trunk (or well) are in situ (Figures 5.1.2 and 5.1.5). Oliver Laing's March 1845 drawings

of the stern of *Erebus* name an "Original stern post" with an added "Angle piece brought on the back of the post to make it vertical for the screw to work" and a "New stern post" aft of the space for the trunk to which the rudder was attached (*Drawings Representing the after Part of the "Erebus" Arctic Ship as Messrs. Greens' Yard Blackwall. April 1848. 1845*). The latter is termed the "rudder post" in this report to avoid any confusion between the two post assemblies; it is now out of alignment from its original position given the damage sustained by the stern. Relatively little recording of this zone took place in 2015 and 2016 although photogrammetric measurements reveal that the in situ propeller trunk at its base is 92 cm wide in profile (fore and aft). The rudder post, which is still attached at its base but otherwise freestanding is 1.1 m at its base and is precariously heeled over to the port side at an angle of 10° and raked aft at an angle of 10°; it extends for 5.05 m above the sediment and debris line at the seafloor. Traces of two highly corroded iron rudder gudgeons were observed on the aft face of this post. The ship's stern post is also 1.1 m wide at its heel.

5.2 UPPER DECK

Charles Dagneau

Erebus' upper deck has standard features, or what would become standard features, for mid-nineteenth century Royal Navy polar discovery vessels (see Figure 2.1.5; Figure 5.2.1). For example, an 1839 description of modifications to *Erebus* by Rice describes its distinctive upper deck planking as follows (Ross 1847:327):

The central planks of the weather deck are six inches thick, laid fore and aft; the remainder of the deck is wrought double; the lower planks, three inches thick, are laid fore and aft; the upper planks, three inches thick, diagonally, having fearnaught dipped in hot tallow, laid between the two surfaces.

The 1839 midship section of *Erebus* shows a layer of "3 in. Fir wrought diagonally over the original deck" on each side of the centerline planking of a single layer of 11 longitudinal "Oak" and "Fir" strakes, called the king planks (*Terror and Erebus, Plan of Upper Deck (as Fitted)* 1839). This planking system is also vividly shown in the *Upper Deck plan of HMS Investigator (Plan of the Investigator's Upper Deck as Fitted for the Arctic Expedition. At Messrs Greens' Yard Blackwall. April 1848.* 1848). The in situ remains on the wreck conform to this contemporary description, although limited scantling recording has taken place to date. The system is visible on upper deck sections in the bow, stern and those displaced to the debris field. On the upper deck itself the planking is supported by transverse deck beams: 20.5-23.4 cm sided; ca. 22 cm moulded; spaced 70 to 90 cm apart. The deck planking is secured to the deck beams using copper alloy dump bolts with a bayonet-style tip, similar to a Phillips screwdriver (circular stem 1.6 cm; circular head 2.3 cm)(see Figure 6.13.1). These upper deck beams are mortised to accept longitudinal carlings (11-12 cm sided) between them at regular intervals, to help strengthen the deck structure.

There seem to be five (longitudinal) carlings over the full width of the vessel, the mid carling being on the centerline, thus absent where there are hatches. These are dovetailed fore and aft to the deck beams. This strong upper deck beam and carling assemblage is supported on both sides of

the vessel by beam shelves that are in turn secured to the ship's frames and also supported by iron hanging (deck) knees. It is unclear at this point where stanchions were used to support the upper deck beams.

The upper deck of *Erebus* can be spatially subdivided into three distinct areas according to its general structural integrity (Figure 5.2.2). Area 1 corresponds to the forward half of the upper deck surface, one that is in a relatively good state of preservation (operations 20 to 36). The forecabin in Area 1 is certainly the section of the vessel that is best preserved, both in terms of deck preservation and three-dimensional structural coherence. Area 2 extends from the main hatch to the capstan. It is certainly the most scrambled area of the deck. In this zone, the upper deck and beams are broken, absent and-or mixed with other lower deck structures. Area 3 includes all of the vessel's decking remains after the capstan. In this last area, the upper deck is split into two separate sections, both heavily collapsed along the vessel's centerline, with their outboard edges resting on beam shelves. Part of what used to be the stern cabin and some of the senior officer's cabins have now collapsed and therefore have reduced three-dimensional coherence.

The following subsections are an attempt to describe the upper deck structures and equipment for each of the above-mentioned areas, keeping in mind that our understanding of the wreck is still based on preliminary observations with limited detailed measurement and direct recording.

AREA 1 – FORWARD SECTION

This deck area as a whole is in a relatively good state of preservation, except for missing planking in discrete areas. The double planking is largely present at the starboard bow and in the centerline of the vessel between the forward ladderway and the main hatch. Here some of the caulking of the uppermost planking layer is in situ. The lower layer of longitudinal planking is visible on the starboard side aft of the windlass' original location, where the uppermost diagonal planking is absent. A 2.5 m-wide section of deck planking is absent from the forward port side of the vessel (sub-operations 24J/K to 36J/K); most of this deck section has been displaced to the seabed below (sub-operations 20G/H to 32G/H) (Figure 5.2.2) (see Section 5.5).

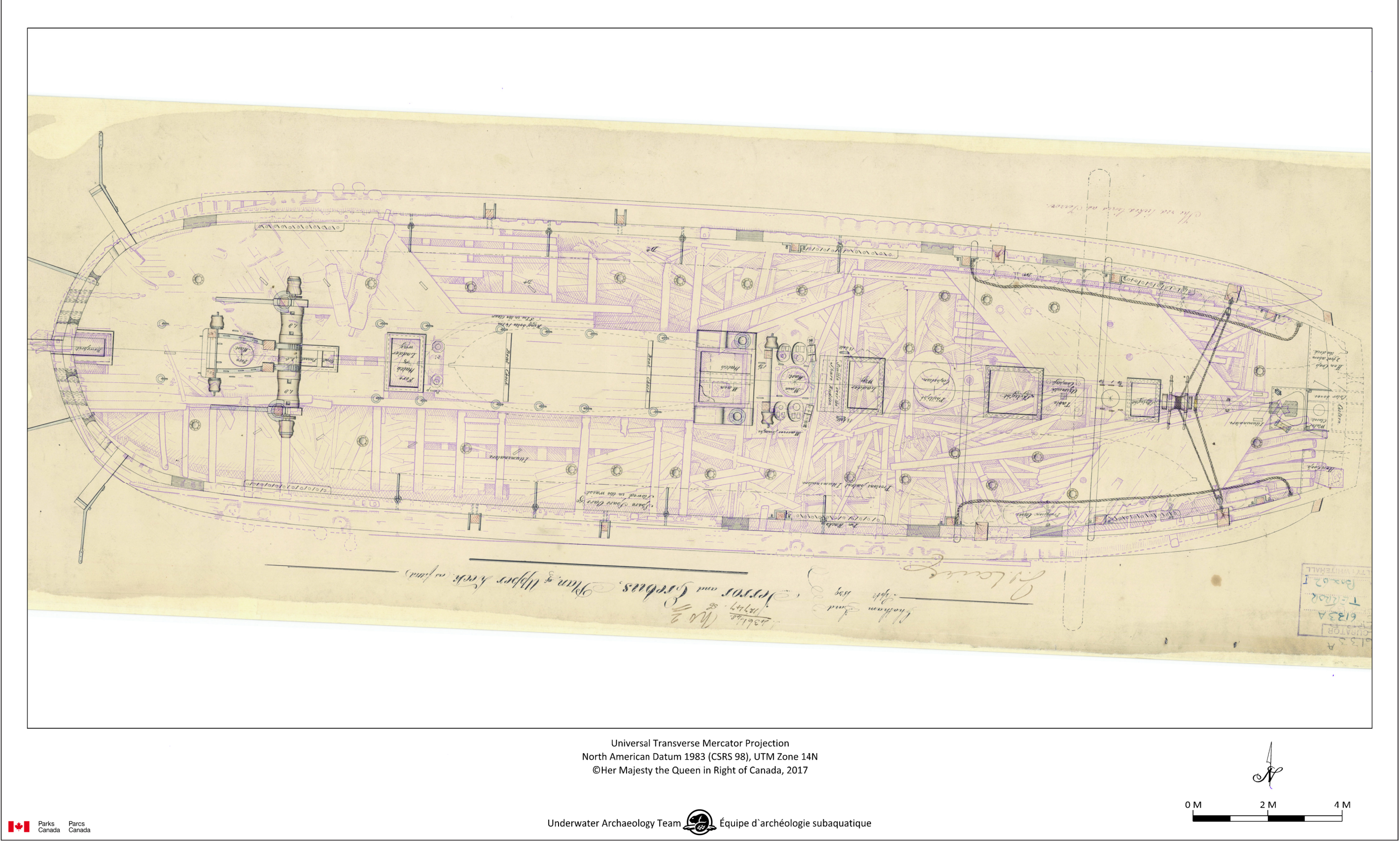


Figure 5.2.1: *Terror* and *Erebus*, Plan of Upper Deck (as Fitted) overlaid with the upper deck site plan (Image: B. Lockhart, Parks Canada; Drawing: C. Pillar, Parks Canada; 89M2017-101-1; Ship plan: National Maritime Museum Greenwich, London (ZAZ 5675, J1409)).

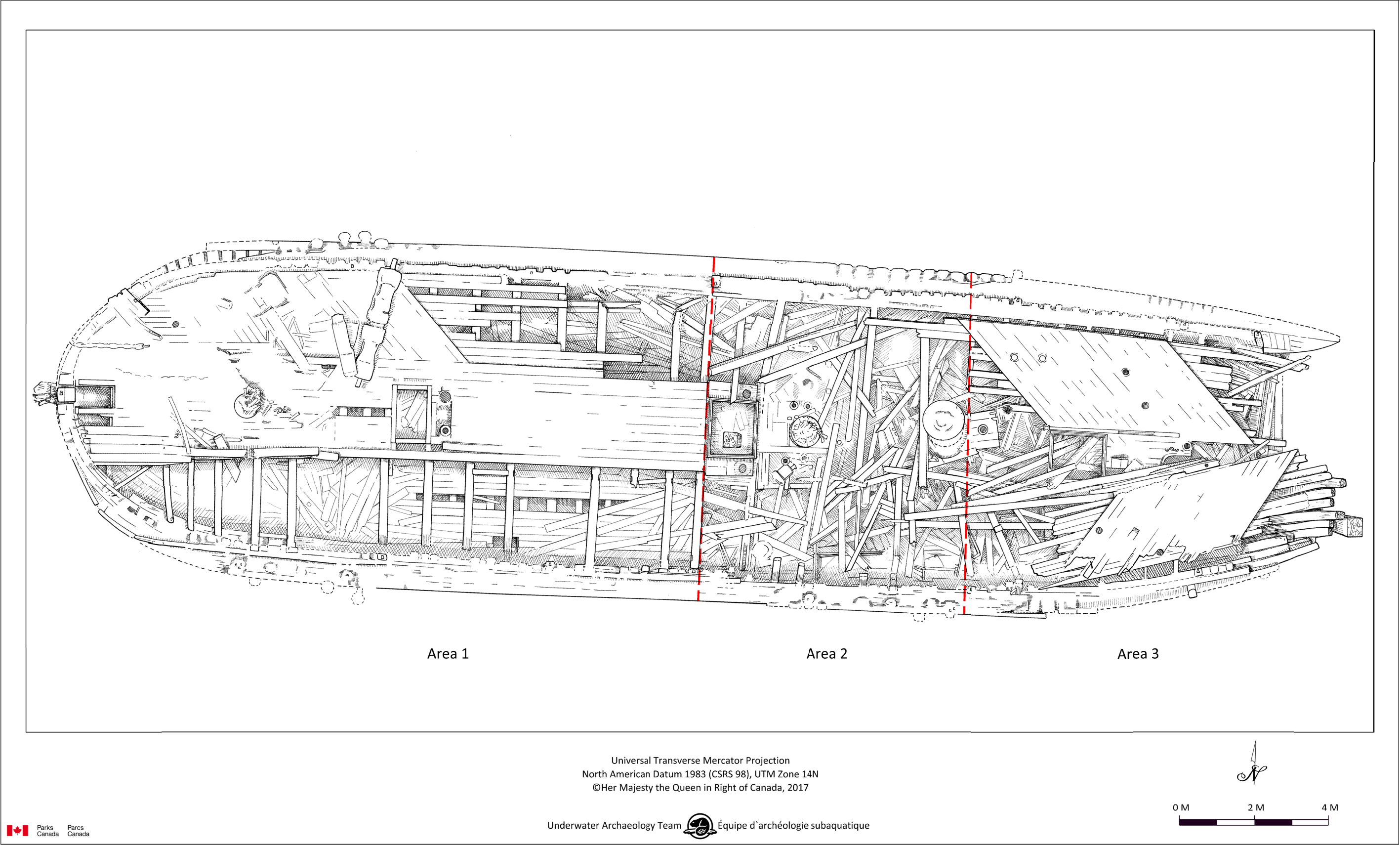


Figure 5.2.2: Upper deck site plan showing the locations of Areas 1, 2 and 3 (Drawing: C. Pillar, Parks Canada; 89M-2017-101-1; Image: B. Lockhart, Parks Canada).

Most deck beams on the forward half of the vessel, ahead of the main hatch, are still preserved more or less in position. That said, deck beams TT102 to 105 have their southern (port side) ends resting almost directly on the lower deck, since the port beam shelf supporting them has collapsed. The iron deck knees supporting this shelf beam have fallen and can be seen on lower deck amongst deck planks and other debris. Another smaller deck section is missing from the starboard side of the vessel in sub-operations 32M/N to 36M/N. The five deck beams visible in this sector have their northern (starboard) ends collapsed onto the lower deck, in a similar way to the ones mentioned earlier (Figure 5.2.3).

Now looking at the vessel's visible framing in Area 1, the futtocks appear to be in good condition. At the bow's tip, although the headpiece is damaged and its upper part broken, the inner and outer stem posts are still in place. These components and the knightheads are all assembled with strong copper alloy bolts (not measured). Most broken or eroded frame ends are visible on both sides of the vessel since the top-timbers and bulwarks are mostly absent. Framing is also visible through different deck openings, but this has not been documented yet.

The upper deck had equipment and openings that are worth describing as well, although most of them have not been studied in detail. Starting at the stem and moving aft, the bowsprit partner is the first opening. The 56 cm-wide and 94 cm-long opening accepted and helped secure the bowsprit heel. Next to this bowsprit partner, there is a copper alloy pipe (ca. 56 cm-long and 7 cm-wide) with a flange at deck level that projects up through the upper deck 2-3 m aft of the stem, close to the centerline. This tube is bent and now rests flat across the upper deck. Its function is unclear, but it may be related to a heating apparatus below.

Moving aft, the foremast stump is visible although partly buried in a mound of concreted material covered with algae. Directly aft of the mast is the windlass used for the two bower anchor chains. This massive piece of equipment seems to be entirely preserved, but has been moved about 3 m north and aft from its original centerline position. The windlass bitts and knees assemblage affixing it to the upper deck are most certainly broken near deck level. Further study may reveal if the windlass was displaced by ice action or other forces, as it is unlikely that it was a result of tension from



Figure 5.2.3: Port-side deck beams partially collapsed onto the lower deck in the forward section of the wreck (Photo: M.-A. Bernier, Parks Canada; 89M04259EF).

the anchors chain(s), as both bower anchors are in place on the seafloor below, with associated stud link chain. There is also much corroded stud link anchor chain forward of the windlass and in an elevated debris zone in front of the foremast, in sub-operations 24-26L. One chain runs from this sector towards the north face of the stem post, where it is highly corroded and broken. It was likely used for the port side bower anchor that now rests on the seabed at the stem. Another chain runs out from the same concreted area towards the starboard bow, about 1 m north of the port side example. This second chain seems to be related to the starboard bower. It would appear that, at some stage, at least the starboard anchor, secured to the windlass by its chain, fell to the seabed after the chain broke, or was torn asunder, or corroded to the point where it could not support the weight of the anchor. A third stud link chain was observed on the fore deck. It runs parallel to the others, from the windlass to a single block with shackle 89M28M100-1 and over the starboard side, where it is corroded and broken. The relationship between the windlass, the anchors and all the chains found on the foredeck will require detailed mapping and study.

Moving slightly aft a little more, the 1.35 m-wide and 0.81 m-long fore hatch is largely unobstructed by debris. Adjacent to this opening, the port side common wooden bilge pump tube rises ca. 60 cm

over the upper deck's top planking. The pump's circular tube head has an external diameter of 28 cm and an internal diameter of 22 cm. Its shape becomes octagonal below the upper deck level, as implied by the 1839 upper deck plan (*Terror and Erebus, Plan of Upper Deck (as Fitted) 1839*) (see Figure 2.1.5). As for the starboard pump tube, it is missing entirely. The corresponding circular hole on upper deck is heavily eroded, with a resulting diameter of 41.5 cm.

More time was spent on attempting to understand and map the main hatch area (Figure 5.2.4). This hatch is located at the limit between Areas 1 and 2, and heavily inclined towards the stern due to collapse. It is still supported by deck beams on its (forward) west side, but the feature is collapsed on its eastern (aft) side. The preserved foredeck planking and deck beams are collapsed at the forward edge of the hatch. The upper deck planking forward of the hatch now stands 1.68 m higher than lower deck planking, some 30-40 cm lower than expected. Aft of the hatch, the upper deck is either non-existent or in small sections. The hatch opening and the chain hawse scuttles on each side correlate with the 1839 upper deck plan arrangement (see Figure 2.1.5). While the hatch opening is 1.56 m by 1.44 m, the coaming itself is 1.60 m by 1.49 m; and the larger hatch-and-scuttle assembly with its partner is 2.51 m wide and 45 cm thick. The heavily concreted metal chain hawse scuttles have an oval or circular opening that varies between 22 and 26 cm in width and 25-26 cm in length; it is worth noting here that the inside diameter of a wooden anchor chain scuttle cover recovered on nearby Sauntalik Island in 2014 is 29.5 cm. There is no visible anchor chain in the scuttles or in this vicinity. This said, one of the actual scuttle tubes (metal inside a vertical timber member) can be observed through the hatch; it still stands below some of the upper deck debris. A large bitt post or stanchion (40 cm by 46 cm) stands almost vertically in the middle of the hatch. It represents one of the most prominent features on the upper deck. For this reason, reference point REF8 was established on this piece's head, as it appears to be a very strong and stable timber. Its function is unclear at this stage.

AREA 2 – AMIDSHIPS SECTION

While the foredeck is in relatively good condition, the situation is much more chaotic amidships, more specifically, aft of the main hatch.

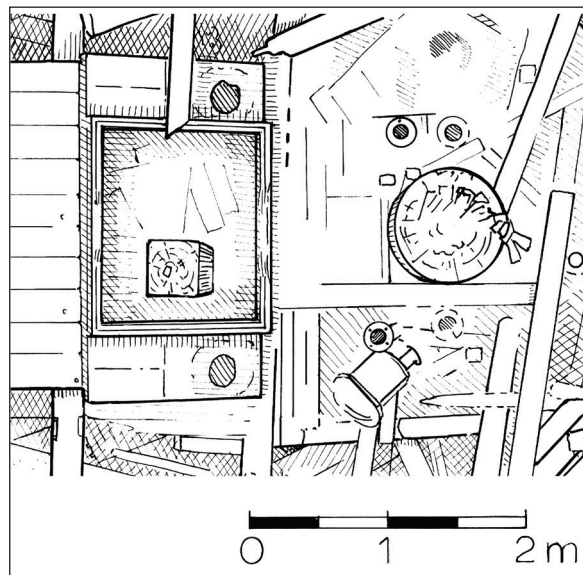


Figure 5.2.4: Detail of the *Erebus* upper deck site plan showing the main hatch area. North is at top and the bow at left (Drawing: C. Pillar, Parks Canada; 89M-2017-101-1)

In this zone, upper deck planking is absent or in pieces; deck beams are either missing or broken, and those remaining are mixed with other structural elements from the lower deck. The principal feature in this area is the main mast and the two Massey patent pumps that straddle it (Figure 5.2.4). These features were not mapped or studied in detail, but careful observation and photo documentation provide a good idea of their arrangement. The port side pump head dimensions are ca. 85 cm long, 50 cm wide and 35 cm high. The main mast stump emerges ca. 50 cm from the mixed lower and upper deck debris around it. Interestingly, it is fitted with a copper alloy strip on its foreside, almost certainly part of a Harris patent lightning conductor system (Bernstein and Reynolds 1978; Harris 1847).

The port side pump head with its associated double action pump tubes are highly distinctive copper alloy features in this area (Figure 5.2.5). The same pump elements are present on the starboard side of the mast, although they are mostly obscured by wooden debris and marine life. It is also worth mentioning that whereas the starboard pump head was clearly visible in April 2015, it was not apparent a few months later in September 2015. This observation illustrates that the site is more dynamic than at first appreciated, as shown by artefact movements on the lower deck induced by a storm in September 2015 (see Section 5.3). Based on the 1839 ship plans, two warping heads were certainly located in this area, just aft of the



Figure 5.2.5: Copper alloy Massey pump tube and pump head on the port side of the main mast stump (Photo: C. Dagneau, Parks Canada; 89Mo2707EF).

main mast, but they cannot be discerned at this stage. The same thing can be said about the spare rudder scuttle and the main ladder way (distinct from the main hatch) as seen on the 1839 upper deck plan (*Terror and Erebus, Plan of Upper Deck (as Fitted) 1839*). More time is necessary for the careful study of these structures in the future.

AREA 3 – STERN SECTION

The third and last area includes the stern deck of the vessel, from the capstan to the propeller trunk. At the west end of this area, the ship's capstan stands proud of the deck but is heeled some 20 degrees towards the starboard side. It stands on its partners that form a larger coherent platform,

resting in the middle of collapsed upper deck and its beam structure. A circular opening of an unknown function that does not appear on the 1839 upper deck plan can be observed a few centimeters aft of the capstan. The opening is fitted with a thick reinforced collar possibly to accommodate a funnel or exhaust pipe for machinery installed below deck in 1845.

Part of the stern deck located aft of the capstan is still in situ, although it is collapsed and broken in two main sections along its centerline (Figure 5.2.6). The larger stern deck section – roughly 10 m long by 8 m wide – is located on the starboard side of the vessel. On the southern edge of this deck section, which corresponds to the ship's centerline, parts of the two aft skylight coamings are preserved forward and aft of the mizzen mast hole: they correspond to skylights over the Ward Room and the forward part of the Captain's Cabin. Small copper alloy hinges are present on the starboard side of the hatch and skylight coaming located forward of the mizzen. These were probably used to secure the skylight that is now absent. A mast or spar part has also fallen into this hatch and now rests on part of the coaming; its upper end is fitted with a tenon of unknown function.

As noted, part of the mizzen mast hole (ca. 50 cm in diameter) and its partner are also present in the same area. Directly adjacent to this mast are three brass staple cleats that were used as tie points for blocks and tackles to hoist the mizzen mast's



Figure 5.2.6: *Erebus* upper deck near the stern, facing starboard (Photo: M.-A. Bernier, Parks Canada; 89Mo5485EF).

spars (Figure 5.2.7). Similar staple cleats are also represented on the 1839 ship plans on both sides of all three masts. The middle cleat is annotated with a “1” and the two others by “7/8” on the plan, measurements that would be consistent with their gauges in inches (*Terror and Erebus, Plan of Upper Deck (as Fitted) 1839*). There is yet another hatch frame visible farther aft along that same line, one that most probably corresponds to the aftermost skylight depicted on the 1839 upper deck plan. Interestingly, three Preston patent deck illuminators are visible on this starboard deck section. Their arrangement in relation with each other and the above-mentioned features are similar to what can be seen on the upper deck plan.

The port side stern deck section is smaller than the starboard section: 8 m long by 3 m wide. It also appears to have shifted aft and rotated counter-clockwise about 30 degrees, based on the longitudinal deck planking orientation. This deck section extends a few meters farther out than the port side section. While its southern edge rests on the port side beam shelf as expected, it is heavily tilted towards the centerline of the vessel, and seems to be partly resting on top of the starboard deck section. Only one Preston patent deck illuminator is visible, although this deck section is still heavily obscured by marine growth (Figure 5.2.8).

The upper deck at the stern is only preserved as far aft as sub-operations 54K/L on the port side and 52L/M on the starboard side. The helm and the steering mechanism of *Erebus* were modified with the fitting of the engine and propeller in 1845, and these elements do not survive in situ. The tiller itself however rests on the upper deck along the north side of the skylight and mizzen mast hole,



Figure 5.2.7: Brass staple cleats adjacent to the mizzen mast hole (Photo: C. Dagneau, Parks Canada; 89Mo2744EF).

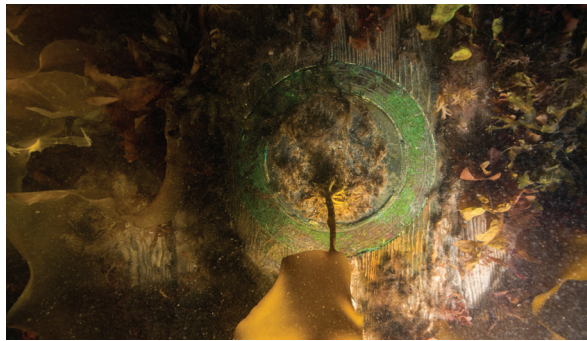


Figure 5.2.8: Preston patent deck illuminator (Photo: T. Boyer, Parks Canada; 89Mo0629EF).

possibly where it was stored before the ship was abandoned, or at a point it came to rest when the stern collapsed. The object is a 3.65 m-long solid brass artefact, made in three different sections. The tiller or fore end, fitted with a double pommeleon for attaching the steering rig, is circular in cross section (diameter 9.0-10.2 cm). The midsection is octagonal in section (diameter 11.3 cm) and the aft section is square in section (10.5 cm sided) (Figure 5.2.9).

A significant area of lower deck at the stern now stands in the open, without the cover of an over-arching upper deck structure. Lower deck bulkheads, some furniture and artefacts were crushed in the middle of the vessel, although they appear more intact in the voids left along the margins of the hull sides. This area is discussed in the following Section 5.3 devoted to the lower deck. And as discussed in Section 5.5, some of the missing stern deck features fell in pieces to the debris field directly aft of the sternpost. For example, what seems to be the remnants of the propeller trunk frame can be identified from the upper deck remains now located in sub-operations 58L/M.



Figure 5.2.9: Tiller on the upper deck near the stern (Photo: M.-A. Bernier, Parks Canada; 89Mo6675EF).

5.3 LOWER DECK

Jonathan Moore

Erebus' lower deck was dedicated to crew accommodation, meal preparation, dining, the Sick Berth and some storage. The 1839 plan of this deck provides a reference to its layout, although any alterations that took place in 1845 are not recorded (Figures 5.3.3 and 5.3.4). The *Terror's* lower deck plan does however have faint pencil annotations that indicate the 1845 changes to the cabin layout and other modifications. The living space on both ships at the outset of the voyage was segregated between on the one hand the 16 officers and warrant officers who would have occupied enclosed and in most cases individual rooms with fitted furniture and who dined in dedicated enclosed mess rooms. These spaces and connecting passageways would have occupied over half of the length of the deck. On the other hand the rest of the crew, some 52 in number, slept in hammocks and dined on mess tables in the “forecastle”, the area situated between the officers’ accommodations and the Sick Berth.

Exploration of the lower deck began in 2014 with fleeting glimpses down through openings in the upper deck, in particular in the forward half of the wreck. Archaeological visibility of the lower deck was compromised in 2014 however by heavy vegetation growth. In 2015 most of the kelp blanketing the upper deck, as well as selected sections of live or dead kelp covering parts of the lower deck open to above were removed, significantly improving both direct diver access to parts of the deck, but also viewsheds into zones not open to above (i.e. still covered by the in situ upper deck). As well, in 2015 and 2016 interior video recording was conducted. The following is a description of selected lower deck zones and archaeological features, from bow to stern. Note that zones from the ship’s lower deck with little or no accumulated observations have been omitted from this discussion.

SICK BERTH

Interior video of this space was obtained in April and September 2015 as well as September 2016 chiefly via the bowsprit partner. This space is mostly enclosed atop, except for a dislodged section of upper deck on the port side that now rests on the seafloor. Inside there is much wooden

debris and silt on the lower deck, to the extent that its surface is obscured (Figure 5.3.1). This debris includes some upper deck planking with copper alloy dumps still articulated. Interior partitions, as shown in the lower deck plan (*Terror and Erebus, Plan of Upper Deck (as Fitted) 1839*) (see Figure 2.1.7) have either collapsed completely or partially, with the cupboard spaces around the main mast partly in place. There is minimal vegetation growth save for the undersides of the upper deck beams and planking. Current-borne sediments have accumulated on horizontal surfaces such as shelves along the starboard side of the hull and on the deck itself. The inner plank lining of this space is preserved on the starboard side; some of this planking bears preserved white paint.

From the vantage point of the bowsprit partner, the bowsprit step (with mortise and reinforcing timbers) is clearly visible. It appears to have reinforcing timbers that secure it to the upper deck beams. At the point where the step passes down through the lower deck there is at least one small opening (scuttle) that presumably opened to the “Store Room” one deck below. Near to the step, on the starboard side, are two seaman’s chests and a wooden bench resting on their sides. On the port side of the space, adjacent to the bowsprit partner, is a copper alloy pipe that stands vertically and passes up through the upper deck. Its heel at the lower deck level is not visible. It appears to have been wrapped by cordage and fabric. Its function is not known as it does not appear in any contemporary ship plans. A cast metal object, possibly a stove part, rests nearby and this could be related to the pipe, which might be a chimney. Another notable feature in the Sick Berth is a thick copper-alloy sheet with a shaped, projecting corner. Parts of the sheet are buried by silt and its function is unknown. Others include a case bottle with attached metal cap, and a belaying pin. Overall the



Figure 5.3.1: View of the “Sick Berth”, facing aft, with the bowsprit step in the middle (Video Still: R. Harris, Parks Canada; 89M2016R003_1449).

Sick Berth is well preserved with many silt-covered surfaces that could mask artefacts, in particular on its starboard side and aft end.

FORECASTLE

The forecandle is an open area on the lower deck between the Sick Berth and the officers' and warrant officers' enclosed living spaces. This is the space where petty officers, Royal Marines and sailors alike hung their hammocks, took their meals, and spent some of their available leisure time. It is also the section of the deck from which numerous and varied artefacts were recovered in 2015 (Figure 5.3.4 and see Figure 6.16.3). In addition, a number of observed artefacts in this rich pocket of finds were not raised, including an oval, copper alloy tag numbered "44" with two circular fastener holes; this could be a tag to identify a hammock position, as other similar tags have been observed on deck beams.

Erebus' lower deck plan shows eight "Seamans Tables" in the forecandle, and two more in the Sick Berth. The plan also depicts a "Seamans Chest in lieu of Stools", 2 ft. wide, 4 ft. long, and 1.9 ft. high (0.61 m x 1.22 m x 0.58 m), holding two

equally-sized compartments - thus likely shared between two sailors for not only seating but also storage of clothing and personal belongings (Figure 5.3.2). Based on both the table and chest sizes, each table could have accommodated one chest per side, therefore presumably four crew members, yielding a total seating capacity of 40 on 20 chests in the 1839 configuration. In 1839 a large "Sail Bin" occupied a central place in this area which would have added to the cramped nature of this living space.

The forecandle is largely accessible through multiple openings in the upper deck described above. The area visible through the deck beams between the galley stove (28K) and the fitted furniture of enclosed cabins (38K) on the port side of the vessel is relatively free of debris and sediment. The upper deck beam shelf, as well as a few dislodged lower deck planks rest directly on the lower deck, intermixed with broken pieces of furniture, iron upper deck knees, as well as a number of readily accessible small artefacts raised in 2015 (see Section 6). The situation is more chaotic towards the midline and starboard side, where different wooden debris and sediment have accumulated to a height of 0.5 to 1.0 m in certain places. The foremost area, aft of the bowsprit step, has many

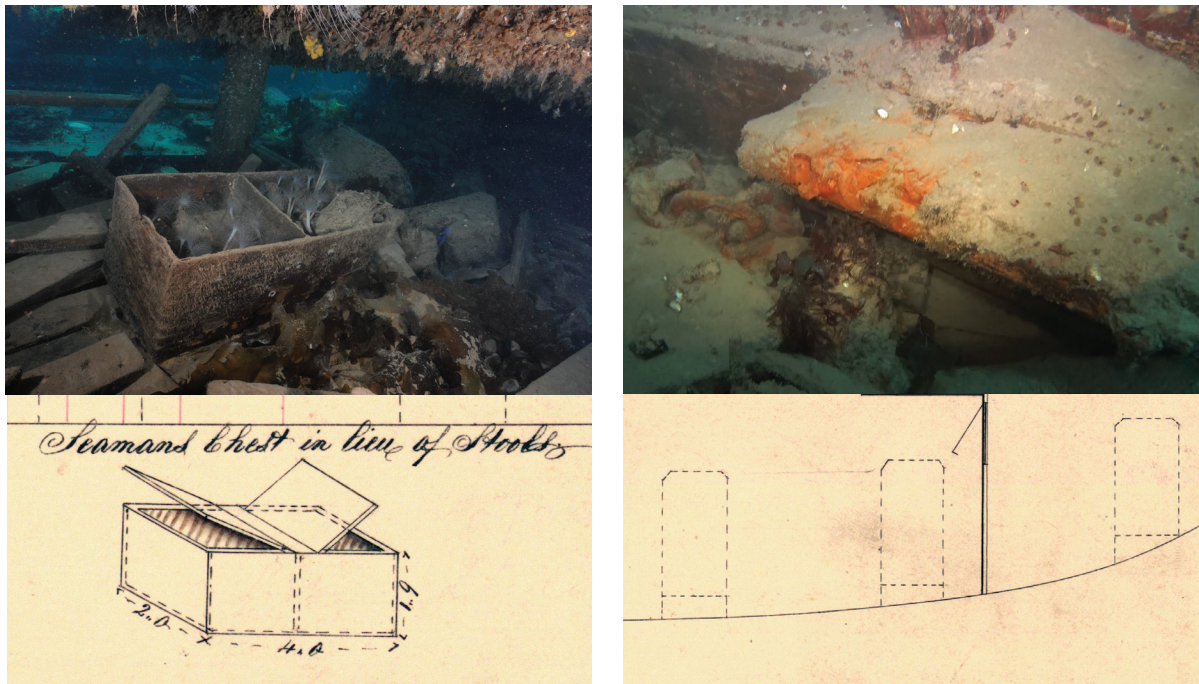
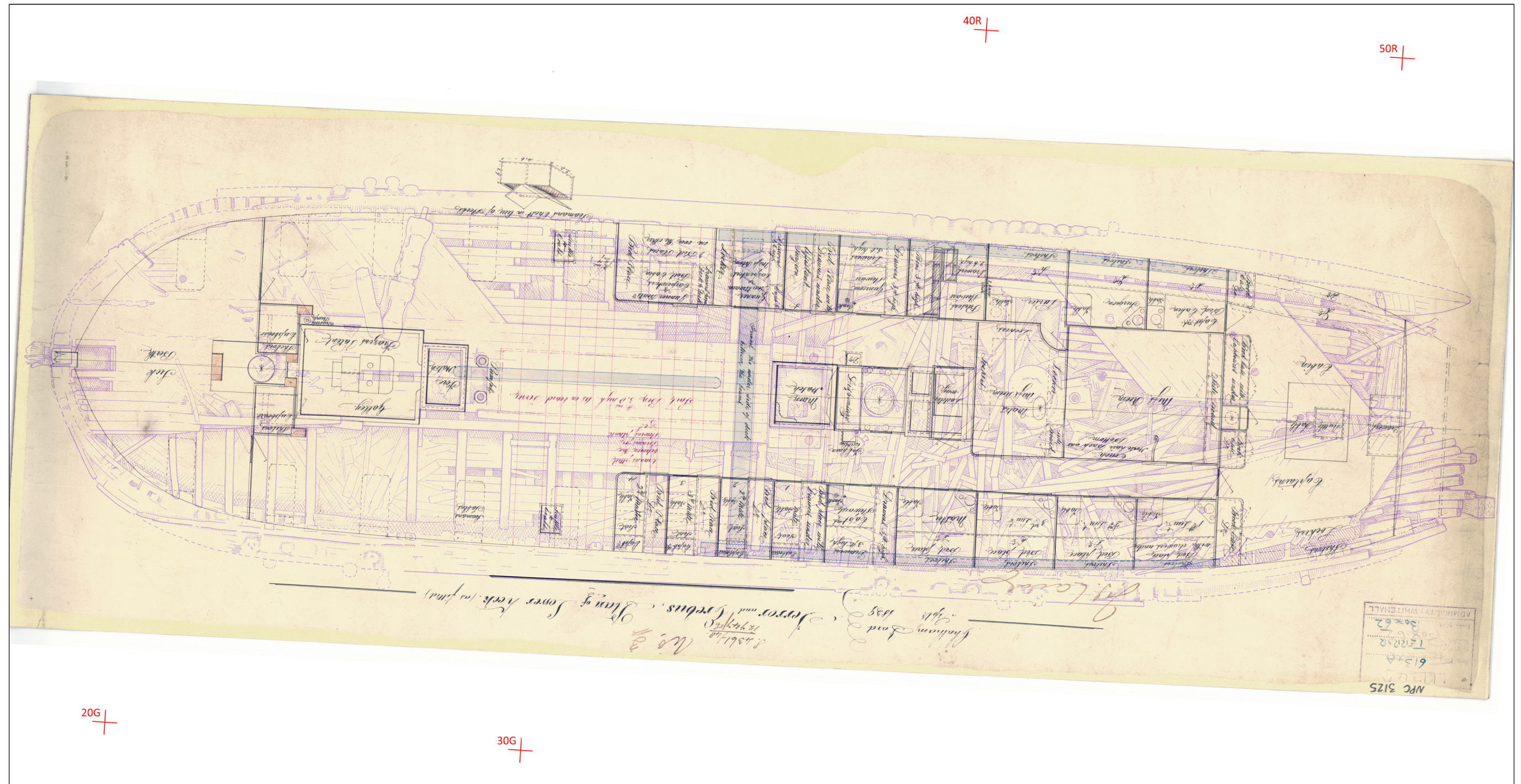


Figure 5.3.2: Seaman's chest on the lower deck (Photo: M.-A. Bernier, Parks Canada; 89M06931EF); detail of seamen's chest in *Terror and Erebus Plan of Lower Deck* (Courtesy: National Maritime Museum Greenwich, London; NPC3125, J8650); table mount on starboard side of lower deck (Video Still: R. Harris, Parks Canada; 89M2016R003_10622); detail of starboard side table mounts in *Terror and Erebus Plan of Lower Deck* (Courtesy: National Maritime Museum Greenwich, London; NPC3125, J8650).



Universal Transverse Mercator Projection
North American Datum 1983 (CSRS 98), UTM Zone 14N
©Her Majesty the Queen in Right of Canada, 2017

Underwater Archaeology Team  Équipe d'archéologie sous-marine

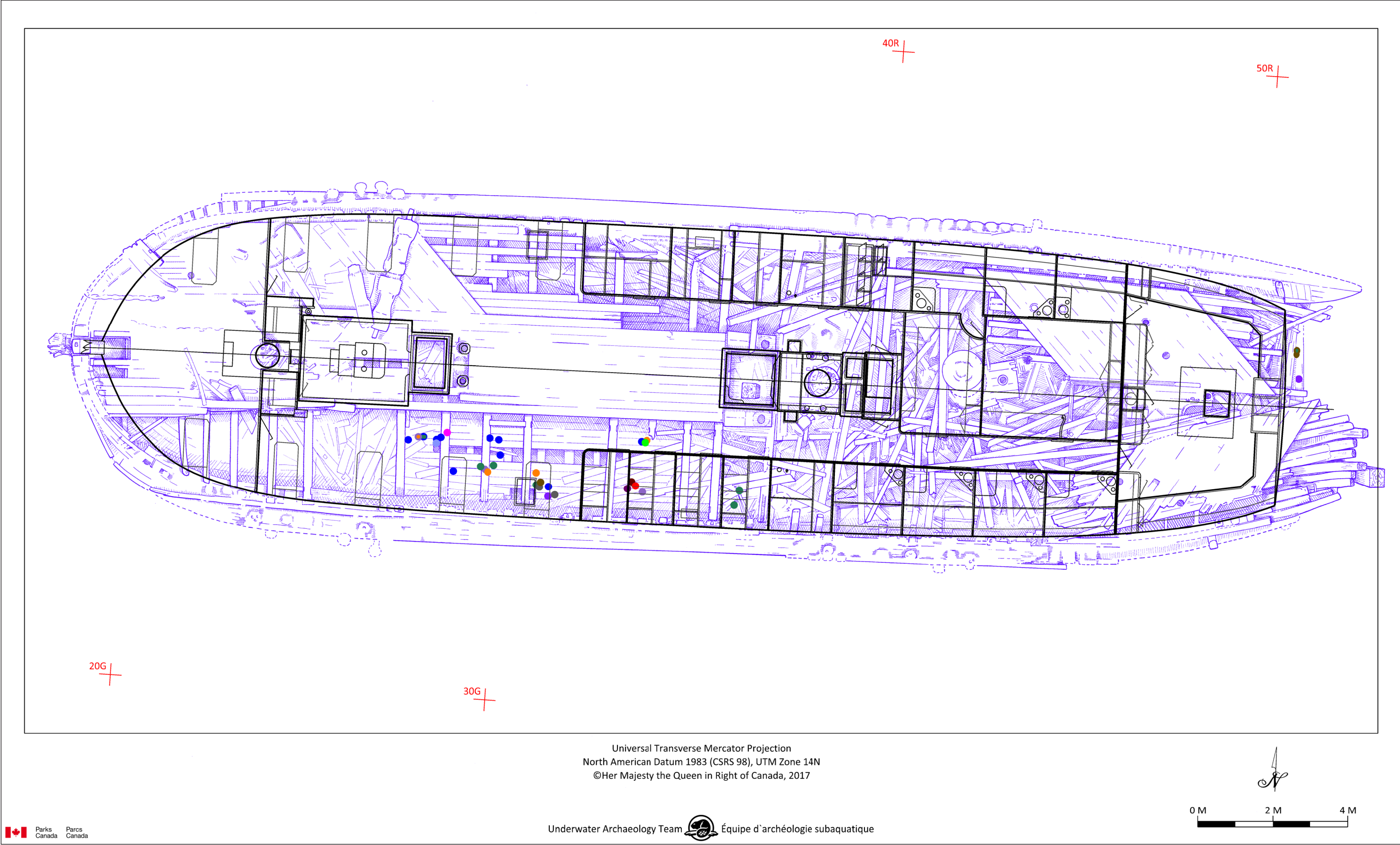


Figure 5.3.4: Vector tracing of the lower deck plan of *Erebus* (1839) overlaid with the upper deck site plan and lower deck artefact distribution. See Figures 6.16.2 and 6.16.3 for more details on artefact positions (Drawing: C. Pillar, Parks Canada; 89M-2017-101-1. Image: B. Lockhart, Parks Canada).



Figure 5.3.5: Forward end of the starboard side of the forecastle, facing the bow. This part of the forecastle is underneath an in situ part of the upper deck. The shelf piece to which the seaman's tables were affixed is visible at the bottom right (Video Still: R. Harris, Parks Canada; 89M2016R003_10921).

vertical and horizontal partition planks still partly in situ (particularly on the starboard side), which likely represent cupboards with shelves that flanked the foremast. The forward ladder-way leading to the orlop deck below is also filled with wooden debris. There is minimal vegetation growth save for the undersides of the upper deck beams and planking in this area. Interior video obtained via the fore hatch and two different openings on the starboard side also show a door frame, piles of wooden cask staves, many deck planks and broken furniture or bulkhead components. An upright seaman's chest, without its hinged lids, is in this lot, close to the in situ, port-side bilge pump tube (see Figure 5.3.2). In 2016 close-up views inside the chest revealed silt-covered contents in both of its compartments, probably including textile (see Figure 7.5.1). Interior video recording of the starboard side of this zone under the articulated upper deck revealed what appear to be at least three outboard mounts for mess tables, affixed to a longitudinal shelf piece (Figures 5.3.2 and 5.3.5). These mounting positions are clearly



Figure 5.3.6: Port side of the galley stove (Photo: T. Boyer, Parks Canada; 89Mo863oEF).

depicted in the lower deck plan of *Erebus* (*Terror and Erebus, Plan of Lower Deck (as Fitted)* 1839) (see Figures 5.3.3 and 5.3.4). In addition, what could be the broken inboard end of a mess table is amidst wooden debris.

The galley stove itself is intact and in position, although covered with some type of fabric, sediment and marine growth, which makes it hard to assess at this stage (Figure 5.3.6). *Erebus* was equipped with a Frazer's Patent galley stove (Battersby and Carney 2011; *Terror and Erebus, Plan of Lower Deck (as Fitted)* 1839). On the port side of the galley, one can distinguish multiple small planks with dovetailed joints, possibly the remnants of another seaman's chest and shelved cupboards appearing on the lower deck plan. Most of the way looking forward on this side of the vessel is obstructed by the collapsed bulkhead structures, deck planks and dense vegetation. Stud link chain, a pulley block, a wood fairlead, a deck beam stanchion, a detached windlass pawl, and shelves along the interior starboard side of the hull have also been observed in this zone.

OFFICERS' ACCOMMODATION AND MESS ROOMS

The 1839 lower deck plan of *Erebus* clearly depicts the officers' and warrant officers' rooms, as well as fitted furniture in plan view. The equivalent plan for *Terror* also shows perspective and elevation views of a bed place, table and wash stand furnishings (*Terror and Erebus, Plan of Lower Deck (as Fitted)* 1839; *Profile of the Terror* 1837). As well, an *Illustrated London News* article dated May 24, 1845 depicts Commander James Fitzjames' cabin (Figure 5.3.7). Except for Captain Franklin, it is probable that the 1845 sleeping assignments or designations differed from those shown in the 1839 plan, and probable that the cabin spaces were reconfigured. Sir John Franklin clearly occupied the "Captain's Cabin" and "Captain's Bed Cabin" (at least presumably until his death on June 11, 1847) and Commander James Fitzjames' cabin, depicted in the *Illustrated London News* article, would have been that of the 1st Lieutenant in 1839: "The three Lieutenants will have moved one cabin forward due to the inclusion of the supernum[er]ary Fitzjames" (Battersby and Carney 2011; Carney 2011). It is possible that Lieutenant James Fairholme occupied what would have been the Master's Cabin in 1839, on the port side at the

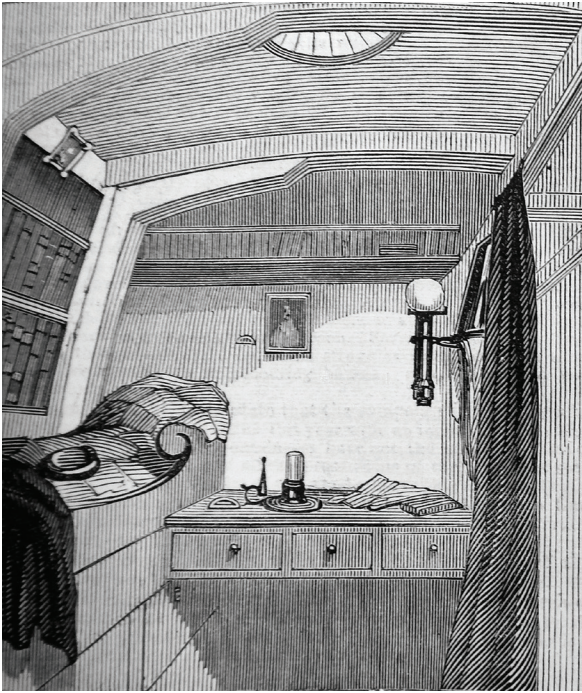


Figure 5.3.7: Commander James Fitzjames' cabin (facing forward) from the *Illustrated London News*, May 24, 1845. The image herein has been flipped to show a port side configuration, versus a starboard configuration as incorrectly shown in the original newspaper.

foot of the "Ladder Way" immediately forward of the capstan, on the basis of correspondence from June 1, 1845:

We were disappointed about the illustrated London News. The sketches are very bad and do not give any idea of the cabins. Mine is certainly the most comfortable one in the ship as to fittings & co but the drawback is the draft from the hatchway which makes it rather cold. It improves with the buffalo cloak for a curtain (Fairholme 1845).

The wreck's upper deck aft of the capstan has split and dropped longitudinally along the ship's centerline, with both the port and starboard extremities more or less at their original elevations. This collapse has formed a distinctive V-shape in cross section, meaning that along the centerline the upper deck comes very close in contact with the lower deck, but there are voids along both sides. At present, the following original rooms as depicted in the 1839 lower deck plan are mostly found under articulated but collapsed upper deck sections: "Captains Cabin"; "Captns. Bed Cabin"; "Mess Room" [Ward Room]; "1st Lieut."; and

"Surgeon". The following rooms are partially under articulated upper deck or more jumbled collapsed timbers, again inferred from the 1839 plan: "Purser" and "Mates Mess Room" [Gun Room]. Other cabins farther forward are found under disarticulated or absent parts of the upper deck. None of the original dividing walls between lower deck rooms in the stern half of the wreck stand or have even been observed, and this is not surprising as originally they would have been of very light construction. Whereas some of the accommodation and eating areas once occupied the amidship area of the ship, few archaeological inferences can be drawn here due to the extent of upper deck collapse in operations 38, 40 and 42 and those farther forward. The proviso here is that the stern of the ship was subject to significant modification to fit the steam propulsion system, and although there is no 1845 plan showing the extent to which the interior arrangements of *Erebus* were altered, they can be inferred from pencil annotations on the lower deck plan of *Terror* showing cabin modifications (*Plan of the Terror Lower Deck 1837; Terror and Erebus, Plan of Lower Deck (as Fitted) 1839*).

Parts of in situ built-in furniture from officers' cabins were found in August 2015 along the inboard port side of the hull at lower deck level, in sub-operations 38J through 44J. As is the case with most of the amidship area, the lower deck here is overlain by collapsed timbers and debris, including parts of the upper deck beam shelf that has dropped from its original position. Following the removal of kelp, the corners of this built-in furniture were revealed. The first example is in sub-operations 38J and 40J and appears to correspond with the location of the Master's cabin in the 1839 plan, which as noted above, could have been Fairholme's at the time of departure in 1845, or for that matter another occupant (Figure 5.3.8). Farther aft sub-operations 42J and 44J encompass the positions of the 3rd and 2nd Lieutenants' cabins as shown on the 1839 plan, and therefore where 3rd Lieutenant James W. Fairholme and 2nd Henry LeVesconte resided respectively. In general the remains of these three presumed cabins comprise the wooden inboard supports of the bed places with the sleeping surfaces partly in place; the spaces beneath what would have been the sleep-ing surface appear to be at least partially filled with wood fittings and other unidentified materi-als, all of which is partly blanketed by silt. In one example in sub-operation 42J the vertical side of a "Bed Place" and some adjacent furniture are in

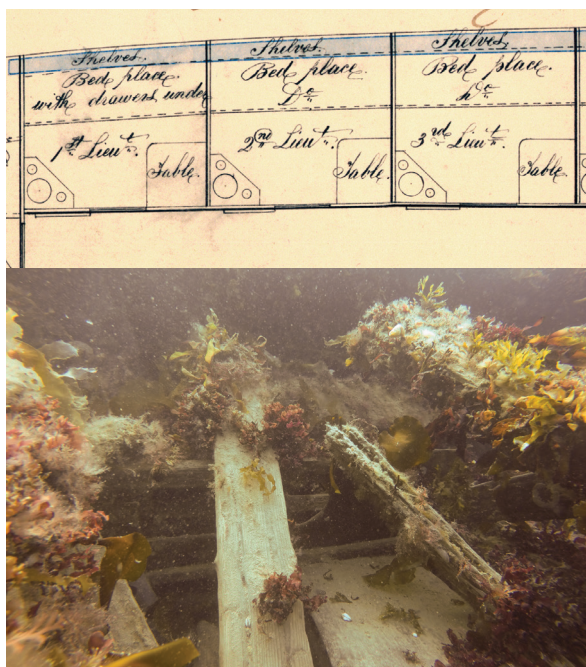


Figure 5.3.8: Detail from *Terror and Erebus Plan of lower deck* (top) showing the 1st, 2nd and 3rd Lieutenants' cabins juxtaposed with a bed place from sub-operation 42J with possible bed place side rail in situ (Photo: J. Moore, Parks Canada; 89Mo4393EF; Ship plan courtesy: National Maritime Museum Greenwich, London; NPC3125, J8650).

situ (see Figure 5.3.8). Further examination, removal of overlying timbers and excavation will ultimately be required to better understand the extant features and artefact potential. Indeed, few artefacts were observed on the surface in this zone, except for several unidentified copper-alloy rings near a bed place. Farther forward however, a cluster of artefacts associated with officers were both observed and recovered. A notable find (not recovered) was a sextant found in sub-operation 36J, in an area corresponding to the cabins of the Mate and First Mate in the 1839 lower deck plan of *Erebus* (Figure 5.3.9).

The approximate position of the 1st Lieutenant's berth on the upper deck plan has articulated but collapsed upper deck in place over top (making direct observation difficult) and this was almost certainly where Commander James Fitzjames resided; his cabin as depicted in the *Illustrated London News* is shown with a starboard versus port side configuration (see Figure 5.3.7).

Franklin's "Captain's Cabin" is of course of prime archaeological interest. Not only was it Franklin's principal working and dining area, but also a working place for all manner of scientific work

taking place on the expedition, at least in its earliest stage. For instance, Assistant Surgeon Harry Goodsir, describes the use of the room:

I work constantly in the Capt's Cabin where we have good light for the Microscope but the ship is not always too steady for such means of observation but notwithstanding have done a good deal in that way. (Goodsir 1845).

In the 1839 plan the forward wall of this cabin would have been immediately forward of the mizzen mast and a series of fitted book cases with cupboards underneath ranged along this divider. The plan shows a central table atop a scuttle down to the orlop deck (*Terror and Erebus, Plan of Orlop and Hold. (as fitted)* 1839). The aft end of the cabin was vividly depicted in the *Illustrated London News*, and shows the table and fitted map cabinets along the transom (marked "Pacific Charts No 1" and "Home and Arctic No 1 *Erebus*"). Three of the four gallery windows are visible, and a portrait hangs on the wall that surrounds the propeller trunk (Figure 5.3.10). Also, what appears to be a heating stove is in the starboard corner of the room (*Terror and Erebus, Plan of Lower Deck (as Fitted)* 1839).

As it exists today, the cabin structure has been severely compromised by collapse including that of the transom with its four stern gallery windows and the propeller trunk. The cabin's upright fitted furniture in this particular zone, such as cabinets and shelving are no longer in situ. Franklin's bed cabin is in place however but covered by the partly collapsed upper deck section on the starboard side and is in relatively good archaeological condition.



Figure 5.3.9: Sextant and two glass hemispheres in sub-operation 36J (Photo: M.-A. Bernier, Parks Canada; 89Mo6631EF).

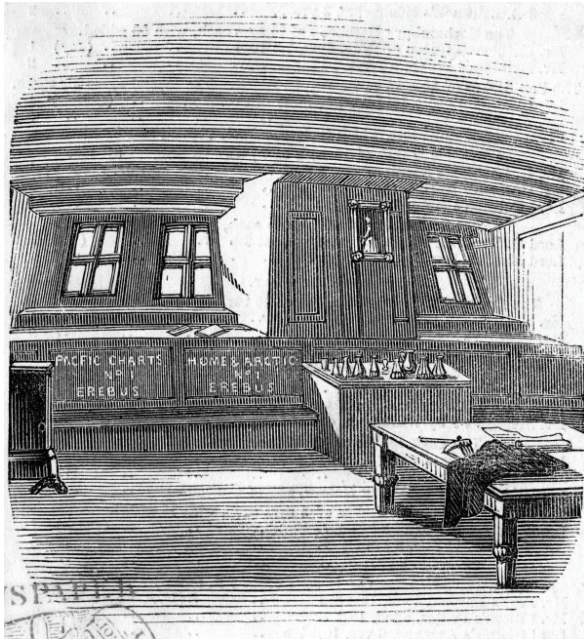


Figure 5.3.10: Captain John Franklin's cabin, facing aft, from the *Illustrated London News*, May 24, 1845, with a probable heating stove at the far left.

Upon the removal of kelp growth, in 2015 it became possible to look under the upper deck at the stern from sub-operation 40M clear aft through to sub-operation 52M (Figure 5.3.11). From this vantage point, collapsed timbers and deck beams were clearly visible, as were fitted shelves along the interior starboard side of the hull side, akin to those shown in the *Illustrated London News* picture of Fitzjames' cabin and the 1839 lower deck plan. One of these shelves is boxed, in that it has a vertical plank to retain its contents. As well there are the parts of vertical cabin walls where they meet the interior of the starboard hull.



Figure 5.3.11: View looking aft along the starboard side of the hull (from sub-operation 40M) along the range of officers' cabins (Photo: T. Boyer, Parks Canada; 89Mo8736EF).

Much of the interior of the surviving Captain's Cabin, officers' cabins, Ward Room and Gun Room farther forward can also be viewed from the vantage point of sub-operation 52M (Figure 5.3.12). Looking forward from here, collapsed deck beams, planks and furniture are visible, most of which is blanketed with some silt and plant and animal life. In places along the starboard side, fitted fore-aft planking and vertical trim that overlies the hull framing are in situ as is possible white paint on selected surfaces. A reinforcing feature of the hull is visible in this area, one that is described by Rice (Ross 1847:328):

Between the upper and lower decks, and also between the lower and orlop decks, thick shelf pieces are wrought, terminating under the transom abaft, and meeting at the middle line at the deck hooks forward.

On the wreck at the stern, not only is this shelf piece visible, but also heavily reinforced iron upper deck hanging knees, backed by a wooden chock; this entire assembly is clearly depicted in the 1839 midship section of *Erebus* (*Terror and Erebus. Midship Section* 1839).

A range of artefacts and features were observed in the Captain's Cabin area from both visual observation from outside of the hull and interior video: a copper-alloy block attached via a shackle to a fixed eyebolt in turn implanted in a sizeable timber, all of which is probably intrusive from the upper deck; a Preston patent illuminator frame; and fixtures along the starboard wall of the cabin, including fitted planking and at least one iron knee. There were several notable artefact finds in this area. Interior video recording revealed a small copper-alloy gun under the upper deck in sub-operation 50L. This is situated along the hull centerline, immediately aft of the heel end of the tiller at upper deck level. It has not been possible to identify the piece, although it could be a signal gun given that it is approximately 0.6 m long. A second notable find was a turned furniture table leg identical in shape to the example recovered from the stern debris area. The former lies trapped under collapsed timbers and was therefore left in situ. Lastly, among the notable finds were a presumed scientific instrument part and pieces of a thermometer tube. The instrument part (89M52L200-1) was found nestled above presumed counter timbers (without any sediment cover) at the extreme aft end of the surviving cabin structure. One of the



Figure 5.3.12: View looking into Franklin's cabin, facing the bow, at sub-operation 52M. Note the breech of the small gun at the top left (Photo: T. Boyer, Parks Canada; 89Mo8736EF).

thermometer tubes (with one rounded, enclosed end) was found within a matrix of mud under pieces of crumpled lead sheet (89M52M200-2) and a presumed piece of stern gallery window glass or skylight glass (89M52M200-1) that in both cases were recovered. As well, a uniform button (89M52M200-3) was found adjacent to the glass and thermometer tube. The two observed pieces of thermometer tube, with presumed liquid mercury still in the tubes, were not recovered but were cached in situ. These finds speak to the use of the Captain's Cabin as a place for scientific research and storage of scientific instruments.

An ROV was flown into the starboard-side void under the collapsed upper deck, in the zone corresponding to the Captain's Cabin, Captain's Bed Cabin, part of the Ward Room and Surgeon's Cabin (Figure 5.3.13). The ROV captured excellent images of features and artefacts in this zone: the small gun first observed in April 2015; masses of collapsed fitted furniture; cabin planking; a five-pane skylight window frame (with in situ mullions



Figure 5.3.13: Inside view of Franklin's stern cabin from 2016 ROV video, showing a possible heating stove at top right (Video Still: R. Harris, Parks Canada; 89M2016R003_5644).

but no glass panes visible) that corresponds with the five-pane skylight over the Ward Room as shown in the profile plan of *Erebus* (*Terror and Erebus*, Profile (as Fitted) 1839); collapsed fitted cabin paneling; paint on cabin interior planking; a possible door frame or skylight frame without mullions; an overturned heating stove, which is most likely the stove in Franklin's cabin shown in a May 1845 *Illustrated London News* article (see Figure 5.3.10); lead sheet draped over the stove; a large-diameter copper-alloy tube, possibly associated with the stove; a second possible stove; and importantly, the presumed bed places in the Surgeon's cabin and Captain's Cabins, as well as "Lockers" in the Captain's Cabin that are in situ and intact.

5.4 ORLOP DECK

Jonathan Moore

Video and photo images were obtained of the orlop deck at three distinct places: through the fore hatch (sub-operations 28L/30L); through the lower deck in sub-operation 32K/34K; and through the Ward Room skylight (sub-operations 46L/48L). In general this imagery revealed intact and well-preserved horizontal and vertical surfaces with relatively little damage and collapse compared to the upper deck and lower deck.

An 1839 plan showing the orlop deck and hold of *Erebus* and Rice's description of modifications to *Erebus* record that they were divided into four distinct spaces by three transverse watertight bulkheads (*Terror and Erebus*, *Plan of Orlop and Hold. (as fitted)* 1839). Rice described them as follows (Ross 1847:327–28):

The thwartship bulkheads of the fore, main, and after holds are wrought diagonally of two thicknesses of 1½ inch African board at right angles to each other, the upper ends rabbetting into the lower deck beams, and the lower ends into four-inch plank, wrought upon the doubling. The bulkheads are caulked on both sides, and rendered water-tight. The wing bulkheads are similarly wrought. The limber boards are likewise caulked down and doubled by a fore and aft plank. Penstocks are introduced in the

limbers at the bulkhead, allowing a communication, when required, from one compartment to another, leading to the well. The fore hold is provided with two common pumps, to work on the weather deck; and the well is furnished with four of Massey's excellent pumps.

The ship plans also show that port and starboard longitudinal (fore and aft) wing bulkheads (so termed by Rice) provided segregated storage space for "Coals" in the main and fore holds. These were apparently of "Two thicknesses of 1 ½ in. African wrought diagonally". They were evidently filled via scuttles that pierced the lower deck.

FORE HOLD

A pole-mounted video camera recorded down through the fore hatch both at upper deck level (sub-operations 28L/30L) and at the lower deck level; these two hatches are superimposed but at lower deck level the vertical path is obscured by debris. The camera reached the "Bread Room" in *Erebus*' fore hold, as depicted on the 1839 orlop and hold deck plan (*Terror and Erebus, Plan of Orlop and Hold. (as fitted).* 1839). This revealed deck beams, iron knees, possible carlings, the insides of hatch coamings, stanchions, and possible horizontal and vertical supports for partitions (Figure 5.4.1). There are some fallen or partly fallen wooden partitions in the field of view. The orlop deck itself was not imaged. The area corresponding to the Bread Room and the passageway connecting the Bread Room with the Carpenter's and Boatswain's Stores in the bow was also investigated by ROV. The passageway partition walls, comprised of wooden stanchions and horizontal tongue and groove planking, have partly collapsed. The stanchions and the header and footer



Figure 5.4.1: Underside of the lower deck as viewed from the "Bread Room" in the orlop deck (Video Still: R. Harris, Parks Canada; 89M2016R003_12628).



Figure 5.4.2: View into the "Carpenter's Storeroom" (Video Still: R. Harris, Parks Canada; 89M2016R003_13213).

partition planks still appear to be in place, yet much of the partition wall planking and three doors are not in situ.

Most of the imagery was of the port side of the Bread Room and the central passageway. Sizeable "rusticles" extend downwards from the undersides of the lower deck structure, and much fine silt blankets the orlop deck itself, debris and other visible features. Imagery revealed views of the following features: a tapered hatch ladder situated in the starboard aft corner of the hatch leading from the lower deck to the orlop; the port-side hull interior and underside of the lower deck showing deck beams, the beam shelf and at least one iron hanging knee articulated to a beam; at least one lower deck beam stanchion; the aft face of the forward watertight bulkhead with caulked diagonal planking; one (possibly two) compartmented shelf or crate with silt accumulated on it yet with some unidentified contents visible; and a splayed cask. Interestingly, the ROV also revealed several as yet unidentified and sizeable wooden hoops on the port side of the Bread Room, some of which appear to mate into sets. Views through the open doorway (given that the door itself is not in place) from the Bread Room passageway forward into the "Carpenter's Storeroom" show what appear to be a fitted shelf and associated bin on the starboard side of the hull (Figure 5.4.2).

The observed structural features in this zone correspond with both the orlop and hold plan as well as the midship section of *Erebus*. Indeed, there were no wing bulkhead on the port side (and probably none on the starboard side) which agrees with both plans (*Terror and Erebus. Midship Section* 1839). It was not possible however to view coal scuttles to wing bulkheads below the orlop deck in this area.

MAIN HOLD

A pole-mounted camera and ROV inserted through gaps in the planking of the lower deck in sub-operations 32L and 34L obtained both video and photo imagery of the main hold, at the port forward intersection of the watertight bulkhead (for the main hold) and the port side wing bulkhead for the coals. This revealed intact lower deck beams of massive scantling and with decorative beading along their lower corners. Several presumed deck beam stanchions in situ were visible. The watertight bulkhead was clearly visible, with its diagonal planking; the forward end of the wing bulkhead butts up against the transverse bulkhead (Figure 5.4.3). At this particular insertion point, the wing bulkhead's planking was vertical and is fitted between and butted under the lower deck beams. As far as the imagery's field of view would reveal, the bulkheads and beams appear to be in excellent condition and with very little attached plant or animal life. The longitudinal wing bulkhead appears to have at least two patches of white paint which are both the width of vertical planks; the function, if any, of these paint patches is not yet known.

The orlop deck itself in the field of view is obscured by a significant accumulation of jumbled wooden debris and artefacts, as well as dead kelp. All of the kelp and some of the artefacts and debris could have originated from both the lower and upper decks above, given the porosity of the lower deck in this zone. Observed artefacts include: two mustard pots; a pair of sea boots in an excellent state of preservation; footwear parts; splayed casks and cask staves and heads; unidentified



Figure 5.4.3: Interior view of the fore hold, facing the bow, showing transverse watertight bulkhead, wing bulkhead (at left) and debris and artefact accumulation (Photo: J. Moore, Parks Canada; 89Mo2777EF).



Figure 5.4.4: Selected artefacts in the fore hold including a "Mustard Pot", barrel components, and footwear (Video Still: R. Harris, Parks Canada; 89M2016R003_4321).

poles; a probable stoneware container; a long arm with a copper-alloy butt plate; possible box, crate or furniture parts with dovetail joints; tongue and groove planking; a possible leather pouch; three Preston patent illuminator frames; a bilge pump piston with leather gasket; a mass of folded fabric or leather; lead sheet; a deadeye; deck beam stanchion(s); and a small unidentified box (Figure 5.4.4). There are many more artefacts and features in this zone that will undoubtedly be revealed with further imagery and investigation. Indeed, by rights, the top of the Sylvester's Patent Heating Apparatus (Battersby and Carney 2011) should be visible in this space and it is quite possible that it is captured by the video imagery but is just short of being visibly identifiable.

Some fleeting video imagery was also recorded inside the port-side coal bunker near where the other main hold video was recorded. The video camera was inserted through either a coal scuttle or gap in the lower deck planking. Here only the uppermost section of the bunker was viewed. A lower deck beam (with beaded lower corner) was visible passing through the longitudinal bulkhead for the bunker as was a reinforcing longitudinal stringer that forms part of the bulkhead.

AFT HOLD

A pole-mounted video camera was inserted down through the Ward Room skylight, which due to the collapse of the upper deck, is more or less resting on the lower deck. The camera was in turn directed through a scuttle piercing the lower deck presumably within the Ward Room. Interestingly, there is no such scuttle shown on the 1839 lower deck plan of *Erebus*, but a "Scuttle" is shown, in pencil, on the lower deck plan of *Terror* (Betts

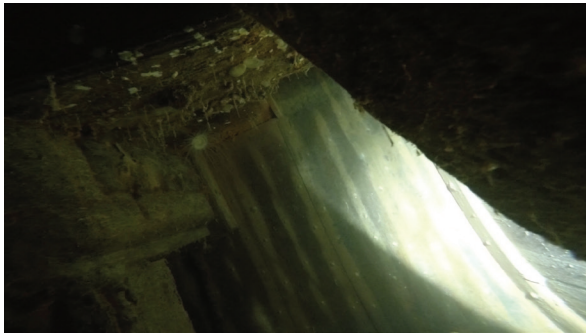


Figure 5.4.5: Interior view of the aft hold showing intact partitions and the underside of the lower deck (Video Still: A. Néron, Parks Canada; 89M2015R008e_0426).

2016:pers. comm.). Indeed, Dr. Matthew Betts has drafted a reconstruction plan of *Terror's* 1845 lower deck, including 1845 pencil marks which shows the addition of air scuttles for the steam engine and the merging of the Ward Room and Gun Room into one mess, among other modifications.

The video down through the scuttle hole revealed an open space with a sizeable lower deck beam in the frame of view as well as the underside of the lower deck planking, a deck beam stanchion, a transverse wall or bulkhead, and other internal partitions, some of which appear to have partially collapsed (Figure 5.4.5). The zone where the camera reached appears to roughly correspond to “flats” adjacent to the powder magazine and near the “Captain’s Storeroom” and “Gunner’s Storeroom” (*Terror and Erebus, Plan of Orlop and Hold. (as fitted)* 1839). It is possible that the camera imaged the aft partition or bulkhead of the 1845 engine room, although this remains to be confirmed.

5.5 DEBRIS FIELD

Jonathan Moore

In 2014 two dives were expressly devoted to exploring the near-hull debris field and observations from these dives were presented in Harris, Moore and Bernier (2015:50–54). In 2015 many more archaeological dives were devoted to exploring this zone. This section provides an updated interpretation of the zone divided into four categories and presents more insights into spatial distribution and feature identification.

HULL STRUCTURE

Detached hull timbers comprise the majority of material in the near-hull debris field which rings the footprint of the hull. Of these, the majority certainly come from the transom, detached upper deck structure (both articulated sections and individual timbers), and hull planks detached from damaged parts of the ice channels. A mass of collapsed timber structure at the stern comes from the transom and its constituent parts, frame timbers, parts of the upper deck and some interior features that spilled out from the ship (Figures 5.5.1 and 5.5.2). At present this mass has not been studied in detail, and save for several elements (see below), most timbers have not been identified by function and origin. With the removal of vegetation in 2015 UAT archaeologists achieved a clearer view of the mass and its deposition. It is evident from observations at the base of the stern post that what is probably the collapsed transom is propped up against the aft face of the stern post, forming a ramp of sorts upon which other timbers rest. Although a significant amount of kelp was removed from this mass of timber debris at the stern, more remains obscured by algae (predominantly in the scour pocket off the starboard quarter).

Throughout the debris zone there are various sizeable and heavily-fastened timbers that are presently unidentified. Examples that have a sizeable scantling and that are heavily fastened are found near the heel of the stem and forward from the bow (see Figure 5.5.2). Three articulated sections of laminated upper deck planking are clearly recognizable. The largest is a 13-m-long and 2-m-wide section of the port bow deck centred in sub-operation 26F. This upright section exhibits both upper diagonal-laid planking and the underlying



Figure 5.5.1: Debris off the stern, facing forward (Photo: T. Boyer, Parks Canada; 89Mo8496EF).

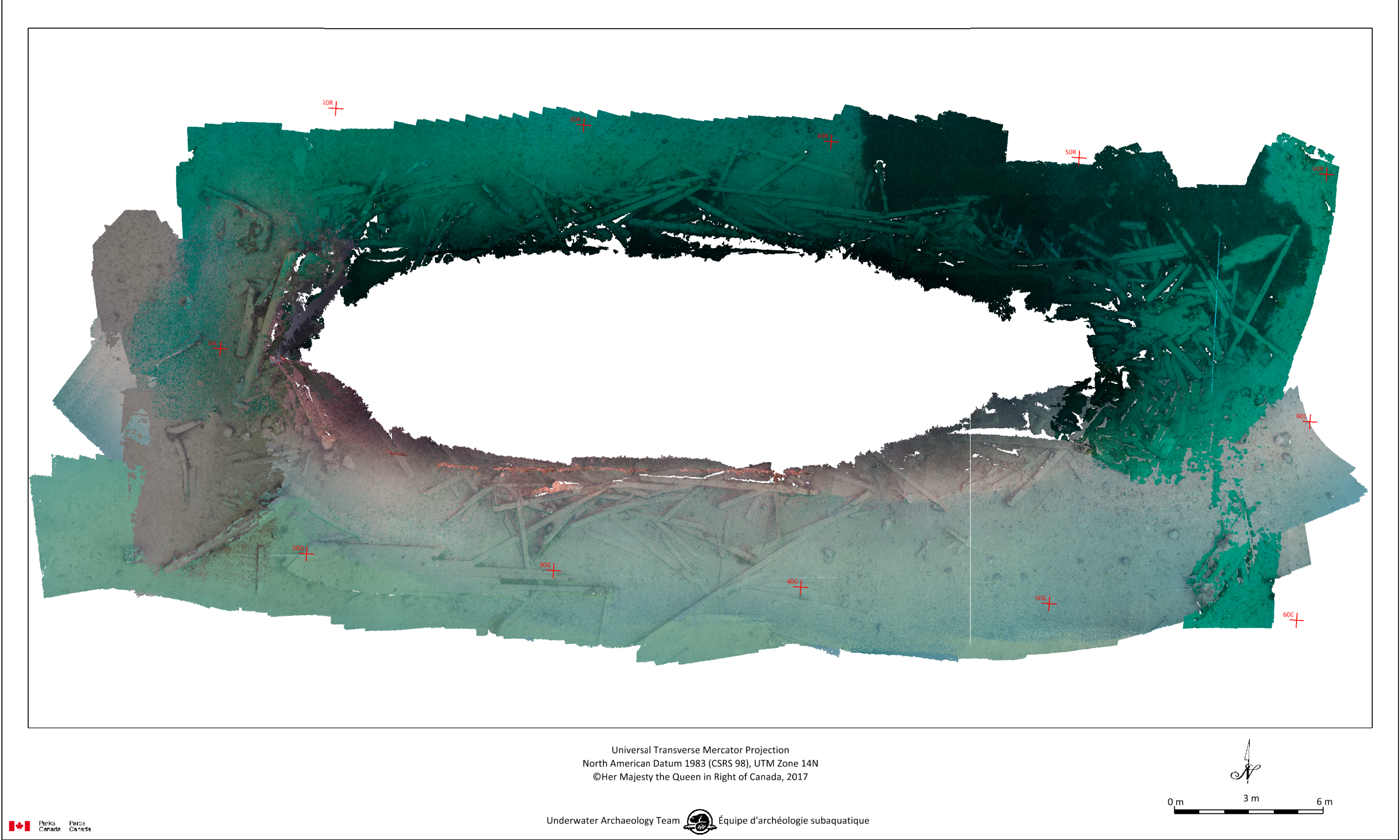


Figure 5.5.2: Photogrammetric model of the debris field immediately surrounding the hull of *Erebus* (Image: T. Boyer and B. Lockhart, Parks Canada).

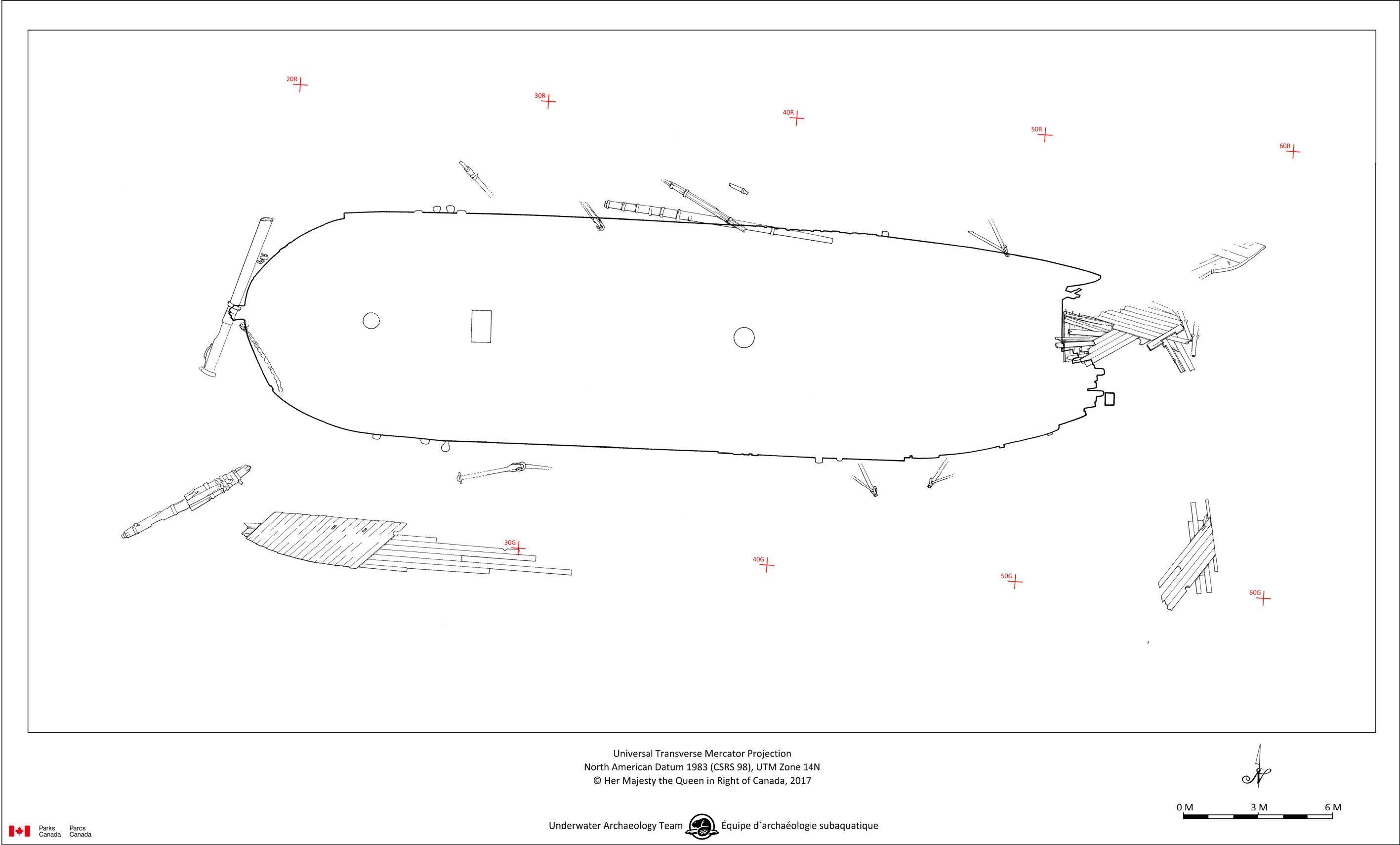


Figure 5.5.3: Site plan of debris field immediately surrounding the hull of *Erebus* showing selected large-scale features (Drawing: C. Pillar, Parks Canada; 89M-2017-101-2; Image: B. Lockhart, Parks Canada).

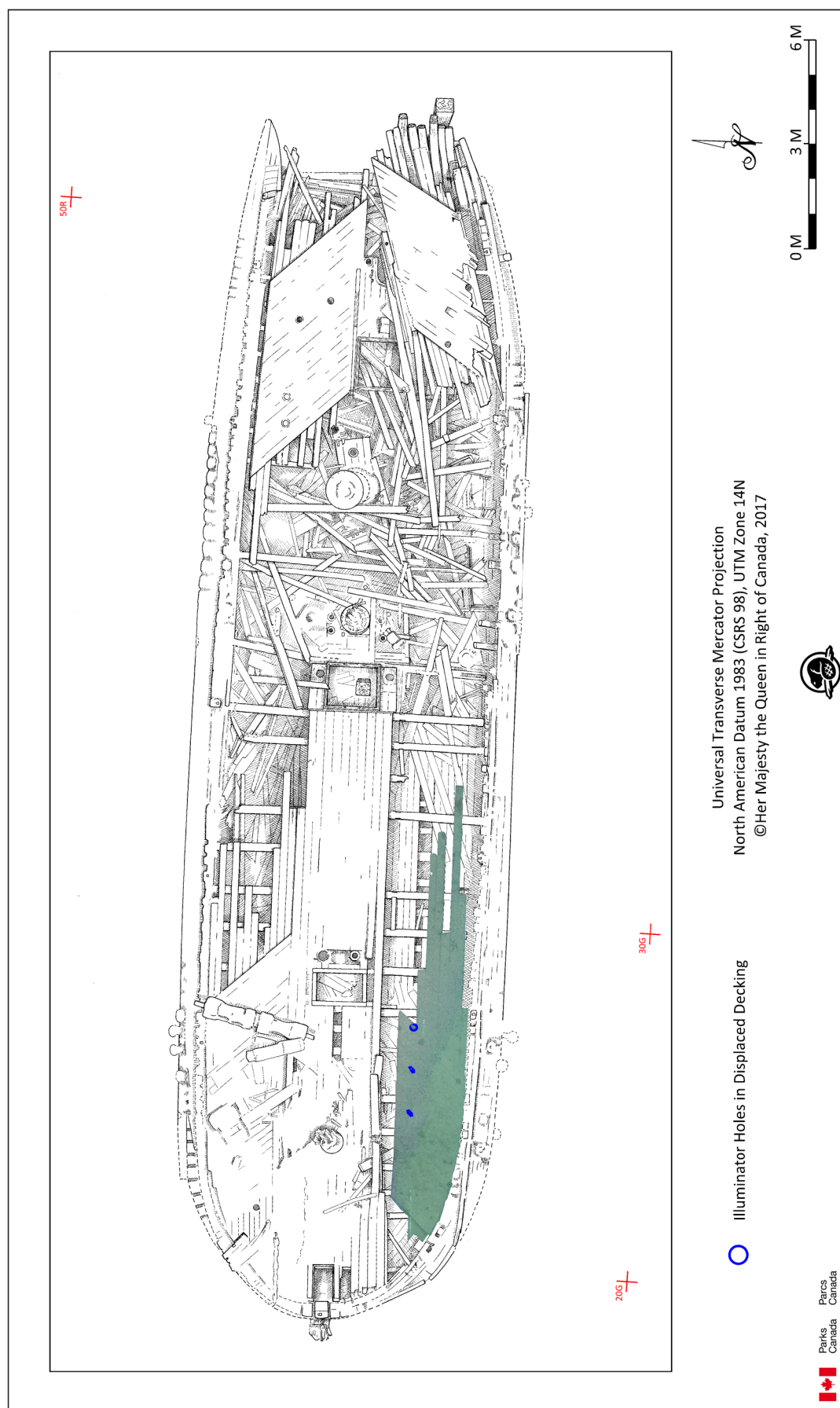


Figure 5.5.4: Upper deck site plan with photogrammetric model of detached section of upper deck (from the debris field, centered on sub-operation 26F) showing reconstructed original position (Drawing: C. Pillar, Parks Canada; 89M-2017-101-1; Image: B. Lockhart, Parks Canada).



Figure 5.5.5: Bulwark section on the port side of the wreck, from above (Photo: J. Moore, Parks Canada; 89Mo4061EF).

fore-aft planking. At its forward end it is pierced by two rectangular deck prism holes, and a round hole for a Preston's patent illuminator (Figure 5.5.3). In April 2015 a glass prism was recovered from atop this feature. The patent illuminator is not in situ and it is probable that one other patent illuminator position is obscured by silt. It has been possible to reconstruct the original position of this deck section the upper deck (Figure 5.5.4). The scantlings of both the upper (diagonal) and lower (fore-aft) planks were measured as follows: upper 19 cm sided and 6.2 cm moulded; lower 15 cm sided and 5.7 cm moulded. As with other sections of decking on the site, the upper planking is fastened to the lower by way of copper alloy dumps. A wood species sample from an upper deck diagonal plank on this section was identified as "most likely Red pine (*Pinus resinosa*) or Scots pine (*Pinus sylvestris*)" (Laflèche 2015a). An upper deck nibbing (margin) strake, probably upside-down, lies adjacent to this deck assembly; originally this would have received the lower-most layer of upper deck planking where the hull curved in to the bow.

Two other yet smaller articulated sections of the upper deck exhibiting the two-layer planking are found at the stern and rest atop one another, and in turn rest atop other collapsed stern structural elements. Both have a distinctive recess believed to be the coaming of the propeller trunk at upper deck level. The original positions of the two sections have also been contemplated, but until direct measurements are taken of the presumed propeller trunk aperture or coaming, their provenance remain conjectural (see Figures 5.5.2 and 5.5.3). As for as individual detached upper deck planking, the majority is found along the hull sides and

at the stern. The apertures for up to four patent illuminators are found in planking on the port side at amidships.

Other identifiable hull timbers are represented on the seafloor. Given the partial break-up of the hull, in particular at the stern, a number of wooden chocks from the ice channels are visible under the port and starboard quarters in particular. These chocks are also seen on the seafloor at the bow, and elsewhere. One section of the ship's bulwarks is found off the port side, near amidships, centered in sub-operations 30G and 32H. This section represents only a fraction of the original length of bulwarks that would have run the length of the hull side (Figure 5.5.5). The whereabouts of other parts are unknown at present. The extant section lies with the outboard side facing upwards with top timbers, exterior bulwark planking and what is probably the rail cap visible. A pinrail is present on its inboard face and two bronze belaying pins are in situ within the pintail. A possible detached pinrail is on the other side of the hull in sub-operations 42P or 44P.

STANDING AND RUNNING RIGGING

Erebus was rigged as a barque on its 1845 voyage and its rig is vividly depicted in a range of contemporary illustrations dating from May through July 1845, although each differ in detail and rig set. There is also valuable comparative information from the 1839 voyage in particular. The three-masted barque configuration entailed square sails on the fore and mainmasts with fore-aft sails on the mizzen. Figures 2.1.2, 2.1.3 and 5.5.6 show that each mast had a lower mast, topmast and topgallant mast and that a bowsprit with jibboom



Figure 5.5.6: Detail of "May 31st 6PM Blazer Taking *Erebus* in tow", by Lieutenant Graham Gore (Courtesy: Scott Polar Research Institute, N1534).

Masts	Spars	Sails
	Bowsprit	Jib
	Jibboom	
	Flying jibboom (?)	
	Martingale	
Foremast	Fore yard	Fore sail
Fore topmast	Fore topsail yard	Fore topsail
Fore topgallant mast	Fore topgallant yard	Fore topgallant sail
	Fore royal yard	Fore royal sail
		Staysail
Mainmast	Main yard	Main sail
Main topmast	Main topsail yard	Main topsail
Main topgallant mast	Main topgallant yard	Main topgallant sail
	Main royal yard	Main royal sail
	Main spencer gaff	Main spencer sail
Mizzen mast	Spanker boom	Spanker
Mizzen topmast	Spanker gaff	Gaff topsail
	Topsail gaff	
Total: 8	Total: 16	Total: 13

Table 5.5.1: Preliminary list of masts, spars and sails on *Erebus*, 1845 as observed from contemporary artwork. In addition, yards could have been equipped with studdingsail booms and irons although these have not been listed.

projected out from the bow at a steep angle. A contemporary newspaper article states that the *Erebus* and *Terror* were fitted with new masts and bowsprits: “The Dove lighter sailed on Thursday for Woolwich with new masts and bowsprits for the *Erebus* and *Terror*, fitting there for a Polar expedition” (*The Times* 1845:7). The masts, spars and sails shown on selected depictions of *Erebus* from 1845 are listed in Table 5.5.1.

All three masts and the bowsprit are detached: the fore and main masts are snapped off at or just above upper deck level leaving visible but frayed stumps, and both the mizzen mast and bowsprit appear to have been un-stepped during or after wrecking. A range of standing and running rigging elements are found in the debris field, some of which are shown in Figure 5.5.3. In fact, few are found anywhere else on the site, including the upper deck, where only belaying pins, blocks and sheaves have been observed. At present interpretation of the rigging elements on the seafloor is limited to visual observation, preliminary identification and a nascent distribution analysis.

Three features can be identified as masts or mast parts. Part of a mast, possibly a lower mast, is off the port bow centered in sub-operation 18G, aligned in a southwest to northeast direction, with its finished head at the southwest end (Figure 5.5.7). Its northeast end is broken and therefore

a sizeable length of the original mast is missing. The hounds are present, and given their orientation, the upside face is probably its original forward face. The trestle trees and cross trees are not articulated and are not visible nearby. There are metal bands around the mast at various locations and those on the underside of the hounds could be for a yard truss; other bands could be for standing blocks. Some crumpled metal sheet is attached to the mast near its northeast end. At least two double blocks and a rope fragment rest on the seafloor nearby. The mast cannot be identified relative to its original function within the rig with certainty; given its position it could be the part of the foremast. Two other mast parts are found on the starboard side, amongst a concentration of mast



Figure 5.5.7: Part of a mast off the port bow (Photo: T. Boyer, Parks Canada; 89Mo2688EF).

and spars abreast the main mast stump. One in or near sub-operation 44N is a short section of a mast with an articulated cap of sizeable scantling. Farther forward, in sub-operation 42N is another short mast section with an attached cap. This mast is of a smaller dimension than the nearby example. It has a square, finished heel end (as its east extremity) that transitions to a round section through one hole in the cap. A second square-section hole through the cap (probably for the head of a lower mast) has no attached mast, but rather some remains of that mast. A large single block lies next to the cap.

A sizeable mast or spar rests in a north to south orientation at the heel of the stem, centered on sub-operation 18L. Its south end has a cap and the remainder is either broken off or becomes buried at this point; its other end is indeed broken. Near the cap are fitted pulley sheaves. An assemblage of three copper-alloy shackles and a thimble (and part of a rope) all of which are articulated together is situated near the cap; these could be the remains of an associated stay. This mast or spar could be the bowsprit, given its location on the site, but this is conjectural.

Farther aft, a sizeable spar is centered in sub-operation 22N and farther aft still there is a concentration of seven spars or parts of spars along the starboard side between sub-operations 36P to 46N/46P. These are unidentified and their provenance in the overall rig is unknown. The largest example here appears to be a sizeable yard with a dozen or more bands around its circumference (Figure 5.5.8). A gaff with a bevelled and lined jaw is in sub-operation 46N; this could be the spanker or topsail gaff for the mizzen mast (Figure 5.5.9). One possible spar (or davit) part has a metal heel



Figure 5.5.8: Unidentified spar, possibly a yard, on the starboard side of the wreck (Photo: T. Boyer, Parks Canada; 89M00698EF).



Figure 5.5.9: Gaff at the starboard quarter showing its jaws at right (Photo: J. Moore, Parks Canada; 89M05438EF).

or head fitting and another possible yard, at a right angle to the hull, has an attached copper-alloy fitting with integrated copper alloy sheaves. A small dimension spar has a fitted copper-alloy collar (with shoulder) around its circumference. A probable mast cap, triangular in shape and with a rectangular hole, is in sub-operation 20P.

On the port side of the hull, abreast the fore hatch in sub-operations 30G/30H, there are two suspected spars, one of which has an octagonal cross-section. There is a possible spar atop the collapsed stern structure, in sub-operation 54M.

Deadeyes and chain plates from the standing rigging are found in the debris field and complement examples that are still attached to the ice channels. As well, there are fragmentary remains of shrouds or stays in several locations. There are at least three deadeyes at the port quarter in sub-operations 48H and 50H, one of which is a lower deadeye with an attached ferrous chain plate; all undoubtedly were for the port-side mizzen mast shrouds. In sub-operation 44P is an upper deadeye (possibly with an articulated fragment of its accompanying shroud) as well as another part of a shroud or stay. There are fragmentary parts of what could be a shroud(s) or stay(s) in sub-operations 20N and 22P.

At this stage no positive identifications of any mast and spar components can be made and further detailed recording will be required to fully understand the standing and running rigging remains at the wreck site. As well, investigation of the debris field farther afield from the hull footprint could yield additional mast or spar finds. Additionally, more mast or spar parts could be found under vegetation cover.

Several general observations about the rig however can be made. First, given that *Erebus* had a total of eight possible mast components and up to 16 spars (not including studdingsails, boat davits and boat masts and spars), the visible mast and spar remains are fewer than the original count. Second, in terms of distribution, there are more features provisionally identified as masts and spars on the starboard side versus the port side. Third, fragmented masts and spars, for example the lower mainmast and lower foremast, attest to the violence of the collapse of the rigging. Fourth, there is very little in the way of visible (or surviving) rope for shrouds, stays, halliards, sheets, downhauls etc. although fragments are found on the seabed. No sails or parts of sails have been observed to date. The total number of observed deadeyes, belaying pins, and blocks appears to be far less than the original totals on board.

ANCHORS AND CHAIN

A total of eight iron anchors have been observed in the near-hull debris zone, each embedded into the seabed to some degree (see Figure 5.5.3). All are covered to some extent by pink coralline algae. Two bower anchors, both with folding iron stocks, are in place at the heel of the stem and in both cases their crown, arms and flukes are buried. The port bower stands upright at the stem and has a large shackle in lieu of an anchor ring; its attached stud-link chain trails off to the south. The starboard bower anchor also stands upright, slightly to the starboard (north) side of the stem, and has attached stud-link chain that extends down from the starboard side of the upper deck (Figure 5.5.10). Given their positions it appears most likely that both anchors had been catted at the time of wrecking and subsequently fell to the seabed, demonstrating that the ship had not been at anchor when it foundered.

Two large anchors are on the seabed abreast the fore hatch, one on the port side and one on the starboard side; they each share a symmetrical fore-aft position. The port-side anchor stands upright at an angle, resting partly on its iron stock which is engaged (whether intentionally or as a result of wrecking); one of its flukes projects above the seabed while its arms, crown and the other fluke are buried. This anchor has a shackle ring (Figure 5.5.11). On the starboard side a similarly-sized anchor lies prone on the seabed with its crown, arms and flukes buried or obscured. It

too has a shackle ring but no associated stock is visible. Farther aft there are two smaller anchors at the port quarter, both of which are prone and have folding iron stocks. Off the starboard quarter there is one smaller anchor, also prone on the seafloor. Given their positions, and on account of contemporary images from 1839-1845 in which extra anchors were stowed on the ice channels, these anchors appear to have fallen from the ice channels. No ice anchors have been observed and no detailed measurements of the in situ anchors have taken place to date.

A list or account of the number and size of anchors originally aboard *Erebus* in May 1845 is not known to the authors. Some direct evidence for anchors from 1845 comes from the two paintings by Lieutenant Graham Gore. Figure 2.1.2 shows *Erebus* at anchor with one other large anchor on the ice channel immediately abaft the foremast shrouds. Another image by Gore shows an anchor fished to the ice channel, immediately abaft the mizzen mast shrouds.



Figure 5.5.10: Spar, starboard bower anchor and anchor chain at the heel of the bow (Photo: J. Moore, Parks Canada; 89Mo6487EF).



Figure 5.5.11: Large anchor on the port side of the hull (Photo: T. Boyer, Parks Canada; 89M008723EF).

There is some historical evidence for the potential number and weights of these anchors based upon the 1839-1843 voyage of *Erebus* and *Terror*. The ship plan “*Terror and Erebus, Profile (as fitted)*” from 1839 (see Figure 2.1.4) shows four folding stock anchors (with shackles for rings) ranged along the starboard ice channel of *Erebus* and fished to the bulwarks. A roster on the plan lists a total of 10 folding stock anchors for *Erebus*; whether the 1839 anchor roster changed for 1845 is not known. Interestingly, the number and distribution of anchors on the *Erebus* wreck site closely mimics the number and distribution in stowing position from the ship plan profile. It is also possible that *Erebus*’ anchor complement was altered after arrival in Greenland. In a July 9, 1845 letter to Captain James Clark Ross, Captain Francis Crozier of *Terror* mentioned that he sent back to England aboard the *Baretto Junior* “... two anchors and cables – iron waist Davits and various other things of weight as I think it better to have the provisions come what may afterwards” (Crozier 1845). At present therefore, it is not

known what percentage of the original number are present, although certainly a majority of the original total are represented.

PROPELLERS

The installation of auxiliary steam screw propulsion on *Erebus* and *Terror* is described by Battersby and Carney (2011:200-207). They state that each ship carried two propellers on the 1845 voyage, one of which was a spare. The novel propeller mounting and retracting arrangement, conceived by Master Shipwright Oliver Lang, is shown in the March 1845 ship plan of the stern modifications (*Drawings Representing the Afterpart of the Erebus Showing the Method Designed and Fitted by Mr Lang for Working a Screw Propeller in That Ship and Her Consort the Terror...* 1845) (see Figure 5.1.5). Battersby and Carney state that the propeller depicted is a “Smith’s pattern” and that “Standard Practice, as reported for later ships, was to supply a main propeller made of gunmetal and another made of iron ‘to replace it should it be broken when out of reach of dockyard help’” (2011:204).

Two propellers have been observed in the debris field of the wreck of *Erebus*. The first propeller, situated on the starboard side of the stern post, is almost entirely buried in a vertical orientation and was first spotted in September 2014 (Figure 5.5.12). Only a portion of one blade tip projects above the surface of sediment and debris; it is quite clearly copper-alloy. The blade tip has a distinctive shape that exhibits an asymmetrical taper.



Figure 5.5.12: Propeller blade projecting above sediment at the stern (Photo: J. Moore, Parks Canada; 89M005420EF).



Figure 5.5.13: Parks Canada underwater archaeologist records the propeller situated 43 m north of the wreck's bow (Photo: J. Boucher, Parks Canada; 89M004523EF).

The second propeller was spotted, quite remarkably, from the surface during flat-calm water conditions in August 2015, some 43 metres north of the ship's bow. Given its distance from the wreck it is outside of the limits of the defined provenience grid systems. It lies prone and partially buried in the seafloor at a depth of 7.1 m, on the flank of a reef to the north of the wreck. One dive was devoted to recording and photography of the propeller, and it remains in situ to this day (Figure 5.5.13). The copper alloy propeller consists of two blades on each side of a central, round hub, 18 cm outside diameter, which has a square slot to receive the end of the propeller shaft. Each blade's radius is 109 cm (from the midpoint of the aperture to the tip) yielding an overall propeller diameter of 218 cm (Figure 5.5.14). Each blade is at least 70 cm wide, although an accurate measurement was not possible given partial burial. The blade tips share the same asymmetrical taper on one edge as the propeller near the stern post.

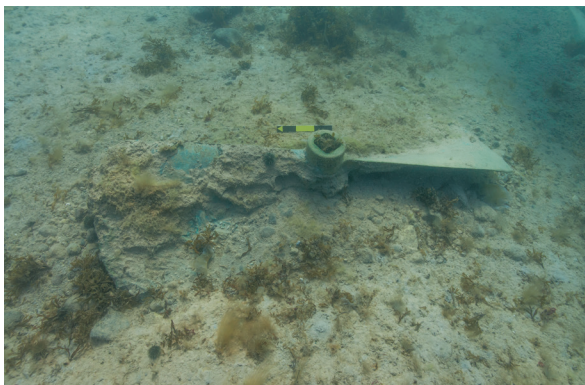


Figure 5.5.14: Propeller situated 43 m north of the wreck's bow (Photo: F. Ronca, Parks Canada; 89M004522EF).

At present it is not possible to state categorically which are the leading edges of the propeller blades, and thereby the forward or aft face of the propeller. Textile remains observed on one of the blades suggests that this example may have been wrapped in canvas or stored in a bag, for protection or handling; this supposition remains to be confirmed however through excavation. Based on its location and the fact that the other propeller was found adjacent to the stern post, it could be the spare, or the propeller serving as the spare. Its distinctive two-blade design corresponds to the propeller shown in Lang's 1845 profile drawing of the stern modifications.

LEAD FEATURES AND ARTEFACTS

A number of lead (or composite lead) artefacts are visible in the debris field and not all are described herein. The most conspicuous is a sizeable object partially buried in sub-operation 56J. This unidentified feature has a rectangular shape and could have been a container that has been flattened and crumpled. It appears to have a lead pipe attached to its northeast corner, and to this is attached a copper-alloy fitting, possibly a valve. Given its location and composition, it could have been a "Cistern" at the taffrail, as shown in the 1839 upper deck plan of *Erebus* (*Terror and Erebus, Plan of Upper Deck (as Fitted) 1839*), if indeed this feature was kept given the extensive stern modifications to the ship in 1845. A cylindrical object formed of lead sheet is found along the port side in sub-operation 32H. Three pieces of sheet lead are found near the bow. A folded piece is off the bow and exhibits nail holes along at least one side; it could have been a lining or protective sheet for an upper deck fitting. Immediately to the north of the stem in sub-operation 20N is a piece of crumpled lead sheet, and another similar piece is in sub-operation 18N. Nearby in sub-operation 18M is a compass timber pierced with small diameter lead-lined scuppers or fairleads.

MISCELLANEOUS

A range of other artefact types are found in the debris field, both near to the hull and farther afield. A timber with an octagonal cross-section tucked under the starboard side of the hull near the bow could be a spar or the detached port-side pump tube originally positioned aft of the fore hatch. Next to this timber is another apparent

cylindrical timber that is similar in appearance to the head of the in situ starboard pump tube at the fore hatch. In sub-operation 24P is a flat and circular wooden object that resembles a cask head; it is covered with copper-alloy sheet affixed with nails around its circumference. In sub-operation 26P and 28P is a shaped timber that resembles the cheek of a windlass bitt; given its location on the seafloor abreast of the windlass on the upper deck this is a likely identification. Another identifiable wooden timber, a solid wood fairlead is situated in or around sub-operation 46P. This timber closely resembles a fairlead shown in the profile plan of

Terror that appears to have been fit into a port in the bulwarks (*Profile of the Terror* 1837). Similar wooden fairleads, but in a double configuration are shown on the profile plan of *Erebus* (*Terror and Erebus, Profile (as Fitted)* 1839). A fragment of the ship's wheel (helm) was found on the seafloor 27 m south from the ship's stem, at a depth of 12.5 m. This represents a small portion of what was originally a double wheeled helm, as shown in a photographic portrait of Lieutenant Henry LeVesconte taken in 1845, and on the upper deck plan of *Erebus* from 1839 (see Figure 6.2.2).

6. ARTEFACT DESCRIPTION

Charles Dagneau and Jonathan Moore

This section provides descriptions of artefacts recovered from the wreck of *Erebus* in 2015. It is organized by original functional group following a classification system adapted for this project and provides information on the following: identification; composition; dimensions and weight; and archaeological context. Also discussed, where appropriate are: date of manufacture; analytical examination; historical evidence; and all manner of material research findings such as comparative contemporary examples, wear and use evidence and some preliminary inferences about shipboard activities and potential contemporary salvage. For some artefacts, the descriptions below should be considered preliminary since their cleaning and conservation treatment have not necessarily been completed. Indeed, as conservation treatment and analytical work progress, new discoveries continue to be made on a regular basis and these will be integrated into future reports. As well, with the 2016 discovery of the wreck of *Terror*, new insights into artefact and feature identifications will undoubtedly unfold, and these will influence our understanding of the artefacts raised from *Erebus* to date. Preliminary artefact distribution plans are found at the end of this section under the heading 6.16. The material culture analysis presented in this section is further synthesized and contextualized in sub-section 7.4 in terms of distribution, association and significance of artefacts aboard *Erebus*. This section represents an archaeological step in the direction of a greater understanding of the fate of the Franklin expedition and presages the promise of future targeted excavation.

6.1 FOOD PREPARATION AND SERVICE

This group of finds relates to containers, wares, and utensils used both for preparing and serving food aboard *Erebus*. It includes six plates, two bowls, one stemware, a bottle fragment, and one possible preserved food can fragment. All artefacts from this group recovered to date are from the lower deck, port side forward area of *Erebus*, in the forecastle (sub-operations 30J/K to 36J/K, lot 200).

CERAMIC DINNER PLATES

89M30K200-1, 89M30K200-2, 89M30K200-3, 89M99X1-11, 89M99X1-12, 89M99X1-13

Six British white fine earthenware dinner plates (24.0 to 26.5 cm diameter) are part of this group, all blue transfer-print whiteware or white granite (Figure 6.1.1). They were found in the forward port side area of *Erebus*, in the lower deck living quarters next to the galley. Five are decorated with a very common blue willow pattern (1815-present), which is not surprising, as blue willow plates represent the most common (and affordable) transfer-print wares used in the nineteenth century (Miller 1991:8-9). Two of the willow plates are stamped “STONE CHINA” and “W & S E”, referring to William and Samuel Edge, Staffordshire Potteries, in operation between 1841 and 1848 (Godden 1991: 1436). Interestingly, two plates and a bowl show crude graffiti on their reverse sides: a broad arrow, what seems to be an anchor or a modified broad arrow, as well as a number “4” (Figure 6.1.2). Four plates and the same bowl also bear respectively a different number of cut marks on their foot ring. It may well be that these different graffiti symbols and cut marks relate to specific messes and/or individuals within a mess unit aboard *Erebus* (Table 6.1.1). Similar marks are often found on fine ceramics in British colonial military contexts, for example on the HMS *Swift* and *Infatigable* wreck sites, and Fort Wellington NHS (Elkin et al. 2011:197-199; Carabias 2016:pers. com.; Sussman et al. 1994: 243).

The relatively low value of these plates and the presence of a broad arrow suggests that these were ship’s property, probably stored in a nearby cupboard. Indeed, three of them were found close to each other on the lower deck, in sub-operations 28-30K (89M99X1-11, 12 and 13). Navy transfer wares of the same period sometimes bore the mess number in the middle of their obverse or reverse sides. The Whampoa flow blue plate was a more fashionable flatware for the period, popular in 1840-1860 (Figure 6.1.1, center). On its back there is a printed floral crest, as well as an impressed Royal arms with the inscription: “Opaque Granite China” and “W R & Co”. This maker’s



Figure 6.1.1: Examples of blue transfer-print whiteware dinner plates showing maker's marks and graffiti. From left to right: 89M99X1-11, 89M99X1-12, 89M99X1-13 (Photos: M. Wilson, Parks Canada; RA3867EF, RA3871EF).

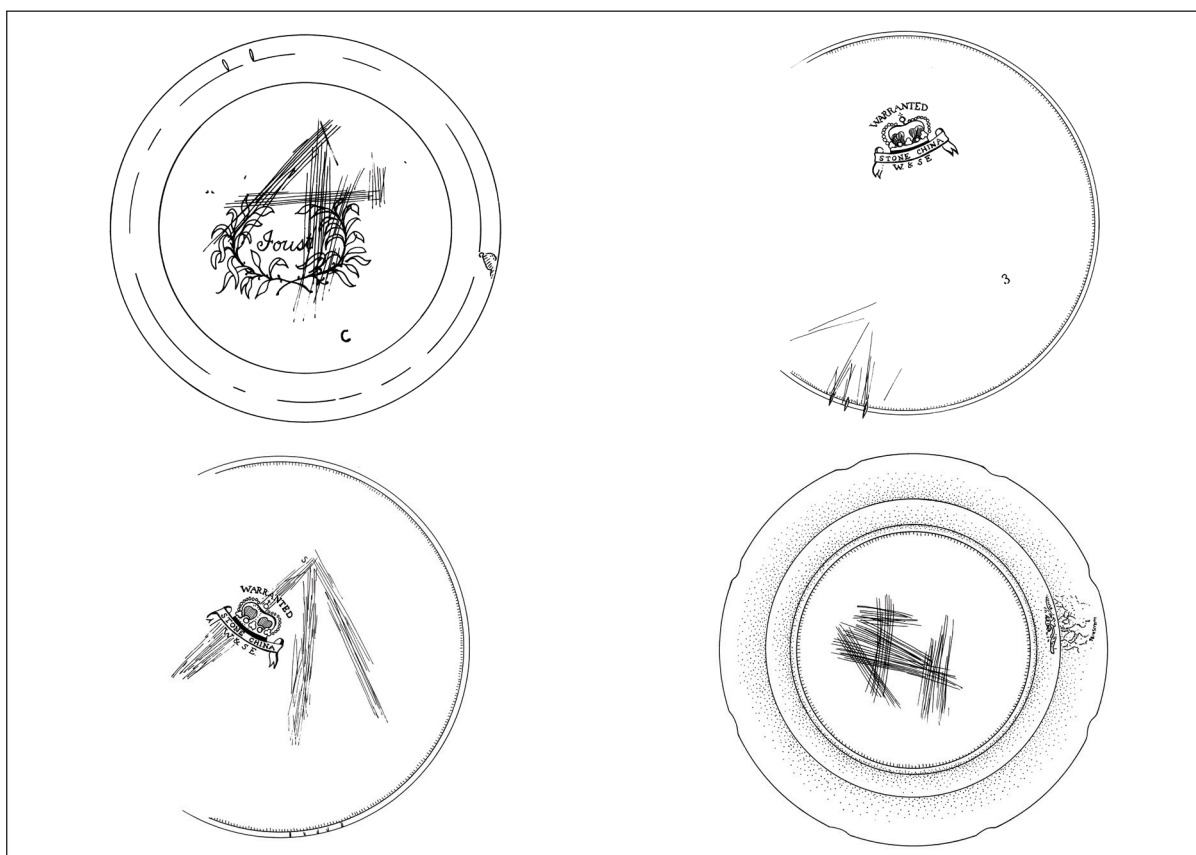


Figure 6.1.2: Examples of graffiti and foot rim cut marks made on whiteware vessels, from top left to bottom right: 89M30J200-6, 89M30K200-1, 89M99X1-12, 89M99X1-13 (Drawings: C. Pillar, Parks Canada; 89M30J200-6, 89M30K200-1, 89M99X1-12, 89M99X1-13).

Artefact #	Shape & Pattern	Maker's Marks & Stamps	Graffiti	Foot Rim Cuts
89M30J200-6	Bowl, Blue Forest and Fern	Forest C	4	2
89M30K200-1	Dinner plate, Blue Willow	WARRANTED STONE CHINA W & S E 3 [Crown]	-	3
89M30K200-2	Dinner plate, Blue Willow	-	-	3
89M30K200-3	Dinner plate, Blue Willow	-	-	6
89M34K200-1	Drinking stem glass	-	S [or] 2	-
89M99X1-11	Dinner plate, Whampoa	OPAQUE GRANITE CHINA W R & Co WHAMPOA [Royal Arms]	-	-
89M99X1-12	Dinner plate, Blue Willow	WARRANTED STONE CHINA W & S E [Crown]	Broad Arrow	5
89M99X1-13	Dinner plate, Blue Willow	STAFFORDSHIRE ... [WAR]RANTED CHINA [Royal Arms]	[Anchor ?]	-

Table 6.1.1: Selected artefacts from *Erebus* showing maker's marks, stamps, graffiti marks and foot rim cut marks.

mark is associated with William Ridgway & Co, Staffordshire Potteries, in operation from ca. 1834 to 1854 (Godden 1991:538).

The presence of the plates on board the wreck accords with Inuit oral history evidence collected in 1879 by Frederick Schwatka's expedition. The Inuk Puhtorook reported that he and others had boarded a ship surrounded by ice west of the Adelaide peninsula: "They found iron chains and anchors on deck, and spoons knives forks tinplates china plates etc. below" (Schwatka 1880:125-126); and "They found plenty of knives, forks, spoons, pans, cups, and plates on board, and afterward found a few such things on shore after the vessel had gone down. They also saw books on board, and left them there. They only took knives, forks, spoons, and pans; the other things they had no use for" (Gilder 1880:78-79). The plates could also represent, therefore, materials left behind during selective Inuit salvage and gathering activities while on board.

BOWL, FOREST PATTERN

89M30J200-6

This medium-sized bowl (16.5 cm diameter) has slightly tapered sides. The footring of this transfer-print whiteware is well defined and thick, something usually considered to be a European shape. A pale blue blooming tree pattern covers most of the artefact, both on the interior and exterior. Decoration is absent from the interior centre. On the underside is a blue fern pattern, evidently with some imperfections in the drawing, and the inscription "Forest" (Figure 6.1.3). Teawares with the same design can be observed

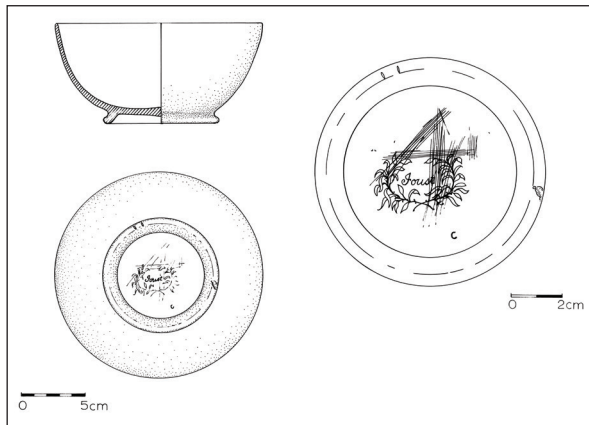


Figure 6.1.3: Bowl, pale blue pattern, 89M30J200-6 (Photo: C, Pillar, Parks Canada; 89M30J200-6).

at the Sunderland Museum, bearing impressed mark "JOHN ALLASON - SEAHAM POTTERY" (Shaw 1973:30; Coysh and Henrywood 1982:II-84). J. Allason operated a manufactory in Seaham Harbour, Nr. Sunderland, Durham between 1839 and 1841 (Godden 1991:82). This piece may originate from Durham, northeast England, but the same pattern is also known to have been used by Staffordshire potters at the same period although in different colours (Shaw 1973:30).

This vessel also has a small blue-printed "C" and a large "4" lightly scratched on its base. As with the other marks on the ceramic plates discussed previously, these might be associated with a mess, or a specific individual.

BOWL FRAGMENT

89M99X1-15

This is a fragment (4.3 cm by 3.7 cm) of whiteware from an open vessel such as a small bowl. Faint paint lines are visible on both sides, possibly traces of overglaze painting: there are two thick lines on the interior near the rim, and four thin lines on the exterior. Based on the arc of the rim, the bowl's estimated original diameter was 12.2 cm.

BOTTLE FRAGMENT

89M32J200-4

Fragment from a cylindrical bottle, made of thick (1.5 cm) dark brown glass, including part of the heel. It is possibly a beer bottle based on its original diameter, estimated at 9.4 cm. This glass container may have been used for a variety of liquids; it was found in the same area as the other artefacts from this group.

DRINKING STEM GLASS, FOOT

89M34K200-1

The foot (diameter 6 cm) of this colourless drinking stem glass is broken at the base of its octagonal stem. The heel under the base is subtle at only 0.6 cm deep (Figure 6.1.4). The underside of the foot bears a lightly incised mark that reads "S" or "2"; it could be a property mark, in which case it might have been the personal property of



Figure 6.1.4: Foot of a drinking stem glass, 89M34K200-1 (Photo: M. Wilson, Parks Canada; RA3926EF).

a crewmember - certainly an officer. It could also be a number showing that this glass was part of a set, possibly managed by a steward in charge of the shipboard wares. A similar glass foot with octagonal stem is depicted in *Glass of the British Military, ca. 1755-1820* (Jones and Smith 1985).

METAL RING

89M99X1-14

This piece of pinched sheet metal may be the partial remains of a metal can (ca. 14.4 cm diameter). The object is slightly thicker on part of its circumference, where the metal is folded on itself. Large quantities of foodstuffs, including canned soups, meat and vegetables, were taken on board *Erebus*, enough to feed over 60 men for at least three years. This said, it is unclear if this specific object indeed represents a food storage can. The analysis of the sample showed that its composition corresponds to a pewter alloy of tin and lead of approximately 30 wt% (Kavousanaki 2016:5).

6.2 RIGGING

Both running and standing rigging elements are presented within this functional group. Four belaying pins, two spindle-rollers, one standard single block, one block sheave, and two specialized blocks were recovered. Although most of these artefacts were located on the ship's upper deck, some were found on the seabed.

BELAYING PINS

89M40N100-1, 89M44N100-2, 89M48M100-1, 89M50M100-1

Three belaying pins and one belaying pin fragment were found resting directly on the upper deck and recovered (Figure 6.2.1), none of which were found in situ in a pinrail, although there are examples of this on the wreck. Only a representative sample was raised to the surface in September 2015 and there are more examples in situ. The overall length of the complete examples, which share an identical form, range from 31 to 33 cm, with a handle diameter of 3.7-4.0 cm. The ship was equipped with many of these pins on the upper deck, in fife rails at the masts but chiefly in pinrails along the inboard faces of the port and starboard bulwarks. These pins were used to attach, or belay, a variety of the ship's running lines. Unlike wooden belaying pins commonly associated with sailing ships, these pins are solid bronze. Two of the pins exhibit damage: 89M44N100-2 is slightly bent while 89M40N100-1 has been broken, most likely when the ship's rigging collapsed, during or after the ship's sinking.

A belaying pin is visible in the daguerreotype of Lieutenant LeVesconte taken on deck prior to the expedition's departure in 1845. The belaying pin appears in the background and is in a mizzenmast fife rail (Figure 6.2.2). Interestingly, in May of 1879, a part of a belaying pin was obtained by the Schwatka Expedition from Inuit living along the Hayes River, to the east of where the wreck of the *Erebus* is located (Schwatka 1880). The pin appears to have been adapted into a tool by Inuit and is now in the collections of the National



Figure 6.2.1: Belaying pins and fragment found on the upper deck, from top to bottom 89M48M100-1, 89M44N100-2, 89M50M100-1 and 89M40N100-1 (Photo: T. Boyer, Parks Canada; 89M07648EF).



Figure 6.2.2: A mizzenmast belaying pin on *Erebus* is visible over the left shoulder of Lieutenant LeVesconte (Courtesy: National Maritime Museum, Greenwich, London; 9191-D).

Maritime Museum in Greenwich, England (NMM AAA2334). This pin has a stopper with a different shape than the pins raised from *Erebus* to date, although this alone does not rule it out from having come from the *Erebus*.

SPINDLES

89M40N100-1, 89M42N100-2

These two solid bronze rollers or spindles bear a shallow U-shaped groove (0.5 and 0.85 cm deep). Their ferrous metal pins are now partly corroded and disintegrated. Their find locations on the star-board side of the upper deck at amidships suggest they were part of the main mast rigging. These artefacts, most probably encased in a frame, were commonly used to guide or “lead” ropes at points where they made turns on a mast, spar or structural element, and also prevented excessive wear or interference with other rigging elements. Both spindles have a broad arrow on both of their sides.

SINGLE BLOCK

89M99X1-2

This standard single wooden block (28 cm or 11 in. length) is only half preserved and was found on the seabed a few centimetres east of the stem post (sub-operation 20L). While its shell is made of elm (*Ulmus* sp.), the sheave is made from lignum vitae (*Gaiacum* sp.), and fitted with a bronze coak. Three broad arrows are stamped on the sheave. The iron pin is corroded and partly disintegrated. Similar wooden rigging blocks with coaked sheaves have been recovered from nineteenth-century shipwrecks, for example HMS *Investigator* (Cohen 2013). Wooden blocks or block components are part of the Franklin relics’ collection at the National Maritime Museum (NMM AAA2198, AAA2247, AAA2299 and AAA2329).

BLOCK SHEAVE

89M40N100-3

This copper alloy sheave (8.2 cm diameter) has a typical late nineteenth century “wheel pattern”, with four rays around a central reinforced axle (Figure 6.2.3). Two broad arrows are visible on the better preserved side of the artefact, the other being covered mostly with corrosion product. The groove has a U-shape of 0.3 cm deep.



Figure 6.2.3: Copper alloy block sheave, 89M40N100-3. Note the broad arrow on the upper middle of the sheave (Photo: T. Boyer, Parks Canada; 89M07578EF).

HOOK BLOCK, 6¼ IN.

89M99X1-4

This high quality hook block made of solid bronze has an ovoid shape with an embossed ray pattern (Figure 6.2.4). There are two broad arrows marks on each side, with the inscription “6¼” on one side, referring to the regulation size of the block in inches (15.9 cm or 6.25 in.). “CHAIN” is stamped on the hook, possibly a mark indicating that the hook can or should be attached to chain or otherwise simply a maker’s mark. The sheave is made of the same alloy, but the iron pin is mineralised and degraded. This solid and seemingly versatile block might have been rigged to a boat davit (to raise or lower ship’s boats from the upper deck) or formed part of the ship’s standing rigging (Nordbok 1975:109-123). Recently in April 2017, similar blocks were observed on the wreck of the *Terror*; further study of in situ examples on this exceptionally well-preserved wreck should shed light on the blocks found on *Erebus*.



Figure 6.2.4: Solid bronze hook block with an embossed ray pattern, 89M99X1-4 (Photo: T. Boyer, Parks Canada; 89Mo7391EF).



Figure 6.2.5: High-quality single block fitted with an integrated shackle, 89M28M100-1 (Photo: T. Boyer, Parks Canada; 89Mo7682EF)

BLOCK WITH SHACKLE

89M28M100-1

This distinctive, high-quality single block fitted with an integrated shackle was found on the fore, starboard side of the upper deck (sub-operation 28M); all of the artefact is brass and ongoing research aims to determine if its presence on a Royal Navy ship fitted-out in 1845 is unusual or novel (Figure 6.2.5). The block per se is 19.8 cm long, and total length of the entire object is 28.0 cm. The two ears forming the shackle are made to accept a large through bolt with a round head. The iron block pin is now absent. The case is reinforced (and possibly decorated) with a radial pattern of raised lines moulded on both sides, similar to hook block 89M99X1-4. A broad arrow is visible on the better preserved side, while corrosion product obscures most of the other side and the sheave. Remnants of cordage are corroded to the sheave, inside the shell. The block was partly crushed by a heavy force, possibly as a result of the sinking of *Erebus* and the collapse of its rigging. Its size might be marked on the block which will be confirmed following conservation treatment.

6.3 CLOTHING AND UNIFORMS

This functional group of finds relating to clothing includes parts of uniforms, footwear, slops and bedding artefacts. At present however, only eight clothing artefacts have been recovered: three uniform buttons, a shoulder belt plate, two belt buckles, a boot, and a piece of jersey fabric.

Like most artefacts recovered in 2015, all artefacts from this group are from the port side of the lower deck in sub-operations 28J/K to 36J/K, lot 200.

BUTTONS, ROYAL MARINES

89M99X1-9, 89M99X1-10

These two 1830-pattern Royal Marine buttons (diameter 2.1 cm) were found together in the forecabin on the lower deck (Figure 6.3.1). These plain domed pewter buttons are decorated with a crowned, foul anchor, a wreath of laurel leaves, and the inscription “ROYAL MARINES” on top (Parkyn 2014:241-242). The button undersides are marked with the maker’s mark “NUTTING” “LONDON”. The Nuttings were registered manufacturers in London between 1800 and 1865. John George Nutting had his premises on Regent Street, Westminster from 1830-1844 (Nayler 1993:53-54). Similar buttons with the same marks can be found at the National Maritime Museum (NMM, UNI6919) and within Parks Canada’s collections.

These two buttons certainly came from the uniform of one of the thirteen “other ranks” (other than commissioned officers) Royal Marines from the Woolwich Division who sailed into the Arctic with Franklin — seven on *Erebus* and six on *Terror* — if indeed both buttons belonged to the same garment (Anon 1845). It is also possible they belonged to the Royal Marine sergeant who used the shoulder belt plate 89M32J200-1 (see below).

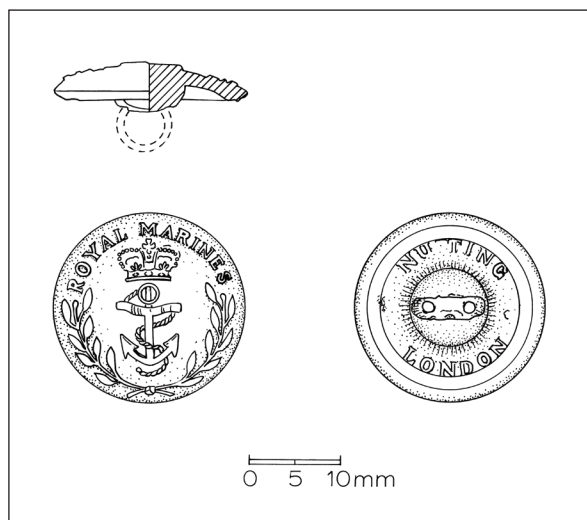


Figure 6.3.1: Royal Marines button, 89M99X1-9 (Drawing: C. Pillar, Parks Canada; 89M99X1-9).

BUTTON, ROYAL NAVY

89M52M200-3

This gilt 1827-pattern brass Royal Navy button (diameter 1.9 cm) is domed and depicts on its obverse side a foul anchor with a crown on top, encircled by a raised line, with a rope design on its rim (Lewis 1945:77-80) (Figure 6.3.2). The background is decorated with very thin incised parallel lines (pre-1901). On the reverse side, there are remains of the shank with a small portion of the eye still protruding. A mark from the pressing process is visible on the back, as well as the maker’s mark “P & S FIRMIN 153 STRAND”, “LONDON”. The Firmings, originally from Birmingham, were well known “button & military ornaments” manufacturers. Their name can be seen on Royal Navy swords and buttons from different collections, including those of the National Maritime Museum (Nayler 1993:26-29).

The edge of the button has a golden colour visible in two spots; both have been identified as gilding. This standard Royal Navy officer’s uniform button was found on the lower deck level at the aft end of the surviving part of the Captain’s Cabin, underscoring the evidence that it came from an officer’s uniform (Miller 2007:132-142).

At least three Royal Navy officer’s buttons have been found at archaeological sites bordering Erebus Bay (King William Island) over the years. These include a high quality button in pristine condition found in 2015 at site NgLj-8. The maker’s mark on button NgLj-8:169 reads “BOGGET & REYNOLDS” (Stenton 2016:pers. com.), a

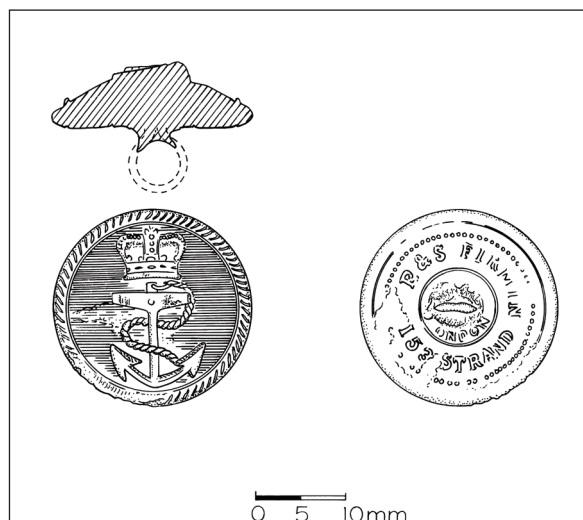


Figure 6.3.2: Royal Navy button, 89M52M200-3 (Drawing: C. Pillar, Parks Canada; 89M52M200-3).

prominent Navy supplier from London (Nayler 1993:14-15). The collection of Franklin relics at the National Maritime Museum holds many buttons of various types, including three Royal Navy officer's buttons (NMM, AAA2042) obtained by John Rae at Repulse Bay in 1854; three Navy buttons (AAA2091, 2 and 3) obtained at Cape Victoria in 1859 by McClintock, and two others (NMM, AAA2239) recovered by Schwatka in 1879 from a grave believed to be that of Lieutenant John Irving at Irving Bay, King William Island (Walpole 2011:51-53).

SHOULDER BELT PLATE

89M32J200-1

This rectangular brass shoulder belt plate (9.5 by 7.5 cm) is decorated with a crowned lion *statant guardant* above a crown, and two banners (Figure 6.3.3). It is made from a slightly concave 1-cm-thick plate with affixed decorative elements. It appears not to be gilded, as no traces of gold were found on its surface (Kavousanaki 2015). The top banner marked "GIBRALTAR" refers to the first battle honour won by the Royal Marines in 1704.



Figure 6.3.3: Royal Marines shoulder belt plate decorated with a crowned lion *statant guardant* above a crown, and two banners, 89M32J200-1 (Photo: M. Wilson, Parks Canada; RA4201EF)

The banner at the bottom of the plate bears the inscription "PER MARE, PER TERRAM", which is the corps' motto, meaning "By Sea, By Land". The two banners and the central crest were added to the plate using small eye-shaped through pins. These pins are locked in place by three small rods visible on the underside. One of the rod holds the central crest and the two others lock the two banners in place. On the underside there are also four hooks to fit on the belt.

The artefact was found face down on the lower deck on the port side of the forecastle, near two uniform buttons (89M99X1-9 and 10) from a British Royal Marine other ranks standard uniform. This belt plate is also part of the 1827 Royal Marine uniform pattern (Parkyn 2014:240-242). Based on its material, design and quality, it likely belonged to one of the two sergeants (non-commissioned officers) from the Woolwich Division that sailed with the expedition (Bradley 2015:pers. comm.), namely Daniel Bryant from *Erebus* or Solomon Tozer from *Terror* (Anon 1845).

A similar shoulder belt plate is in the collections of the National Maritime Museum (NMM, UNI1560), with the only difference between the two the presence of husk flowers on the banners on the National Maritime Museum example. Interestingly, a Royal Marine shako badge was found at Cape Felix, at the northern end of King William Island (NMM, AAA2121). This copper alloy badge was collected by Lieutenant Hobson at an abandoned camp site at Cape Felix, King William Island on May 25, 1859. The camp site was presumably occupied by a small party of Franklin's men in the summer of 1847, and was apparently abandoned in haste (Stenton 2014:519-522).

BELT BUCKLES

89M32K200-1, 89M30K200-4

These two common belt buckles made from copper alloy wire (ca. 1 cm diameter) were found on the port side of the lower deck in the forecastle near the galley (Figure 6.3.4). Each consists of a rectangular frame (5.8-5.9 by 3.7 cm) with a cross piece (bar) welded on top. The wires are flat on one side, and curved on the upper side. Their prongs are still in place. This type of buckle was usually used to fasten a belt around the waist or to adjust a shoulder strap on a bag (Barthorp 1982:68, 70).

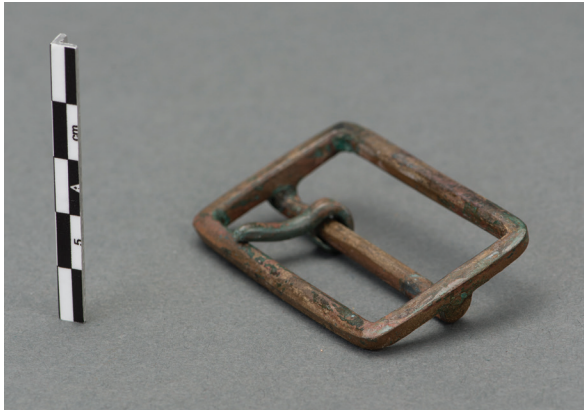


Figure 6.3.4: Common belt buckle made of copper alloy wire, 89M30K200-4 (Photo: M. Wilson, Parks Canada; RA4025).

They could have formed part of a Royal Navy or Royal Marine uniform(s) and could relate to a Royal Marine shoulder belt plate found nearby or other uniform elements.

TEXTILE

89M38J200-7

The piece of textile (14 cm wide) was sampled from a larger garment (ca. 60 cm long) found in 2015 on the lower deck that was left in situ. This piece of beige, knit wool is decorated with two dark blue stripes and a wide light blue band (Figure 6.3.5).



Figure 6.3.5: Piece of textile sampled from a larger garment found on the lower deck, 89M38J200-7 (Photo: M. Wilson, Parks Canada; RA3981EF).

The blue yarns were coloured using indigo in both instances (Kavousanaki 2016). This type of stockinette stitch is not uncommon for sweaters, mittens or scarves (Lafèche 2015b; Mickeljohn 2016:pers. com.). This piece of textile was found in a cabin on the port side, next to boot 89M38J200-8 (Feature 4, sub-operation 38J) and was sampled from a much larger piece left in situ.

BOOT

89M38J200-8

This largely complete boot is of a hand-stitched welt-type construction, as machinery for sewing leather uppers and sole bottoms was introduced in 1856, a decade after the *Erebus* and *Terror* sailed (Figure 6.3.6) (Pratt and Woolley 2008:71-76; Mickeljohn 2016:pers. com.). The slender sole (possibly rubber) is crooked to fit a left foot (28 cm or 11 in. long). The inside of the boot has a liner and the back is reinforced. The vamp has a pointed, square toe and meets with the quarter at mid-length. This patent leather or “ironed hide” body is completed by what seems to be an integrated gaiter, made of an unknown fabric. The upper part and a thick smooth leather strap with five holes are collapsed inside the boot; this is believed to be part of an attachment system, made to fit vertically along the ankle. The upper seems to have been lined with fur, possibly only its upper edge. Indeed, thick patches of short black hairs were found inside the boot, and identified as seal (*Arctocephalus* sp.) (Lafèche 2016). Tacks are visible around the heel and elsewhere under the sole; X-radiography examination clearly shows small tacks around the sole. This boot must have been well-used by one of the crew members, since the portion of the sole under the ball of the foot is worn out. Based on its quality and design, it is most certainly a fashionable civilian cold weather product belonging to one of the officers (Mickeljohn 2016:pers. com.). This boot was in fact found in an officer’s cabin amidships on the port side (sub-operation 38J), next to the textile fragment (Feature 4).

The boot was found filled with mud, bivalves, some wood splinters and possibly other material. Laboratory excavation of its contents and treatment have been completed. The excavation was undertaken in order to allow sampling of the inner sole and back pieces, all the while limiting contamination as much as possible. Six small 1 cm by 1 cm



Figure 6.3.6: Largely complete boot, 89M38J200-8 (Photo: T. Boyer, Parks Canada; 89M07545EF).

leather samples were collected and sent for human DNA extraction and sequencing (Schmerer 2003) at Lakehead University's Paleo-DNA Laboratory. It was expected that some human skin fragments or blood may be found on high friction points in the boot, providing a possible hint to the identity of its wearer. Indeed, a mitochondrial DNA profile was retrieved from the boot samples (Fratpietro 2016). The DNA profile that was sequenced could be indicative of haplogroup P4a (16319A), specifically found in Southeast Asia/Australia, or haplogroup R (16319G), very widely distributed but most common in West Eurasia. This data will be compared with different datasets related to the Franklin expedition in an attempt to find the identity of the bearer.

6.4 HEALTH AND HYGIENE

Finds in this functional group can be linked to the surgeon's tools and pharmacy, as well as personal belongings used by officers and seamen alike for medicinal and personal hygiene purposes. Only three objects recovered to date could be part of this group (based on either their original intended use or later reuse) but they might in fact be associated with food preservation or preparation, or some other undetermined function.

OINTMENT POT

89M30K200-5

This small, fine white earthenware cylindrical container or "ointment pot" bears the stamp "1 oz" on its underside (diameter 6.1 cm; height 2.8 cm) (Figure 6.4.1). Vessels in this classic shape were used for selling various products, typically shaving cream, shoe polish and facial cream. They sometimes contained fine condiments like anchovy paste. The covers of similar ointment pots, absent in this case, were often decorated with decals promoting the product and its maker. The pot contained a clay-like substance upon recovery, later identified as natural silt deposition. No traces of its original contents could be detected. It was found on the lower deck next to a mass of concreted percussion caps, two belt buckles and other objects in the forecabin on the port side of the galley (Feature 2).

PESTLE

89M34K200-9

This small, 18.5-cm-long ceramic pestle is an emblematic artefact, one which would have belonged to any physician of the mid-nineteenth century. It has a bulbous, oval end (4 cm diameter) that tapers to a smaller spherical end to form a handle

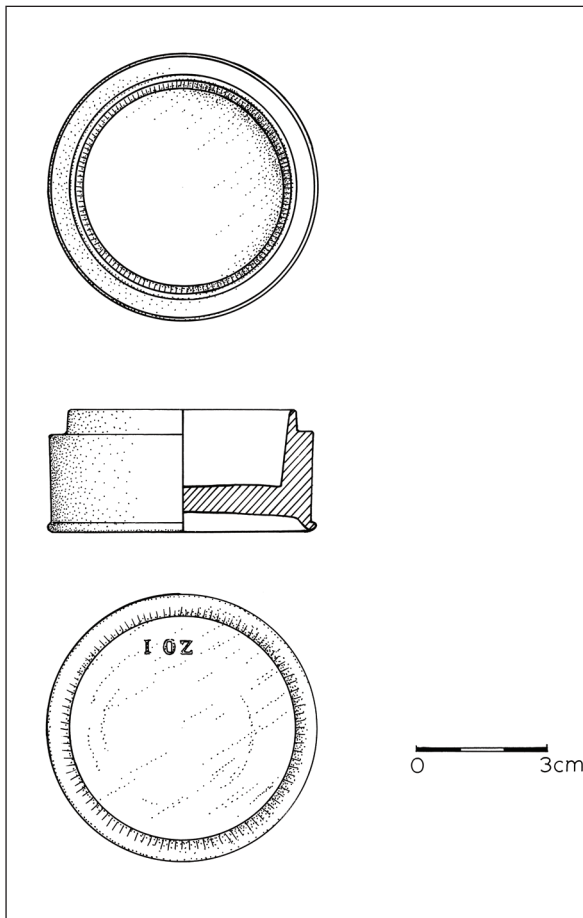


Figure 6.4.1: Fine white earthenware cylindrical container or “ointment pot”, 89M30K200-5 (Drawing: C. Pillar, Parks Canada; 89M30K200-5).

(Figure 6.4.2). The wider end is marked “2” on its side, undoubtedly because it was part of a set with multiple sizes. This object may well have been used for other purposes than medicine, such as paint or food preparation (Romieux 1986). The crushing part of this pestle was analyzed for any trace elements that could indicate what substance it last ground, without any success. This artefact was found in the officer’s cabin area on the port side of the lower deck amidships next to an artificial horizon 89M34K200-6, a sword hilt 89M34K200-5 and a fireplace broom handle 89M34K200-9 (Feature 3).

PHARMACEUTICAL BOTTLE

89M99X1-8

This artefact is a glass medicine bottle marked with embossed lettering “SAMUEL OXLEY” on one side and “LONDON” on the other (Figure

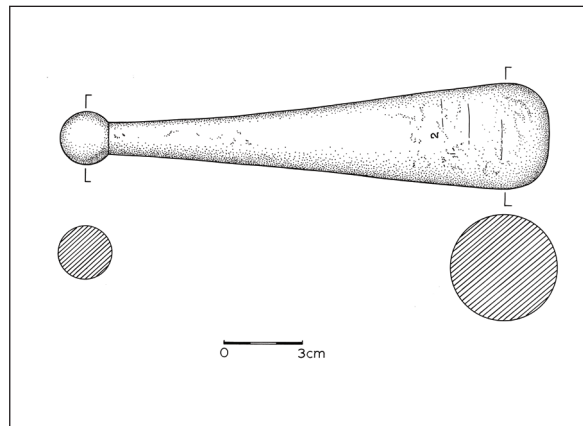


Figure 6.4.2: Small ceramic pestle, 89M34K200-9 (Drawing: C. Pillar, Parks Canada; 89M34K200-9).

6.4.3). The octagonal, colourless glass bottle (4.3 by 3.2 cm in section) has a short neck with a well-defined flat lip. Its overall height is 12.5 cm. Samuel Oxley was a royal chemist who invented and sold a “Concentrated essence of Jamaican ginger root” beginning in 1806. Despite contemporary criticism (*The Medical Observer* 1806), Oxley claimed his medicine could relieve and cure “Rheumatism, Indigestion, Windy Complaints, Nervous Head-ach and Giddiness, Hypochondria and Lowness of Spirits, Anxieties, Tremors, Spasms, Cramp, Palsy, etc.” It seems this product saw some popularity and was sold for many years for self medication. Indeed, it was commercialized by many up to the twentieth century (Figure 6.4.4). Oxley’s essence of ginger is mentioned in multiple editions of medicinal recipe books, for years to come, such as the *Cyclopaedia of Practical Receipts*, even up to 1892 (Cooley 1892:682).

This bottle was found in the lower deck forecabin (Feature 2), and filled with an unidentified muddy substance. To our surprise, the bottle contained one lead buck shot (0.65 cm diameter) and 18 smaller lead bird shot (0.32 cm diameter). Detailed content analysis performed by Conservation Science staff also found traces of gum Arabic and potassium bicarbonate (Kavousanaki 2016). The former, also referred to as acacia gum (*Acaciae gummi*), is an emulsifier used in a variety of products in the nineteenth century, including paint, food, ointments and creams. It was also part of every standard Royal Navy medicine chest. Potassium bicarbonate, referred to as *Potassae subcarbonatis* (K_2CO_3) is a white salt, soluble in water which forms a strongly alkaline (caustic) solution. It has multiple commercial applications, but was also carried in every standard Royal Navy medicine chest (Royal Navy 1835).

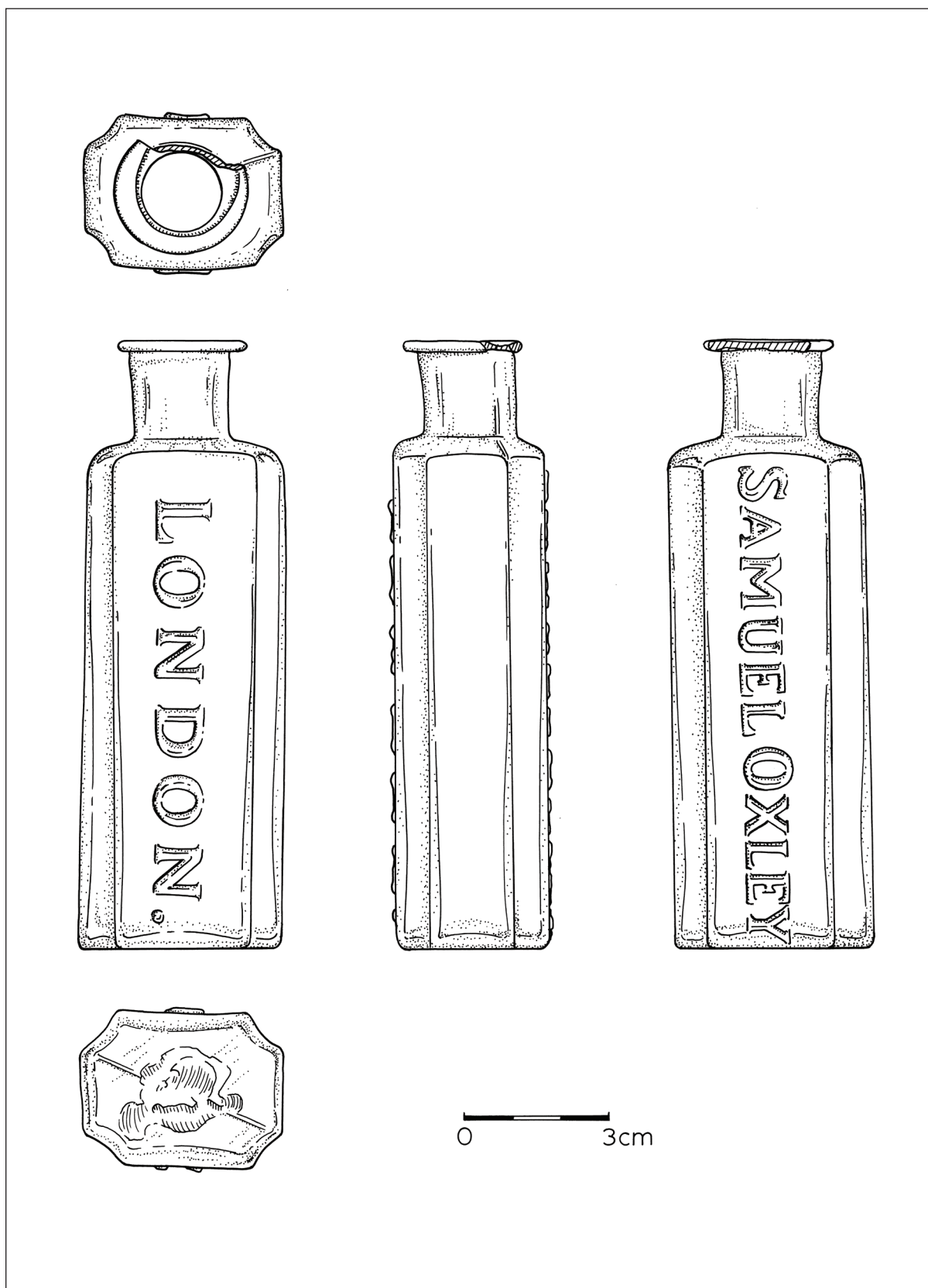


Figure 6.4.3: Samuel Oxley's essence of Jamaican ginger pharmaceutical bottle. It was probably reused at some point to store gum Arabic and-or potassium bicarbonate for an unknown amount of time and was finally used as a bird shot flask, 89M99X1-8 (Drawing: C. Pillar, Parks Canada, 89M99X1-8).

GOUT AND NERVOUS COMPLAINTS.

Rheumatism, Indigestion, Windy Complaints, Nervous Head-ach and Giddiness, Hypochondria and Lowness of Spirits, Anxieties, Tremors, Spasms, Cramp, Palsy, &c.

OXLEY'S CONCENTRATED ESSENCE of JAMAICA GINGER. This most valuable Preparation has received the sanction and recommendation of some of the first Medical Practitioners in the United Kingdom, who have witnessed its great effects in the above Complaints.

Sold Wholesale and Retail by the Inventor and sole Proprietor, Samuel Oxley, her Majesty's Chymist, 21, Tavistock-street, Covent-Garden, London; and sold by his appointment by Messrs. Hudson and Co. Haymarket; Tutt, Royal Exchange; Bacon Oxford-street; and by every reputable Vender of Medicines throughout the United Kingdom and America, in Bottles 2s 9d. 4s. 6d. and 10s. 6d. each duty included.

N. B. A letter post paid, inclosing a One Pound Note to the Proprietor, may have a One Pound Case sent to any part of the United Kingdom, that contains equal to five 4s. 6d. bottles.

* * * No Bottle can be genuine but which is signed by the Inventor Mr. Oxley. [618]

Figure 6.4.4: Samuel Oxley medicine ad in *La Belle Assemblée* or *Bell's Court and Fashionable Magazine*, vol. III, July 1 to December 31, 1807.

It is believed that while this bottle might have been acquired for its original contents being Oxley's essence of Jamaican ginger, possibly years before the 1845 expedition, it was later reused at some point to store gum Arabic and-or potassium bicarbonate for an unknown amount of time, most logically aboard *Erebus*. Based on the 1835 instructions, these two chemicals were stored in different bottles each with a distinct shape (Royal Navy 1835:88). This said, it is still possible that cross contamination occurred somehow within the chest during an emergency. The bottle was finally used as a bird shot flask, in other words to store small ammunition for hunting birds. The bottle may not have been thoroughly cleaned when reused for this last purpose aboard the ship and was possibly an improvised container. The lead shot may also have been used to help shake a solution of gum Arabic in suspension. More research will be needed to validate this possible use and how Arabic gum was generally conditioned.

Re-use of glass (and ceramic) containers was frequent in the nineteenth century, but to find such clear evidence of multiple use from the same object through its lifespan is quite remarkable (for example, see Turgeon 1996). For reference, we note that a small mahogany "field" medicine chest (NMM, AAA2224) from *Erebus* or *Terror* was found near Ross Cairn, Point Victory, King William

Island in 1859 by the McClintock expedition of 1857-1859 (Cyriax 1947:1-3); it did not contain the substances found in bottle 89M99X1-8.

6.5 ORDNANCE

This category of artefacts includes naval guns, generally referred to as "ordnance" with related tools and ammunition. Four objects recovered to date are part of this group, namely a light bronze 6-pounder and round shot found inside its bore.

CANNON, LIGHT BRONZE 6-POUNDER, ROUND SHOT

89M99X1-6, 89M58M1-3, 89M58M1-4, 89M58M1-5

One of the two light bronze six-pounders from the stern debris field was raised in 2015 (Figures 6.5.1 and 6.5.2). This Blomefield gun has a typical cascabel with two loops made to insert an elevating screw below the button. This "light" six-pounder is named as such because it is significantly lighter than its predecessor, approximately 680 pounds instead of approximately 800 pounds, and thus rapidly became the standard gun type for both marine and land uses after 1812 (McConnell 1988:41-46). Its length, breach to mouth, is 152.4 cm (60 in.), its overall length is 165.6 cm (65.2 in.) and its bore diameter is 9.1 cm (3.58 in.).

Viewing it from the cascabel towards the muzzle, multiple markings are observed:

- Aiming gradations are chiseled in the base ring;
- Between the vent field astragal and the first reinforcement ring the letters "GR" and number "3" are encircled by the motto "HONI SOIT QUI MAL Y PENSE" (middle French: shame on him who thinks evil of it) and a crown atop is the monogram of King George III;
- On the first reinforcement ring, the inscription "I&H King – 1812" indicates that it was cast by John and Henry King at the Royal Brass Foundry in 1812;

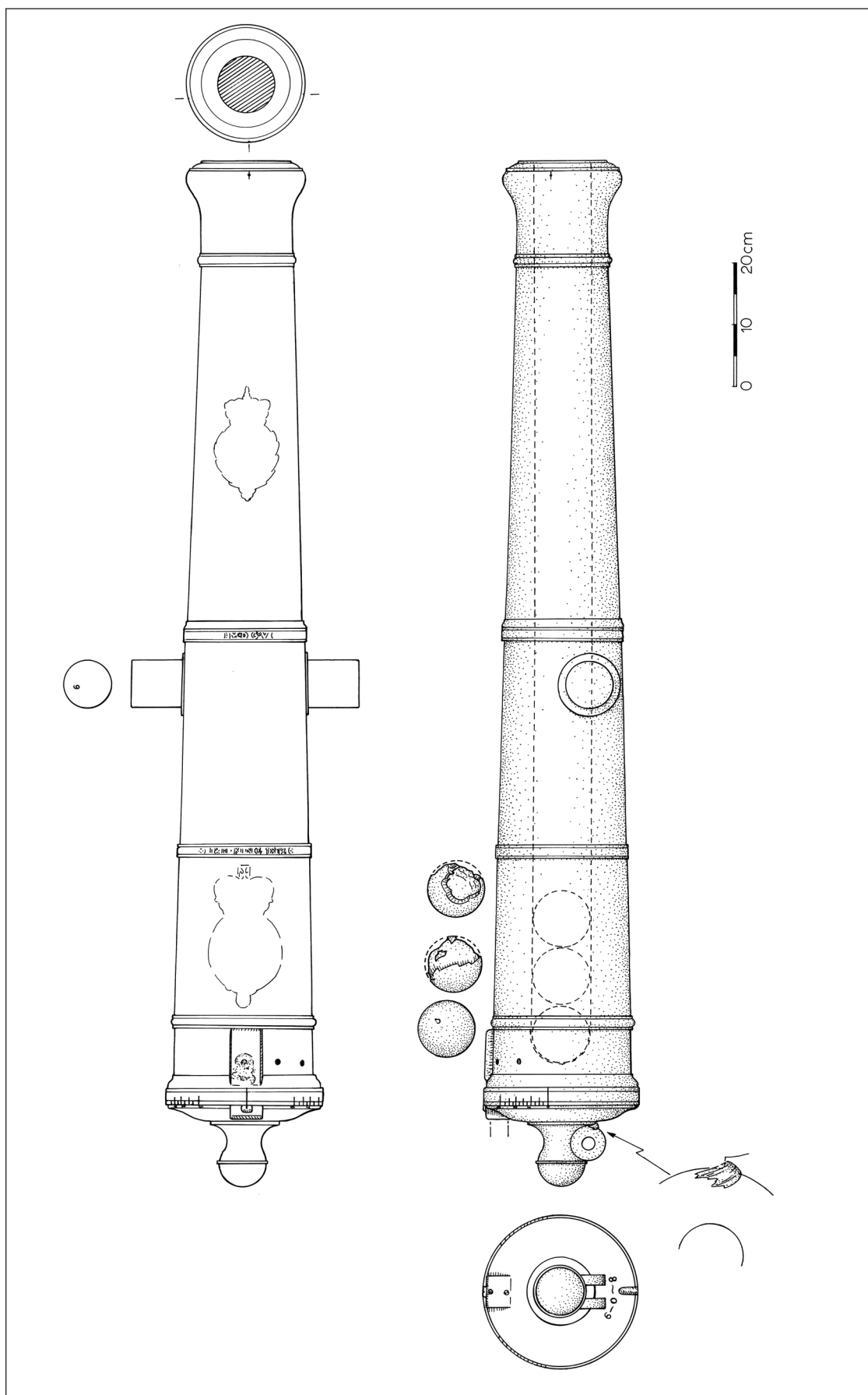


Figure 6.5.1: Light bronze six-pounder cannon (89M99X1-6) raised from the stern debris field and three round shot recovered from its bore (89M58M1-3, 89M58M1-4, and 89M58M1-5) (Drawing: C. Pillar, Parks Canada, 89M99X1-6).



Figure 6.5.2: Light bronze six-pounder cannon raised from the stern debris field, 89M99X1-7 (Photo: T. Boyer, Parks Canada, 89M02750EF).

- The Roman numeral serial number “MDCV” (1605), although partly obscured by corrosion product, is located on the second reinforcement ring; and
- Between the second reinforcement ring and the muzzle astragal, a large monogram “M” stands for Henry Phipps, First Earl of Mulgrave, Master General of the Ordnance (Blackmore 1976:43-45).

This bronze cannon was made to fire 6-pound cannon balls. The weight of the cannon itself is indicated on the breech end, beneath the cascabel: “6-o-8” denoting that the gun weighs six hundred-weights (672 pounds), 0 quarter hundred-weight, and 8 pounds, for a total of 680 pounds (McConnell 1988:44-50). There is also a “6” or “9” on the face of the left trunnion. Although partly obscured by corrosion, the number “[...] f 60[8]” is stamped beneath the gun. Two small attachment holes on the second reinforcement, on both sides of its longitudinal axis, may have been used for mounting a sight. Two other small holes are visible next to the vent patch, a raised block typically used to mount a gun lock (Blackmore 1976: 248). A small cylindrical brass “vent insert” is also present in the vent patch.

This cannon is one of three guns reportedly on board *Erebus* for its last voyage (Admiralty Records 1845). Although it is dated 1812, most dimensions for this brass gun are very close or identical to specifications from “*Aides Mémoires to the Military Science*”, vol. I, 1845-1846 (McConnell 1988:50).

Nearly identical British bronze six-pounders can be found at the Armouries of the Tower of London and Fort Beauséjour – Fort Cumberland National Historic Site in New Brunswick, Canada (Blackmore 1976:81). Such bronze naval guns were likely part of numerous British casts made in preparation for the War of 1812; they remained in use for many years and were fitted on different ships through time (McConnell 1988:49).

Laboratory excavation of the gun’s bore was undertaken in June 2016. A small window glass fragment (89M58M1-2) and three solid round shot (89M58M1-3, 4 and 5) with a diameter of 9.0 cm each were recovered from the bore of the gun during the excavation. A rope fragment (89M58M1-6) was also found in the elevation screw loop; its function is unclear and it may have ended up at this location by accident. The window glass fragment almost certainly originates from one of the stern cabin or skylight window panes, given that the gun was found at the stern and most likely fell from the upper deck as the stern partially collapsed during or after wrecking.

The three shot were found in situ at the back of the bore. Interestingly, no powder charge, nor any wad or wadding remains were found behind the shot, meaning that the gun was not loaded or ready for firing. The presence of three shot without a charge (unusual in and of itself) may have been to prevent the gun from being used upon desertion of *Erebus*. Careful observation of the gun’s vent revealed that it had not been significantly and intentionally damaged so as to render the gun inoperable (i.e. spiked).

While no wooden gun tampion has been found on site so far, an example was found by the Schwatka expedition reportedly at Starvation Cove (NMM, AAA2375) and was believed to have come from the wreck sunk to the west of the Adelaide Peninsula. The tampion’s tapered inner end was measured by UAT archaeologists in 2013 as 10.7 cm or 4 3/16 in. in diameter, thus it could not have been used for one of *Erebus*’ six-pounders as their bore diameters are 9.1 cm. Indeed, the tampion is marked with “B↑O 12” denoting it as being for a 12-pounder gun.

6.6 EDGED WEAPONS, FIREARMS AND AMMUNITION

LEAD SHOT AND BIRD SHOT,

89M28K200-2, 89M32K200-2, 89M32K200-3,
89M34K200-3, 89M28K200-1

Three lead shot of similar calibre (1.6-1.7 cm diameter), a concretion of approximately 40 percussion caps, as well as one lead buck shot (0.65 cm diameter) and 18 smaller lead bird shot (0.32 cm diameter) found inside pharmaceutical bottle 89M99X1-8 (as discussed above) are part of the assemblage of small arms ammunition. They were all found on the lower deck on the port side of the galley.

The lead shot were likely cast from a mould, as evident by the remains of a sprue on each. These were made to be fired from a smoothbore muzzle-loading firearm, such as a musket or pistol. Eleven lead shot from the Franklin Expedition were found at a supposed abandoned camp at Cape Felix by the McClintock Expedition in 1859, and another example was found by the Schwatka Expedition in a boat near the shore of *Erebus* Bay (King William Island) in 1879. All eleven examples, now held by the National Maritime Museum, have a diameter of 1.6 cm (NMM, AAA2124 and 2295). A great number of bird, buck and musket shot have been found at archaeological sites on the shores from Cape Felix on King William Island to as far south as the Back River (for example Stenton 2014:511-514).

PERCUSSION CAPS

89M30K200-6

A small mass of percussion caps was found corroded together on the lower deck in the forecabin; they appear to have been originally held in a container, possibly a pouch, that has since degraded and disappeared. The concreted mass holds approximately 40 unused, four-flanged (top hat) type percussion caps, a variety used predominantly by the British military (Gooding 1966a, 1966b) (Figure 6.6.1).

Percussion caps are small, copper alloy cylinders (height 0.9-1.0 cm; external diameter 0.6 cm) closed on one end that contained a small explosive

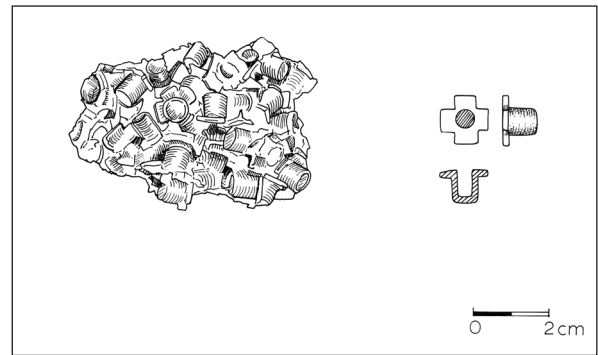


Figure 6.6.1: Corroded percussion caps (lot 89M30K200-6 (Drawing: C. Pillar, Parks Canada; 89M30K200-6).

charge typically made of fulminate of mercury, chlorate of potash, and powdered glass. They were stored in tin magazines, pulp bags, and glass or ceramic containers with a wide opening, and ultimately placed inside a patent leather pouch worn on a uniform belt when in use. Percussion caps specifically associated with the Franklin Expedition were found by the 1857-1859 McClintock Expedition in an abandoned boat on King William Island (Stenton 2014:520). As well, numerous percussion caps from the Franklin Expedition have been found at archaeological sites on King William Island.

While lead shot was ubiquitous at the time of sailing of *Erebus* and *Terror* in 1845, percussion caps were fairly new. They had been adopted by the Royal Navy starting in 1836 and a number of firearms equipped with flintlock mechanisms were later converted to use percussion caps by the Royal Navy (Blackmore 1969:167-179).

During the archaeological investigation of the wreck of HMS *Investigator* in 2011, the UAT recovered an 1839 pattern musket (77M38N1-1) which was the first type of percussion musket mass produced for the British military. In addition, percussion caps were collected from McClure's Cache, a mass of stores and equipment deposited on the shore of Mercy Bay (Banks Island) following the abandonment of HMS *Investigator* in 1853-1854.

Inuit oral tradition brings an interesting angle to these artefacts. During the Fifth Thule Expedition (1921-1924), Knud Rasmussen noted that when Inuit first visited the *Erebus* "they said a quantity of percussion caps they found were "little thimbles", and they really thought that among the white men there lived a dwarf people who could use them" (Rasmussen 1931:130).



Figure 6.6.2: Comparison of the *Erebus* sword hilt 89M34K200-5 (left) and a similar British Royal Navy officer's sword from Parks Canada's historic object collection, X.75.58.2 (right). Both are 1827 pattern swords. Note that sword hilt X.75.58.2 is approximately scaled to the *Erebus* hilt (Photos: T. Boyer (left) and M. Wilson (right), Parks Canada; 89M07627EF, 89M07630EF, RA3858EF, RA3862EF).

SWORD HILT

89M34K200-5

This 1827 pattern Royal Navy officer's sword hilt was located on the port side of the lower deck near the galley (Figure 6.6.2). Its hilt, with a half basket guard, is made of gilt brass and decorated with a typical crown and fouled anchor badge. The folding rear guard section is broken off and missing. Its pommel has the shape of a lion's head. The shark skin cover, degraded or missing, on a wooden core grip, was bound with gold-plated copper (the latter with lead impurities), collectively partly corroded and discoloured. Two strands from the sword knot are still attached to the guard. The sword knot is made of silk with gold-plated silver (with copper impurities) threads woven in; future examination of this cordage might indicate if it has Royal Navy blue or Royal Marine scarlet median strings within the gold borders (Bradley 2015:pers. comm.). A similar sword is held by the National Maritime Museum (NMM, WPN101); another example can be found in Parks Canada's historic object collection (PC, X.75.58.2).

It is noteworthy that the blade is missing from the hilt. It is possible that the blade was broken or corroded away on account of natural processes, or that it has yet to be observed on site. It is also possible that the blade was intentionally separated from the hilt while the vessel was still afloat, possibly on account of Inuit visitation to the ship, although there is no direct evidence to support this supposition. This notion stems from the fact that a sword blade was acquired from Inuit by the McClintock expedition in 1859, somewhere between the Boothia Peninsula and King William Island (Figure 6.6.3). The Inuit knife is now held

at the National Maritime Museum, Greenwich (NMM, AAA2104). McClintock describes the relic as follow:

I also purchased a knife which had some indistinct markings on it such as ship's cutlasses or swords usually have; the man told us it had been picked up on the shore near where a ship lay stranded ; that it was then about the length of his arm, but his countryman who picked it up broke it into lengths to make knives (McClintock 1860:226-227).

6.7 HEATING

FIREPLACE BROOM

89M34K200-8

This 48 cm long brass artefact is believed to be a fireplace broom. It consists of a square rod (sided 0.8 cm) with an eye at one end, made from a separate attached piece. The distal end is damaged and partly bent, although its original rectangular shape is recognizable. There are no hairs or fibres remaining on the distal end. This broom was found in the zone of an officer's cabin on the port side of lower deck next to an artificial horizon 89M34K200-6, a sword hilt 89M34K200-5 and a pestle 89M34K200-8.

6.8 LIGHTING DEVICES

Both natural and artificial lighting devices would have been used aboard *Erebus* to light interior spaces. To date, only natural lighting devices have been found at the wreck site, namely a deck prism and patent illuminator used to direct daylight to the cabins, corridors, mess rooms, and Sick Berth of *Erebus's* lower deck. Both of these types of devices are shown in the 1839 upper deck plan of *Erebus*: 11 rectangular prisms and 30 patent illuminators, giving a combined total of 41, at least in 1839 (*Terror and Erebus, Plan of Upper Deck (as Fitted)*, 1839).



Figure 6.6.3: Inuit knife blade recovered by McClintock in 1859 (Courtesy: National Maritime Museum, AAA2014).

ILLUMINATOR, DECK PRISM

89M99X1-3

Originally installed in the upper deck of *Erebus*, this rectangular deck prism (22 cm long; 7 cm wide; 6 cm thick) is made of glass and was used to distribute much-needed daylight to the ship's lower deck (Figure 6.8.1). It was set flush to the decking with the flat side up, making it easy for crew members to walk over it and ensuring that as much light as possible was captured and directed below deck. It was found resting atop the detached section of upper deck situated on the seafloor off the port bow of the wreck and therefore would have illuminated the forecabin on the port side of the lower deck.

ILLUMINATOR, PRESTON'S PATENT

89M99X1-7

This Preston's patent illuminator consists of a round glass prism (16.7 cm diameter), also called a "bull's eye", set into a circular brass rim or flange (23.5 cm diameter) (Figure 6.8.2). The underside of the flange is marked with a largely illegible embossed inscription, most probably "PRESTON

PATENT ILLUMINATOR". The flange is perforated with 24 fastener holes originally used to affix the illuminator flush to the upper deck; one copper nail remains in one of the holes. The top of the glass surface is engraved with a broad arrow and is also chipped in three spots, possibly as a result of removal or replacement at some stage. White putty was found both between the glass and its flange as well as on the underside of the flange where it was seated into a circular hole in the upper deck. Composition analysis revealed that the putty was made of lead and linseed oil (Kavousanaki 2015; Thornton 1998).

This illuminator was found in the forecabin on the port side of the lower deck (sub-operation 28K), along with three ceramic plates, two Royal Marine buttons, a possible tin can rim, all part of Feature 1. It may have come loose and fallen from the large section of the upper deck that once covered this area, but later became detached and moved to the seabed off the port bow of the wreck.

According to an original 1818 patent, "Preston's Improvements in Deck Glass Rims and Safety Glass", the illuminator could have its glass prism replaced with a brass safety ventilating grate to direct fresh air below the upper deck (Preston

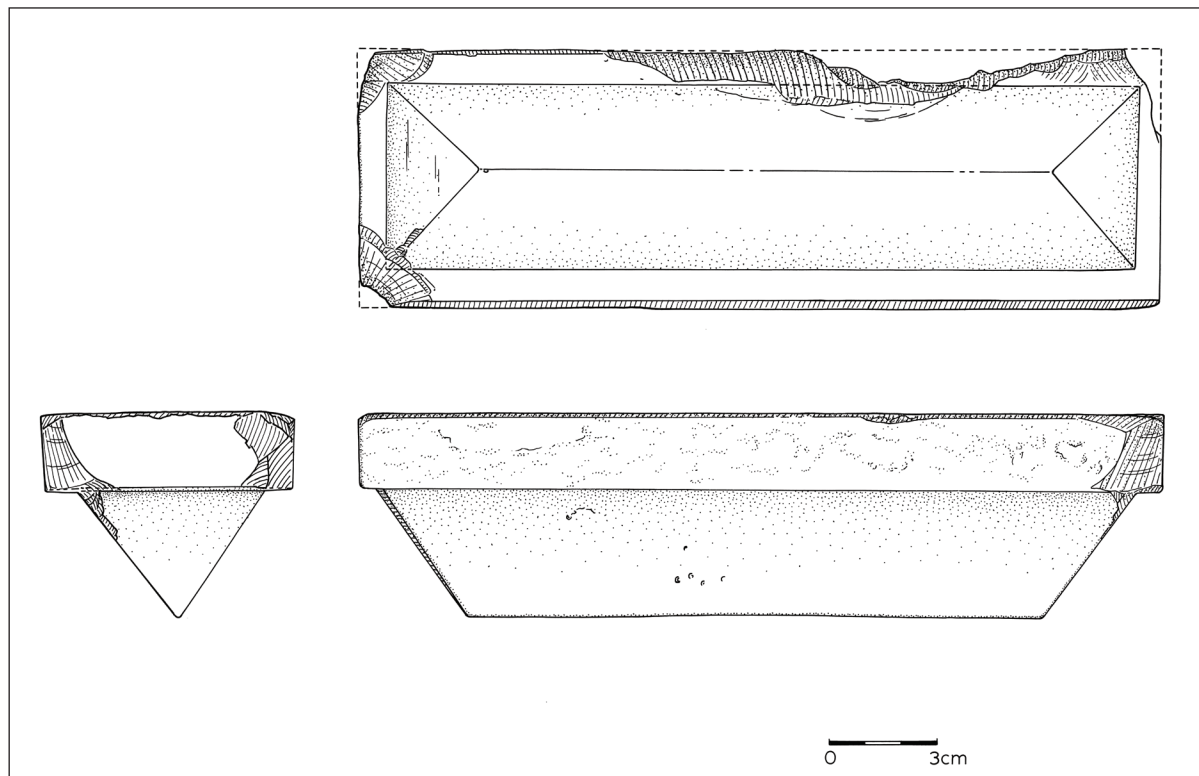


Figure 6.8.1: Rectangular deck glass prism used to distribute much-needed daylight to the ship's lower deck, 89M99X1-3 (Drawing: C. Pillar, Parks Canada; 89M99X1-3).

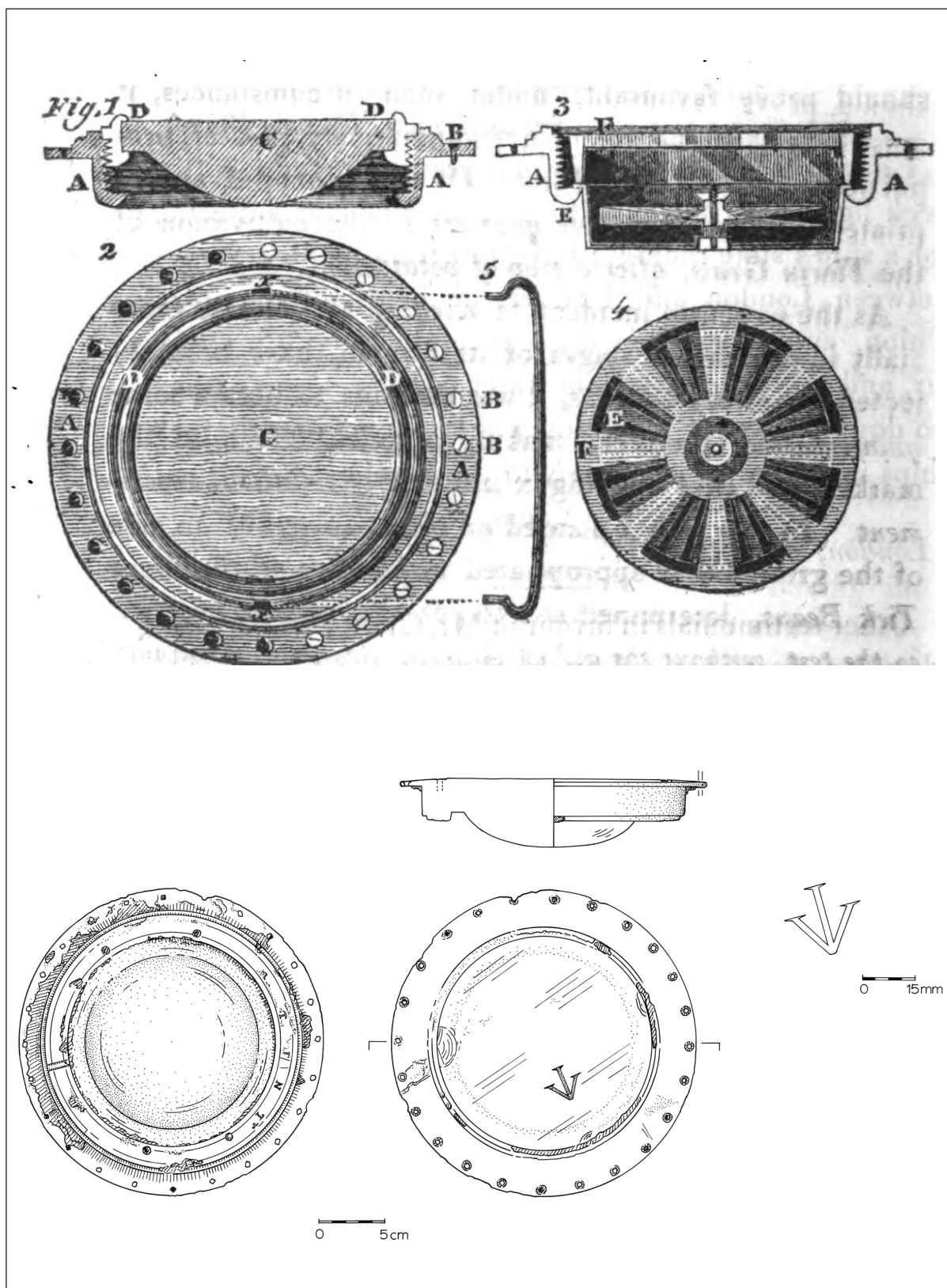


Figure 6.8.2: Preston patent illuminator technical drawing (Preston 1818a:360) (top) and the Preston patent illuminator recovered from the wreck of *Erebus*, 89M99X1-7 (Drawing: C. Pillar, Parks Canada; 89M99X1-7).

1818a, 1818b). The example recovered from *Erebus*, and those observed in situ to date, are of a much simpler and possibly more reliable design, compared with the 1818 patent drawing. The drawing shows a glass prism set into a brass case that in turn screws into a mating threaded case that is set into the deck. The recovered illuminator from *Erebus*, 89M99X1-7, consists of a circular glass prism mounted in a flange that was affixed directly to the deck. It is unclear at present if the present recovered example could also accommodate a ventilating grate.

Preston patent illuminators were first installed in the upper deck of *Erebus* and *Terror* in 1839 immediately before the 1839-1843 expedition to the Antarctic under the command of Captain James Clark Ross. Primary research at the National Maritime Museum has revealed a contemporary chain of correspondence that explain how they came to be fitted to the ship. It was Captain Ross himself who specifically requested on April 23, 1839 that the Admiralty furnish 124 “Preston’s Patent Deck Illuminators” for *Erebus* and *Terror*, considering them “essentially necessary for the proper ventilation of the ships and for the preservation of the health of their crews” (Ross 1839b; Admiralty Records 1839). Writing from *Erebus* at Chatham on May 17, 1839, in response to an Admiralty demand to further justify his request, and now requesting “about 100”, Ross (1839a) wrote:

I beg to acquaint you for the information of My Lords Commissioners of the Admiralty that the peculiar advantage of these illuminators were strikingly manifested in the wholesome & dry state in which by these means the lower deck of the *Hecla* and *Fury* were kept during the winter, thus contributing essentially to the preservation of the health of the officers & crew – They differ from those in ordinary use of the Navy by being capable of being taken out at pleasure, thus allowing the foul air & vapour to escape into a condenser & admitting a circulation of fine [?] air into the cabins & lower deck. The *Hecla* & *Fury* had each about 40 of these illuminators in their Deck [...]

A notation on this letter dated May 18, 1839 stated:

Provide the number suggested by Capt. Ross & if any of [the] Illuminators which were supplied to the *Hecla* are now in store they are to be applied to the *Erebus* and *Terror* in part of this demand ...”

This order is referenced in the Admiralty’s digest of correspondence cited above. A letter from the Storekeeper General at the Admiralty dated May 25, 1839 to the Captain Superintendent of Chatham Yard (Storekeeper General 1839) had the following instructions:

With reference to the Officers’ demand of the 23rd ulto., [April] I have to request you will direct them to receive 22 Preston’s Illuminators from Woolwich Yard, and 78 from Mr. Preston, observing that 100 of these Illuminators are considered by their Lordships sufficient for the *Terror* & *Erebus* instead of 124 as demanded.

It would appear that in 1839 *Erebus* and *Terror* were furnished with 22 Preston patent illuminators from stores, possibly recycled from HMS *Hecla* which was used by Sir Edward Parry during four Royal Navy Arctic voyages and which was sold out of the Royal Navy in 1831, and 78 units direct from the manufacturer. This suggests that two distinct lots of Preston’s illuminators could have been installed on *Erebus* in 1839, each of which might have had different dates of manufacture. It is presumed that most or all of the 1839 illuminators remained in place on *Erebus* for the 1845 Franklin Expedition.

6.9 STEERING

SHIP’S WHEEL (HELM)

89M100A1-2

This fragment of one of the ship’s double steering wheels (approximately 20%) includes portions of two spokes and corresponding handles, all mahogany (Figure 6.9.1). The rim is rectangular in cross section, with carved edges and it was made of multiple wooden components, assembled with lap-joints and copper alloy nails. The remaining spokes are at angles of 35° and 36° centerline to centerline respectively: the wheel therefore originally had 10 spokes (i.e. 10 x 6° = 360°). The

outer diameter of the rim is estimated to have been 120 cm (3.9 ft.). The artefact represents about 20% of one of the original wheels.

Erebus' double wheel, along with the tiller (89M48L100-1), were connected to the ship's rudder and were part of *Erebus'* steering mechanism. *Erebus'* wheel was originally mounted on the upper deck at the stern of the vessel, but was found resting on the seafloor, some 27 meters south of *Erebus'* bow (174° True). Quite remarkably this same wheel appears in a daguerreotype portrait of Lieutenant Henry LeVesconte taken aboard *Erebus* prior to expedition's departure in 1845 (see Figure 6.2.2). Equally remarkable is the condition of *Terror's* wheel, which is completely intact on the upper deck of the wreck. *Erebus'* wheel was likely very similar in shape and dimension.

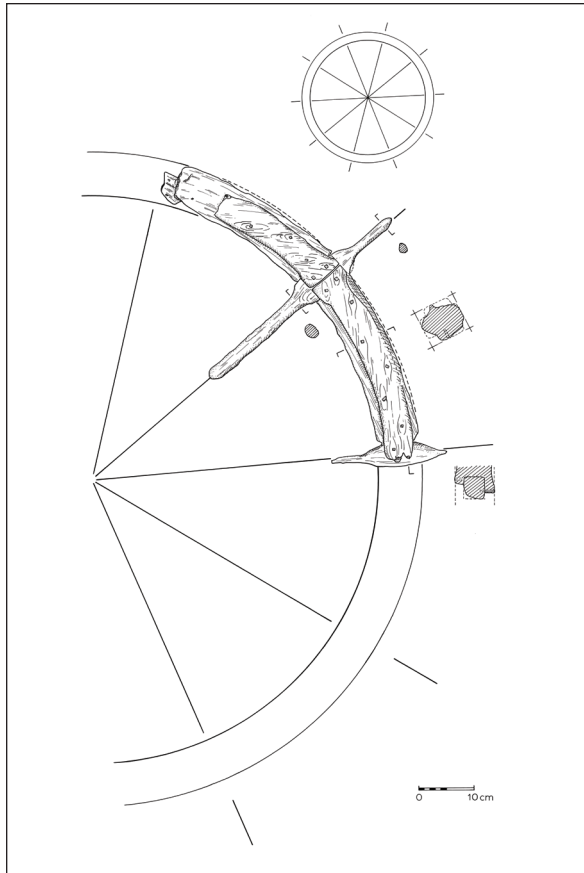


Figure 6.9.1: Part of the *Erebus'* double wheel, 89M100A1-2 (Drawing: C. Pillar, Parks Canada; 89M100A1-2).

6.10 SHIP'S FITTINGS

STANCHION

89M48L100-2

This bronze stanchion for a short railing is fabricated from two welded sections, with its heel-end fastening severely eroded and with an integral eye or loop at its tip (Figure 6.10.1). Its original height from the base of the pedestal to the tip of the eye was 51.7 cm (20 3/8 in.). The stanchion is beautifully constructed and even sculptural, with a rectangular base, octagonal shaft and rounded shape just below the eye. The stanchion's construction was therefore both functional and decorative. Like many other items on the wreck, it is marked with a broad arrow.

This artefact was found on the upper deck along the centerline of the wreck near the stern. It was found lying prone, having been forcibly broken and detached from its original upright position. Indeed, it has a slight bend along its length. It is clear that it once was part of a short railing, given the eye in its upper end for a rope to pass through and join it to other stanchions. Its exact function is not known but it is similar in appearance to small metal stanchions shown in ship plans of *Erebus*, *Terror*, and other Royal Navy ships used in the search for Franklin's lost ships, including for example HMS *Investigator* (see *Profile of the Terror. As fitted for a North-Pole discovery Ship, at this Port. March 1836, 1837, 1845 and Midship Section of the Investigator as fitted for the Arctic Expedition At Messrs. Green's Yard Blackwall, April/48., July 1848, ZAZ6548*). All of these plans show stanchions positioned on the upper deck along the interior side of the bulwarks, whereby they and their connecting ropes were used to stow detachable spars and oars. The artefact recovered from *Erebus* might be too short to have been part of one of these rails however. It could have been for a short railing to secure "Provision Casks" on the upper deck as shown in an 1839 plan of *Erebus*. Alternatively it could have been part of a handrail otherwise not shown in 1839 plans of *Erebus* and *Terror* or not shown in subsequent plan amendments (*Terror and Erebus, Plan of Upper Deck (as Fitted) 1839*).



Figure 6.10.1: Bronze stanchion for a short railing, with a rectangular base, octagonal shaft and rounded shape just below the eye, 89M48L100-2 (Photo: T. Boyer, Parks Canada; 89Mo7603EF).

6.11 NAVIGATION, SURVEYING AND SCIENCE

Artefacts belonging to this group include navigational and surveying instruments, as well as any artefact related to the scientific work conducted aboard *Erebus*. This group includes geographical, magnetic, astronomical, zoological and botanical examination tools, records and potential specimens.

ARTIFICIAL HORIZON, PART

89M34K200-6

This artefact is one part of a roof for a mercurial artificial horizon. The artefact was originally intact and upsidedown when first observed in situ, but was broken into pieces during a storm

in September 2015 and only one part was subsequently observed and raised to the surface (Figure 6.11.1). This artefact was located in the area of an officer's cabin on the port side of the lower deck, next to the sword hilt 89M34K200-5, the fire broom 89M34K200-8 and the pestle 89M34K200-9 (Feature 3). The recovered part comprises a rectangular brass frame (13.5 by 9.5 cm) with an inset glass pane articulated at 50 degrees to another part of the roof frame (Figure 6.11.2). Small metal fasteners are visible on both side edges.

The original artefact observed in situ was composed of two similar glass frames and panes, a plain flat top, and two plain trapezoid sides. The roof was originally used to fit over a rectangular brass tray which would hold liquid mercury. Mercurial artificial horizons were used in conjunction with sextants to determine latitude (whether on land or at sea) at times when the horizon was not visible in low visibility or in the case of Arctic navigation, when obscured by immovable obstacles, such as large ice floes. Captain George Back reported that the Admiralty provided one artificial horizon and a spare bottle of mercury to his 1836 expedition (Back 1838:5). He describes at least two instances of its use amongst the treacherous ice of Hudson Bay:

The land was much raised by refraction, and we seemed to have neared it a little. I say seemed, for, in consequence of a gentle undulatory motion of the ice close to the ship, which, though imperceptible to the eye, was proved by the mercury in the artificial horizon, the observations could not always be relied on as exact.



Figure 6.11.1: Artificial horizon in situ on the lower deck. Note that the roof was found upsidedown as in this photo (Photo: T. Boyer, Parks Canada; 89Mo6500EF).

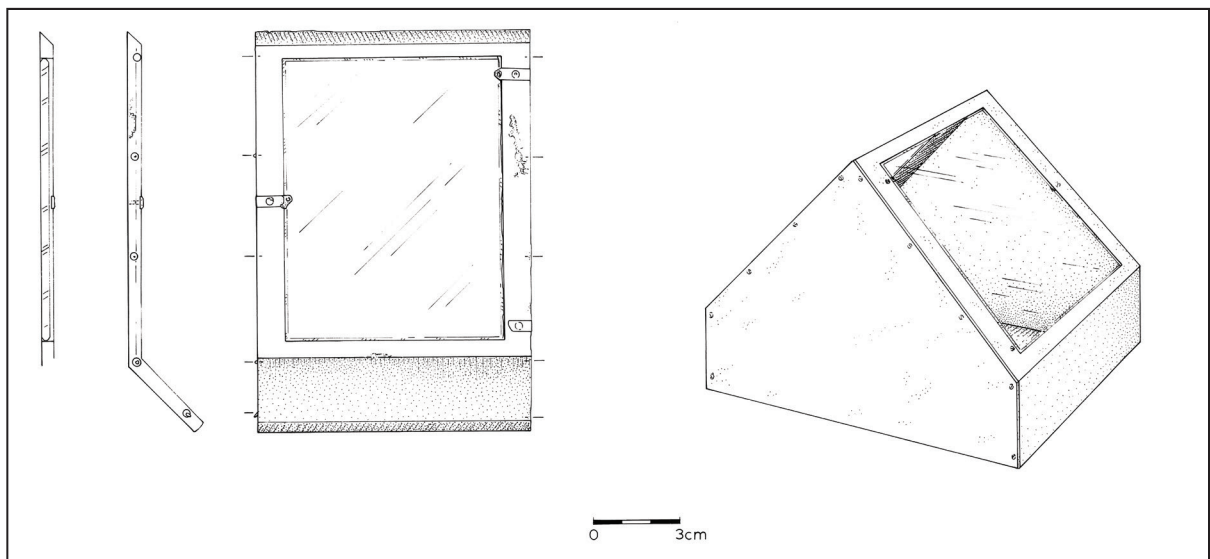


Figure 6.11.2: Recovered artificial horizon part 89M34K200-6 (left) with reconstruction drawing of artefact as found (Drawing: C. Pillar, Parks Canada; 89M34K200-6).

The horizon was still obscured at noon ;
but from sights with the artificial horizon,
the latitude was found to be ...

traces of gilding and find location, it is believed
that it could be part of a scientific instrument, and
ongoing research aims to positively identify it.

Interestingly, a watercolour by Second Lieutenant Owen Stanley of *Terror* made during the 1836-1837 expedition vividly shows an artificial horizon in use in winter quarters in January 1837 (Stanley 1837:19)(Figure 6.11.3). It is similarly shown in use in First Lieutenant William Smyth's *Position of H.M.S. Terror on the 22nd Feby. 1837* that illustrates Back's narrative (Back 1838:238ff.).

At present it is not possible to identify the date of manufacture and name of its manufacturer yet it is possible that identifiers are present on other parts of the object that remain in situ. Comparative examples are found in the collections of the National Maritime Museum, Greenwich (Mörzer Bruyns and Dunn 2009:193, 285-287).

FRAME OF SCIENTIFIC INSTRUMENT (?)

89M52L200-1

This delicate artefact is made of round-profile brass posts articulated with perforated brass sheets that together form a frame (Figure 6.11.4). The object has an integrated mount for a small, cylindrical component, 0.4-0.6 cm in diameter. Its original orientation (i.e. top) is not yet known. It was found at the extreme aft end of the stern cabin at the transom. Given its refined manufacture,



Figure 6.11.3: An officer of HMS *Terror* uses a sextant and artificial horizon (middle bottom) in January 1837 in this painting by Lieutenant Owen Stanley (Courtesy: Thomas Fisher Rare Book Library, University of Toronto, F7383).



Figure 6.11.4: Artefact made of round-profile brass posts articulated with perforated brass sheets that together form a frame 89M52L200-1 (Photo: T. Boyer, Parks Canada; 89Mo7540EF).

KNURLED KNOB

89M34J200-1

This circular knob (4.1 cm diameter) with an integrated cylindrical, stepped stem is made of brass (Figure 6.11.5). There are fine serrations or knurls on the edge of the knob demonstrating that this object may be an adjustment knob for an unidentified instrument. It was found on the lower deck in association with a sextant and the roof of the mercurial artificial horizon. As well, the form of the knob matches comparative contemporary examples in collections at the National Maritime Museum, Greenwich.

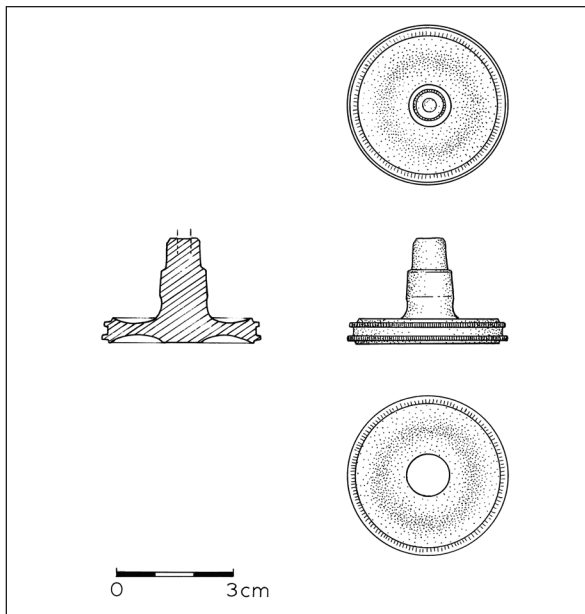


Figure 6.11.5: Brass circular knob with an integrated cylindrical, stepped stem, 89M34J200-1 (Drawing: C. Pillar, Parks Canada; 89M34J200-1).

6.12 FURNITURE AND FURNISHING HARDWARE

LOCK PLATE

89M34K200-11

This brass “notch” type lock plate (5.1 by 4.6 cm), is so named since it was seated in a notch in the wood to which it was fastened. The side face of the plate shows the opening for the movement of the lock bolt, the metal part that blocks the opening of a door or drawer. The mortise is obstructed by an intrusive pebble. It was found on the lower deck to the port side of the galley. While its exact function is not known, this plate would have been used to secure the lock mechanism inside furniture components such as drawers and cupboards. It was recovered in the forecastle along with most of the artefacts from 2015. It may be related to one of the cupboards or stores from the galley.

SCREW HOOK

89M44N100-1

This hook (11.5 cm long) is made of bronze rod which is round in section (0.7-1.1 cm diameter); its threaded tip is 5.5 cm long and its curved hook end is 5.1 cm in diameter. This type of screw hook could have been used to hang or attach a range of objects, such as a lantern, tool or small ropes on a temporary basis. Although this particular example was found on the starboard side of the upper deck amidships, it might also have been used to suspend hammocks between the sides of the upper deck beams.

FURNITURE LEG AND STRETCHER

89M99X1-5

This piece of mahogany furniture consists of a leg and part of an attached stretcher or skirt (Figure 6.12.1). The leg (69.0 cm high) has a square top section and a round (turned) lower section. The stretcher frame piece (1.29 m long, 9.5 cm wide) bears a recess, possibly to accommodate a drawer(s). The end of the stretcher piece has a nipple that suggests it was made to be disassembled. Three wooden fasteners pass vertically through the plank, possibly to attach a table top or to hold



Figure 6.12.1: Leg and part of an attached stretcher or skirt found in the debris field at the stern of the wreck (Photo: T. Boyer, Parks Canada; 89M00740EF).

supports for a drawer(s). The overall leg to leg estimated dimension is 1.39 m (4 ft. 6 in), which indicates likely a 2.5 ft.-high, and 5-ft.-wide piece of furniture, likely a table. Whereas this furniture piece was found on the seabed in sub-operation 54N, a similarly-designed leg and stretcher has been observed on the lower deck in the Captain's Cabin, in sub-operation 52M. This leg's design and one dimension (length 69 cm) are similar to furniture leg 89M99X1-5, although its stretcher is 1.06 m long (including a 5-cm-long tenon) and 12.5 cm wide. The overall leg-to-leg dimension of this piece of furniture would have been 1.12 m (3 ft. 8 in.), possibly representing a 4-ft.-wide and 2.5-ft.-high table. Thus, we may well be facing two different pieces of unknown furniture or a single small 5 ft. by 4 ft. table.

Interestingly, a contemporary artistic representation of Franklin's cabin published in the *Illustrated London News* shows a chart table in the center of the cabin which could be the origin of the leg and stretcher (*The Illustrated London News* 1845).

6.13 SHIP'S ARCHITECTURE

DUMP BOLT

89M32J200-5

This broken tip of a bronze bolt (1.6 cm diameter; 7.2 cm long) was used to nail thick upper deck planking to beams (Figure 6.13.1). This particular fastener variety is called a short bolt or "dump" and has a round cross-sectional shank and a sharp tip with a bayonet-shaped section (McCarthy

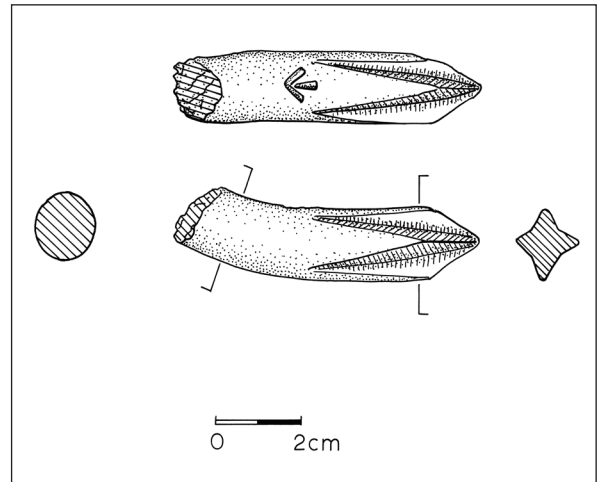


Figure 6.13.1: Broken tip of a cooper alloy bolt used to nail thick upper deck planking to beams, 89M32J200-5 (Drawing: C. Pillar, Parks Canada; 89M32J200-5).

2005:177). This type of bolt was driven through both timbers it was used to fasten, and the tip would have been sunk into its timber attachment substrate. Such dumps seem to have been used extensively across *Erebus'* upper deck. The shank of this particular example was evidently snapped off during wrecking or later structural collapse. Given its location on the lower deck (sub-operation 32J), it probably came from the upper deck and fell to its find location on the lower deck. This artefact was raised specifically to carry out a series of analytical tests to better define its metal composition and manufacture technique, analysis which is not yet complete.

WINDOW GLASS FRAGMENTS

89M52M200-1, 89M58M1-4

Two window glass fragments have been found to date in the stern area, both likely originally parts of window panes from the stern gallery window(s) and/or the skylight(s) above the Captain's Cabin and the Ward Room, all of which admitted natural light into these interior spaces. The original dimensions of the complete glass panes are unknown, given the small size of the recovered fragments. The larger artefact, 89M52M200-1 (18.5 by 7.8 cm, 0.45 cm thick) was found on the lower deck, at the surviving extremity of the Captain's Cabin, underneath a crumpled piece of lead sheet (89M52M200-2). Part of a window pane side is preserved and shows a small area of glass that is scratch free, indicating where the pane was inserted in its wooden frame.

The smaller artefact, 89M58M1-4 (1.9 cm long by 1.2 cm wide; 0.45 cm thick) was recovered from the bore of the bronze 6-pounder gun (89M99X1-6) that rested on the seafloor below the transom. Both fragments are 0.40-0.45 cm thick.

6.14 COMMUNICATION

SHIP'S BELL

89M99X1-1

This object is certainly one of the most iconic artefact from the collection. It was also the first to be recovered in September 2014 and was found on the starboard side of the upper deck, immediately aft and adjacent to the displaced windlass barrel (Figure 6.14.1). Given its find location and standard practice at the time, not to mention the mounting arrangement for the bell shown in the 1839 profile of *Erebus*, it was almost certainly mounted on an arched metal belfry that straddled vertical timbers bracing the windlass (*Terror and Erebus, Profile (as Fitted)* 1839). A bell is not shown in any plan amendments dating to 1845. *Erebus'* bronze bell has a standard bell shape (37.8 cm diameter; 38 cm total height), although its crown has only two ears instead of the usual six (Figure 6.14.2). Upon close examination it appears that the crown

as cast was later modified, probably to accommodate a different mounting system; the two pairs of ears were evidently removed, and a hole drilled through the central crown post.

The weight of this artefact without the clapper is 31.6 kg (69.6 lb.). Although present, its clapper was covered with iron corrosion product upon recovery and thus impossible to observe before conservation treatment. The body of the bell is decorated with multiple raised lines. The date “1845” in raised numerals is found between the two top lines below the shoulder. A raised broad arrow is below the date, at mid height. Although this bell does not bear the ship's name, it was apparently cast just before the expedition, given its date. It is most likely that the mounted, axial orientation of the bell had the date and broad arrow facing aft, given that this way these markings would not have been obscured by the foremast immediately forward of its presumed mounted position atop the windlass. It is also possible that there was more than one bell aboard *Erebus* upon its departure in 1845, that is, in addition to the one found at the windlass on the upper deck. For instance, Captain George Back reported that in navigating HMS *Terror* amongst and around drift ice “... in spite of all our care, the ship would sometimes drive on them with a concussion that made all the bells ring, and almost threw those below from their chairs” (Back 1838:58).



Figure 6.14.1: The bell in situ on the upper deck of *Erebus*, 2014 (Photo: T. Boyer, Parks Canada; 89M00523EF).

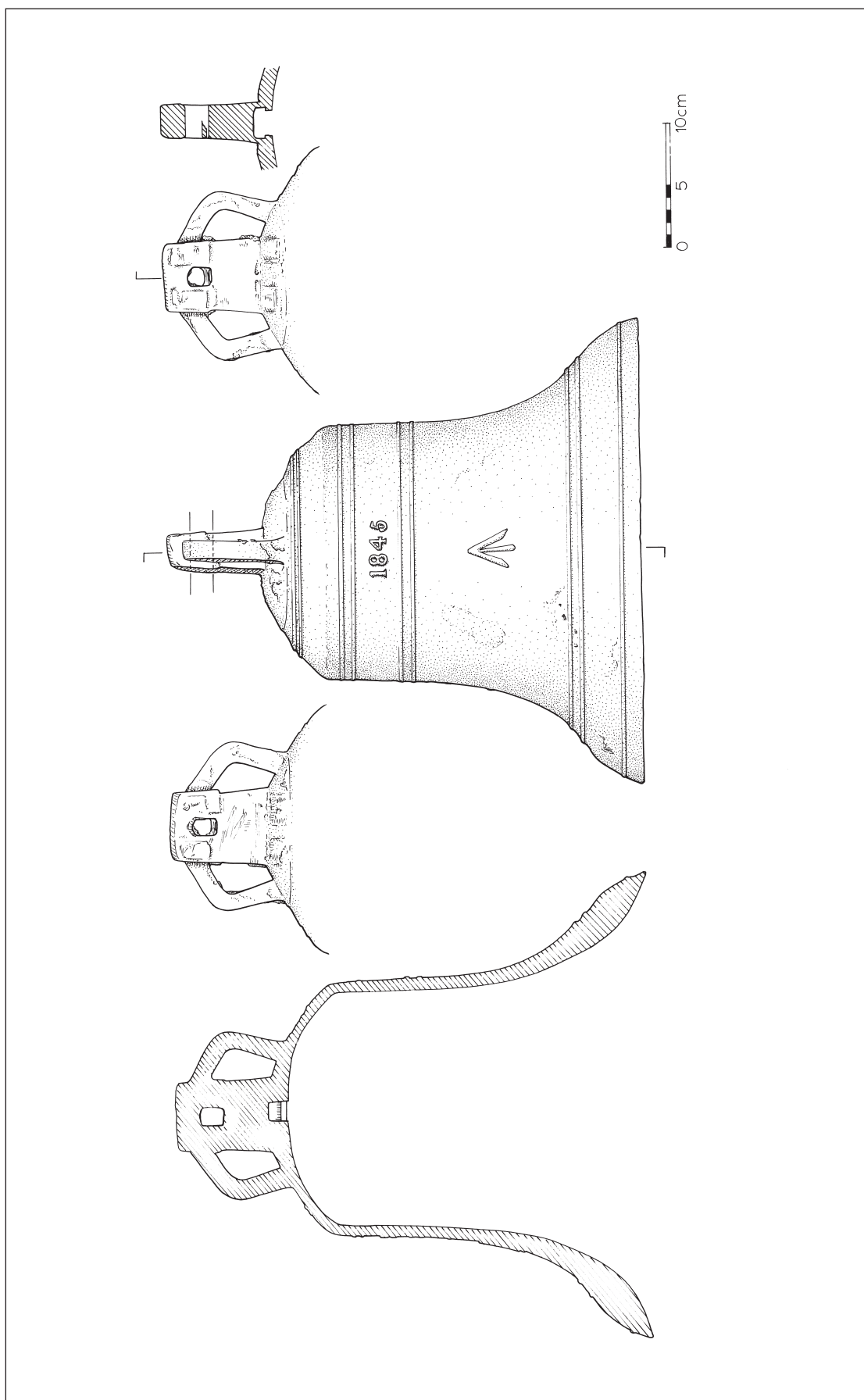


Figure 6.14.2: The ship's bell recovered from the upper deck of *Erebus* in 2014 (Drawing: C. Pillar, Parks Canada; 89M99X1-1).

6.15 UNKNOWN FUNCTION

Four objects from the collection have an unknown function, and in fact could have had multiple applications aboard a vessel like *Erebus*.

KNOB, RECTANGULAR BASE

89M34J200-2

This knob, made of bronze, has a rectangular base (6.7 by 8.0 cm) with an attached pommel sphere in its middle. The top of the knob is perforated, possibly to mount another missing component. An impression of wood grain is visible on the reverse side, along the edge of the base, a possible indication of how the knob was mounted.

SHEET LEAD

89M52M200-2

This object is a partly folded piece of sheet lead (27 cm long, 11 cm wide, and 2 mm thick). It could have been either part of a larger artefact or a fitting attached to the ship. There are no clearly identifiable finished ends or fastener holes to provide clues to its identity. This said, sheet lead was commonly used on ships to patch, line, waterproof and protect wooden structures, or to fashion containers and pipes for storing and moving liquids, such as cisterns and drains. This artefact has a slightly cupped shape. It was found at the stern end of the wreck, at the level of the lower deck, just below where the now collapsed stern gallery windows were situated. Given its location it might have formed part of a window sill or a lining for the stern gallery.

SHEET COPPER

89M32J200-6

This 1-mm thick copper alloy sheet (14.0 cm by 12.7 cm) could be raw material stock or part of a larger object. There are no clearly identifiable finished ends or fastener holes to provide clues to its identity. As was the case for lead sheet, copper alloy sheet metal was used for a variety of shipboard features, including ducts, pipes, containers, etc.

ROD WITH TWO EYES

89M48L100-3

The last object within this category is a small copper alloy rod (0.8 cm diameter; 21.0 cm length) fitted with two eyes, one at each end. The object is flattened near each end where it is pierced with round holes (0.6 cm diameter). Its shape is similar to a stretcher, and it was certainly part of a larger composite artefact.

6.16 ARTEFACT DISTRIBUTION

Artefact distribution plans for the upper deck, lower deck and debris field are presented below (Figures 6.16.1-6.16.4). They should be considered preliminary and simply provide location information only for those artefacts mentioned in the text.

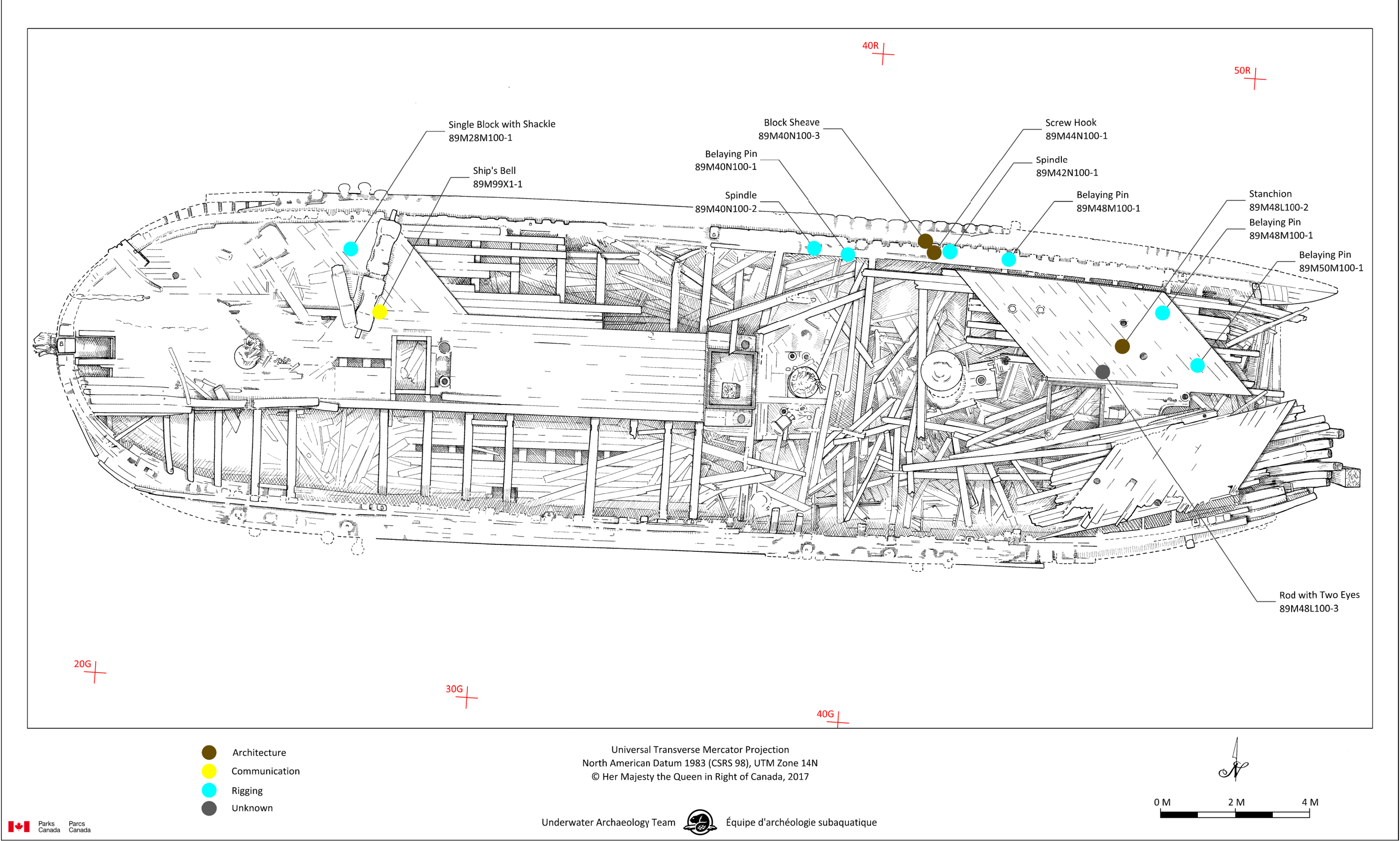


Figure 6.16.1: Distribution of recovered artefacts from the upper deck, 2014-2015 (Drawing: C. Pillar, Parks Canada; 89M-2017-101-1. Image: B. Lockhart, Parks Canada).

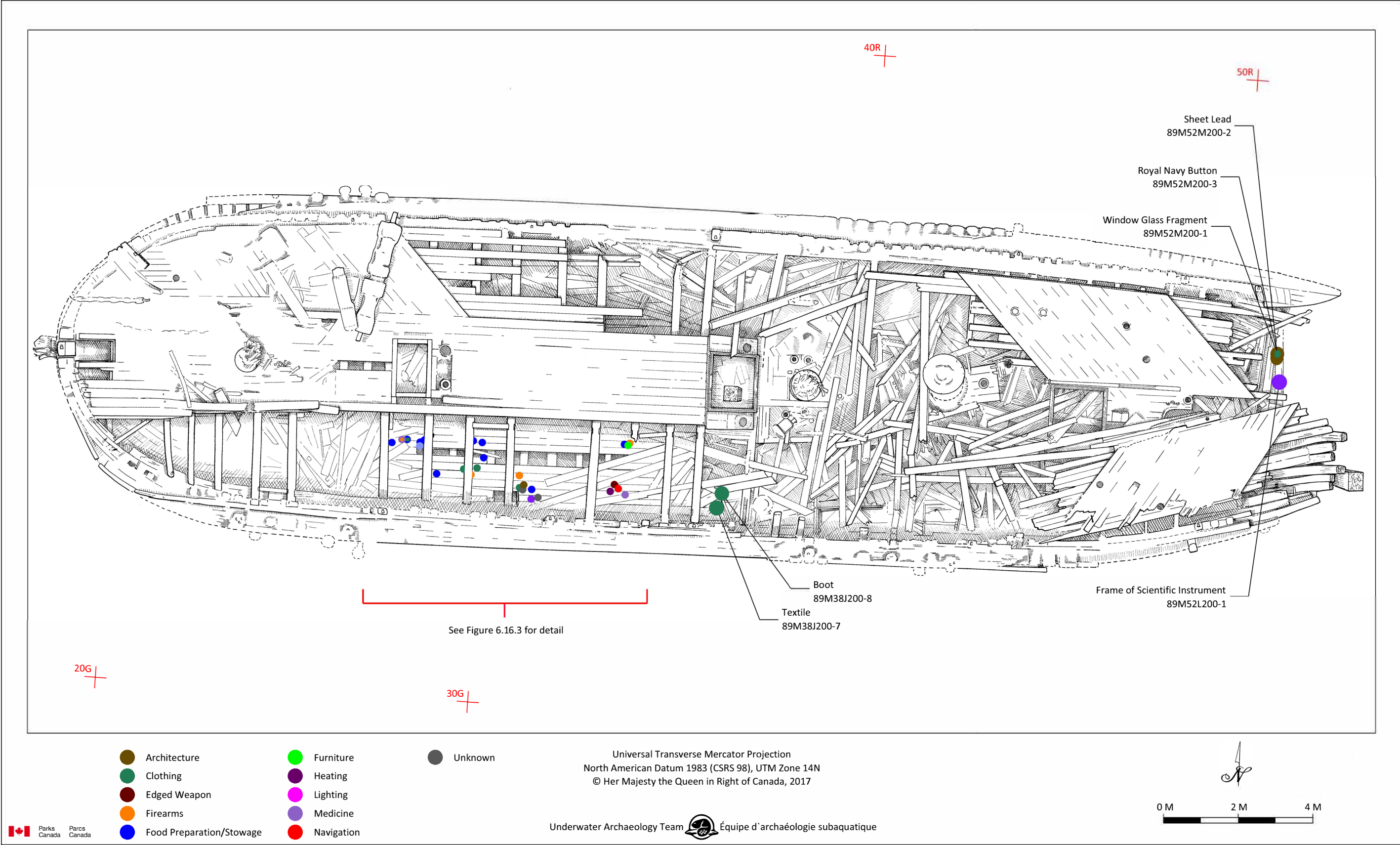


Figure 6.16.2: Distribution of recovered artefacts from the lower deck, 2015 (Drawing: C. Pillar, Parks Canada; 89M-2017-101-1. Image: B. Lockhart, Parks Canada).

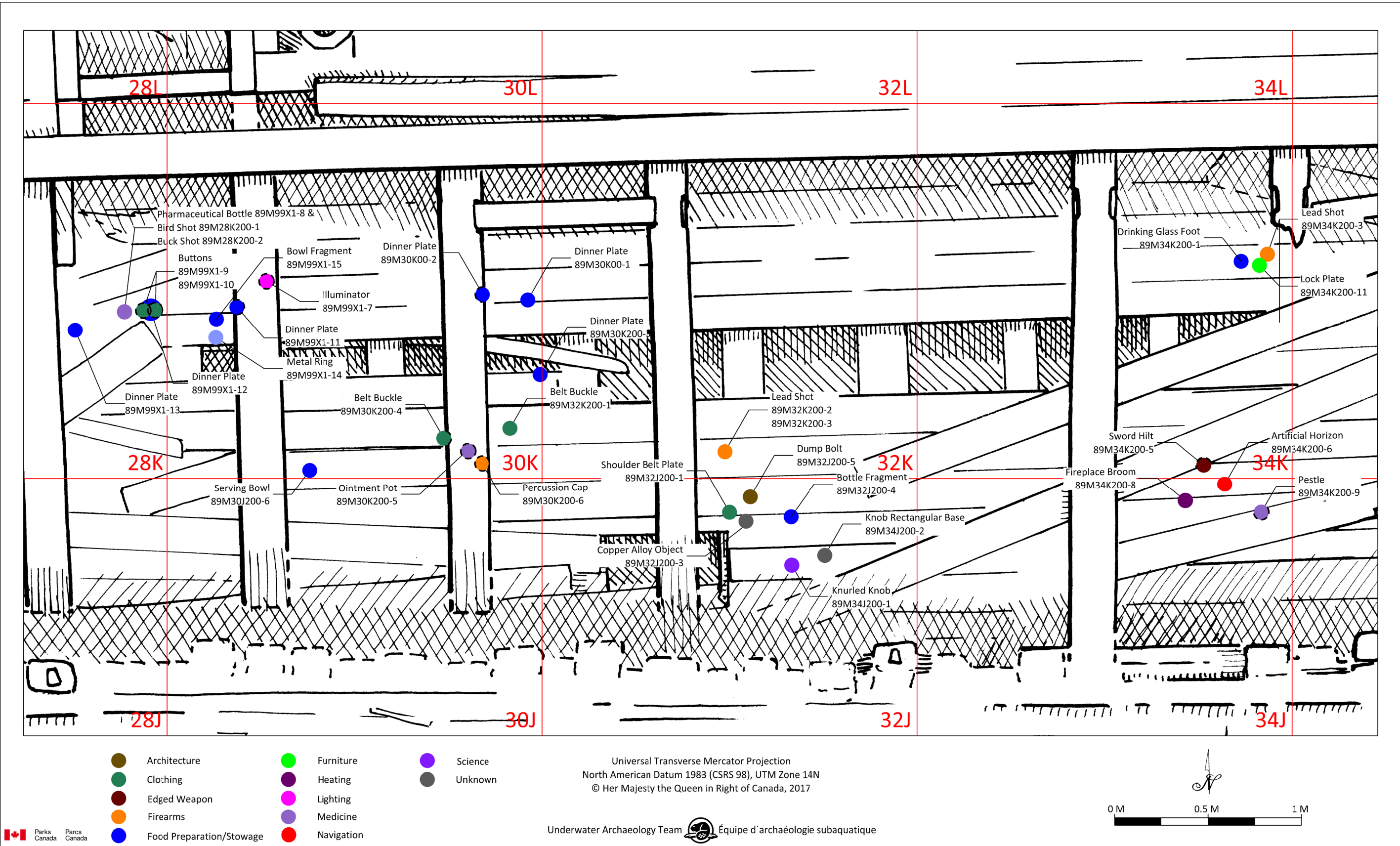


Figure 6.16.3: Detail, distribution of recovered artefacts from the lower deck (Drawing: C. Pillar, Parks Canada; 89M-2017-101-1. Image: B. Lockhart, Parks Canada).

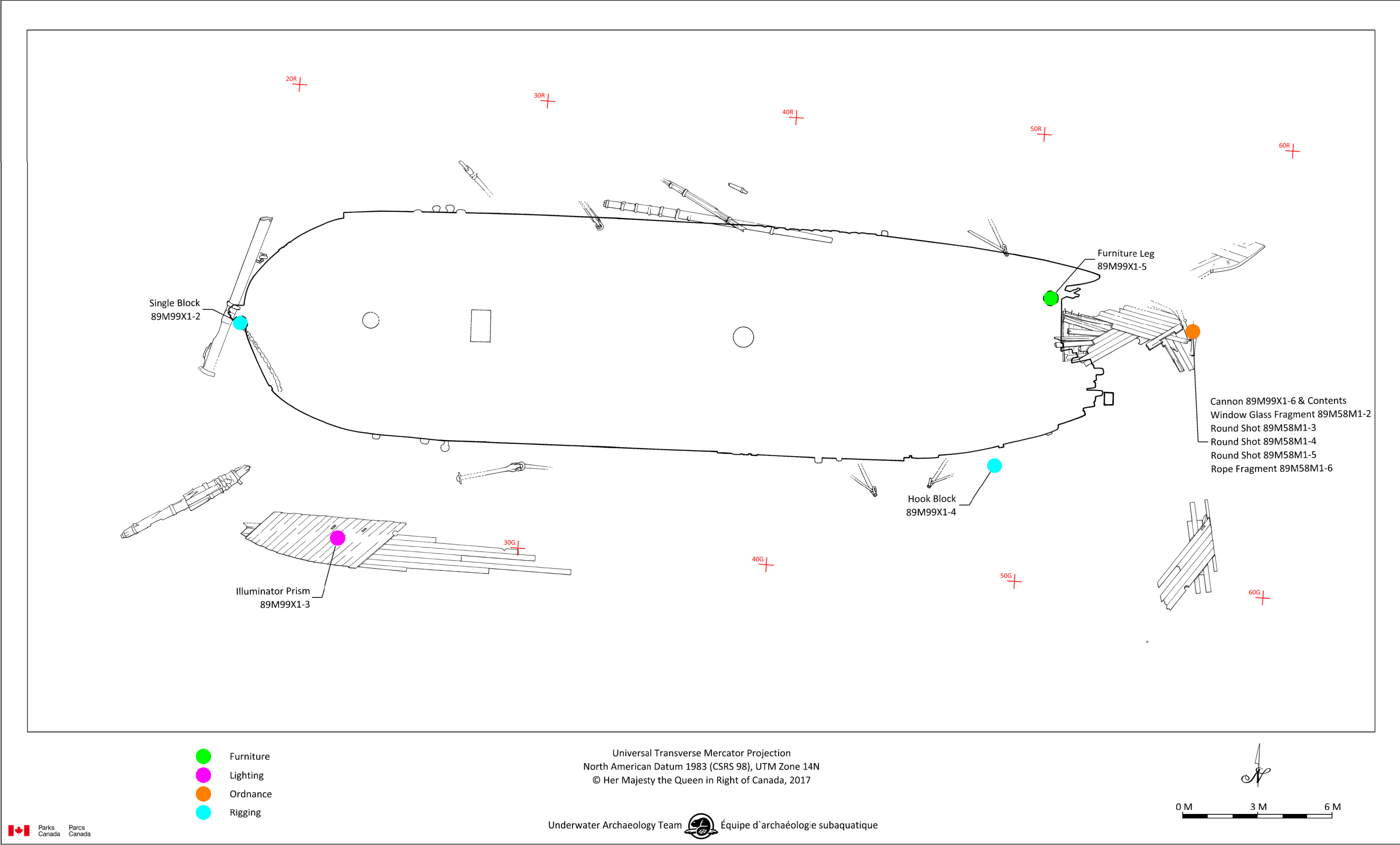


Figure 6.16.4: Distribution of recovered artefacts from the debris field, 2015 (Drawing: C. Pillar, Parks Canada; 89M-2017-101-2. Image: B. Lockhart, Parks Canada).

7. CONCLUSIONS AND RECOMMENDATIONS

The stated purpose of this report is to present the results of the UAT's archaeological assessment of the wreck of HMS *Erebus*. While Sections 1 to 4 set the context and the methodology of the work conducted to develop this analysis, the core of the acquired and analysed data were presented in Sections 5 and 6. This section summarizes some key elements of the evaluation process and results, and points towards future archaeological work on the site.

7.1 SITE ENVIRONMENT

Charles Dagneau

Preliminary observations on the site environment were outlined in Section 4. From these observations, it is possible to identify some of the major environmental factors (N-Transforms) directly affecting the wreck of *Erebus*, as follows: ice formation and movement; wind-generated waves; sedimentation/erosion dynamics; and marine growth.

As noted above, there is great variation in weather conditions over the course of a year in Wilmot and Crampton Bay. The temperature typically varies from -35°C to 9°C in the area, with an average daily high temperature above 2°C in the summer and below -22°C in the winter. In terms of diving conditions, observed water temperatures range from -2°C to +6°C. The tidal range at the *Erebus* site is 1 m or less with minimal associated currents. Cold water and semi-permanent ice coverage typical of the Canadian Arctic, as well as minimal current are factors that have contributed positively to the long term preservation of the site to date.

Thick ice coverage on site between November and July offers protection against wind-generated waves and also likely inhibits the rapidity of marine growth on site. This said, *Erebus* was without a doubt affected by ice action before and shortly after it first sank. The ship's masts and standing rigging projecting from the water or ice surface were certainly broken and dispersed due to both ice and wave action. After years of destructive processes, the site has reached a certain degree of stability with its upper structures and rigging flattened out and may indeed now be beyond the reach of ice effects. Indeed, *Erebus* is located within an

archipelago of small islands and shoals, and thus appears relatively well protected from any large packs of ice floes pushed south through Alexandra Strait upon breakup every spring. As well, the area experiences the formation of single-year ice only, rather than thicker multi-year ice that can form potentially damaging ice keels at pressure ridges that result in scouring of the seabed. Multi-beam echosounder and side-scan sonar data confirm that there is no significant or recent ice scouring on the seafloor in the area. Thus, it is believed that the main damage to the hull at the stern for example is more likely historic and could have been from ice pushing on the mizzen mast while it was still standing, soon after the vessel sank, rather than the result of a large pack of ice running onto the wreck at a later date.

Wind-generated waves are another important factor, and probably the most critical natural threat to the wreck site at present, considering its relatively shallow depth. The islands surrounding the site are very low, thus offering little or no protection against winds. This means that during the summer months the site is subjected to strong winds that generate waves and a swell powerful enough to move wooden timbers and small artefacts on the seafloor, on the upper deck and even within exposed areas of the lower deck. As discussed above, UAT archaeologists have documented the movement of artefacts and loose deck planking on the lower deck caused by a storm in September 2015. Moreover, a section of the upper deck between the fore and main hatches – now detached from deck beams below – was observed to pulse up and down under the influence of a 1-2 m surface swell: this deck section hit against the beams below every few seconds, making adjacent structures tremble at every stroke. Whereas this particular September 2015 storm may have been strong, it was probably not an isolated weather event. Nevertheless, the intensity of the effects of the swell inside the wreck came as a surprise. It might have been partly induced or amplified by the shape of the wreck and its missing upper deck section. As well, kelp removal might also have contributed to this phenomenon as it might have dampened the velocity of the water movement inside the hull. As a consequence, wind-generated swells and waves are considered at present to be the greatest natural threat to the integrity of the *Erebus*, as they can break apart a section of the



Figure 7.1.1: UAT archaeologist swims above the kelp-covered upper deck of *Erebus* in August 2015 prior to substantial kelp removal (Photo: T. Boyer, Parks Canada; 89M3660EF).

upper deck at any moment, exposing or crushing intact artefacts and structures below, such as the galley stove and an seamen's chest. This deck section would likely need to be partly consolidated or simply removed to prevent further damage from happening, which would implicate the excavation of the lower deck areas being exposed. Lastly, stormy weather and wave action also have an effect on surface diving operations and visibility underwater. While visibility on site is generally between 5 m to 10 m, and up to 20 m under ideal flat and sunny conditions, it can drop to less than a meter immediately after a heavy storm.

The wreck of *Erebus* rests on the seafloor in 10 to 11 m of water on a gentle slope running from northeast to southwest. The bow is differentially embedded 1.3 m and the stern 2.5 m in the seafloor, as a result of that seabed slope. The hull is surrounded by a scour pocket that runs along the footprint of the hull and extends off the stern and the starboard stern quarter, as deep as 1.5 m and up to 20 m wide. The sedimentation and erosion dynamics at the site are still largely unknown at this stage. Logically they should be the result of diurnal current regimes with minor seasonal variations. These dynamics and the resultant seafloor

topography are also quite possibly affected by drastic events such as storms hitting the site periodically. It was noted that there is little deposition of sediment over much of the debris field, except for areas north of the scour pocket on the starboard quarter where loose silt and sand have accumulated over time. Sediments are also largely absent from the lower deck, except for small pockets trapped within and around standing and collapsed structures. On the contrary, fine sediment has accumulated preferentially in the orlop deck and in the hold, partially covering accumulated debris, structures and artefacts within these enclosed spaces. Increased sedimentation generally leads to better preservation of archaeological material.

The last factor to consider here is marine growth. The upper surfaces of the exposed wreck structures were initially covered by a thick kelp coverage (Figure 7.1.1). Although most of it has now been removed (at least temporarily), smaller plants, molluscs and fine sediments still cover and obscure most wreck surfaces for archaeological study and recording. It is expected that marine flora will slowly grow back in one form or another, despite the limited ambient light and the cold

water. As a result, significant dive time may be needed in future to achieve a thorough cleaning of the hull in order to allow its detailed study recording using both 3D photogrammetry techniques and standard recording methods. That said, marine growth does not represent a real threat per se in the short and mid-term and indeed might offer some degree of protection from water movement.

7.2 HULL INTEGRITY

Charles Dagneau

The wreck of *Erebus* has often been said to be “largely intact” and in “pristine condition”, still “standing proud” of the seabed. Such terms are used mainly to emphasise the fact that mid-nineteenth century shipwrecks found in saltwater environments are not often preserved as three-dimensional structures. In reality, it would be evident to most marine archaeologists that *Erebus*’ hull is far from “intact”. The following discussion attempts to provide an assessment of the hull integrity in order to inform short and mid-term decisions on its excavation, as well as long-term decisions concerning the management of the site.

Erebus’ exterior hull is well preserved up to the upper deck, with the notable exception of the transom and stern structures, partly broken and scattered on the seabed (Figure 7.2.1). The uppermost parts of *Erebus* have long since gone except for mast stumps and a few other features. Virtually none of the chain plates, bulwarks, rail caps, davits, and rigging are in their original positions anymore. In fact, rigging elements, many detached hull timbers from the transom, and detached deck structures and parts of the ice channels are observed in the debris field surrounding the hull.

The upper deck itself is only partly intact with missing or displaced sections. Although the forecastle and bow structures are well preserved, there are large decking sections missing between the fore and main hatches, and the situation is very chaotic amidships, where deck planking, beams and stanchions are all broken and mixed with lower deck structures. At the stern, the upper deck is split into two large and coherent sections collapsed along the vessel’s centerline with no centerline deck beam stanchions actually standing. These two sections are no longer fixed to the hull sides by any



Figure 7.2.1: UAT underwater archaeologist inspects the stern structure of *Erebus*, 2016 (Photo: T. Boyer, Parks Canada; 89Mo8434EF).

means, and simply rest on a few futtock heads and collapsed structures. The decking section between the fore hatch and main hatch is mostly detached from its (otherwise loose) deck beams. The aft end of this section in fact exhibits a pulsating up and down movement under or after heavy wind conditions. Overall, it is not yet possible to evaluate quantitatively the remaining strength of wooden and iron fasteners at the upper deck level as well as the hanging knees supporting the beam shelves and deck beams. Considering the above, the upper deck appears to be more a dead weight adding pressure to the hull rather than contributing to its strength.

Lower deck spaces have been observed firsthand by UAT archaeologists and have been documented by photography and video. In all cases, vertical inner structures and fitted furniture have been severely crushed or reduced down to their foundations. On the other hand, the lower deck planking itself seems largely intact, apart from some planking missing on the port side forecastle.

Interior video and photo images of the orlop deck and hold reveal well-preserved horizontal and vertical inner structures. These deck spaces contain a wide variety of mixed debris and artefacts with significant accumulation of sediment. Based on preliminary inspection, it seems that lower deck beam shelves, hanging knees, deck beams, stanchions and watertight bulkheads are still in position. These observations suggest that most of the structures below the lower deck are still in good condition, likely playing a key role in maintaining the structural integrity of the hull.

While the hull of *Erebus* appears to be relatively intact from a distance, it is inevitable that it will eventually collapse. Predictive modelling for this type of multi-factor process has proven very hard to achieve and typically provides imprecise results at best. In such circumstances, when dealing with an unstable, partly degraded underwater composite wood and metal structure standing in the water column, common sense rather than costly, complex mathematical calculations by engineers may yield the best results.

The fragile and disarticulated condition of the upper hull will not necessarily affect targeted excavations focused on the debris field and promising and accessible areas of the lower deck, such as parts of the galley, some officers' cabins, areas of the forecastle on the lower deck and indeed the far aft end of Franklin's cabin. The mapping and excavation of the upper deck and the debris field are also uninhibited, and their study will certainly deliver a wealth of archaeological information as well. In the near term however the project team will proactively manage how it deals with unstable and mobile structures, particularly those of the upper deck, to safely gain access to archaeological features in an overhead environment. The shoring and/or partial dismantling of upper deck sections, for example, will be responsible measures to provide safe diving and working access, and to protect the integrity of unrecorded archaeological features within the hull. As well, heavy upper and lower deck features such the windlass, stove, capstan, etc. could be studied in situ and, if so desired, carefully removed to reduce stress and safety hazards as archaeological work proceeds deeper into the hull. In anticipation of these potential intrusive actions, as well as to boost diving and safety capacity at the wreck of *Erebus*, Parks Canada acquired a new ship, barge and appropriate commercial diving, excavation, and lifting tools for such undertakings.

7.3 ARCHAEOLOGICAL AND SITE FORMATION INFERENCES

Jonathan Moore

One of the principal archaeological objectives of work at the wreck of HMS *Erebus* (coupled with work on the wreck of HMS *Terror*) is to reconstruct shipboard activities of crewmembers and the events of the expedition from its beginning to end. Recovered underwater archaeological evidence will in turn be juxtaposed with historical and other evidence streams. For the time being however, with just over two years of archaeological research on the wreck under our belt, the UAT can put forward a limited number of very preliminary inferences about past events on the ship before, during and after its sinking. As well, the UAT is beginning to understand the formation process of the site, or in other words, the way the ship was transformed from its original state to how it appears today, whether as a result of natural or human forces.

Most obviously, *Erebus*'s hull withstood presumed pressure and damage from multi-year ice off the north flank of King William Island following its besetment in September 1846 and after its desertion in April 1848 to the extent that it remained afloat. Direct observation reveals that the hull sides and bow, notably the doubled planking and sheathing, are in good condition, with hull damage most acute at the stern. Therefore *Erebus* remained relatively watertight or had been pumped as required (or a combination of the two) to permit its movement from its 1848 desertion point to sinking location in Wilmot and Crampton Bay.

Whether living or dead expedition members were aboard the ship when it arrived to the west of the Adelaide Peninsula, as described by Inuit oral histories, cannot be confirmed archaeologically at present. Importantly, no human remains have been observed on the site to date. If indeed men had been aboard, it is clear that the movement of the *Erebus* between the 1848 desertion point and the sinking location bridged the gap, north to south respectively, between the prior explorations of James Clark Ross in 1831, George Back in 1834, and Peter Warren Dease and Thomas Simpson in 1839. Indeed, the wreck is located within a matter of kilometres to where Dease and Simpson passed on both their outbound and return journeys (Figure 7.3.1). If live crewmen were indeed

aboard, then they would have completed this significant navigational objective, an outcome long suspected and brought more into focus following the 2014 discovery of *Erebus*. As to the state of the ship prior to sinking we can offer several observations:

- The bower anchors appear to have been catted before the ship sank, given their position on the seabed under the eyes of the ship. This means that the ship was not anchored at the time of its sinking with these two anchors in the way in which a ship would have been anchored in open water (Figure 7.3.2);
- Based on their location on the seabed, the ship's six (at least) supplementary anchors were still stowed on the ice channels prior to sinking. Whether ice anchors were deployed cannot be answered; none have been observed at the site;
- It seems likely that the bulwarks were dislodged from the upper deck, with attached or fished anchors after the ship had sunk, given the fact that the anchors are positioned very close to the ship's hull;

- The tiller appears to have been removed from the rudder stock by the crew and stowed on the upper deck some time prior to sinking, and the rudder is not in situ. If indeed this was the only tiller aboard, the ship was not being steered by the rudder immediately prior to sinking. The locations of the primary and spare rudders are unknown;
- One of the light 6-pounder guns (and possibly both) appears to have been rendered temporarily unserviceable by the insertion of three round shot into its bore; and
- The wreck's location within an archipelago and complex network of reefs suggests that the ship was more likely than not manned and navigated to the zone of its eventual sinking; this is a provisional observation.

Notwithstanding the evidence outlined above, the question of whether the ship was manned or not upon its arrival in Ugiulik remains a central question for ongoing archaeological research at *Erebus*.



Figure 7.3.1: Map showing the locations of the April 1848 desertion of *Erebus* and *Terror*, the wreck of *Erebus* and the wreck of *Terror*, in relation to reconstructed exploration routes of Ross, Back and Dease and Simpson (outbound routes as solid lines, return routes as dashed). As well, white shading indicates geographic zones believed to be unknown to the Franklin Expedition prior to sailing in 1845 (Map: G. Harvey, Parks Canada).



Figure 7.3.2: UAT underwater archaeologist at the bow, showing the two bower anchors and attached chain cables at the heel of the stem. The anchors, upright and partially embedded in the seabed are at bottom left of this image (Photo: J. Moore, Parks Canada; 89Mo6480EF).

Whereas there is no readily recognizable evidence to date of contemporary Inuit salvage activities aboard the ship prior to its sinking, archaeological observations are consistent with nineteenth-century Inuit oral histories. For example, some features observed by Inuit on the ship (as reported chiefly to Charles Francis Hall and Frederick Schwatka) are indeed present on the wreck, for example, “many empty casks”, “iron chains and anchors on deck” and “china plates” as reported by the Inuk Puhtoorok who said he went aboard *Erebus* (Schwatka 1880:125-126) and “boxes” as reported by Ek-kee-pee-re-a (Nourse 1879:403-405). Given the number of artefacts still on the wreck, the salvage appears not to have been completely wholesale.

The date and circumstances surrounding the sinking of the ship have not yet been demonstrated archaeologically. Indeed, it is not known whether the location of the wreck of the *Erebus* corresponds with the location of the contemporary Inuit salvage, as the ship could have drifted amidst ice prior to foundering. The facts that the ship sank upright, and that on account of its sinking depth the ship’s masts would have projected up out of the water (or ice), are both consistent

with contemporary Inuit observations of the ship following its sinking. While there is no archaeological evidence for a hole having been created in the hull side that would have caused the ship to sink, as reported by some contemporary Inuit accounts, whether there is evidence of interior timber removal that caused sinking remains to be seen (see Nourse 1879:403-405).

Analysis of post-sinking changes to the ship’s hull and interior has only just begun; selected salient observations are presented below from many dozens of discrete observations. Clearly annual ice formation and breakup would have worked on the masts and the bowsprit in short order after *Erebus* sank. Indeed the main mast and fore mast snapped off at their intersection with the upper deck while the bowsprit and the mizzen mast were forcibly un-stepped. The collapse of the masts occasioned many of the shrouds and chain plates to part from the hull sides at the ice channels in places and the chain plates flipped downwards against the hull sides. Whether all topmasts and other spars were in their working positions before sinking is unknown, although the number of spars visible in the immediate debris field appears to be less than would have originally been on board

the ship. The upper deck and transom have been heavily affected by crushing forces (presumably by ice) and the bulwarks were sheared off, with only a fraction now visible in the debris field. Davits and boat cradles were also swept aside, and importantly no boat remains have been identified at the wreck to date. The windlass was also sheared or pulled from its mounting position although the formerly articulated bell fell to the upper deck next to it. Much of the upper deck planking has separated from the upper deck beams, some in large sections resting on the seabed. The two light 6-pounder cannon appear to have been positioned at the stern and fell to the seabed; a fragment of window glass in the tube of gun 89M99X1-6 suggests that the gun could have come into contact or fell through either the stern gallery window or a skylight during or after sinking.

On the lower deck, interior partitions and fitted furniture partly or wholly collapsed and all manner of mobile features and objects were displaced from their original positions. Partitions and bulkheads appear substantially intact on the orlop deck, although much debris and sundry artefacts are found on this deck, some of which appears to have originated from the lower and upper decks and farther aloft. Exploration of the debris field surrounding the wreck is still incomplete and further study will no doubt reveal many insights into the wreck's site formation processes.

7.4 ARTEFACT POTENTIAL

Charles Dagneau

Although still in its early stages, archaeological analysis and interpretation of the artefact assemblage will certainly play a key role in providing answers regarding the fate of the Franklin Expedition. Building on the description of ship's remains and raised artefacts from Sections 5 and 6, the present section attempts to provide a broad interpretation of the collection based on artefact distribution, association and context. It also aims to demonstrate, if necessary, the enormous potential of the site. Indeed, it consists of a substantially intact vessel with coherent structures and enclosed areas, providing great potential for the interpretation of in-context artefact clusters in relation to their location on board. Based on their function and location aboard the *Erebus*, most of the collection can be divided in three major

groups: rigging artefacts from the upper deck and debris field; artefacts related to living quarters and cabins on the port-side of the lower deck; and the captain's and officers' cabins on the lower deck as well as at the starboard stern.

When looking at artefacts from the upper deck and within the debris field, the site presents great potential for the understanding of running and standing rigging elements. The hull of *Erebus* is surrounded by collapsed sections of masts and the bowsprit, with some top masts and spars, a gaff, deadeyes, shroud plates, etc. The mapping and detailed study of that part of the site has not yet been initiated, but the pre-disturbance visual inspection gives an impression that many elements are present (see Sections 5.2 and 5.5). Many small rigging artefacts are visible on the upper deck. A few of them were raised, like the brass hook block and block with shackle, a wooden single block, two bronze rollers, and four belaying pins, out of a great number distributed on the upper deck at various locations. It is hard to infer anything of substance based on these artefacts alone, but the careful observation of the debris field in situ already yield some interesting information (see Section 7.5).

Two interesting groups of finds were located within the forecabin on the lower deck. The first group contains artefacts related to food service: seven transfer-print whiteware plates and bowls, as well as a possible beer bottle fragment. These finds were clustered in sub-operations 28-30J/K, adjacent to the Galley, where the Frazer's Patent Stove is located. They may have been originally stored in the shelved cupboards depicted on the 1839 lower deck plan (*Terror and Erebus, Plan of Lower Deck (as Fitted) 1839*). Preliminary observation of the collapsed wooden debris in 28K also seems to indicate that much of this fitted furniture may still be found in situ.

The second artefact cluster in the forecabin (lower deck) includes artefacts which are part of British Royal Marine standard equipment, or related to their duty on board. This includes two Royal Marine buttons, a Royal Marine officer's belt plate, two belt buckles, and some 40 percussion caps, all within units 30-32J/K. The pharmacy bottle and the 19 small lead shot it contained can also be added to the group, as the bottle is believed to have been re-used as a shot flask (Figure 7.4.1). It is now clear that these firearms and Royal Marine-related objects were found in this area given that



Figure 7.4.1: Pharmaceutical bottle 89M99X1-8, which originally held a preparation made by Samuel Oxley of London, England was evidently later re-used by *Erebus* crew members, quite surprisingly, as a shot flask or container. The wreck promises to yield many more artefacts like this example and thereby unique archaeological insights into events and life aboard the ship (Photo: M. Wilson, Parks Canada; RA388oEF).

Royal Marines would have occupied this living space in the forecabin. Other artefacts like the ointment pot – and possibly the pharmaceutical bottle if our interpretation is wrong – do not fit well in the picture. Both should more likely come from the Sick Bay (at the bow), or from one of the officers' cabin. This said, these two assemblages illustrate how the excavation of *Erebus* can deliver coherent groups of artefacts even from the most exposed areas of the site, and despite all the past and present dynamics affecting the site.

The remaining artefacts found on port side of the lower deck come from sub-operations 34-36 J/K. Although the excavation and study of these units is not completed and no cabin wall remains were mapped to date, this zone corresponds to the foremost cabins typically assigned to lower ranked or warrant officers. The 1827 pattern British naval officer's sword hilt was found next to the pestle, the fire broom, the mercurial artificial horizon, and the small knurled knob in sub-operations 34-36J/K. A sextant was also located nearby, close to the boot and the textile in 38J, although it could not be retrieved. The artefacts found in this area relate to very different shipboard functions. This said, the sword hilt, the artificial horizon and the sextant can logically be associated with Royal Navy officers' duties. The boot and the piece of jersey may have belonged to one of the officers on

board. The pestle could have been used by one of the two surgeons or by one of the other officers, for example to process scientific samples or to crush painting pigments.

Towards the stern, *Erebus*' transom and most of the captain's cabin were ripped off and scattered on the seafloor below, probably due to ice action. The open transom now provides access to the captain's cabin, but also the captain's bed cabin and other officers' cabins along the starboard side of the vessel. That being said, it still unclear at this point what the cabin assignments and configuration were following the 1845 refit. This area has only been documented with photo and video so far, and no formal recording or excavation has been initiated. Although very little is known from this area at the moment, it does offer some of the most promising enclosed spaces on the lower deck under the half-collapsed starboard upper deck section. Remains of shelving on the walls of the cabins as well as different pieces of furniture are visible through openings, including a stove, a writing desk, bed frames, etc.

It was at the extreme aft end of the intact lower deck that a brass frame for a possible scientific instrument and a Royal Navy officer's button were found in sub-operations 52L/M. A piece of mahogany furniture comes from the same area:



Figure 7.4.2: This sea boot observed in the main hold underscores the excellent preservation conditions and artefact potential within the hull of *Erebus* (Video Still: J. Moore, Parks Canada; 89M2015R005b_0243).

a leg and stretcher in the captain's cabin in 52M, and another leg and stretcher (possibly related), from the seafloor underneath, in 54N. Lastly, the two six-pounders and associated round shot still in one of them were also found on the seafloor at the stern in 58M. They were likely originally located on the upper deck above the captain's cabin. Again, the distribution of artefacts found in this area with regards to their function seems coherent at this early stage, and thus very promising for the future.

The work on *Erebus* has focused so far on the most accessible (and most exposed) areas of the wreck, certainly the most subject to scrambling and destructive dynamics. In the future, as excavation progresses deeper into the wreck, in other parts of the lower deck, orlop deck and in the hold, more coherent and meaningful artefact clusters will be found, as suggested by some of the interior ROV video imagery (Figure 7.4.2)(see Section 5.4).

Material culture analysis and artefact interpretation are also strengthened by the relative abundance of archival material available for this period and type of expedition. The Muster List in particular makes it possible to link some of the finds to specific crew members.

This said, let us keep in mind that the most accessible areas of this rather shallow site are subject to scrambling dynamics dependant on weather and sea conditions, as it was observed during a September 2015 storm. The wreck was also visited multiple times by Inuit parties when it was beset in the ice before it sank. A recent re-examination of the different Inuit oral testimonies available

suggests that Inuit actions on *Erebus* were much more intrusive than expected at first. As our knowledge of the site and its surroundings progresses along with the excavation of the site, artefact distribution patterns may also be indicative of how Inuit scavenged the vessel (McClintock 1860; Schwatka 1880; Hall 1879; Rasmussen 1931).

7.5 FUTURE STEPS AND RECOMMENDATIONS

Marc-André Bernier

The introduction of this report outlined two fundamental questions for the assessment work to answer: “What information can we realistically hope to extract from this site?” and “How do we tackle this three-dimensional puzzle located in an environment that only provides a limited annual window of opportunity to access the promised information?”. We are confident that we have acquired enough information to address these questions in order for the archaeological work to proceed. The first question is directly answered in this report; the second has been tackled and will be developed further in a research design in a separate document.

There is no doubt that the archaeological and historical potential of the wreck of *Erebus* is vast. In evaluating this we recognize two elements. First, its value lies in the range and importance of the historical questions the site could answer. In the case of the Franklin Expedition, these questions are numerous and have increased in number and evolved in character given the context of the wreck's location in Wilmot and Crampton Bay. For example, important and tantalizing questions range from:

- What caused men to return to *Erebus* after April 1848, if indeed they did so, and how much of the supplies remained in the final stages of their ultimately fatal journey?
- When and how did *Erebus* arrive in Wilmot and Crampton Bay?
- What were the number and identities of living crew members on the ship in the area of its sinking (*Ugjulik*), if any; and

- What was the fate of these men once the ship could no longer travel farther?

The shipwreck promises many more insights into the general chronology and progress of the expedition, especially in its later stages.

Second, the potential of the site lies in its intrinsic archaeological value. It was immediately evident to all and very early during the first dives that this potential is immense. The integrity of the ship's hull, and the protection it has offered its contents from the elements, has led to the presumed encapsulation of a mountain of information. Systematic inquiry over the last two years, as demonstrated in this report, has confirmed that although the natural elements have impacted the site and in some areas relatively significantly so, many zones offer untouched capsules of what could be the very last moments of the expedition. The area with the highest potential is the stern half of the lower deck based on our current understanding of the site. This is where the officers' cabins are found, and initial investigation has shown that they still have integrity, at least as high as their fitted bed places for example. This is quite remarkable and promises to yield important information, not only because of the role of the officers in recording events and the probability of identifying specific individuals, but also because of the clearly compartmentalized nature of the area; these are clearly capsules within a capsule. A few of the cabins are readily accessible, and most

would become accessible by either removing or consolidating part(s) of the collapsed upper deck. The galley area is also of interest but it is generally devoid of physically compartmented spaces. Some elements, like an intact seaman's chest, are visible yet out of reach at present; it would offer a unique insight into the life of the lesser known figures of the expedition (Figure 7.5.1). The Sick Bay needs to be further explored because it is well sheltered at the bow and on account of perennial interest in the decline of the health of the crew.

The orlop deck will be more of a challenge because of the limited and constrained access points, and the challenge of working deep inside the wreck, but the first images obtained clearly reveal that we have a lot to learn from what has been well preserved in the hold. Indeed, we have yet to image any interior elements of the steam propulsion system. What is more, there are seemingly limitless questions regarding the technology encapsulated by the ship, shipboard life within its wooden walls, and material culture employed in relation to not only British polar explorations of the mid-nineteenth century in general, but also the most exquisitely equipped and storied of them all. Finally, the debris field cannot be omitted as some areas outside the wreck clearly relate to key interior spaces of the ship, notably the stern cabin that has partly collapsed onto the seabed. Indeed, the inner periphery of this debris field will help to understand the site formation process during and after sinking, while the outer periphery, namely



Figure 7.5.1: This well-preserved seaman's chest in the forecabin of the lower deck appears to have its original contents in situ, albeit partially covered by silt and anemones. Future excavation of this feature has the potential to reveal fascinating insights into the lives of the two men who shared this locker (Photo: M.-A. Bernier, Parks Canada; 89M06932EF).

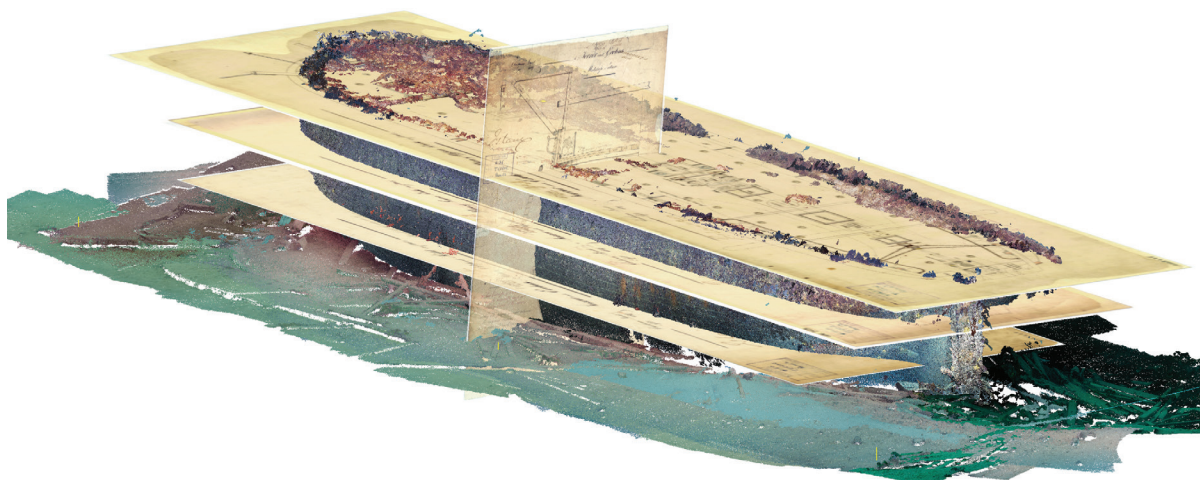


Figure 7.5.2: Ship plans of Erebus superimposed on a photogrammetric model of the wreck of *Erebus* (Image: B. Lockhart and T. Boyer, Parks Canada).

a reef to the north and east, could offer insights into the trajectory of the ship inside the pocket of islands of Wilmot and Crampton Bay.

Beyond exploring the potential of the site to shed light on a pivotal historical moment in the exploration of the Northwest Passage, a crucial component of the assessment work was to pinpoint the threats that loom over the wreck. Again, firsthand observation of the site quickly demonstrated that in some areas it is very vulnerable to the elements. Whereas historically ice has undoubtedly affected the site, the present day pounding effects of summer storms as they periodically channel in from the north and west are very real. The displacement of timbers and artefacts, and in one case the fracture of one object, not to mention the pulsating movement of a deck section were witnessed firsthand by the UAT archaeologists immediately after a gale in September 2015. There is no doubt that the site is still actively deteriorating, and will continue to do so.

Moving forward, it is clear that the methodology developed in the research design will have to mirror that used during the site assessment phase: efficient use of multiple tools adapted to the questions at hand and to the specificity of the area under direct investigation. Excavation will be warranted in areas of higher interest, of concentrated contents and of good integrity, like the officer's cabins, the Sick Bay, the debris field astern of the wreck and the individual seaman's chests. At this point, an intrusive approach is really the only way to fully address the important questions that are before us. It is also not only required,

but also justified in the context of the observed impacts of the harsh environmental conditions present in this part of the Arctic. Less intrusive documentation will need to be utilized in more disturbed areas or in pockets harder to access that are not as exposed to the impact of the elements. Documentation with remotely operated tools will likely be the norm for interior zones that offer limited physical accessibility. All the same, the recording will need to be flexible and adapted to the desired objectives and the time restrictions imposed by the situation and the environment. Already, the recording methodology developed during the last three years has embraced this reality, using three-dimensional techniques (multi-beam and photogrammetry) for site mapping, direct survey methods and basic baseline and datum points to support the traditional hand mapping of artefacts (Figures 7.5.2 and 7.5.3). These methods are interrelated through a grid system based on the Parks Canada alpha-numerical methodology which in turn is integrated in a GIS. This flexibility permits the use of just about any recording method, whether traditional or high technology, to provide the required results given the time at hand. In turn, this assembled and synthesized archaeological data is translated into physical models, conceptual reconstructions and archaeological interpretations (see Figure 7.5.3).

Article 2.5 of the UNESCO Convention cited above attests that the “preservation in situ of underwater cultural heritage shall be considered as the first option before allowing or engaging in any activities directed at this heritage”. This does not mean that it is the only way forward: the spirit of

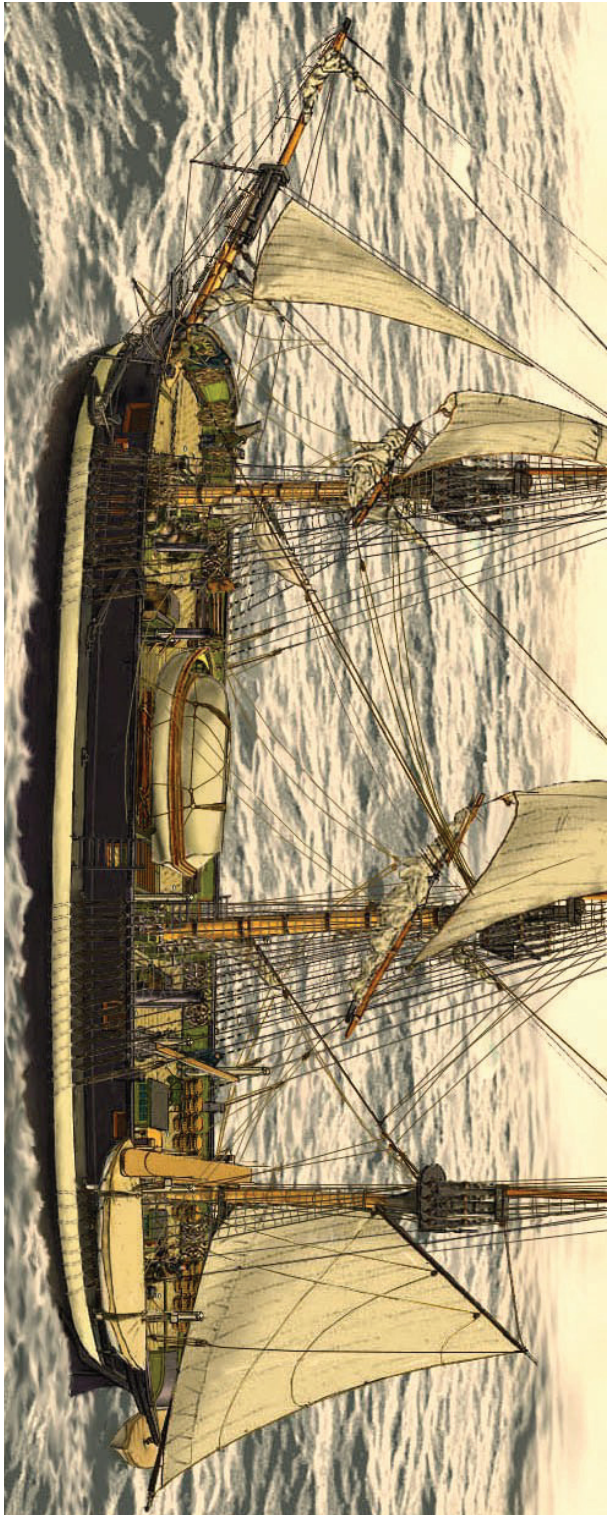


Figure 7-5-3: Preliminary artistic reconstruction of *Erebus* under sail (top) based on both historical and archaeological evidence, the latter including a photogrammetric model of the wreck of *Erebus* with the bow at left (bottom). Future archaeological study of the wreck of *Erebus* will permit additional scientific reconstructions of the ship, its fittings, and operation, both externally and internally. This photogrammetric view of the intact hull underscores the efficacy of advanced recording techniques and the wreck's outstanding archaeological potential (Illustration: F. Werthman, Parks Canada; Photogrammetry: T. Boyer, Parks Canada).

the Convention encourages an intrusive approach like excavation if important scientific or historical questions can be answered through this type of project, or if the site is threatened. We have not seen many sites in Canada that meet the spirit of these values so completely. Indeed, we hope that this assessment report has demonstrated that targeted excavation of portions of the HMS *Erebus* wreck is the only way forward. Through underwater archaeology we can unlock some of the mysteries in *Erebus* about its compelling story and ultimately preserve the commemorative integrity of its unique assemblage of archaeological materials.

This assessment report will serve as the foundation for the development of a research or project design for the work to be conducted at HMS *Erebus*.

This research design will spell out the principle research questions, and the methodological approach and techniques to be used, as well as a discussion around all the crucial elements of the multi-year project to come. The document will have to take into account the recent discovery of HMS *Terror* in September 2016 in a state of preservation that seems even greater than that of *Erebus*. We are in the privileged position of having access to an unprecedented amount of data regarding the 1845 Franklin Expedition, something unfathomable less than a decade ago, data that will rewrite the story of the fate of Franklin's men. Parks Canada is committed to using the highest archaeological standards to shed light on this important story from the Canadian Arctic.

REFERENCES CITED

Admiralty Collection (Ship Plans)

- 1837 *Plan of the Terror Lower Deck*. ZAZ5676 (J1410). National Maritime Museum, Greenwich.
- 1837 *Profile of the Terror*. ZAZ5672 (J1406). National Maritime Museum, Greenwich.
- 1839 *Terror and Erebus, Plan of Upper Deck (as Fitted)*. ZAZ5675 (J1409). National Maritime Museum, Greenwich.
- 1839 *Terror and Erebus, Plan of Lower Deck (as Fitted)*. NPC3135 (J8650). National Maritime Museum, Greenwich.
- 1839 *Terror and Erebus. Midship Section*. ZAZ5678 (J1412). National Maritime Museum, Greenwich.
- 1839 *Terror and Erebus, Profile (as Fitted)*. ZAZ5673 (J1413). National Maritime Museum, Greenwich.
- 1845 *Drawings Representing the after Part of the "Erebus" Arctic Ship; ... March 17*. ZAZ5683 (J1529). National Maritime Museum, Greenwich.
- 1848 *Plan of the Investigator's Upper Deck as Fitted for the Arctic Expedition. At Messrs Greens' Yard Blackwall. April 1848. July 26*. ZAZ6546 (J2209). National Maritime Museum, Greenwich.

Admiralty Records

- 1839 *Projects in Chemistry, & Means for Preventing the Dry Rot*. ADM 12, volume 358, 1839, Digest 42a-60, cut 59-9. National Archives of the United Kingdom, London.
- 1845 *Admiralty List Books*. ADM 8, volume 125, f. 25. National Archives of the United Kingdom, London.

Anon.

- 1845 *List of Officers, Seaman and Marines of Her Majesty's Ships 'Erebus' and 'Terror' Who Sailed from England May 1845 in the Expedition under the Command of Captain John Franklin*. LO214. National Maritime Museum, Greenwich.

Back, George

- 1838 *Narrative of an Expedition in H.M.S. Terror Undertaken with a View to Geographical Discovery on the Arctic Shores, in the Years 1836-7*. John Murray, London.

Barr, William, editor,

- 1987 *Overland to Starvation Cove: With the Inuit in Search of Franklin 1878-1880. First published as Als Eskimo unter den Eskimos: eine Schilderung der Erlebnisse der Schwatka'schen Franklin-Aufsuchungs-Expedition in den Jahren 1878-1880*. A.Hartleben Verlag and Viennaandby William Barr, translators. University of Toronto Press, Toronto.
- 1999 *Searching for Franklin: The Land Arctic Searching Expedition 1855: James Anderson's and James Stewart's Expedition via the Back River*. Hakluyt Society, London.

Barthorp, Michael

- 1982 *British Infantry Uniforms Since 1660*. Blandford Press, Poole.

Battersby, William, and Peter Carney

- 2011 Equipping HM Ships Erebus and Terror, 1845. *International Journal for the History of Engineering & Technology* 81(2):192–211.

Bernstein, Theodore, and Terry S. Reynolds

- 1978 Protecting the Royal Navy from Lightning-William Snow Harris and His Struggle with the British Admiralty for Fixed Lightning Conductors. *IEEE Transactions on Education* 21(1). February:7–14.

Betts, Matthew

- 2016 Curator, Canadian Museum of History.

Blackmore, Howard Loftus

- 1969 *British Military Firearms, 1650-1850*. Herbert Jenkins, London.
1976 *The Armouries of the Tower of London: Ordnance*. H.M. Stationery Office, London.

Bradley, Charles

- 2015 Retired Parks Canada Material Culture Specialist.

Canadian Standards Association

- 2013 Z275.5 - Occupational Diver Training. In *Diving and Pressurized Environments*. CSA Group, Mississauga.
2015 Z275.2 - Occupational Safety Code for Diving Operations. In *Diving and Pressurized Environments*. CSA Group, Mississauga.
2017 Z275.4 - Competency Standard for Diving, Hyperbaric Chamber, and Remotely Operated Vehicle Operations. In *Diving and Pressurized Environments*. CSA Group, Mississauga.

Carabias, Diego

- 2016 Archaeologist, Centro de Investigacion En Arqueologia Maritima Del Pacifico Sur Oriental.

Carney, Peter

- 2011 Fitzjames' Cabin. *Erebus & Terror Files*. December 7. <http://erebusandterrorfiles.blogspot.ca/2011/12/fitzjames-cabin.html>.

Cohen, Andrew

- 2013 *Lost Beneath the Ice: The Story of HMS Investigator*. Dundurn, Toronto.

Cooley, Arnold James

- 1892 *A Cyclopaedia of Practical Receipts, and Collateral Information in the Arts, Manufactures, Professions, and Trades, Including Medicine, Pharmacy, and Domestic Economy : Designed as a Comprehensive Supplement to the Pharmacopœias, and General Book of Reference for the Manufacturer, Tradesman, Amateur, and Heads of Families*. J. Churchill, London.

Coysh, Arthur Wilfred, and Richard K. Henrywood

- 1982 *The Dictionary of Blue and White Printed Pottery 1780-1880*. Antique Collectors' Club, Woodbridge.

Crozier, Francis R. M.

- 1845 Crozier to Ross. July 9. Ms 248 / 364; 26. University of Cambridge, Scott Polar Research Institute, GB 15 Francis Crozier Collection.

Cyriax, Richard J.

- 1939 *Sir John Franklin's Last Arctic Expedition: A Chapter in the History of the Royal Navy*. Methuen, London.
- 1947 A Historic Medicine Chest. *Canadian Medical Association Journal* 57(3):295–300.

Davis, J. E.

- 1845 *HMS Erebus and HMS Terror Part Company with HMS Blazer and HMS Rattler, June 1845*. N972. University of Cambridge, Scott Polar Research Institute.

Eber, Dorothy

- 2008 *Encounters on the Passage: Inuit Meet the Explorers*. University of Toronto Press, Toronto.

Elkin, Dolores, Christian Murray, Ricardo Bastida, Monica Grosso, Amaru Argueso, Damian Vainstub, Chris Underwood, and Nicolas Ciarlo

- 2011 *El Naufragio de La HMS Swift - 1770 - Arqueologia Maritima En La Patagonia*. Vazquez Mazzini, Buenos Aires.

Fairholme, James Walker

- 1845 Fairholme to His Father, June 1 1845. R14108-0-9-E (MG24-H18). Library and Archives Canada, Fairholme Papers fonds.

Fratpietro, Stephen

- 2016 SER035-16 Final Report. Lakehead University Paleo-DNA Laboratory. Manuscript, Underwater Archaeology Team, Parks Canada, Ottawa.

Gilder, William H.

- 1880 *Schwatka's Search: Sledging in the Arctic in Quest of the Franklin Records*. Sampson Low, Marston, Searle, and Rivington, London.

Godden, Geoffrey A.

- 1991 *Encyclopaedia of British Pottery and Porcelain Marks*. Barrie and Jenkins, London.

Gooding, S. J.

- 1966a The Top-Hat Cap. *Canadian Journal of Arms Collecting* 4(1):26–27.
- 1966b The Percussion Primer. *Canadian Journal of Arms Collecting* 4(5):127–149.

Goodsir, Harry

- 1845 Harry Goodsir to John Goodsir, June 28, 1845. ARC/4/32. Royal Scottish Geographical Society, Harry Goodsir Collection.

Government of Canada

- 1985 *Labour Code. R.S.C., 1985, c. L-2.*
1986 *Canada Occupational Health and Safety Regulations. SOR/86-304, Part XVIII.*
2015 *Order Amending the National Historic Sites of Canada Order. SOR/2015-88.*

Hall, Charles Francis

- 1879 *Narrative of the Second Arctic Expedition Made by Charles F. Hall: His Voyage to Repulse Bay, Sledge Journeys to the Straights of Fury and Hecla and to King William's Land, and Residence Among the Eskimos During the Years 1864-'69.* Editor J. E. Nourse. Government Printing Office, Washington.

Harris, Ryan, and Thierry Boyer

- 2016 *Wrecks of HMS Erebus and HMS Terror National Historic Site of Canada: Remote Sensing Search for HMS Terror 2015.* Underwater Archaeology Team, Parks Canada, Ottawa.

Harris, Ryan, Jonathan Moore, and Marc- André Bernier

- 2015 *Wrecks of HMS Erebus and HMS Terror National Historic Site of Canada: Remote Sensing Search 2014 and Discovery of HMS Erebus.* Underwater Archaeology Team, Parks Canada, Ottawa.

Harris, William Snow

- 1847 *Remarkable Instances of the Protection of Certain Ships of Her Majesty's Navy, from the Destructive Effects of Lightning.* R. White Stevens, London.

Jones, Olive R., and E. Ann Smith

- 1985 *Glass of the British Military ca. 1755-1820.* Parks Canada, Ottawa.

Kavousanaki, Despoina

- 2015 *Analysis of Some Metallic Artifacts from HMS Erebus.* Conservation Science, Parks Canada, Ottawa.
2016 *Analysis of HMS Erebus Artefacts.* Conservation Science, Parks Canada, Ottawa.

Keith, Darren, and Louie Kamookak

- 1999 *Franklin Oral History Project October 12-19, 1998.* Underwater Archaeology Service, Parks Canada, Ottawa.

Klutschak, Heinrich W.

- 1881 *Als Eskimo Unter Den Eskimos: Eine Schilderung Der Erlebnisse Der Schwatka'schen Franklin-Aufsuchungs-Expedition in Den Jahren 1878-80.* Wien: A. Harleben.

Laflèche, Louis

- 2015a *Wood Identification of a Deck Planking from the HMS Erebus.* Conservation Science, Parks Canada, Ottawa.
2015b *Analysis of a Textile from the HMS Erebus.* Conservation Science, Parks Canada, Ottawa.
2016 *Identification of Hair Possibly Associated to a Boot from the HMS Erebus.* Conservation Science, Parks Canada, Ottawa.

Lewis, Michael

1945 Naval Buttons. *The Mariner's Mirror* 31(2):56–83.

McCarthy, Michael

2005 *Ships' Fastenings: From Sewn Boat to Steamship*. Texas A&M University Press, College Station.

McClintock, Francis Leopold

1860 *The Voyage of the Fox in the Arctic Seas. A Narrative of the Discovery of the Fate of Sir John Franklin and His Companions*. Ticknor and Fields, Boston.

McConnell, David

1988 *British Smooth-Bore Artillery: A Technological Study to Support Identification, Acquisition, Restoration, Reproduction, and Interpretation of Artillery at National Historic Parks in Canada*. National Historic Parks and Sites, Environment Canada, Parks Canada.

Ménard, Nadia, Lisa Treau de Coeli, Philippe Archambault, Micheline Manseau, and Marc-André Bernier

2015 *Characterization of Benthic Communities on and Around the HMS Erebus Wreck Site: 2015 Pilot Study Field Report*. Parks Canada, Gatineau.

Meredyk, Shawn

2016 Mooring Instrumentation Professional, ArcticNet, Université Laval.

Mickeljohn, Heather

2016 Curator, Parks Canada Agency.

Miller, Amy

2007 *Dressed to Kill: British Naval Uniform, Masculinity and Contemporary Fashions, 1748-1857*. National Maritime Museum.

Miller, George L.

1991 A Revised Set of CC Index Values for Classification and Economic Scaling of English Ceramics from 1787 to 1880. *Historical Archaeology* 25(1):1–25.

Moore, Jonathan, Ryan Harris, and Peter Northover

2014 Copper Hull Sheathing and Royal Navy Arctic Discovery Ships: The Case of *Erebus* and *Terror*. Manuscript, Underwater Archaeology Team, Parks Canada, Ottawa.

Mörzer Bruyns, Wilhem F.J., and Richard Dunn

2009 *Sextants at Greenwich: A Catalogue of the Mariner's Quadrants, Mariner's Astrolabes, Cross-Staffs, Backstaffs, Octants, Sextants, Quintants, Reflecting Circles and Artificial Horizons in the National Maritime Museum, Greenwich*. Oxford University Press and National Maritime Museum, Oxford.

Nayler, Peter

1993 *Military Buttons Manufacturers from the London Directories 1800-1899*. Ministry of Supply and Services Canada, Canadian Heritage, Parks Canada, Ottawa.

Nordbok, A.B.

1975 *The Lore of Ships*. Crescent Books, New York.

Nourse, J.E., editor,

1879 *Narrative of the Second Arctic Expedition Commanded by Charles Francis Hall*. Government Printing Office, Washington.

Parks Canada

2002 *Parks Canada Directive on Diving Safety*. Parks Canada, Ottawa.

2005 *Parks Canada Archaeological Recording Manual: Excavations and Surveys*. Parks Canada, Ottawa.

2013 *Cultural Resource Management Policy*. Parks Canada, Ottawa.

Parkyn, Major H.G.

2014 *Shoulder-Belt Plates and Buttons*. Naval & Military Press, Uckfield.

Pratt, Lucy, Linda Woolley, and Sara Hodges

2008 *Shoes*. Victoria and Albert Museum, London.

Preston, Grant

1818a Description of a Portable Deck Glass, and Ventilator. In *The Repertory of Arts, Manufactures, and Agriculture: Consisting of Original Communications, Specifications of Patent Inventions, Practical and Interesting Papers, Selected from the Philosophical Transactions and Scientific Journals of All Nations*, 32:358–360. Nichols, Son and Bentley Printers, London.

1818b Deck Glass Rim, and Safety Grate for Ships. Great Britain, April 1 1818 (4222). Intellectual Property Office, Newport.

Rae, John

2014 *John Rae's Arctic Correspondence, 1844-1855*. TouchWood Editions, Victoria.

Rasmussen, Knud

1931 *Report of the Fifth Thule Expedition, 1921-24; the Danish Expedition to Arctic North America in Charge of Knud Rasmussen*. Gyldendal, Copenhagen.

Romieux, Yannick

1986 *De la Hune au Mortier ou L'histoire des Compagnies des Indes, leurs Apothicaires et leurs Remèdes*. Éditions ACL, Nantes.

Ross, James Clark

1839a Ross to Admiralty, May 17, 1839. ADM 1, volume 2437, Captain's Letters - Surnames R-Y, 1839. National Archives of the United Kingdom, London.

1839b Ross to Admiralty, May 2, 1839. ADM 1, volume 2437, Captain's Letters - Surnames R-Y, 1839. National Archives of the United Kingdom, London.

1847 *A Voyage of Discovery and Research in the Southern and Antarctic Regions, During the Years 1839-43*. Vol. 1. John Murray, London.

Ross, W. Gillies

2002 The Type and Number of Expeditions in the Franklin Search 1847–1859. *Arctic* 55(1):57–69.

Royal Navy

1835 *Regulations and Instructions, for the Medical Officers of His Majesty's Fleet*. London.

Schmerer, Wera M.

2003 Extraction of Ancient DNA. *Methods in Molecular Biology* 226:57–62.

Schwatka, Frederick

1880 *Journal 1878-1880*. G.W. Blunt White Library. Misc. Vol. 163. Mystic Seaport Museum, Mystic.

1899 *The Search for Franklin. A Narrative of the American Expedition Under Lieutenant Swatka, 1878-1880*. T. Nelson and Sons, London.

Shaw, J. T., editor,

1973 *Sunderland Ware: The Potteries of Wearside. A Summary of Their History and Products*. Sunderland Museum and Art Gallery, Sunderland.

Stackpole, Edouard, editor,

1965 *The Long Arctic Search: The Narrative of Lieutenant Frederick Swatka, U.S.A. 1878-1880, Seeking The Records Of The Lost Franklin Expedition*. Marine Historical Association, Mystic.

Stanley, Owen

1837 *H.M.S. Terror January 1837*. Drawings Made by Captain Owen Stanley When on the Arctic Expedition on H.M.S. "Terror" 1836 and 1837. F7383. Fisher Rare Book Library, University of Toronto, Toronto.

Stenton, Douglas R.

2014 A Most Inhospitable Coast: The Report of Lieutenant William Hobson's 1859 Search for the Franklin Expedition on King William Island. *Arctic* 67(4):511–22.

2016 Archaeologist and Former Director of Heritage, Government of Nunavut.

Storekeeper General

1839 A Letter from the Storekeeper General at the Admiralty Dated May 25, 1839 to the Captain Superintendent of Chatham Yard. CHA/H/3D, Superintendent, Letters from Admiralty, Chatham Dockyards. National Maritime Museum, Caird Library.

Sussman, Lynne, Charles Bradley, Stephen Davis, Phil Dunning, Gérard Gusset, Catherine Sullivan, Joe Last, and Susan Plousos

1994 *Material Culture of the Royal Canadian Rifle Regiment: Artefacts Found in the Latrine at Fort Wellington, Prescott*. Microfiche Report Series No 523. Parks Canada, Ottawa.

The Illustrated London News

1845 Departure of the "Erebus" and "Terror" on the Arctic Expedition. *The Illustrated London News* May 24 (160):328.

The Medical Observer

1806 Concentrated Essence of Jamaica Ginger. *The Medical Observer*(1):21–26.

The Times

1845 The Arctic Expedition. *The Times* April 15:7.

The Weather Company

2015 Weather Underground. <https://www.wunderground.com/history/airport/CWIL/201>.

Thornton, Jonathan

1998 A Brief History and Review of the Early Practice and Materials of Gap-Filling in the West. *Journal of the American Institute for Conservation* 37(1):3–22.

Turgeon, Laurier

1996 Le chaudron de cuivre en Amérique: parcours historique d'un objet interculturel. *Ethnologie Française* 26:58–73.

UNESCO

2001 *Convention on the Protection of the Underwater Cultural Heritage*.

Walpole, Garth

2011 The Search for, and an Analysis of, the Relics of the Franklin Expedition 1848-1880. Undergraduate thesis, Bangor University, Bangor.

Woodman, David C.

1991 *Unravelling the Franklin Mystery: Inuit Testimony*. McGill-Queen's University Press, Montréal.

2001 *Ujulik 2001 Expedition Report*. Manuscript. Department of Culture, Language, Elders and Youth, Government of Nunavut, Iqaluit.

2003 *Ujulik 2003 Expedition Report*. Manuscript. Department of Culture, Language, Elders and Youth, Government of Nunavut, Iqaluit.

