



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

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NATIONAL HISTORIC SITE OF CANADA

REMOTE SENSING SEARCH 2014 AND DISCOVERY OF HMS EREBUS



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*REMOTE SENSING SEARCH 2014 AND
DISCOVERY OF HMS EREBUS*

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TABLE OF CONTENTS

Summary	ii
Acknowledgements	iv
List of Abbreviations	vi
1 Project Description	1
1.1 Introduction	1
1.2 Project Rationale	1
1.3 Project Organization	2
1.4 Objectives	4
1.5 Definition of the Study Area	4
1.6 Provenience System	6
2 Historical and Archaeological Background	9
2.1 Historical Background	9
2.2 Previous Surveys	16
3 Methodology	17
3.1 Fieldwork Description	17
3.2 Navigation and Positioning	18
3.3 Survey Equipment	21
4 Survey Results	27
4.1 Archaeological Survey	27
4.2 Isolated Shore Finds	33
4.3 Discovery of HMS <i>Erebus</i>	34
5 Wreck of HMS <i>Erebus</i>	37
5.1 Site Description and Environmental Setting	37
5.2 Visual Hull Inspection	39
5.3 Identification	48
6 Conclusion and Recommendations	51
6.1 Conclusion	51
6.2 Recommendations	51
References Cited	53
Appendix 1: Memorandum of Understanding	57

SUMMARY

The Underwater Archaeology Team (UAT) is a section within Parks Canada's Archaeology and History Branch, Heritage Conservation and Commemoration Directorate, based in Ottawa. The UAT provides specialized services and advice in managing submerged cultural resources to Parks Canada nationally and to the wider Canadian federal government. These services range from conducting inventories, site-specific surveys and excavations, research and evaluations, management plans and the preparation of heritage presentation materials.

Between August 13 and September 21, 2014, the UAT carried out the sixth field season of a multi-year survey to locate the polar exploration vessels HMS (Her Majesty's Ship) *Erebus* and HMS *Terror*, lost during Sir John Franklin's ill-fated 1845 expedition in search of a Northwest Passage. Although the 2014 project was officially named "The 2014 Victoria Strait Expedition", for a third year in a row, survey was undertaken in both northern and southern search areas, representing the two general vicinities where the Franklin vessels were thought to have foundered; their fates were believed to have diverged after their abandonment together in 1848. These two areas comprise Victoria and Alexandra Straits in the north, and Wilmot and Crampton Bay in the south, the latter being the body of water located northeast of O'Reilly Island; both search areas are situated in Nunavut, Canada. Although heavy ice cover in Victoria Strait in 2014 all but thwarted ambitious plans to survey in the northern area, searching continued in the southern area unabated. Here the project culminated in the September 2014 discovery of the wreck of *Erebus*, receiving worldwide media coverage upon its announcement by Prime Minister Stephen Harper.

In both planning and execution, the 2014 Parks Canada led underwater archaeological survey enjoyed the broad-based support of a number of federal and territorial government departments including the Canadian Coast Guard (CCG), Canadian Hydrographic Service (CHS), Royal Canadian Navy (RCN), Defence Research and Development Canada (DRDC), Canadian Space Agency (CSA), Canadian Ice Service (CIS), and Government of Nunavut (GN). The private not-for-profit Arctic Research Foundation (ARF)

likewise continued their considerable involvement that began in 2012. In 2014 the Royal Canadian Geographical Society, One Ocean Expeditions, the W. Garfield Weston Foundation and Shell Canada joined Parks Canada as project partners.

The total project duration in 2014 amounted to 40 days, including transit time to and from the survey areas, both at the outset and conclusion of the project, as well as during return calls to port for re-supply, crew exchange, participation in the Prime Minister's 2014 northern tour, and media announcements. As would be expected, a certain amount of down time was also experienced due to the usual bouts of inclement weather.

The Canadian Coast Guard Ship (CCGS) *Sir Wilfrid Laurier* served as the principal project platform, during its regularly scheduled patrol in the central Canadian Arctic. From it were deployed the Parks Canada survey vessel *Investigator* and its UAT crew. As well, the CHS launches *Gannet* and *Kinglett* and a CHS team were deployed from the *Sir Wilfrid Laurier*, which operated in both the northern and southern search areas. The survey was also staged from the MV *Martin Bergmann*, supplied by ARF, which operated in the southern search area. As well, the *One Ocean Voyager* (*Akademik Sergey Vavilov*) supplied by One Ocean Expeditions deployed a DRDC team and completed some limited survey in the northern search area in the face of the heavy ice cover. A fourth platform, the RCN's HMCS *Kingston* could not reach the northern search area due to heavy ice in the region.

Remote-sensing equipment used to search for the Franklin wrecks included digital side-scan sonar systems that were towed from each of the *Martin Bergmann* and the *Investigator*. As well, a digital side-scan sonar system and multi-beam echosounder were mounted on DRDC's *Arctic Explorer* autonomous underwater vehicle which in turn was deployed from the *One Ocean Voyager*. The underwater survey work was conducted under the authority of a Nunavut Class 2 archaeology permit (no. 2014-19A) taken out by Ryan Harris of the UAT.

Shore parties from the *Sir Wilfrid Laurier* conducted terrestrial archaeological fieldwork on both King William Island and on islands in the southern search area. This was carried out by a GN team comprising Dr. Doug Stenton and Dr. Robert Park (with support from *Sir Wilfrid Laurier* crew members including helicopter pilot Captain Andrew Stirling) and is the subject of a separate report. On September 1, 2014 this team made two notable artefact finds on an island in the southern search area: a davit pintle and a plug for a deck hawse clearly of Royal Navy origin, and quite possibly from a nearby shipwreck. The shore finds resulted in the ongoing marine search shifting closer to the terrestrial find location.

The subsequent discovery of a suspected Franklin shipwreck in the southern search area was made by the UAT on September 2, 2014 using its side-scan sonar towed by the RV *Investigator*. Sonar images revealed an intact wreck lying upright on the seafloor. It was confirmed as a Franklin wreck (still not identified by name) during a remotely-operated vehicle (ROV) dive on September 7, 2014 staged by the UAT from the *Investigator*. This ROV dive provided the first images of the

shipwreck, underscored both its excellent state of preservation and outstanding archaeological potential. At a press conference held at the UAT offices in Ottawa on September 9, 2014 Prime Minister Stephen Harper announced the discovery of the wreck. On September 17 and 18, 2014 the UAT completed a total of 7 tandem dives to the wreck totalling 12 hours of combined bottom time, all of which was carried out from *Investigator*, in turn staged from the *Sir Wilfrid Laurier*. In parallel with these diving operations the CHS team carried out a multi-beam bathymetric survey of the wreck and surveyed an approach corridor to the wreck site. Following the return of the UAT to Ottawa the wreck was identified by Ryan Harris of the UAT as *Erebus*, which in turn was announced by Prime Minister Harper in the House of Commons on October 1, 2014.

The 2014 fieldwork received extensive media coverage, in particular following the wreck discovery. A film crew from Lion Television was present for most of the fieldwork, and a photographer from the Royal Canadian Geographical Society was aboard the *Martin Bergmann*.

ACKNOWLEDGEMENTS

One of the reasons for the success of the ongoing projects to search for the lost ships from Sir John Franklin's expedition is the great collaboration between numerous partners from the public, private and academic sectors. To list everyone who was involved in the 2014 search for the Franklin ships would be impossible but the UAT would like to acknowledge a number of individuals, groups and teams who were key in the field operations.

The UAT is grateful for the support, hospitality, and expertise offered by the CCGS *Sir Wilfrid Laurier* (red crew cycle), most particularly Captain Bill Noon, Chief Officer Rich Marriott, Boatswain Rhett Miller, and the entire ship's Deck Department. Collectively they took expert care of the Parks Canada research vessel (RV) *Investigator* and the CHS launches *Gannet* and *Kinglett* during the delicate launch and recovery routine each day. As well, Deck Department members Cory Glencross and Gabriel Giguere supported UAT diving operations by ferrying crew members between the *Sir Wilfrid Laurier* and the wreck site using the ship's Hurricane 733 rigid-hull inflatable boat. The skill and expertise of the ship's company were showcased during the delicate transfer of the *Investigator* from the *One Ocean Voyager* to the *Sir Wilfrid Laurier* on August 31, 2014.

In 2014 a CHS team rejoined the project following a year-long hiatus. On the *Sir Wilfrid Laurier* Hydrographer-in-Charge Scott Youngblut was accompanied by Hydrographers Ryan Battista, Christine Delbridge, Marcus Beach and Arthur Wickens as well as Electronics Technician Rudy Cutillo. CCGS *Sir Wilfrid Laurier* crew members Keith Graham and Nicholas Frith expertly served as coxswains for the *Gannet* and *Kinglett*. Hydrographers Glenn Toldi, Bernard Labrecque and Julie Larrivée were stationed aboard HMCS *Kingston* which was not able to reach the search area. Theresa Nichols of the Department of Fisheries and Oceans (DFO) provided invaluable media and communications support from onboard the *Sir Wilfrid Laurier*.

ARF made their vessel *Martin Bergmann* available for the full duration of the survey, 4 weeks in all and we are extremely grateful for this significant contribution. Indeed, during the course

of three field seasons this vessel has contributed significantly to side-scan sonar coverage in both the northern and southern search areas. Adrian Schimnowski, Project Manager for the foundation, oversaw significant upgrades and important refits to the vessel in the lead-up to the 2014 field season while tending to crewing, provisioning, scheduling, and many other vital logistical preparations. The UAT is also indebted to the *Martin Bergmann* crew, consisting of Captains Darryl Clow, David McIsaac, and Gerry Chidley, deckhands Clyde Bursey and Daniel McIsaac, as well as cook Athlyne Etienne. Royal Canadian Geographical Society photographer Tyrone Burke was also aboard the *Martin Bergmann* for the entire duration of its deployment.

The RCN provided three valuable personnel to augment the crew of the *Martin Bergmann*. This contribution was facilitated by a provision-of-service agreement between Parks Canada and the RCN, which allowed their personnel to be seconded to work aboard the ARF vessel. Leading Seaman Brandon Patey served as Boatswain and Leading Seaman Shane Milmore as Cook. Petty Officer 1st Class Yves Bernard, of Fleet Diving Unit Atlantic (FDU (A)) assisted with side-scan sonar operations.

The RCN also made HMCS (Her Majesty's Canadian Ship) *Kingston* available to survey in the northern area. Special thanks to Lieutenant-Commander Peter Koch and Lieutenant-Commander Paul Smith, and the crew of the *Kingston*, for making every possible effort to bring the vessel down to join the search efforts.

DRDC participated in this season's search with the deployment of the *Arctic Explorer*, an unmanned underwater vehicle equipped with synthetic aperture sonar. The DRDC team led by Richard Pederson was composed of Timothy Murphy, Owen Shuttleworth, Valeri Shepeta, Sean Spears, Vincent Myers with DRDC; Leading Seaman Stewart Riggs and Leading Seaman Antony Savard from RCN; and David Shea from Kraken Sonar. The *Arctic Explorer* was transported to and from the search zone, and deployed from the *One Ocean Voyager*. This vessel was operated by One Ocean Expeditions that was brought into the project, along with the W. Garfield Weston



Ship's company of CCGS *Sir Wilfrid Laurier* at the conclusion of the 2014 search (Photo: T. Boyer, Parks Canada, 89M1001EF).

Foundation and Shell Canada, by the Royal Canadian Geographical Society to support the development of a school curriculum around the Franklin expedition. Thank you to these organisations, to Andrew Prossin for the use of the vessel to transport and deploy the *Arctic Explorer* and to Aaron Lawton and the crew of the *One Ocean Voyager* for their skills and expertise.

Richard Sanfaçon (Director) of the Institut Maurice Lamontagne, CHS Laurentienne Region, loaned their Klein 3000 side-scan sonar system for the duration of the survey, this for the sixth occasion since 2008.

Tom Zagon of the CIS again offered his expertise and support in providing seasonal ice forecasts and regular updates on ice movements, all specific to the survey schedule and search areas, while relaying regular weather updates to the crew of *Martin Bergmann*. Thanks also to members of the CSA who collaborated with the project and to Yves Crevier who helped out in the surveillance work following the shipwreck discovery.

The UAT's RV *Investigator* and its Seaeye Falcon ROV were transported from Halifax, Nova Scotia to the study area aboard One Ocean Expedition's *One Ocean Voyager*. The UAT is again grateful to Andrew Prossin and Aaron Lawton for arranging this transport.

The Department of Culture, Language, Elders and Youth for the GN provided a second side-scan sonar cable winch back in 2008 which continues to serve as an essential piece of equipment supporting the survey. Indeed, the close collaboration between the GN terrestrial team led by Dr. Doug Stenton, and the Parks Canada led marine search teams that first took shape in 2008 was a major contributing factor in the discovery of *Erebus*.

Thank you to the hamlets of Gjoa Haven and Cambridge Bay as we look forward to increased collaboration in projects to come on *Erebus*.

Finally, special thanks are due to some of the Parks Canada team who worked closely with us to make this happen: Alan Latourelle, Andrew Campbell, George Green, Marty Magne, Meryl Oliver, the communications and web teams, and so many others. UAT Underwater Archaeologist Thierry Boyer assisted with the completion of this report's layout. Senior Underwater Archaeologist Filippo Ronca reviewed the visual site inspection section and the maps were prepared by Underwater Archaeologist Charles Dagneau.

LIST OF ABBREVIATIONS

ARF	Arctic Research Foundation
AUV	Autonomous underwater vehicle
CHS	Canadian Hydrographic Service
CCG	Canadian Coast Guard
CCGS	Canadian Coast Guard Ship
CIS	Canadian Ice Service
CSA	Canadian Space Agency
CSL	Canadian Survey Launch
CSRS 98	Canadian Spatial Reference System 1998
DFO	Fisheries and Oceans Canada
DGPS	Differential global positioning system
DRDC	Defence Research and Development Canada
FDU (A)	Fleet Diving Unit (Atlantic), Royal Canadian Navy
GHz	Gigahertz
GIS	Geographic information system
GN	Government of Nunavut
GNWT	Government of the Northwest Territories
GPS	Global positioning system
HD	High-definition
HMCS	Her Majesty's Canadian Ship
HMS	Her Majesty's Ship
HSMBC	Historic Sites and Monuments Board of Canada
hp	Horsepower (1 hp = 746 Watts)
in.	Inches
InSAS2	Interferometric Synthetic Aperture Sonar
kHz	Kilohertz

kW	Kilowatt
L	Litre
m	Metre
MBES	Multi-beam echosounder
MV	Motor vessel
NAD 83	North American Datum 1983
RCGS	Royal Canadian Geographical Society
RCN	Royal Canadian Navy
RHIB	Rigid-hull inflatable boat
ROV	Remotely operated vehicle
RV	Research vessel
SBAS	Satellite-based augmentation system
SCUBA	Self contained underwater breathing apparatus
UAT	Underwater Archaeology Team
UTM	Universal Transverse Mercator
UUV	Unmanned underwater vehicle
VAC	Volts alternating current
VDC	Volts direct current
WAAS	Wide Area Augmentation System

1 PROJECT DESCRIPTION

1.1 INTRODUCTION

Long since their shocking disappearance, the fate of the doomed Franklin Expedition and the whereabouts of the *Erebus* and *Terror* have remained the subject of enduring international scrutiny and speculation. Representing the single greatest loss of life of any Royal Navy expedition to the Arctic or Antarctic seas, the Franklin saga has taken its place as the most venerated episode in the annals of polar exploration and a resonant theme in the history of the Canadian North.

This report describes the sixth field season of a multi-year commitment to search for the wrecks of *Erebus* and *Terror*, lost during the disastrous Sir John Franklin Expedition of 1845 in search of a Northwest Passage. As well, it describes the September 2014 discovery of the wreck of *Erebus*. To date the survey and discovery have drawn together the considerable expertise, resources, and capabilities of a broad range of project partners, representing both the government and private sectors where common interest in Arctic research has been identified. The 2014 underwater archaeological survey was a multi-disciplinary collaborative effort between Parks Canada's UAT, the CG, GN, RCN, CSA, CIS, DRDC, the private not-for-profit ARF, W. Garfield Weston Foundation, Royal Canadian Geographical Society (RCGS), One Ocean Expeditions, and Shell Canada.

At the outset of the 2014 field season the marine archaeological survey aimed to locate the remains of Franklin's two missing ships using marine remote sensing. The discovery of *Erebus* during the first week of September 2014 immediately shifted the project aims to an evaluation of the structural and commemorative integrity of the site, assessment of its environmental conditions, and a preliminary inventory of exposed structures and artefacts.

1.2 PROJECT RATIONALE

As part of its mandate, the UAT is charged with identifying, preserving, and presenting nationally significant examples of Canada's underwater cultural heritage, including the wrecks of the *Erebus* and *Terror*, for the present and future benefit of the Canadian public.

In 1992, the Historic Sites and Monuments Board of Canada (HSMBC) took the deliberate step of designating the missing wrecks as a National Historic Site, stating that "the ships *Terror* and *Erebus* are of national historic significance due to their association with Franklin's last expedition". The fact that neither wreck had as yet been located was regarded as a temporary formality. The designation was undertaken as a pre-emptive measure to safeguard the wrecks in the face of perceived external threats, the Board advising that once "the wrecks are found, the Canadian Parks Service should cooperate with other levels of government to ensure the protection of the ships and their artifacts" (Parks Canada 2006).

This soon paved the way for UAT involvement in two field projects directed at locating one or the other of the two Franklin wrecks, the first in 1993 and the second in 1997 (Harris and Moore 2011). In each case, Parks Canada worked in cooperation with the Government of the Northwest Territories (GNWT): (i) to represent the interests of the Federal Crown as the responsible Canadian authority on the protection, investigation and exploration of the wrecks; and (ii) to provide archaeological guidance regarding proper archaeological protocols and to provide remote sensing surveying capability during fieldwork, as well as to supply diving gear and personnel in the event of a wreck discovery. In a further effort to ensure the long-term protection of the two vessels, a "Memorandum of Understanding Between the Governments of Great Britain and Canada Pertaining to the Shipwrecks *Erebus* and *Terror*" was signed in 1997, assigning custody and control of the wrecks to Canada in the event that either is located, and establishing Canada as the agent for Great Britain for the purposes of ensuring the "commemorative integrity of the wrecks through the orderly and scientific exploration, recovery



Figure 1.3.1: Parks Canada's RV *Investigator* being craned from the CCGS *Sir Wilfrid Laurier* for a day of survey in Queen Maud Gulf, Nunavut (Photo: J. Moore, Parks Canada, 89M0011EF).

and disposition of the wrecks and their contents" (Appendix 1: Memorandum of Understanding). On behalf of the Government of Canada, Parks Canada and the UAT, as a recognized federal authority on submerged cultural resource management, bear responsibility for upholding the terms of this bilateral international agreement.

With the formal separation of the Nunavut Settlement Area from the political boundaries of the Northwest Territories in 1999, regional responsibility for the *Erebus* and *Terror* devolved from the GNWT to the new GN (this based on the presumed location of the two wrecks lying somewhere in the general vicinity of King William Island). Recognizing that the wrecks, once found, would ultimately require and benefit from mutual federal and territorial input into their effective management, Parks Canada and the GN have consulted closely on matters pertaining to the wrecks. In 2013, this inter-governmental level of cooperation was more formally established under a memorandum of understanding signed between Parks Canada and the GN.

In October 2014 the Historic Sites and Monuments Board of Canada updated the site's name to "Wrecks of HMS Erebus and HMS Terror National Historic Site of Canada" and approved an updated plaque text.

1.3 PROJECT ORGANIZATION

The present project was initially conceived as a joint hydrographic and archaeological survey conducted by the UAT and CHS (DFO), leveraging their respective resources for reciprocal benefit where departmental mandates could be seen to intersect. Where Parks Canada was concerned with locating the wrecks of *Erebus* and *Terror*, CHS was focused on conducting seafloor mapping for nautical charting purposes in the same general area. This partnership precipitated a very productive multi-year collaborative survey, beginning modestly in 2008 and 2010, but evolving into an ambitious inter-departmental Arctic Charting and Mapping Pilot Project undertaken in 2011 and 2012 - this implicating an impressive array of government and non-government interests. The first four field seasons all involved the CCGS *Sir Wilfrid Laurier*, with ship time arranged by CHS. In 2012, this platform was joined by the MV *Martin Bergmann*, a survey vessel provided by ARF after Parks Canada and the Foundation had entered into a three-year Memorandum of Understanding, beginning in 2012, to engage the latter's direct support for the search for the Franklin wrecks.

For the 2013 survey, Parks Canada assumed much of the logistical planning responsibility that CHS had previously shared, when the latter reported



Figure 1.3.2: The MV *Martin Bergmann* with CSL *Gannet* and CSL *Kinglett* at anchor in Gjoa Haven (Photo: T. Boyer, Parks Canada, 89Mo302EF).

that they would be unable to participate directly (at least in the near term) due to scheduling and budgetary constraints. Parks Canada subsequently negotiated the continued involvement of the Coast Guard platform and continued to host regular planning meetings with the various project partners to coordinate research and field activities. Arrangements were made to have the UAT's RV *Investigator* sent to the Arctic to stand in for the CHS survey launches used previously, and this staged from the CCGS *Sir Wilfrid Laurier* as before (Figure 1.3.1). In the course of the planning process, a significant new project partner was also enlisted for the 2013 field season, with the RCN agreeing to send three of their personnel to supplement the crew of the MV *Martin Bergmann*.

Following the conclusion of the 2013 search, planning for the 2014 season soon began, with the addition of four project partners. The RCGS entered into a memorandum of understanding with Parks Canada, with its chief contribution to be outreach and education initiatives. The RCGS also drew in One Ocean Expeditions, the W. Garfield Weston Foundation and Shell Canada as partners. One Ocean Expeditions made available its ice-rated adventure cruise ship *One Ocean Voyager* (*Akademik Sergey Vavilov*) as a search platform all the while carrying paying passengers, a group of students and researchers, and a team from DRDC. The latter, an active partner since 2013,

provided its *Arctic Explorer* autonomous underwater vehicle (AUV) with a support team collectively deployed from the *One Ocean Voyager*. As in all previous search seasons, the CCGS *Sir Wilfrid Laurier* was secured for a dedicated search period (Figure 1.3.1). The RCN committed the Maritime Coastal Defence Vessel HMCS *Kingston* to the search and the CHS committed hydrographers to serve on the CCGS *Sir Wilfrid Laurier* and HMCS *Kingston*. The ARF committed the MV *Martin Bergmann* for the full duration of the search (Figure 1.3.2) and the RCN kindly provided three additional crew members for this research vessel: Petty Officer first class Yves Bernard, Leading Seaman Shane Milmore and Leading Seaman Brandon Patey.

On behalf of Parks Canada, the UAT serves as the archaeological project authority and is responsible for ensuring that all survey activities are compliant with the Nunavut Archaeologist Permit conditions, the Nunavut Archaeological and Palaeontological Sites Regulations, and the *Guidelines for Nunavut Archaeological and Palaeontological Sites*.

Activities directed at finding and studying the *Erebus* and *Terror* shipwreck sites by both the UAT and its project partners are guided by the "Rules concerning activities directed at underwater cultural heritage" that form the Annex to

the *UNESCO Convention on the Protection of the Underwater Cultural Heritage* (2001), in particular Rules 3, 6, 10 and 22-23 regarding the minimizing of impacts to the site, acceptable recording standards, project design, and competence and qualifications. Likewise, following the September 2014 discovery of what later proved to be *Erebus*, site investigations were led by Parks Canada and conducted with full respect for the 1997 “Memorandum of Understanding Between the Governments of Great Britain and Canada Pertaining to the Shipwrecks *Erebus* and *Terror*” (see Appendix 1).

Given that it had been impossible to predict with any certainty if and when one of the wrecks would be located, the fieldwork plan had initially anticipated up to three years of remote sensing activity. This was subsequently extended for an additional three years (2012 through 2014) in an announcement made by Prime Minister Stephen Harper in Cambridge Bay on August 23, 2012.

The 2014 survey activities were carried out between August 13 - September 21. The months of August and September represent the optimal weather window and period of ice-free navigation for research work in the central Canadian Arctic, as well as the period of seasonal availability of the *Sir Wilfrid Laurier*.

The UAT fieldwork participants were Marc-André Bernier, Ryan Harris, Jonathan Moore, Filippo Ronca, Thierry Boyer, Charles Dagneau, Chriss Ludin, and Joe Boucher. Other Parks Canada staff contributed to the delivery of the various media products that served to present the 2014 search for *Erebus* and *Terror* and the discovery of the *Erebus* to the public.

1.4 OBJECTIVES

The project aims as originally conceived, were to make a substantial contribution to the history, archaeology and geography of the Canadian Arctic by locating and documenting the wreck(s) of one or both of Sir John Franklin’s two ships, *Erebus* and *Terror*, both abandoned in 1848 while searching for a Northwest Passage.

In 2008 and 2010 surveys were carried out in a large expanse of the seafloor in a primary search area off the western flank of the Adelaide Peninsula

using high-resolution side-scan sonar imagery (Harris and Moore 2010, 2011). Initially the three-year scope of this remote-sensing project aimed to produce sufficient area coverage, and this with a high probability of target detection, to determine whether one of Franklin’s abandoned ships sank off the western shores of the Adelaide Peninsula, as reported by nineteenth-century Inuit oral history. This reported wreck is referred to as the Ugjuklik Wreck (see below). Instead of carrying out a third season of work in this southern primary search area, due to hydrographic survey imperatives, in 2011 the survey shifted north to a secondary search area at the northern approach to the Alexandra Strait west and northwest of the Graham Gore Peninsula of King William Island. This search area targeted one of Franklin’s ships reportedly wrecked off the west side of King William Island (see below). In 2012, given the availability of both the CCGS *Sir Wilfrid Laurier* and the MV *Martin Bergmann*, survey activities took place in both the southern and northern search areas. The same two-front approach was adopted again in 2013 with the renewed availability of these same two platforms, but with the Parks Canada RV *Investigator* standing in for the CHS multi-beam survey launches *Gannet* and *Kinglett* which had staged from the icebreaker the year before. In 2014 the two-area approach was again adopted, with the prime focus of activity to be the northern search area, should the ice clear sufficiently in Victoria Strait.

1.5 DEFINITION OF THE STUDY AREA

The 2014 survey aimed to repeat the ambitious schedule adopted in 2013 in targeting both lost Franklin vessels in the same season (Figure 1.5.1), this involving remote-sensing operations in two distinct survey zones, 125 km apart, where the wrecks are respectively thought to lie. Both the northern and southern search areas, as they are termed within the context of the present project, lie within the Kitikmeot Region (Qitirmiut) of Nunavut, Canada. Despite the fact that both search areas were to be targeted in 2014, the official project title was the “2014 Victoria Strait Expedition”, reflecting the intended focus on the northern area.

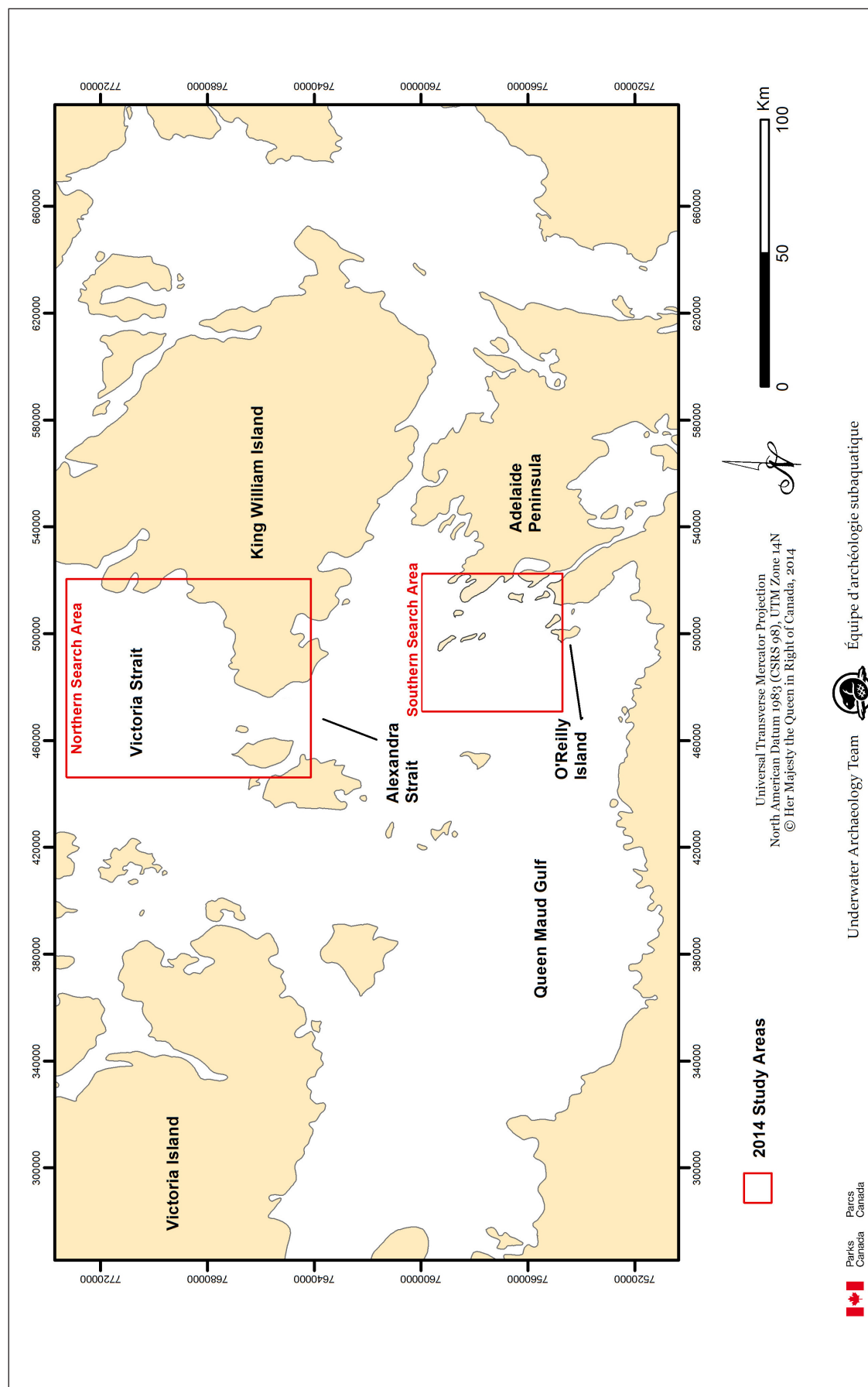


Figure 1.5-1: The central Canadian Arctic showing the 2014 *Erebus* and *Terror* southern and northern search areas (Map: C. Dagneau, Parks Canada).

The 2014 field operations began with a two-and-a-half week survey in the southern search area, consisting of the eastern waters of the Queen Maud Gulf off the west side of the Adelaide Peninsula. More particularly, the 2014 search focused on building coverage in Wilmot and Crampton Bay, north of O'Reilly Island. This was a continuation of previous surveys from 2008, 2010, 2012, and 2013, now expanding to the north, northwest and northeast. The decision to once again start the season with survey in the south was influenced by the earlier breakup of ice in this location relative to the northern search area, the latter typically becoming open for unimpeded navigation at least two weeks later.

In 2014 however, the ice in the northern search area did not break up as anticipated, so surveying in the southern area continued through to September 3. Whereas the northern search program was slated to start on or about August 28, only limited searches could be accomplished in the waters encompassing Alexandra and Victoria Straits. Survey in this area initially began in 2011 after a brief reconnaissance was made in 2008. As there are few available historical clues as to the potential loss location of the reported northern wreck, virtually any area of Victoria Strait and Alexandra Strait presents a valid and potentially profitable archaeological search area. A 2010-2011 historical ice climatology study by Tom Zagon (Moore, Harris and Zagon 2012), however, sought to narrow the field by identifying historically recurrent patterns of ice formation, drift, and breakup that would potentially constrain the trajectories of the beset vessels post-abandonment.

No.	Survey Block Name
51M43	North of O'Reilly Island - Block 1 - MV <i>Martin Bergmann</i>
51M44	North of O'Reilly Island - Block 2 - MV <i>Martin Bergmann</i>
51M45	North of O'Reilly Island - Block 3 - RV <i>Investigator</i>
51M46	North of O'Reilly Island - Block 4 - RV <i>Investigator</i>
51M47	Alexandra Strait - Block 1 - RV <i>Investigator</i>
51M48	Alexandra Strait - Block 2 - RV <i>Investigator</i>
51M49	Erebus Bay East - RV <i>Investigator</i>
89M	HMS <i>Erebus</i>

Table 1.6.1: UAT provenience designations for the 2014 *Erebus* and *Terror* search. Numbers 51M43 to 51M46 are situated in the southern search area, and 51M47 through 51M49 in the northern search area. Site 89M is of course in the southern search area.

This research suggested that drifting ice in the Victoria Strait inevitably encountered a bottleneck where it funneled into the constricted entrance to Alexandra Strait, causing highly dynamic friction with the immobile landfast ice on either side. The resulting upheaval and rafting of southbound ice would have presented a perilous situation for a wooden sailing vessel, and consequently the sheer lines on either side of the bottleneck became a priority for survey. The search efforts in 2011 and 2012 were focused on the western side of the bottleneck, while efforts in 2013 shifted progressively to the east. Only limited additional coverage was added in 2014.

1.6 PROVENIENCE SYSTEM

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). The *Erebus* and *Terror* search has been assigned the project code 51M – the “M” designating a Parks Canada marine or underwater project. Within a given project, geographic zones or “operations” are routinely assigned to specific islands and bodies of water to further distinguish subsets of collected fieldwork data. In the case of the present survey, remote-sensing data acquired in 2014 falls under the provenience designations 51M43 and 51M46 for records associated with the southern search area (Figure 1.6.1), and 51M47 through 51M49 for those associated with the northern search area (Figure 1.6.2). These designations identify individual survey “blocks” determined by Ryan Harris and Jonathan Moore of the UAT; each block designates a working area for a given survey vessel or combination of vessels. The provenience designations and block names are listed in Table 1.6.1. Upon the discovery of the wreck that later proved to be *Erebus*, the site was assigned the Parks Canada provenience number 89M. All field data and site records linked to the wreck itself fall under this provenience designation. At the time of writing this report, the wreck site has not been registered as an archaeological site nor assigned a Borden number. In consultation with Dr. Doug Stenton, Director of Culture and Heritage of the Government of Nunavut, no site location information for *Erebus* (site 89M) nor geomatic data for the southern search area that would point to a site location will be included in this interim report.

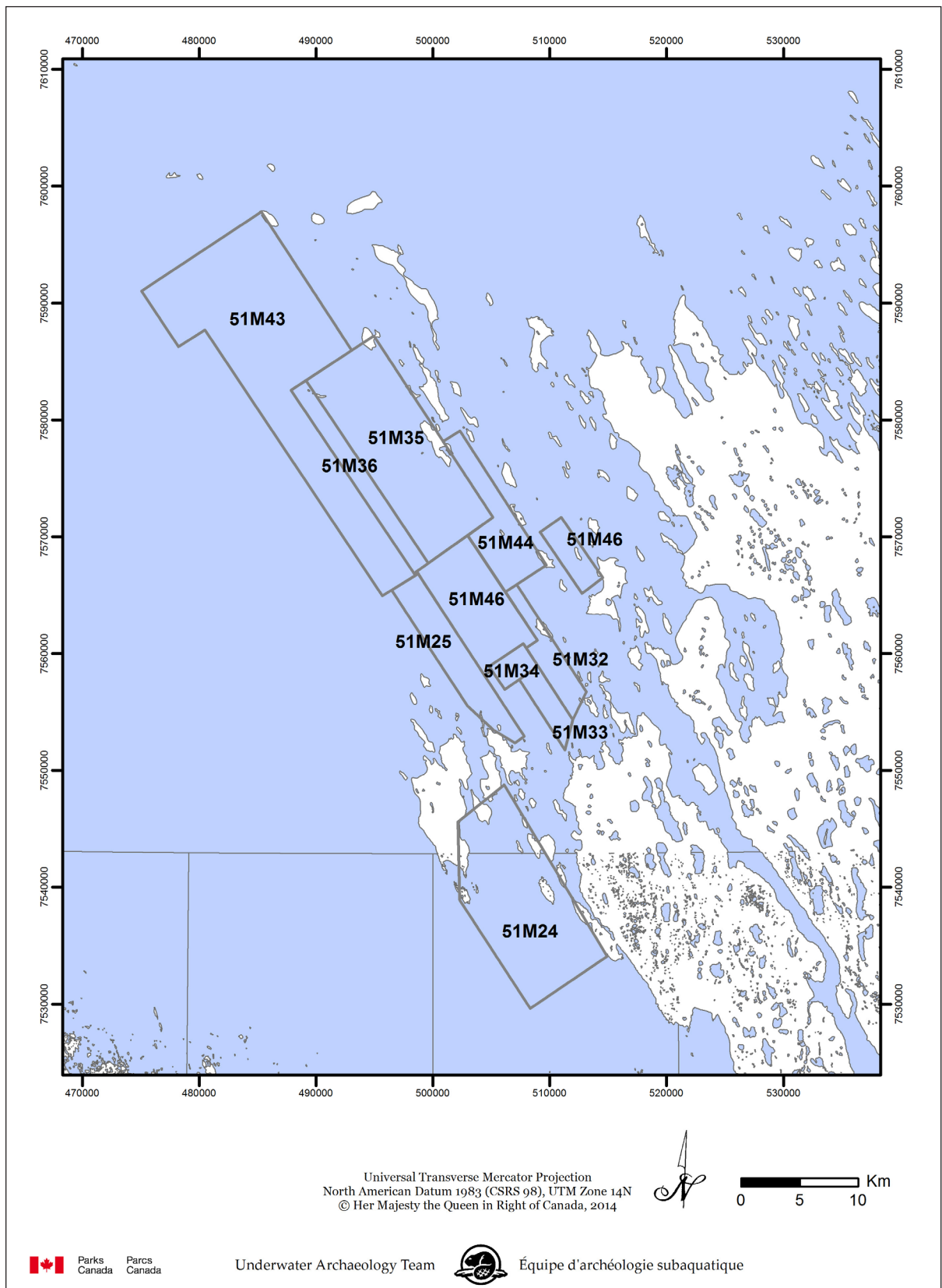


Figure 1.6.1: Provenience designations for survey blocks in the southern search area, 2008, 2010, 2012, 2013 and 2014 (Map: J. Moore and C. Dagneau, Parks Canada; Base map: CanVec).

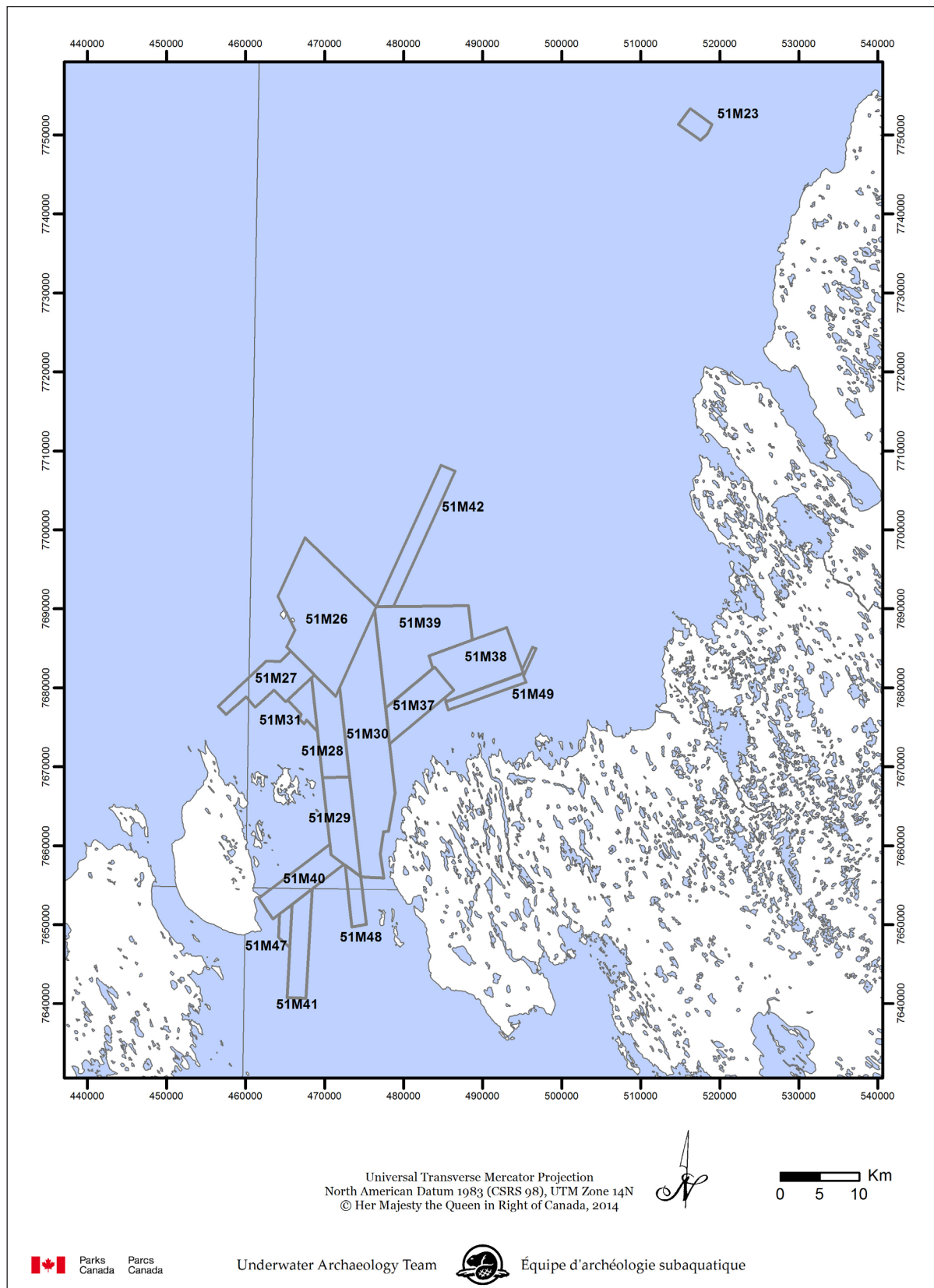


Figure 1.6.2: Provenience designations for survey blocks in the northern search area, 2008, 2011, 2012, 2013, 2014 (Map: J. Moore and C. Dagneau, Parks Canada; Base map: CanVec).

2 HISTORICAL AND ARCHAEOLOGICAL BACKGROUND

2.1 HISTORICAL BACKGROUND

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. *Erebus* and *Terror* were converted bomb vessels of 378 and 331 tons respectively and both had already seen prior service in polar exploration. They were stoutly-built and soundly reinforced for operation in the ice, 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 (Cyriax 1939: 28 ff.) (Figure 2.1.1). Sir John Franklin's orders were to traverse the passage and return to England without delay via the Pacific (Cyriax 1939: 45 ff.).

The expedition initially overwintered in 1845-1846 at Beechey Island, on Barrow Strait before, in all probability, descending Peel Sound in the direction of the North American mainland to the south. On September 12, 1846, their steady progress of the previous year was halted off the north end of King William Island when both ships became firmly beset by pack ice (Figures 2.1.2-2.1.4). There they remained drifting slowly southwards from Larsen Sound and into Victoria Strait, locked in the unyielding embrace of the ice floes

for a full year and a half. Presumably confronted by dwindling supplies and with no foreseeable hope of extrication on the horizon, the desperate crews abandoned both ships on April 22, 1848. The remaining 105 expedition members then began a long and ultimately unsuccessful retreat south towards the Great Fish (modern Back) River under the command of Crozier, Franklin having died in June 1847. The above events were pieced together chiefly from a message left in a cairn at the retreating party's landfall on King William Island south of Victory Point (McClintock 1860; Cyriax 1939: 121-181) (Figure 2.1.3).

A succession of Royal Navy and private search expeditions between 1848-1880 failed to locate any surviving members of Franklin's lost expedition or either of its missing ships (Cyriax 1939: 71-99). Explorers Dr. John Rae, Francis Leopold McClintock, Charles Francis Hall, and Frederick Schwatka searched for traces of the Franklin Expedition and its records in 1854, 1857-1859, 1864-1869 and 1878-1880 respectively, chiefly on and in the vicinity of King William Island. In doing so they and their travel 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 first-hand observations and oral histories about the fate of Franklin's men and their ships (Rich and Johnson 1953; McClintock 1860; Nourse 1879; Gilder 1880).

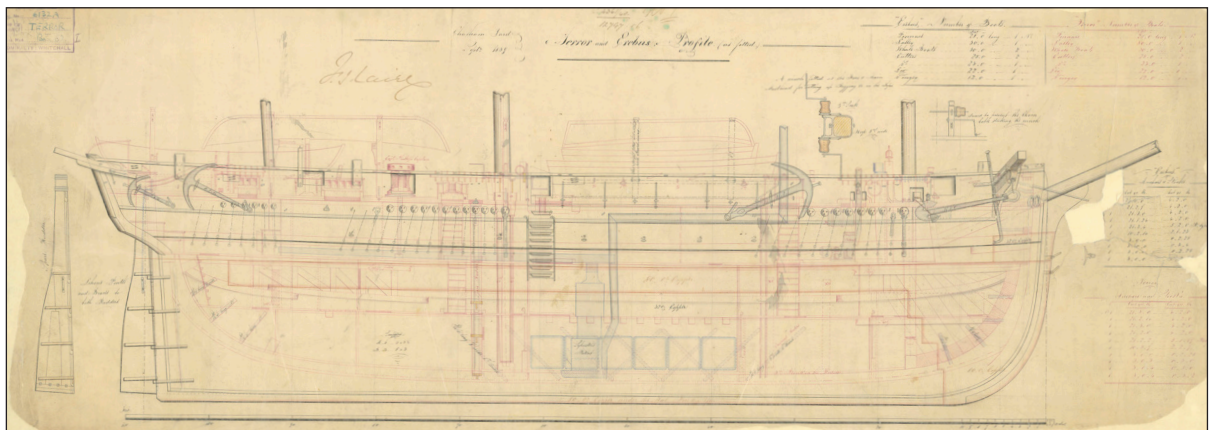


Figure 2.1.1: Inboard profile of HMS *Erebus* as fitted for James Clark Ross' Antarctic expedition, 1839-1843 (Courtesy: National Maritime Museum, Greenwich, London, ZAZ5673, J1407).

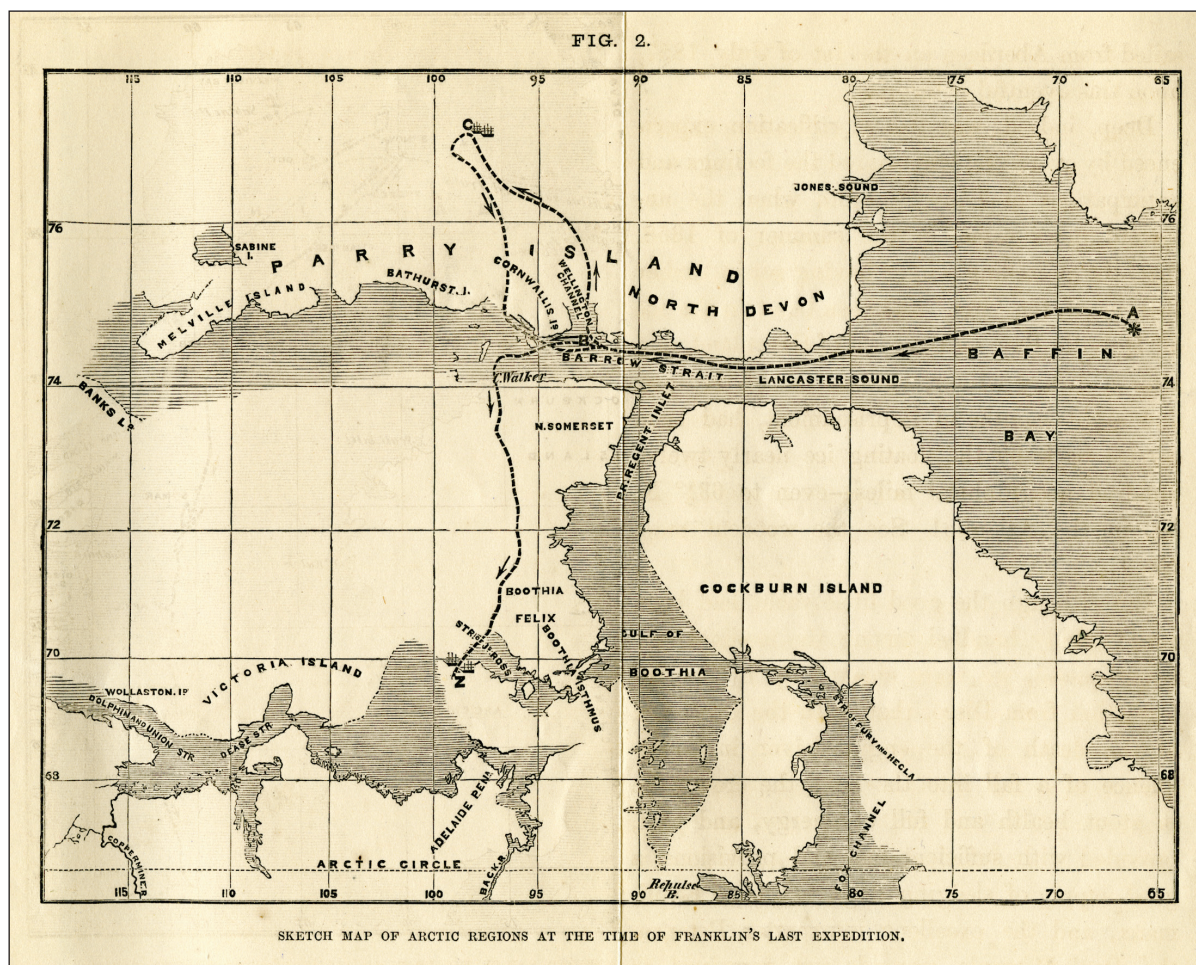


Figure 2.1.2: *Sketch Map of Arctic Regions at the Time of Franklin's Last Expedition* in McClintock (1860: Figure 2). This map, which reconstructs the movements of the *Erebus* and *Terror* as learned by McClintock in 1859, gives some indication of the scope of the search for the *Erebus* and *Terror* faced by nineteenth-century and present-day searchers: evidence for the movement and sinking following their abandonment (marked Z) is both extremely limited.

The events following the abandonment of the *Erebus* and *Terror* in April 1848 have thus been gleaned from Inuit oral history and archaeological evidence. It is clear that the majority of expedition members perished on the southward retreat, some of whom reached as far south as Starvation Cove on the Adelaide Peninsula, with possible further traces of crewmen further south and east. Until 2014, the fate of the vessels themselves was far less clear (see Cyriax 1939: 182-194); whereas *Erebus* has now been located, the sinking position of *Terror* remains to be determined.

Inuit oral histories recount the sinking of one of the ships to the west of King William Island, while others report that one of the vessels was lost much further south in a place called Ugjulik, which correlates to the Queen Maud Gulf immediately west of the Adelaide Peninsula; this wreck is now

known to be *Erebus*. The abovementioned explorers' accounts and their associated records of Inuit oral history 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).

The primary (southern) and secondary (northern) search areas reflect how the respective fates of the *Erebus* and *Terror* apparently diverged after they were abandoned. Inuit accounts of the demise of the Franklin Expedition, as chronicled by a series of subsequent search expeditions led by Francis Leopold McClintock (1857-1859), Charles Francis Hall (1864-1869), and Frederick Schwatka (1878-1880), and which survive to some extent in Inuit oral tradition to the present day, suggest that one of Franklin's two ships was crushed in the ice west

of King William Island (*Terror*) while the other (*Erebus*) made its way through Victoria Strait as far south as the Adelaide Peninsula where it finally sank in the waters of Uggulik (spelled variously Utjulik, Ootjoolik etc.).

The longstanding emphasis on surveying the primary search area in the south stems from the fact that Inuit witnesses to the event have left far more tangible evidence as to the possible disposition of the Uggulik vessel, having reportedly seen it firsthand. 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 provide an approximate starting point for a systematic search. Indeed, it was this evidence that ultimately underpinned the wreck discovery in 2014.

The loss of the other northern ship (*Terror*), conversely, was not witnessed directly by the Inuit, but was instead reported to them second hand by the retreating Franklin crews. What information they did glean was for the most part vague. All that can be said is that the other northern vessel was supposedly crushed somewhere west of King William Island. Unless it actually happened to sink in close proximity to the ships' last recorded position, however, an inordinately large area would have to be surveyed to find it. As it stands, there is no telling just how far this ship may have drifted from where it was abandoned off Victory Point before ultimately succumbing to the pressures of the ice. To complicate matters, a large-scale search in this area has to contend with the deep waters typically found in the Victoria Strait, as compared to the relatively shallow waters found at the eastern end of Queen Maud Gulf. Consequently, the secondary survey area located northwest of King William Island can only be broadly defined as comprising the whole of Victoria Strait.

Whereas available Inuit oral history evidence for the northern wreck is less abundant than for the southern Uggulik Wreck (*Erebus*), and the potential for a wreck there has received less attention from modern researchers, there were two important sets of "relic" finds made in 1851 and 1853 on the southeast shore of what is now Victoria Island (Nunavut) that potentially represent drifting wreckage from the *Erebus* and/or *Terror*. While there is no absolute certainty that these items, described below, came from the *Erebus* and/or *Terror*, they are pertinent to discussion of the

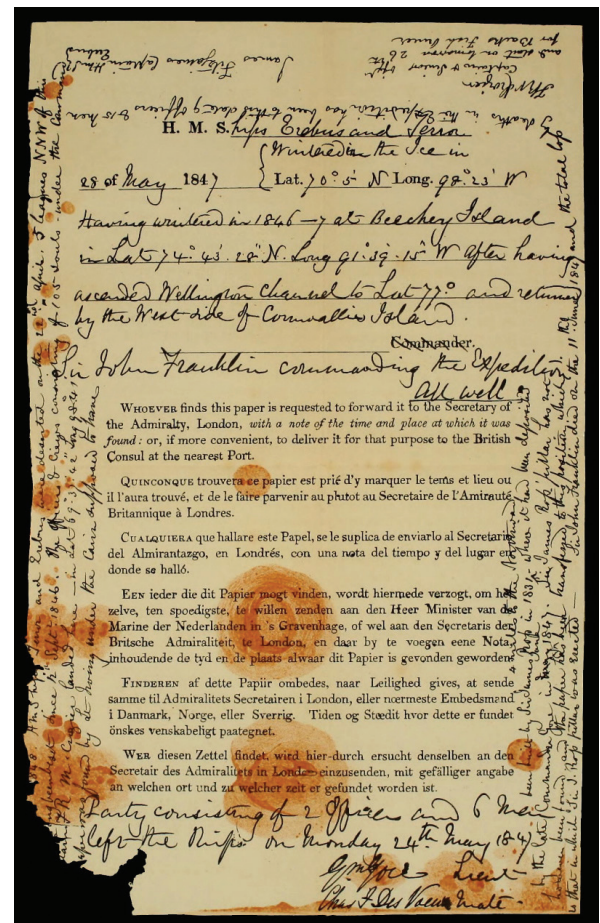


Figure 2.1.3: Message left in a cairn at the landfall of the surviving *Erebus* and *Terror* crewmen on King William Island (south of Victory Point), dated April 25, 1848 (McClintock 1860).

northern wreck given the geographic positions of their discoveries in the path of drifting ice flushed from Victoria Strait. Importantly, although not realized at the time of their initial discovery, they represent some of the first signs of the Franklin Expedition collected by contemporary search expeditions.

On August 21, 1851, Dr. John Rae of the Hudson's Bay Company found two wooden items on the fore-shore of Parker Bay, situated on the southeast shore of what is now Victoria Island, Nunavut (Figure 2.1.4). Believed to be drifting wreckage, they were described in a letter from Rae to Archibald Barclay, Secretary of the Hudson's Bay Company, dated September 27, 1851, later published in the British Parliamentary Papers (1852: 1-10; Cyriax 1939: 80-81) and later in Rich and Johnson (1953: lxx-lxxi, 209, 214). One item was a small turned oak stanchion, 3 ft. 8 inches long, and 3-3/2 inches in diameter. The other was what appeared to be

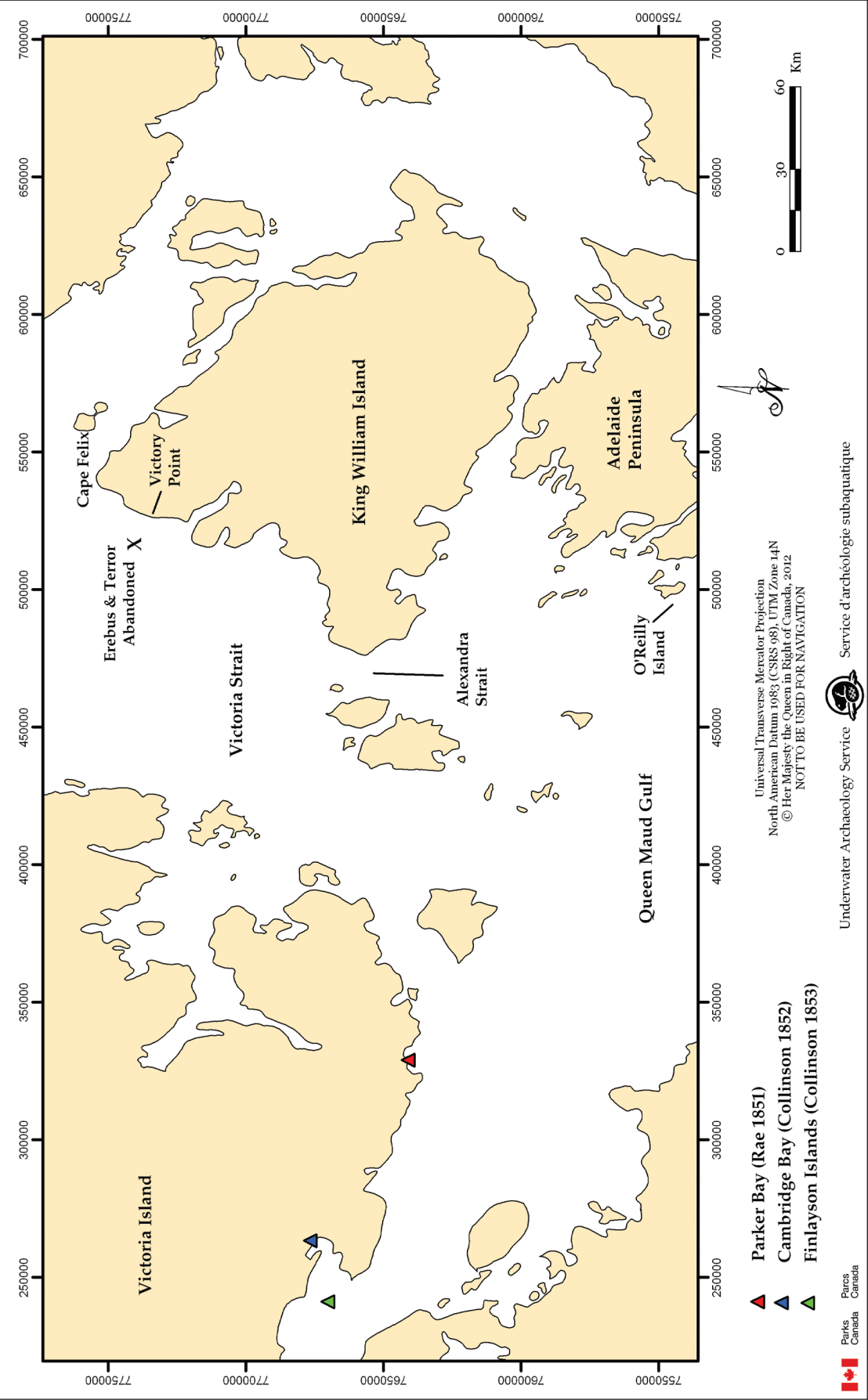


Figure 2.1.4: The central Canadian Arctic showing the locations of finds made in 1851 and 1852-1853 by Dr. John Rae and Captain Richard Collinson respectively. An approximate position is given for the Cambridge Bay finds (Map: C. Dagneau, Parks Canada).

a softwood mast or flagstaff marked “S.C.”, 5 ft. 9 in. in length, round in section except for its square heel (2¾ inch width) and with an attached loop of line affixed by two copper tacks. The line incorporated red thread and the two tacks each bore the broad arrow, which in all three cases revealed that they originated from Royal Navy vessel(s). Cyriax (1939: 80) stated that this relic “seemed to be part of the flagstaff of a service cutter”. Findlay (1856: 27) had identified these two finds as the mizzen mast of a ship’s second cutter and a boat’s awning stanchion, but without citation to any Royal Navy authority. Rae believed that they had been carried, amidst ice floes, by the flood tide setting from the north via Victoria Strait that wrapped around the southeast corner of Victoria Island. He had no way of knowing at the time that the *Erebus* and *Terror* had been deserted in Victoria Strait over three years previously (Rich and Johnson 1953: 209-210; Cyriax 1939: 81). In the introduction to Rich and Johnson (1953: lxviii), J.M. Wordie and R.J. Cyriax concluded:

Relics derived from the *Erebus* and *Terror*, when these were beset in the upper part of Victoria Strait, would have drifted towards Parker Bay from the north, the precise direction from which Rae concluded that the pieces of wood had come. That these pieces were derived from the Franklin expedition has not been proved, but that they were so derived is virtually beyond doubt.

Cyriax in Rich and Johnson (1953: lxviii-lxxi) presented a detailed account of contemporary discussion of the provenance of the two items and noted that Rae’s drawings of the objects are in the Admiralty records “Arctic Expeditions, 1852” in the Public Record Office, now the National Archives of the United Kingdom.

On October 15, 1852 Captain Richard Collinson of HMS *Enterprise* obtained from Inuit at Cambridge Bay, Victoria Island, two items of European manufacture, both of which had been mounted into horn handles and fashioned into adzes (Cyriax 1939: 84; Barr 2007: 150) (Figure 2.1.4). Collinson described the items in a report to the Admiralty, later published in the British Parliamentary Papers (1855a: 947-949) and accompanied by a scale illustration. One item was later determined to be part of an anchor shank, originally one of a number of anchors in a cache of boats and supplies left near the Coppermine River

in 1848 by Sir John Richardson and Rae. The other, marked with a broad arrow, was according to the Chief Engineer of Chatham Yard, Alexander Laurie, part of a “bolt nail” which “... may have formed part of the “*Erebus*” or “*Terror*,” or it may have been obtained from another of Her Majesty’s ships” (British Parliamentary Papers 1856: 45).

The following year, in the first week of July 1853, a member of Collinson’s crew found a small piece of wreckage at the Finlayson Islands, just south of Cambridge Bay (Barr 2007: 176-177) (see Figure 2.1.4). Collinson provided a description of its discovery in his published correspondence to the Admiralty noted above (British Parliamentary Papers 1855a: 947-948) and this find also appears in the accompanying scale illustration. He described the discovery as follows:

In the course of a visit to the Finlayson Islands, and in a bay on the east side of the largest islet of the group, a fragment of a companion hatchway or door-frame, bearing unequivocal marks of having been fitted from Her Majesty’s stores, was found [...]. it does not appear to have formed part of a boat’s fittings: otherwise it might be presumed to have belonged to Dr. Rae’s party, whose boats crossed here from the continent; nor does the boatswain of this ship, who served in the *Erebus* during the antarctic expedition, recognize it as a portion of the fittings of that vessel.

In evidence given to the parliamentary committee on the Franklin relief expeditions in July 1855 Collinson provided additional details and interpretation, noting that it was found on the beach, that he believed it to have drifted to its find location by the tide and that he thought it was from the *Erebus* or *Terror* (British Parliamentary Papers 1855b: 30). The fragment was later sent to Woolwich Yard for examination (British Parliamentary Papers 1856: 45):

... there seems reason to believe that it may have belonged to either the “*Terror*” or “*Erebus*,” founded upon the following statement of Mr. Reed, the foreman of joiners, who superintended the fitting of these vessels, viz. “that the doors of the winter hoods of the “*Erebus*” and “*Terror*” were not framed but made of ¾ board, and ledged similar to the fragment

of framing brought home by Capt. Collinson, and that the winter hoods of other vessels subsequently fitted out at this yard on searching expeditions were framed in panels in the usual manner.

In Collinson's journal, published many years later by his brother Major-General T.B. Collinson further information and interpretation of the Finlayson Island discovery are presented (Collinson 1889: 7, 277-279, 340; Barr 2007: 176-177).

Inuit oral history evidence that points to the possibility of a northern wreck came the year following Collinson's discovery of the part of the winter hood at the Finlayson Islands, with the flood of information and relics collected at Repulse Bay by Rae in 1854. In one version of his infamous report on the discovery of the fate of the Franklin Expedition, he reported (Rich and Johnson 1953: 274-275):

In the Spring, four winters past, (1850) whilst some Esquimaux families were killing Seals near the north shore of a large Island named in Arrowsmith's Charts, King William's Land, about forty white men were seen travelling in company southward over the ice, and dragging a boat and sledges with them. They were passing along the west shore of the above named Island. None of the party could speak the Esquimaux language so well as to be understood, but by signs the Natives were led to believe that the Ship or Ships had been crushed by ice, and that they were then going to where they expected to find deer to shoot.

In March 1859 McClintock gleaned more evidence that specified a northern wreck from a group of Inuit met at Cape Victoria on the Boothia Peninsula (McClintock 1860: 211-212; Woodman 1991: 29):

Next morning, 4th March, several natives came to us again. I bought a spear 6½ feet long from a man who told Petersen distinctly that a ship having three masts had been crushed by the ice out in the sea to the west of King William's Island, but that all the people landed safely; he was not one of those who were eye-witnesses of it; the ship sunk, so nothing

was obtained by the natives from her; all that they have got, he said, came from the island in the river ... One old man, "Oo-na-lee," made a rough sketch of the coast-line with his spear upon the snow, and said it was eight journeys to where the ship sank, pointing in the direction of Cape Felix. I can make nothing out of his rude chart.

McClintock's party fell in with the same group of Inuit in April 1859 and learned more from Oo-na-lee and a young man (McClintock 1860: 227-228; Woodman 1991: 29):

After much anxious inquiry we learned that two ships had been seen by the natives of King William's Island; one of them was seen to sink in deep water, and nothing was obtained from her, a circumstance at which they expressed much regret; but the other was forced on shore by the ice, where they suppose she still remains, but is much broken. From this ship they have obtained most of their wood, &c.; and Oot-loo-lik [Ugjulik] is the name of the place where she grounded ... They both told us it was in the fall of the year – that is, August or September – when the ships were destroyed; that all the white people went away to the "large river," taking a boat or boats with them, and that in the following winter their bones were found there.

McClintock (1860) incorrectly interpreted the location of the (second) vessel forced on shore (Oot-loo-lik) as being on the west shore of King William Island. This is now well-attested as a more southerly location in the Queen Maud Gulf immediately west of the Adelaide Peninsula (Woodman 2012, personal communication). This misunderstanding may have been the result of imperfect translation, however McClintock's sense of what he had been told was of a wreck, presumably visible from shore, on the west coast of King William Island for he often remarks that his detached party under Lieutenant Hobson, who had first searched this coast, had not seen any evidence of the wreck. He reported that his own party was disappointed in its own search for it was not "probable that we could have passed the wreck had she existed there, as there are no off-lying islands to the northward of Cape Crozier" (McClintock 1860: 261; Woodman 2012, personal communication).



Figure 2.1.5: The Franklin Point plank found on King William Island, believed to have come from either *Erebus* or *Terror* when beset in Victoria Strait (Courtesy: Karen Ryan, Canadian Museum of History, Gatineau).

Charles Francis Hall gathered some oral history evidence from Pelly Bay Inuit that can be interpreted as referring to the northern wreck versus the more southerly Ugjulik Wreck (Nourse 1879: 255-257; Woodman 1991: 198, 209ff.). In April 1866 near Cape Beaufort (Committee Bay) he learned from Kok-lee-arng-nun and his wife Koonarnng that:

... these Innuits [sic] had been at one time on board of the ships of *Too-loo-ark*, (the great *Esh-e-mut-ta*, Sir John Franklin), and had their *tupiks* [tents] on the ice alongside of him during the spring and summer. They spoke of one ship not far from Ook-kee-bee-jee-lua (Pelly Bay), and two to the westward of Neit-tee-lik, near Ook-goo-lik ... The old man and his wife agreed in saying that the ship on board of which they had often seen *Too-loo-ark* was overwhelmed with heavy ice in the spring of the year. While ice was slowly crushing it, the men all worked for their lives in getting out provisions; but, before they could save much, the ice turned the vessel down on its side,

crushing the masts and breaking a hole in her bottom and so overwhelming her that she sank at once, and had never been seen again. Several men at work in her could not get out in time, and were carried down with her and drowned.

Hall's testimony from See-pung-er recorded in June 1866 suggested that the *Erebus* and *Terror* could have been crushed by ice off the west side of King William Island (Nourse 1879: 277). Furthermore, in April 1869 at Simpson Lake, Hall observed European items in the possession of Pelly Bay Inuit (Nourse 1879: 392):

... a snow-shovel 3 feet long, made of pine or spruce, ... This last article the Innuits said they got out of a ship's beam or plank at Ki-ki-tuk – King William's Land. On asking *Tung-nuk* about this snow-shovel, he said it came from a large *ou-mi-en* (ship). Was it there now? No; it had sunk. Did the ice break it? No; the Innuits, in getting wood (timber or beams) out of it, made a hole in the ship,

and soon after, it sunk [sic]. The snow-shovel was made of material very much thicker than it is now.

Knud Rasmussen collected Inuit oral history evidence during the Fifth Thule Expedition of 1921-1924 from Qaqortingneq at Malerualik (Simpson Strait) about a wreck off the northwest coast of King William Island that mimicked accounts of the unintended Inuit sinking the ice-bound Ugiulik vessel during scavenging collected by Hall in May 1869 (Nourse 1879: 400-407; Rasmussen 1999: 238-240; Woodman 1991: 219-220). Similarly Roald Amundsen collected similar testimony while at Gjoa Haven that led him to conclude, perhaps erroneously, that a wreck “... had been crushed by the ice on the north side of the Royal Geographical Society Islands” (Woodman 1991: 218-219). More recent Inuit testimony has also linked the Franklin Expedition to the Royal Geographical Society Islands. Modern Inuit tales of a “ship at Imnguyaaluk” and an associated “fire-place trail” are also associated with these islands (Eber 2008: 85-86). A notable find made in the 1950s on the northwest coast of King William Island, recently reported by Karen Ryan (2013) supplements the scant evidence for the northern wreck collected in the nineteenth century. Ryan (2013) describes a ship’s deck plank found on Franklin Point that likely originated from either *Erebus* or *Terror* (Figure 2.1.5).

2.2 PREVIOUS SURVEYS

Since the 1960s, marine remote sensing activities directed at finding the *Erebus* and *Terror* have focused on the Ugiulik Wreck off the west side of the Adelaide Peninsula in the Queen Maud Gulf (Harris and Moore 2011: 11-13). Following its discovery in 2014 this wreck was confirmed to be the *Erebus*. Prior side-scan sonar and echosounder surveying in this area under the umbrella of the present initiative was carried out in 2008, 2010, 2012 and 2013 (Harris and Moore 2010, 2011, 2014; Moore and Harris 2013).

Marine remote sensing searches for the northern wreck reported lost in the ice off the west side of King William Island began in 2008 with a CHS and UAT hydrographic reconnaissance near the reported April 1848 desertion position of the *Erebus* and *Terror* (Harris and Moore 2010: 17-21). Searching this expansive area began in earnest in 2011 with a side-scan sonar and multi-beam echosounder survey at the northern approach to the Alexandra Strait (Moore, Harris and Zagon 2012). Searching continued in the northern search area in 2012 and 2013 (Moore and Harris 2013; Harris and Moore 2014).

3 METHODOLOGY

3.1 FIELDWORK DESCRIPTION

The months of August and September represent the optimal weather window and period of ice-free navigation for research work near King William Island, as well as the period of seasonal availability of the CCGS *Sir Wilfrid Laurier* and scheduled timeframe for the Canadian Forces Operation QIMMIQ. A six week field project was initially planned, with time divided variously between the northern and southern search areas as weather, ice conditions, and the operational schedules of the respective project partners would collectively dictate.

As in previous field seasons, operations were coordinated from the 83 m CCGS *Sir Wilfrid Laurier*, this during a roughly three-week period between August 27 and September 21. The ship was used to deploy three smaller survey vessels: the 7 m CHS launches *Gannet* and *Kinglett*, and the 10 m Parks Canada RV *Investigator*. The lead archaeologist for Parks Canada and hydrographer-in-charge for CHS both worked from the CCGS *Sir Wilfrid Laurier*, where they collectively tasked the various survey platforms (Figure 3.1.1).

A significant addition to the project for the 2014 field season was to come in the form of two new large vessel platforms that offered support to the survey. The RCN planned to contribute the 55 m maritime coastal defence vessel HMCS *Kingston*, which was to join the search in Victoria Strait for a period of two weeks as part of the naval exercise ‘Op QIMMIQ 2014’, while One Ocean Expeditions provided the 117 m arctic research vessel *One Ocean Voyager* for a period of eight days between August 31 and September 7, courtesy of the RCGS and the W. Garfield Weston Foundation. The primary survey tasking of the *Voyager* was to transport and stage the operations of the DRDC autonomous underwater vehicle *Arctic Explorer*. The *Voyager* also shipped the Parks Canada RV *Investigator* to the Arctic from Halifax, Nova Scotia, and likewise conveyed the Parks Canada remotely operated vehicle (ROV) from Lancaster Sound, as it had initially been shipped from Halifax on the HMCS *Kingston* but ultimately had to be transferred to the CCGS *Sir Wilfrid Laurier* for operations.

As planned, the first part of the field project saw a continuation of prior search activity in the southern search area with systematic survey in the remaining uncharted areas of Wilmot and Crampton



Figure 3.1.1: CCGS *Sir Wilfrid Laurier*, RV *Investigator*, CSL *Gannet* and CSL *Kinglett* depart in formation from the southern search area and site of *Erebus*, September 18, 2014 (Photo: T. Boyer, Parks Canada, 89Mo789EF).

Bay to the west side of the Adelaide Peninsula. This was conducted from the 20 m MV *Martin Bergmann*, once again made available by the private not-for-profit ARF. This platform was ultimately used to survey for four weeks in all, from August 19 to September 18, with a rotation of two Parks Canada and one RCN FDU (A) staff on board at all times to collect side-scan sonar data around the clock.

The second part of the field project was supposed to see survey operations shift to the northern search area, with a plan to survey an area spanning from the initial point of abandonment in 1848 off Victory Point down towards where the Victoria Strait funnels into the northern part of Alexandra Strait between the Royal Geographical Society Islands and the Graham Gore Peninsula of King William Island. Here the MV *Martin Bergmann* was to be joined by the CCGS *Sir Wilfrid Laurier*, HMCS *Kingston*, and *One Ocean Voyager*, where survey efforts would expand upon areas searched in 2011, 2012, and 2013. A return to the southern search area with the MV *Martin Bergmann* would then be entertained towards the end of the field season, if weather conditions permitted. Ultimately, extensive ice cover that never quite cleared from the northern search area caused a significant change to the overall survey plan, with emphasis focused back on the southern search

area where the bulk of survey activity took place. In the end, HMCS *Kingston* was never able to join the survey and DRDC was severely limited in its ability to deploy the *Arctic Explorer*, the *Voyager* remaining in the north in faint hope that ice conditions might eventually improve.

3.2 NAVIGATION AND POSITIONING

Four survey vessels were employed in the course of the 2014 remote sensing search: MV *Martin Bergmann*, RV *Investigator* and Canadian Survey Lauch (CSL) *Gannet* and *Kinglett*. This section will not describe HMCS *Kingston* as this vessel did not reach the study area. Autonomous underwater vehicles (AUV), described below in Section 3.4, were deployed from both the *One Ocean Voyager* and the MV *Martin Bergmann*.

ARF was able to contribute the MV *Martin Bergmann* for the full duration of the field season in 2014 - four weeks in all. The MV *Martin Bergmann* is a 20 m long and 6.1 m wide wooden fishing trawler converted for Arctic research (Figure 3.2.1). Its wooden hull was covered with fibreglass as part of a previous refit. The vessel has an estimated draft of 2.75 m and a total hull



Figure 3.2.1: MV *Martin Bergmann* in the southern search area during a personnel transfer from CCGS *Sir Wilfrid Laurier* (Photo: T. Boyer, Parks Canada, 89Mo302EF).

displacement of approximately 90 tons. Its engine is a Detroit 12V93 turbo 530 hp inboard diesel with a fuel tank capacity of approximately 12,000 L. At Parks Canada's request, the ARF kindly outfitted the vessel with a hydraulic A-frame to better accommodate towed side-scan sonar operations. For shipboard power, the vessel is equipped with two diesel generators installed on the boat deck, a 13 kW and a 8 kW, where they are plumbed into the boat's fuel system, one supplying 120 VAC and the other 240 VAC. The MV *Martin Bergmann* is fitted to accommodate five crew members and five supernumeraries for voyages lasting approximately ten days from re-supply. Remote-sensing equipment for use during the underwater archaeological survey was supplied by Parks Canada.

The RV *Investigator* is a custom-built 10 m aluminum dive tender and remote-sensing survey boat fabricated to UAT specifications by Kanter Marine, of St. Thomas, Ontario (Figure 3.2.2). The hull is a transom free design to facilitate the deployment and recovery of remote-sensing equipment, moorings, and archaeological divers from the working deck. The boat has a hydraulically actuated A-frame for towing side-scan sonar from the stern. In anticipation of one day staging surveys from large seagoing ships like the CCGS *Sir Wilfrid Laurier*, the vessel was built with four reinforced lifting eyes at each quarter allowing the

vessel to be hoisted by crane up to its maximum operating weight of 6,020 kg (Figure 3.2.3). A steel support cradle was manufactured to this end, specifically for use during the 2013 survey, allowing the RV *Investigator* to be loaded onto the CCGS *Sir Wilfrid Laurier*'s well deck. RV *Investigator* is powered by twin 5.7 L Volvo Penta V8 duoprop inboard/outboard gasoline engines, yielding a combined 700 hp. Fifteen 205 L drums of gasoline were procured in Cambridge Bay, Nunavut, and brought aboard the CCGS *Sir Wilfrid Laurier* to meet the fuel requirement for the 2014 survey, with the RV *Investigator*'s onboard fuel capacity exceeding 680 L. Onboard 120 VAC power is supplied by a 6 kW Westerbeke gasoline generator, which also drives the hydraulic pump. In 2014 the RV *Investigator* was loaded aboard the upper deck of *One Ocean Voyager* in Halifax, Nova Scotia, for transport to the Arctic and transferred to the CCGS *Sir Wilfrid Laurier* during a rendezvous in Queen Maud Gulf.

Survey navigation software was used on both survey platforms to ensure efficient and thorough area coverage by providing a series of predefined survey lines that could be easily and precisely followed by the helmsman (Figure 3.2.4). This also allowed the line coverage of the two survey vessels to be carefully coordinated so as to avoid unwanted gaps or duplication. On both the MV *Martin*



Figure 3.2.2: RV *Investigator* towing side-scan sonar in 2013 (Photo: T. Boyer, Parks Canada, 51M2495EF).



Figure 3.2.3: RV *Investigator* is transferred from the *One Ocean Voyager* to CCGS *Sir Wilfrid Laurier* (Photo: J. Moore, Parks Canada, 51M2822EF).

Bergmann and the *Investigator* the software used was Chesapeake RV Technology Limited's SonarWiz 5.

Vessel positioning and georectification of the resultant side-scan sonar data were achieved by means of differential global positioning system (DGPS) satellite navigation. A NovAtel Propak-V3-VBS mapping grade global positioning system (GPS) receiver was utilised on both the MV *Martin Bergmann* and the RV *Investigator* for survey positioning. The latter represents permanently installed equipment on the Parks Canada vessel, while the former is enclosed in a portable waterproof enclosure that the UAT uses when surveying in small open boats and from larger vessels of opportunity. Satellite-based augmentation (SBAS) for differential corrections was registered through the receivers' access to the North American Wide Area Augmentation System (WAAS).

The *Gannet* and *Kinglett* are 7 m long fiberglass survey boats custom built for DFO by Hourston Glascraft Ltd. of Vancouver, British Columbia (Figure 3.2.5). Both are fitted with antenna guards and reinforced lifting points so as to be easily deployed and retrieved by crane from alongside the CCGS *Sir Wilfrid Laurier*. Welded steel cradles accommodated the launches securely on the well deck of the ship, one to either side of the forward hatchway. The cabin layout of each boat was generally conceived for a crew of two, comprising a coxswain and a hydrographer. Each launch is fitted with a Volvo Penta marine diesel engine with counter-rotating duoprop inboard/outboard stern-drive unit, offering improved fuel economy



Figure 3.2.4: Night operations towing side-scan sonar from the MV *Martin Bergmann* (Photo: T. Boyer, Parks Canada, 51M2840EF).



Figure 3.2.5: CSL *Gannet* in the southern search area (Photo: J. Moore, Parks Canada, 89M0025EF).

and facilitating line steering for extended bathymetric survey work. In 2014, each launch was fitted with an R2Sonic 2022 multi-beam echosounder system (MBES) with Applied Microsystems Limited (AML) sound velocity sensors and a 120-VAC, 6.5 kW diesel power generator.

Vessel positioning and georectification of acquired multi-beam sonar data were achieved by means of DGPS navigation. Coordinate information was registered using an Applanix POSMV 320 V5 inertially aided position and orientation system installed on board each survey launch, interfaced with its respective sonar system. SBAS for differential corrections was registered through the receiver's access to the North American WAAS. Boat positioning was post-processed using POSPac software and observations from Trimble R7 shore-based GPS reference stations.

Hypack/Hysweep survey navigation and data logging software was employed to ensure efficient and thorough area coverage by providing a series of predefined survey lines that could be easily and precisely followed by either coxswain. This also allowed the line coverage of the two launches to be carefully coordinated so as to avoid unwanted gaps or duplication. This in turn was coordinated with the MV *Martin Bergmann* and RV *Investigator* platforms.

A consistent side-scan sonar survey line spacing of 150 m first adopted in 2008 was continued in 2014 predominantly; this balanced efficient area coverage with a high probability of target detection. Multibeam line spacing in 2014 varied as a function of depth, with the swath width between three and five times the water depth, with significant overlap of 30 percent to adjacent swaths.

Following the discovery of the 89M site, a range of sonar line spacings were employed for detailed wreck imaging by both side-scan and multibeam sonar.

3.3 SURVEY EQUIPMENT

SIDE-SCAN SONAR

A Klein 3000 digital side-scan sonar system running Sonarpro 12.1 acquisition software was deployed on both the MV *Martin Bergmann* and RV *Investigator* (Figures 3.3.1 and 3.3.2). In 2014 side-scan sonar systems were not deployed from the CHS launches *Gannet* and *Kinglett*.

The Klein 3000 system is capable of producing accurate and detailed images of the sea floor using the transmission of acoustic pulses. All data in

2014 was collected at a frequency of 445 kHz. The side-scan transducers are housed in a towed sensor or “towfish” that is trailed far behind the survey vessel at the end of a long coaxial cable. This permits the sensor to be deployed at depth so as to minimize the signal attenuation that is caused by sound waves traveling through too much of the water column. This also serves to accentuate the relief of raised bottom features, as the lower incident angle of the sound waves tends to produce acoustic shadows on the lee side of standing objects. These shadows are very conspicuous on the sonar record, and can be used to gauge the height of the respective objects that cast them.

On each boat a 200 m length of 0.40 in. diameter armoured tow cable was spooled onto a CSW-7 oceanographic instrumentation winch manufactured by A.G.O. Environmental Electronics of Victoria, British Columbia (Figures 3.3.1 and 3.3.2). The winches were mounted to the working deck in the stern of either vessel as in 2013. While the cable winch on the RV *Investigator* was the manufacturer’s standard 120 VAC 1-hp unit, with a 0-90 VDC variable speed motor controller, the second winch on MV *Martin Bergmann* had been converted in 2013 by A.G.O. to operate on hydraulics with an 8 cubic inch hydraulic motor with integral parking brake to resist drum slippage. Here the intention had been to achieve much faster line retrieval speed (approximately six times faster) in order to avoid the towfish coming into contact with the bottom in the event of sudden shoaling. This was important given that the slow acceleration and limited cruising speed of the MV *Martin Bergmann* would not permit the practice adopted on the RV *Investigator* and generally by the UAT, which is to use significant increases in throttle and the resulting drag induced in the tow cable to quickly raise the towfish over hazards.



Figure 3.3.1: Towed side-scan sonar operation from the MV *Martin Bergmann* (Photo: J. Moore, Parks Canada, 51M2684EF).

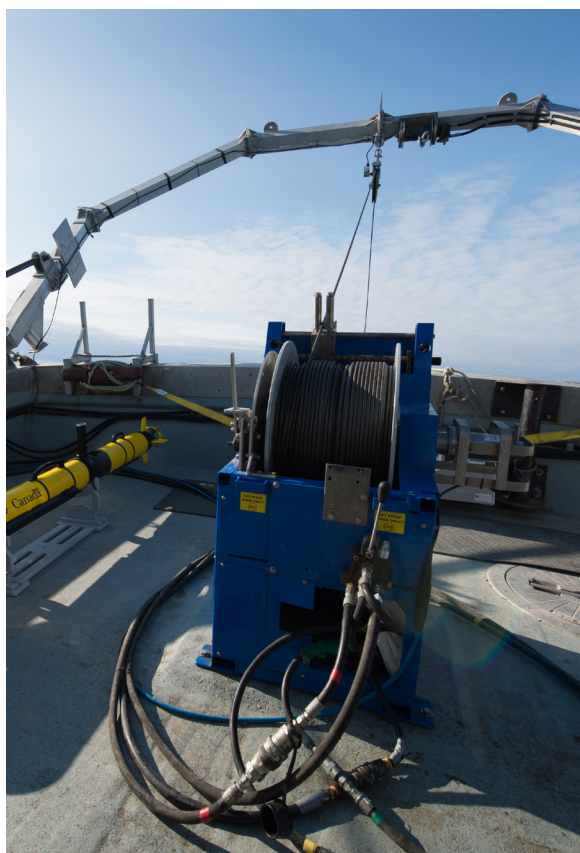


Figure 3.3.2: CSW-7 oceanographic instrumentation winch installed on the stern deck of MV *Martin Bergmann* for towed side-scan sonar operation (Photo: J. Moore, Parks Canada, 51M2681EF).

In order to ensure accurate positioning of the towed side-scan data, it was necessary to accurately gauge the longitudinal offset or ‘layback’ of the towfish relative to the survey vessel where the GPS antenna was mounted. This was accomplished by means of a model SD41 digital metering sheave block (manufactured by 3PS Inc.), which uses magnetic sensors set in the turning sheave to precisely monitor the total amount of



Figure 3.3.3: Retrieval of the side-scan sonar towfish aboard *Investigator* at the end of a day of survey (Photo: J. Moore, Parks Canada, 51M2848EF).

deployed cable at any given time. This measured 'cable out' value combined with the indication of towfish depth coming from its integral pressure sensor, are sufficient to provide the sonar processor the trigonometric parameters necessary to determine the XY layback of the side-scan towfish in real time. This block was suspended from the A-frame on either vessel (Figures 3.3.1 to 3.3.3).

AUTONOMOUS UNDERWATER VEHICLES

For the first time in 2014, the UAT planned to deploy a recently procured Iver3 AUV (Figure 3.3.4). This third generation AUV is equipped with a Klein UUV-3500 dual frequency side-scan sonar. The two frequencies, 455 and 900 kHz respectively, are optimized for expansive area survey on the one hand and detailed imaging of identified seafloor targets on the other. After determining its position and heading on the surface using GPS, sub-surface navigation is achieved by means of an inertial navigation system drawing attitude and heading information from a series of monolithic ring-laser gyroscopes, 3-axis accelerometers, a

600 kHz phased array Doppler velocity log for tracking XYZ velocity relative to the seafloor, and a sound velocity sensor for accurately calibrating all onboard acoustic systems. Inertial navigation is essential for AUV operations in the Arctic where traditional magnetic compasses are wholly unreliable due to the proximity of the Earth's north magnetic pole. Communication with the vehicle is achieved by wireless network, 2.4 GHz handheld radio remote control, and Iridium satellite uplink (when travelling on the surface) and acoustic modem when submerged.

The advantage of an AUV as compared to a towed side-scan sonar system is that the AUV offers a stable platform for sonar survey regardless of surface sea state, producing exceptional imagery in conditions that would thwart towed sonar operations. At 2.3 m in length, the Iver3 AUV can also be deployed manually by two people working from any vessel of opportunity, including small boats, and can even be launched from shore. The Iver3 has a total mission endurance of 10-12 hours, scanning a series of parallel survey lines in the same manner as a vessel-towed sonar.



Figure 3.3.4: Ryan Harris (left) prepares to deploy the Iver3 AUV in the southern search area (Photo: J. Moore, Parks Canada, 51M2689EF).

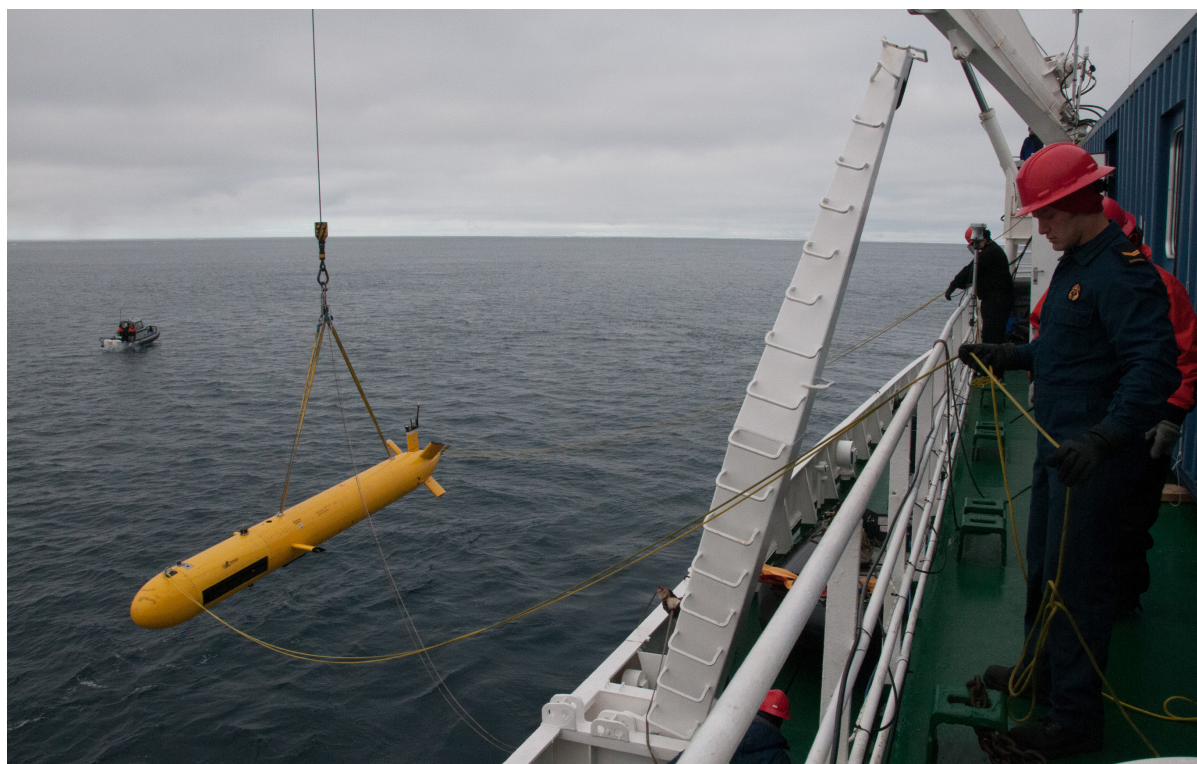


Figure 3.3.5: DRDC's *Arctic Explorer* AUV as it is lowered for deployment from the *One Ocean Voyager* (Photo: M.-A. Bernier, Parks Canada, 51M2913EF).

A second and substantially more capable AUV was added to the survey program for 2014. The *Arctic Explorer* AUV is a 7.5 m long 2,200 kg autonomous submersible manufactured by International Submarine Engineering of Vancouver, British Columbia (Figure 3.3.5). The *Arctic Explorer* is capable of conducting 72 hour long submerged missions before having to surface for a recharge of its batteries and download of accumulated data. The vehicle is operated by DRDC who outfitted it with a new second-generation AquaPix Interferometric Synthetic Aperture Sonar (InSAS2) system manufactured by Kraken Sonar Systems Inc. of St. John's, Newfoundland. InSAS2 technology was developed for NATO mine countermeasures in order to achieve very high resolution imagery over significantly longer ranges in hopes of effectively detecting low relief embedded seafloor targets in the course of large-scale area surveys. The system was designed to achieve 530 m wide swath coverage at consistent 3 cm spatial resolution, all at typical survey speeds of 3 knots.

The *Arctic Explorer* is further outfitted with an IXSEA PHINS 6000 inertial navigation system employing extremely precise fibre-optic

gyroscopes, an RDI 300 kHz DVL, acoustic modem, Iridium antenna, and other fully integrated navigation and telemetry sensors.

REMOTELY OPERATED VEHICLE

The UAT planned to ground-truth high potential targets identified in the course of the side-scan and multi-beam sonar surveys with its Saab Seaeye Falcon ROV (Figure 3.3.6 and 3.3.7). The Falcon is depth rated to 300 m and is operated from the surface by means of a 300 m length of umbilical which provides the interface between the underwater vehicle and the surface control unit. Parks Canada's vehicle is equipped with a broadcast quality Kongsberg OE-504 high definition video camera and a Kongsberg 1171 sector scanning sonar system. The variable frequency 625 to 800 kHz mini sonar head is specifically designed for use on inspection-class ROVs, such as the Falcon, for underwater navigation and target imaging purposes. To accommodate the wide bandwidth necessary for real-time feed of high-definition (HD) video and high resolution sonar data, Parks Canada's ROV is furnished with fibre-optic telemetry. The Falcon represents a highly capable underwater inspection tool, and with a

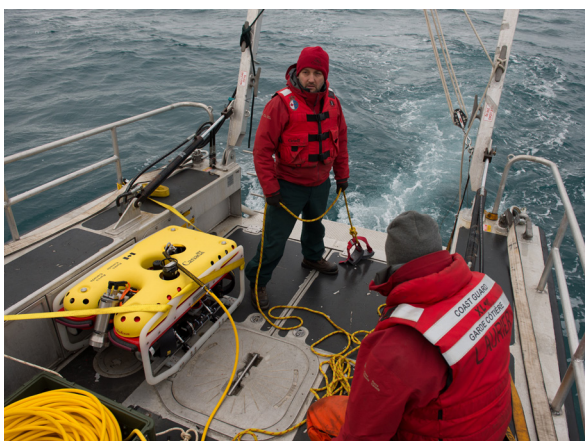


Figure 3.3.6: Jonathan Moore and Joe Boucher on the stern deck of RV *Investigator* preparing to launch the Falcon ROV for a dive on the site of *Erebus* (Photo: M.-A. Bernier, Parks Canada, 51M2913EF).



Figure 3.3.7: Preliminary ROV inspection of the wreck of *Erebus*. Ryan Harris (right) pilots the vehicle while Jonathan Moore looks on (Photo: M.-A. Bernier, Parks Canada; 89M0104EF).

Gigabit Ethernet channel, is capable of deploying a variety of sensors to assist in the documentation of submerged archaeological sites.

MULTI-BEAM ECHO SOUNDER

A multi-beam echosounder efficiently plots a swath of high density bottom soundings along a surface vessel's survey track, providing detailed 3D imagery of seafloor topography. Multi-beam situates the wreckage in a detailed three-dimensional bathymetric context. Moreover, conspicuous wreckage presenting significant topographical relief would also be detectable by multi-beam, particularly in areas where the seafloor is otherwise featureless. A total of four R2Sonic 2022 multi-beam echo sounder systems were slated to be deployed in 2014, one pole-mounted on both the CCGS *Sir Wilfrid Laurier* and HMCS *Kingston*, and the others hull-mounted on the two CHS survey launches, *Gannet* and *Kinglett*. The plan was for the ships to scan the deeper waters found near the 1848 point of abandonment, while the launches would focus on the shallower near-shore areas located in Erebus Bay and Alexandra Strait where towed side-scan sonar cannot be deployed as efficiently or safely.

DIVING

As has been the practice since the outset of the present survey in 2008, the UAT's dive equipment was left in Ottawa pending the actual requirement for it up north. This had the intention of defraying

the considerable cost of transporting the large bulk of gear to the Arctic and back each season; equipment which was also typically implicated in other projects scheduled before, during, and after the *Erebus* and *Terror* survey in any given year.

When diving self contained underwater breathing apparatus (SCUBA), the UAT typically deploys two free-swimming divers working in tandem, with one diver designated as a dive team leader. All divers have the ability to communicate amongst themselves and directly with the surface using



Figure 3.3.8: Jonathan Moore and Ryan Harris as they swim towards the descent line for the first dive on the wreck of *Erebus* (Photo: T. Boyer, Parks Canada, 89M0337EF).

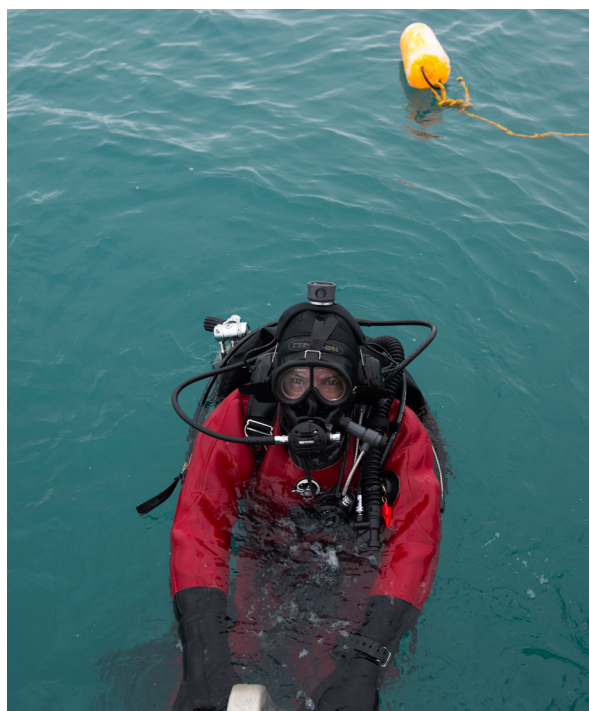


Figure 3.3.9: Marc-André Bernier hangs off the dive ladder of RV *Investigator* prior to his first dive on the wreck (Photo: J. Moore, Parks Canada, 89MO554EF).

Orcatron single-side band wireless underwater headsets with microphones set into CressiSub full face masks (Figures 3.3.8 and 3.3.9). Insulation is provided by 7 mm neoprene drysuits, hoods, and three-finger mitts. A fully redundant bailout cylinder with dedicated regulator are carried at all times, and a designated standby diver is always available on the surface to intervene in the event of an emergency. Dives are managed and logged by a topside dive supervisor, who is also responsible for monitoring hazards on the surface. As this implies, the UAT typically deploys a minimum four person dive team.

The UAT uses a wide range of specialised tools during underwater inspection work, befitting the particular project at hand. For ground-truthing and preliminary site investigations, both high-resolution still photo and HD video cameras are typically used. For the present survey, a 16 megapixel Nikon D4 camera in an Aquatica 90 m depth-rated pressure housing with synced Ikelite DS161 strobes was used for still photo acquisition, while a Panasonic HVX200 in a Gates 90 m depth rated pressure housing with Keldan Luna-8 LED lights was used for HD video capture.

All diving operations were conducted in compliance with Section 18 of the *Canada Labour Code* (Diving) and Parks Canada's Departmental Directive on Diving Safety (Government of Canada 1985; Parks Canada 2002).

POST-FIELDWORK DATA PROCESSING

Side-scan sonar data were assembled into localized area coverage maps and images of the wreck of *Erebus* using Chesapeake Technology's SonarWiz mosaic generation software. These mosaics show the overall topography of the seafloor and any salient relief features found on the bottom.

Field notes, photographs, video, remote-sensing data, and historical reference materials making up the project archive were all inventoried, catalogued, and filed at the conclusion of the fieldwork. All geomatic information collected during the project was assembled into a geographic information system (GIS) using ESRI ArcGIS software. Geographic data were referenced to the North American Datum 1983 (NAD 83) Canadian Spatial Reference System 1998 (CSRS 98) datum in Universal Transverse Mercator (UTM) projection (zone 14N).

4 SURVEY RESULTS

4.1 ARCHAEOLOGICAL SURVEY

As in the previous two years, the 2014 field season commenced in the southern search area where the winter ice tends to break up and clear almost two full weeks earlier than is typical in the northern search area. Once again, the survey was kicked off by the MV *Martin Bergmann* which sailed from Cambridge Bay with three UAT members on the afternoon of August 18 and commenced towed side-scan sonar operations the following evening. This starting date represented a delay of approximately one week as compared to previous years, owing to delayed breakup of ice in the Queen Maud Gulf. Thereafter, survey continued under highly favourable weather conditions for several days, the crew experiencing calm winds and an agreeable sea state, with very good sonar data being realised as a result. Twenty-four hour operations were conducted whenever possible, given the availability of three sonar operators on board working in shifts. The MV *Martin Bergmann* then returned to port for a required crew change allowing Ryan Harris and Jonathan Moore to join the Prime Minister's Northern Tour on August 23, after flying from Cambridge Bay to Pond Inlet, being replaced on the MV *Martin Bergmann* by Thierry Boyer and Charles Dagneau. The MV *Martin Bergmann* then returned to the southern search area with minimal delay where it continued to survey.

The second stage of the 2014 field season had planned to see the survey operation shifted to the northern search area, where the MV *Martin Bergmann* was slated to be joined by the CCGS *Sir Wilfrid Laurier* (with the CSL *Gannet* and *Kinglett* on board), HMCS *Kingston*, and the *One Ocean Voyager* (with the DRDC *Arctic Explorer* AUV and RV *Investigator* on board). As it turned out, however, the pack ice in Victoria Strait never cleared in the months of August and September and productive survey ultimately proved almost impossible there. In consequence, the decision was made for *Kingston* to remain farther east, the RCN electing not to risk passage through Bellot Strait and an uncertain egress. The ship's deployment time was reallocated to assist the CHS in an ongoing multi-beam hydrographic survey of Eclipse Sound. The MV *Martin Bergmann*

remained in the southern search area where it could continue to survey productively. The *Laurier* and *One Ocean Voyager* eventually picked their respective ways through the ice to a rendezvous north of Todd Island, allowing the Parks Canada RV *Investigator* and its inspection-class ROV to be transferred to the Coast Guard ship.

After an initial abortive attempt by the CSL *Gannet*, CSL *Kinglett*, and RV *Investigator* to conduct side-scan and multi-beam sonar survey in the south end of Alexandra Strait where the ice cover was only 2/10 in isolated areas, it was soon deemed impractical to work in even moderate ice cover from the small boats. In consequence, the decision was made on the *Laurier* to take the ship to the southern search area and resume survey work there. Here advantage could be taken of the remarkably benign weather conditions, the same calm winds and gentle seas which were discouraging break-up of ice in the north. There was no such recourse available to the *One Ocean Voyager*, however, as the *Arctic Explorer* AUV was not configured for under ice operation in the northern search area, and could not otherwise operate safely in the shallow waters of the southern search area. As a result, the *Voyager* was encouraged to bide its time until an opening in the ice sufficient to allow the AUV to be safely deployed might finally avail itself. Figures 4.1.1 to 4.1.5 show the survey lines and sonar coverage for the northern search area.

In the end, only limited opportunities materialised to deploy the *Arctic Explorer* given the unrelenting ice conditions. Ultimately, DRDC was able to conduct three test missions in the vicinity of Jenny Lind Island and the Royal Geographical Society Islands over three separate days, these in the open water situated immediately south of the ice floe edge. Sandwiched between these test missions were three short survey missions conducted over the course of two consecutive days in Victoria Strait on September 5 and 6 where patches of navigable water were identified. While the aggregate sonar coverage that this represented amounted to only 28 km² overall, the deployment successfully demonstrated the capability of the vehicle and the performance of the Kraken AquaPix synthetic aperture sonar system. Together, these closely integrated systems achieved a remarkable survey

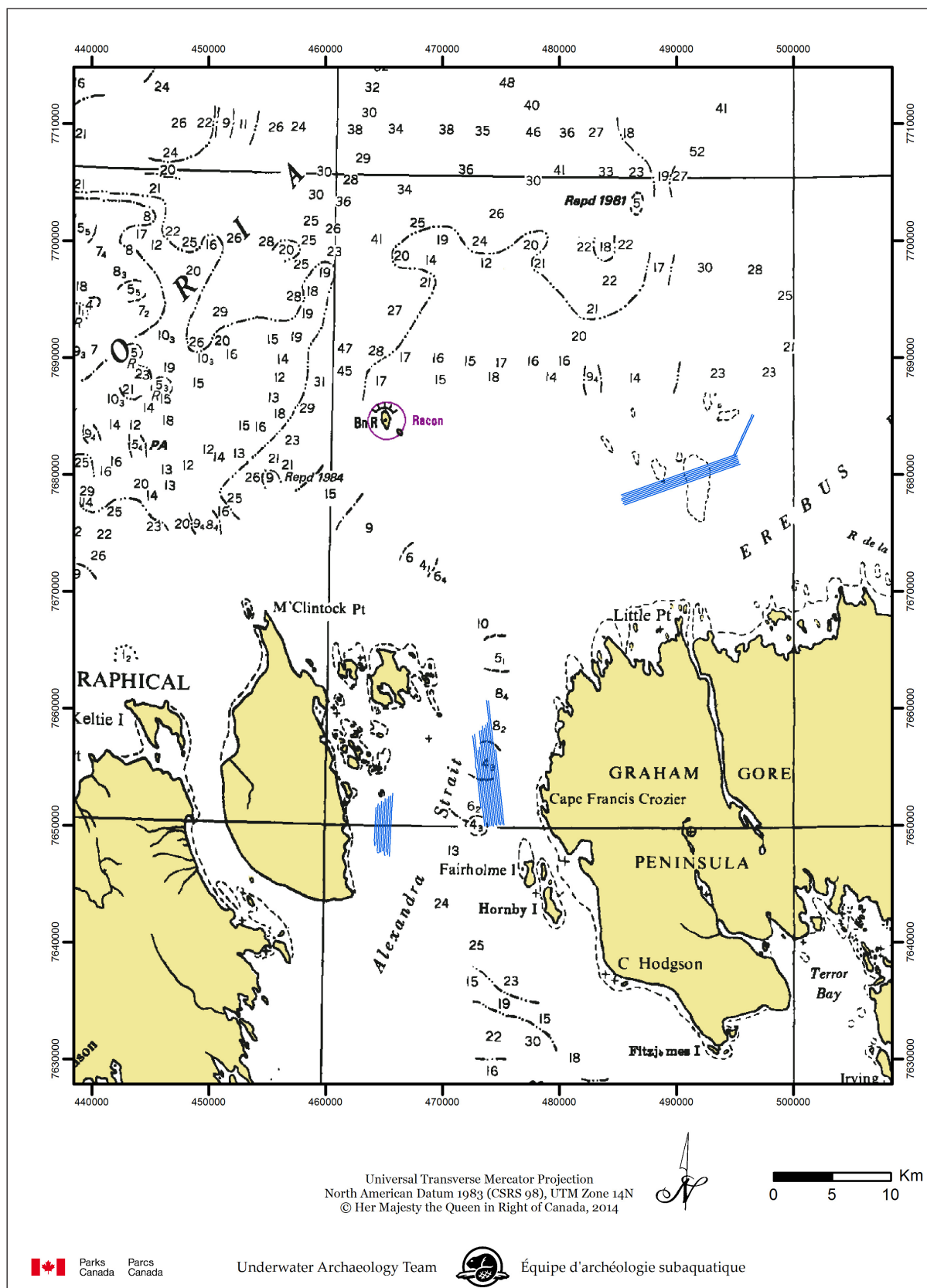


Figure 4.1.1: RV *Investigator* survey track plots in the northern search area, 2014 (Map: J. Moore and R. Harris, Parks Canada; Base map: CHS chart 7784).

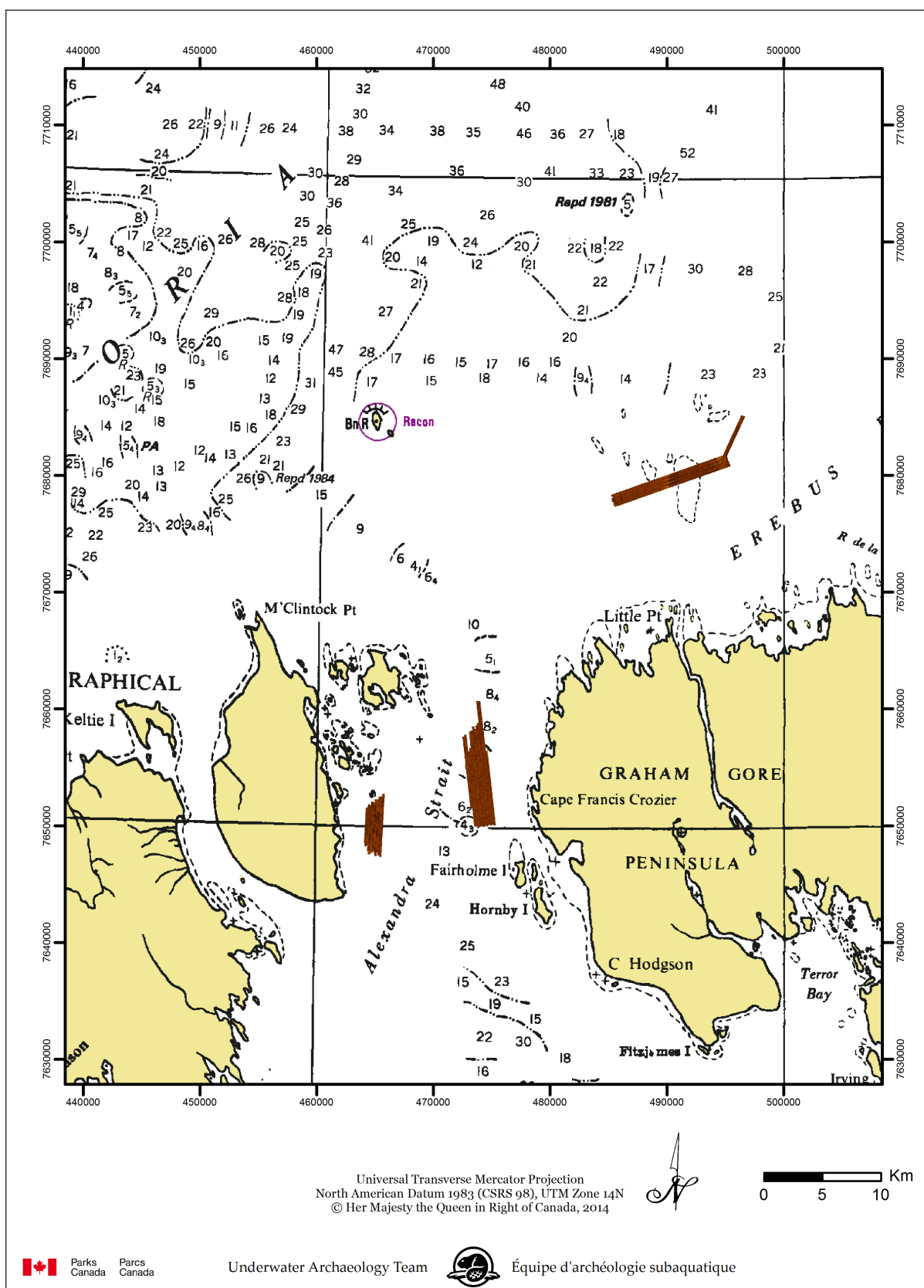


Figure 4.1.2: RV *Investigator* side-scan sonar coverage in the northern search area, 2014 (Map: J. Moore and R. Harris, Parks Canada; Base map: CHS chart 7784).

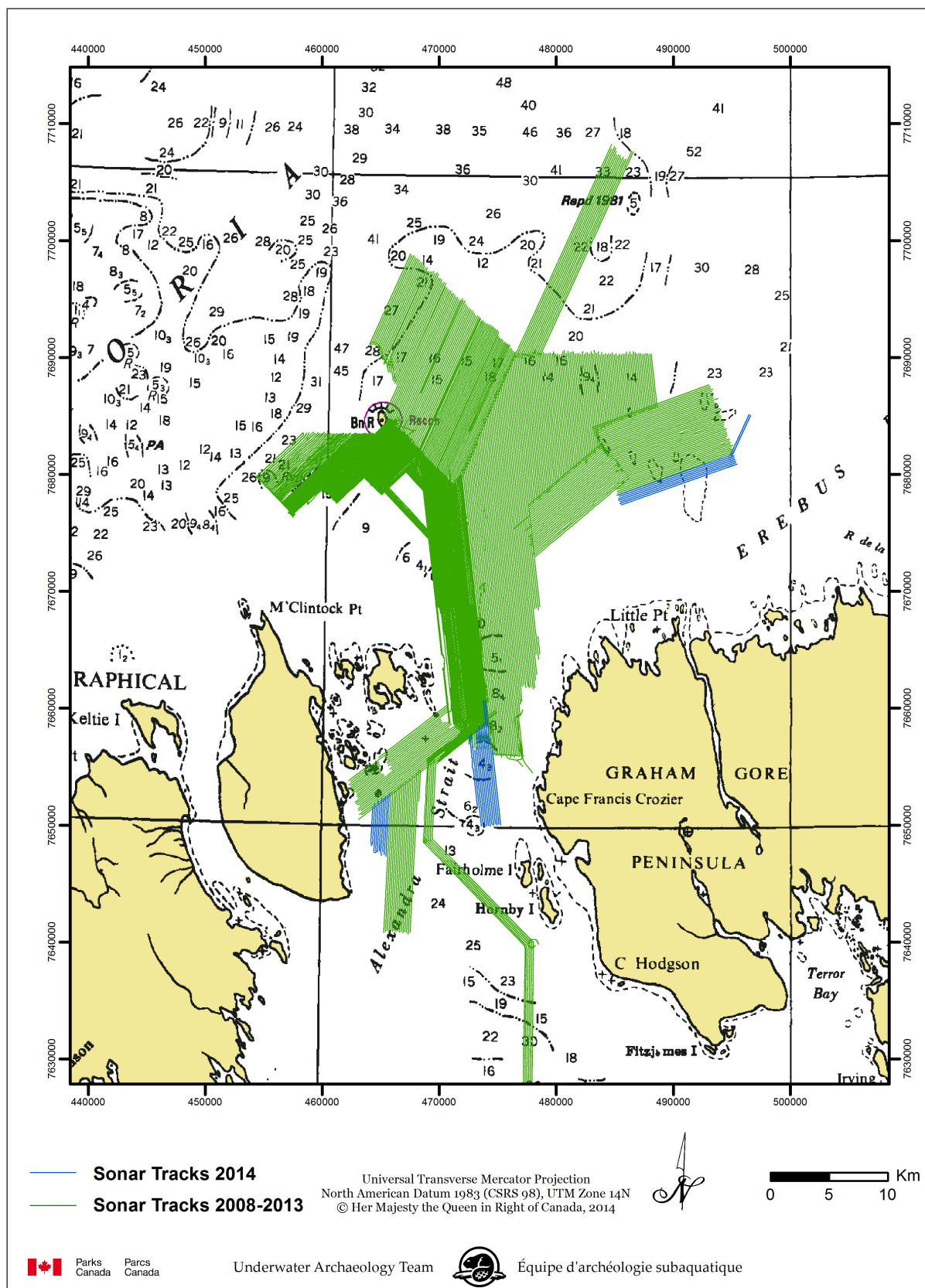


Figure 4.1.3: Cumulative survey track plots in the northern search area, 2011-2014 (Map: J. Moore, Parks Canada; Base map: CHS chart 7784).

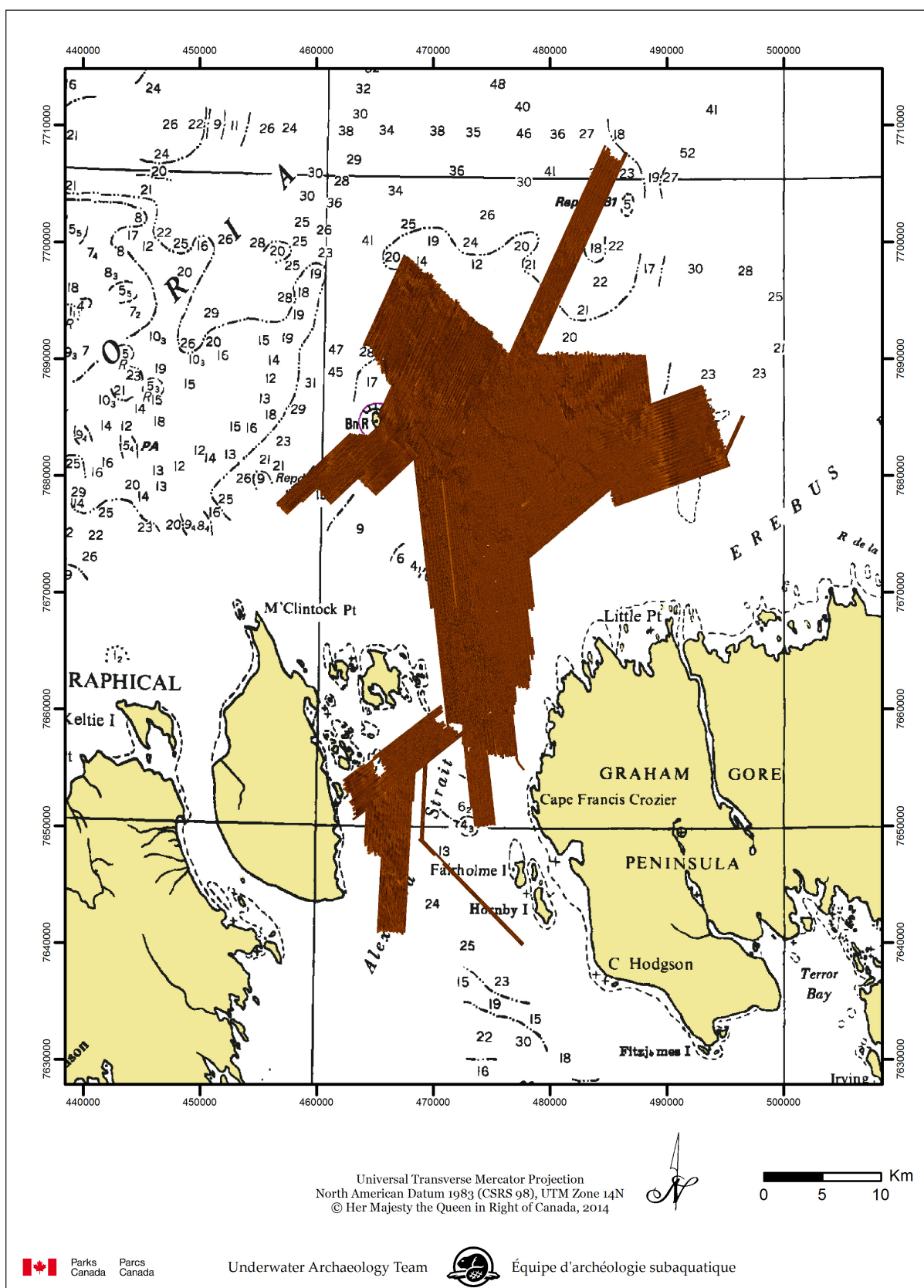


Figure 4.1.4: Cumulative side-scan sonar coverage in the northern search area, 2011-2014 (Map: J. Moore and R. Harris, Parks Canada; Base map: CHS chart 7784).

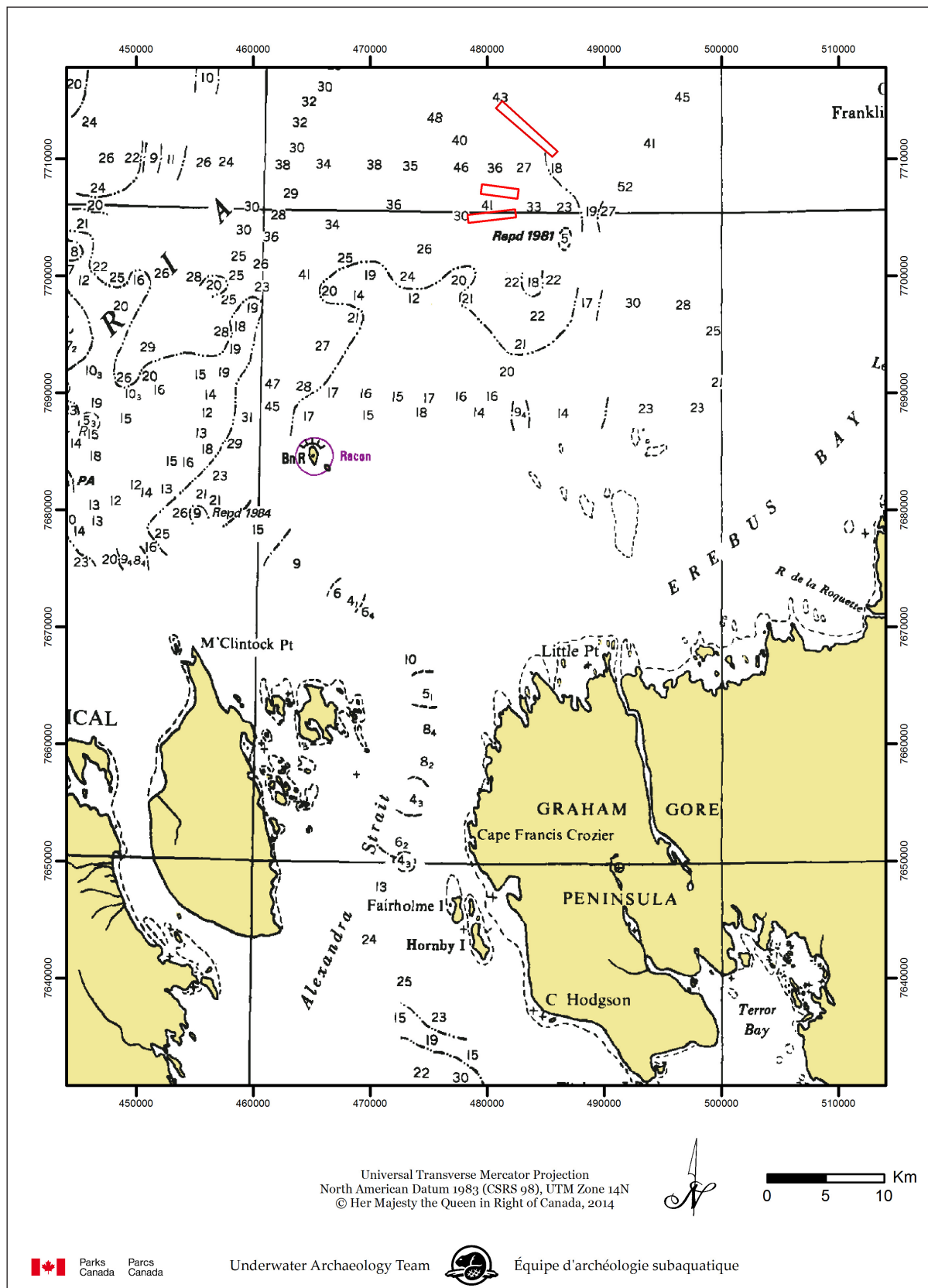


Figure 4.1.5: DRDC's Arctic Explorer AUV survey coverage (red polygons) in the northern search area, 2014 (Map: C. Dagneau, Parks Canada; Base map: CHS chart 7784).

coverage rate exceeding 2.5 km²/hour with a spatial resolution of 3 cm across the entire sonar swath, a swath extending 315 m on both the port and starboard sides of the vehicle. The potential of this state-of-the art technology to greatly increase coverage rates and the detectability of subtle debris targets in marine archaeological area survey is truly noteworthy, particularly in marginal weather conditions that would otherwise stymie survey by surface vessels.

4.2 ISOLATED SHORE FINDS

As the *Sir Wilfrid Laurier* approached the southern search area almost 130 km distant, Scott Youngblut, the CHS Hydrographer-in-Charge expressed his operational need to deploy, via helicopter, a terrestrial GPS reference station on one of the surrounding islands in Wilmot and Crampton Bay, in order to calibrate the multi-beam survey data anticipated for the area in the coming days. The option to accompany the hydrographer on the flight ashore, and indeed to select the particular island to be occupied, was presented to GN archaeologist Dr. Doug Stenton, who took the opportunity to conduct a few more hours of shoreline walking survey. As in previous survey years, Coast Guard pilot Captain Andrew Stirling lent his keen eyes and zeal in assisting Douglas Stenton and Robert Park with survey whenever the aircraft was on the ground.

During this particular trip ashore on September 2, Captain Stirling located and brought to Dr. Doug Stenton's attention a pair of artefacts that would prove portentous for the marine archaeological survey in the days to come. These included an iron object bearing a stamped number '12' between a pair of distinct broad arrow marks, a clear indication of provenance from one of Franklin's ships (Figures 4.2.1 and 4.2.2). This artefact was examined by the UAT in the ship's forward lab allowing Jonathan Moore to quickly identify the fitting as a davit pintle after consulting the ship's plans for *Erebus* and *Terror*. This fitting essentially seated the bottom of a vertical boat davit stanchion timber in a socket or gudgeon at deck level, part of the mechanism for lowering and recovering boats from the flank of the vessel (see Figure 4.2.1). The second artefact was a wooden disc, heavily weathered, covered with lichen, and exhibiting a repair made with square wrought iron nails (Figure 4.2.3). This antiquated piece appeared to derive

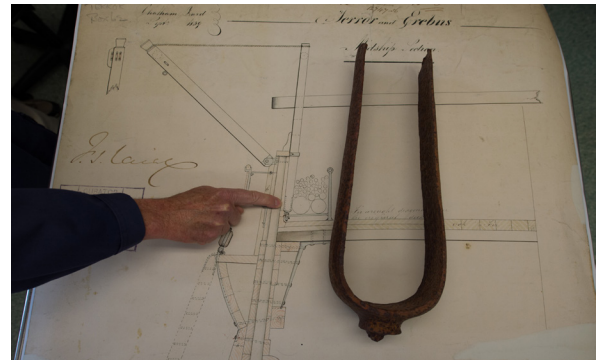


Figure 4.2.1: Davit pintle found on shore juxtaposed with the midship section ship plan of *Erebus*. The location of a matching davit pintle is indicated (Photo: J. Moore, Parks Canada; 89MO130EF).

from the period, and was tentatively identified in the lab as a plug for a deck hawse, judging from a pronounced notch that would seemingly have fit around a link of anchor chain where it descended down through the scuttle and into the chain locker below.

Both artefacts were interpreted as upper deck fittings that were carried away from a wreck and deposited as flotsam on shore, borne by ice in the case of the pintle and floating away in the case of the wooden plug. In the case of the heavy iron fitting, it was suspected that the associated wreck must likely lie close at hand. As was observed with the wreck of HMS *Investigator* in Mercy Bay, Banks Island, where an actual davit stanchion timber was found deposited on shore nearby (Harris, Moore and Boyer 2011: 33), it is suspected that when ice



Figure 4.2.2: Close-up of the davit pintle found on shore showing two broad arrow marks and the number 12 (Photo: T. Boyer, Parks Canada; 89MO252EF).



Figure 4.2.3: Wooden artefact found on shore, tentatively identified as a plug for a deck scuttle, top view (Photo: T. Boyer, Parks Canada; 89Mo257EF).

swept the masts away from the sunken hull, the associated tangle of shrouds likely snagged on the lee-side davits and carried them away.

These two artefacts were seen as strong evidence indicating a wreck was likely located somewhere in the immediate vicinity. This seemed particularly probable in the case of the pintle which was unlikely to have been transported far by natural forces, and which apart from its small finial which is now missing, would have been a bulky and inutile burden to the Inuit. It is possible that the finial was broken off for reuse by the Inuit, close to where the object may initially have been found, and the rest discarded or possibly cached behind the prominent boulder where it was eventually discovered by Captain Stirling. The boulder may even have served as a suitable anvil upon which the finial was struck off, allowing the small piece of detached iron to be rendered into a useful tool. Accordingly, after the survey block then being scanned by the RV *Investigator* at the time was completed, a new survey block was established in closer proximity to the land finds as the focus for continued search.

4.3 DISCOVERY OF HMS *EREBUS*

Within a week, the wreck of *Erebus* was detected by the towed side-scan sonar system deployed from the Parks Canada RV *Investigator* (Figures 4.3.1-4.3.3). The wreck was found to lie at a depth of 11 m in the waters of Wilmot and Crampton



Figure 4.3.1: Photo of Parks Canada crew of RV *Investigator* taken soon after the discovery of *Erebus* (from left to right): Jonathan Moore, Ryan Harris, Joe Boucher and Chriss Ludin. At the time of discovery, Jonathan Moore and Ryan Harris were operating the side-scan sonar, while Joe Boucher was at the helm, under the supervision of Chriss Ludin (Photo: J. Moore, Parks Canada, 89M0031EF).

Bay, in the Kitikmeot Region of Nunavut. Initial sonar imagery revealed the wreck as surviving in remarkably sound condition, with only a moderate amount of damage having been sustained by

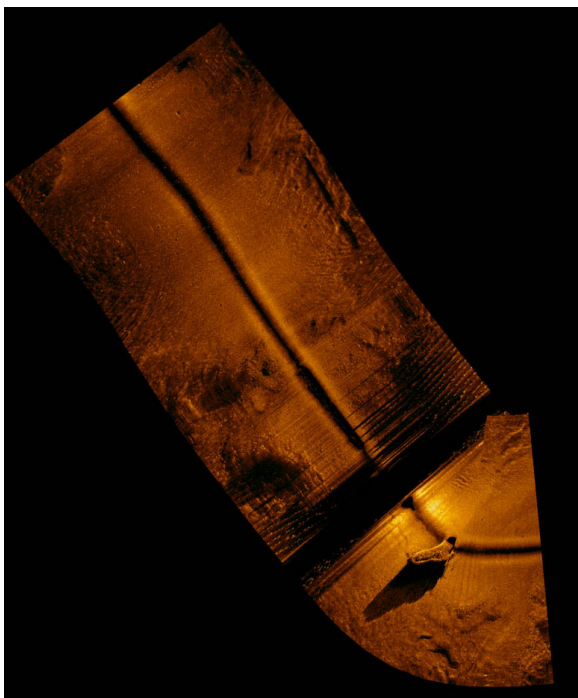


Figure 4.3.2: The first sonogram of the wreck of *Erebus* as the towfish cleared a shoal directly before the discovery. The wreck is in the bottom right of this image and north is at top (Sonogram: 100 m range, 445 kHz; Parks Canada).

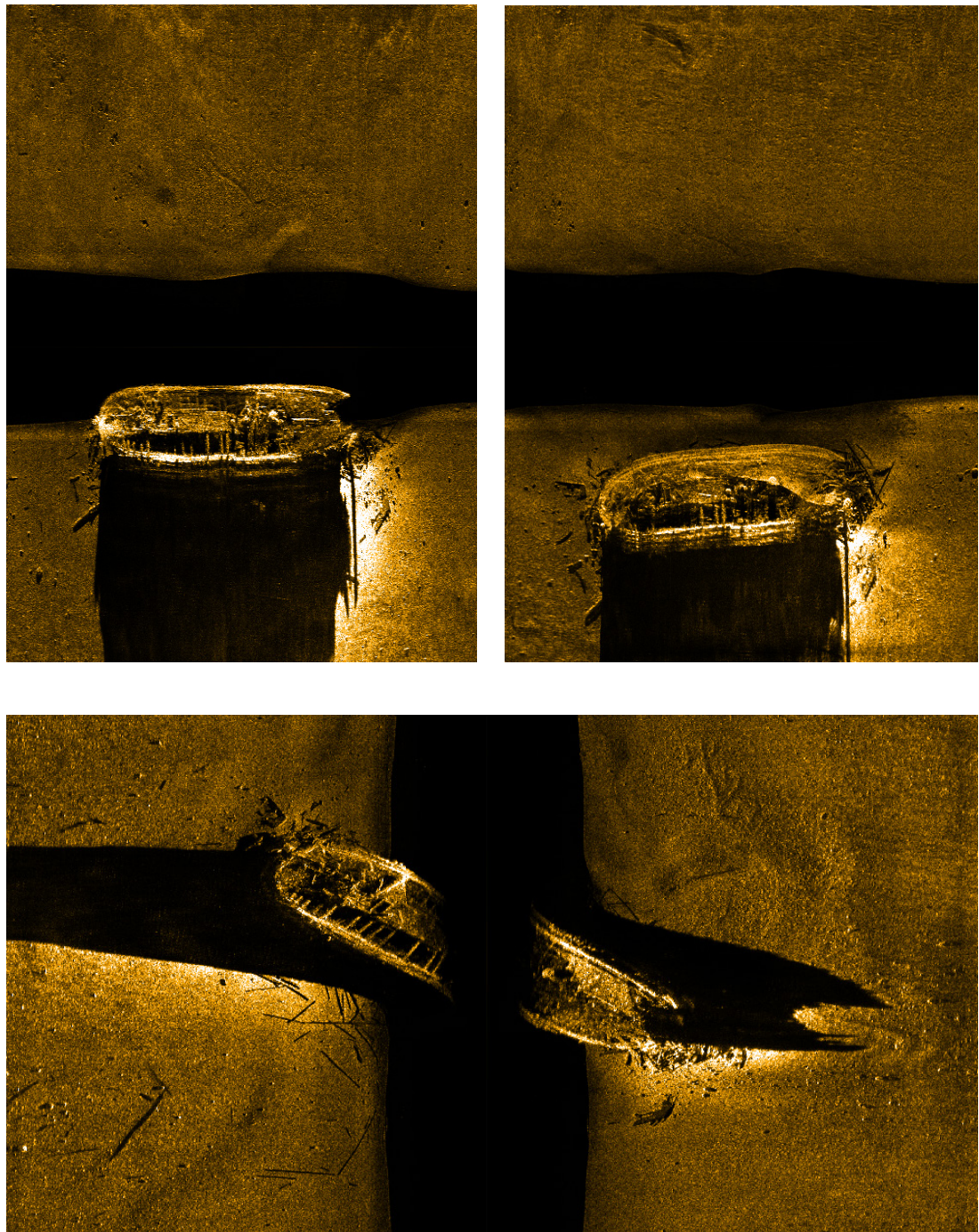


Figure 4.3.3: Selected side-scan sonograms of the wreck of *Erebus*, 2014, with the bow towards the left in all three views: (top left) exposed upper deck beams can be seen along the port side, where deck planking has been stripped away by the ice; (top right) the starboard side of the hull with its intact planking is underscored by this image; (bottom) ice damage to the stern can be seen to the right. Note debris visible in this image off the port side, bow and stern (Sonograms: 37 m range, 445 kHz; Parks Canada).



Figure 4.3.4: The discovery of one of the Franklin ships is announced in Ottawa on September 9, 2014, by the Prime Minister of Canada, the Right Honourable Stephen Harper, with the Honourable Leona Aglukkaq, Minister of the Environment and Minister responsible for Parks Canada, Ryan Harris, Jonathan Moore and project partners present (Photo: Parks Canada).

ice occasionally grounding on the wreck structure since its sinking circa 1850. Following initial target detection, a series of 31 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 (Figure 4.3.2). 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's ROV in the days following initial target detection (see Figures 3.3.6 and 3.3.7). This preliminary inspection was cut short by deteriorating weather. In the span of a brief 40-minute dive under increasingly adverse sea state conditions, two bronze cannons were found lying on the seafloor astern of the wreck (interleaved with structural debris), as well as several conspicuous features of the upper deck including the capstan, forward hatchway, and a nearby suction pump for the forward watertight compartment. The ROV video also revealed the site as being covered by a substantial overgrowth of kelp which obscures much of the wreck detail.

The UAT made their way back to the site less than a week later, after a short trip to Ottawa for the official announcement of the discovery (Figure 4.3.4) and to return with SCUBA equipment and additional personnel to conduct a series of preliminary firsthand inspection dives on the site. A total of seven dives were completed over the span of two days, each dive consisting of a two person dive team. These dives amassed a total of 12 underwater hours spent on site. These efforts focused on recording diagnostic photo and video imagery, while undertaking a preliminary site evaluation focused on assessing structural integrity and overall artefact potential, which both appear high. The ship's cast bronze bell, bearing a raised British government broad arrow mark and the date 1845, was also identified and recovered.

Between dives on the second day, the CHS took the opportunity to image the wreck with multi-beam sonar, yielding an accurate three-dimensional model of the hull situated in a precise georeferenced bathymetric context (see Figure 5.2.1).

5 WRECK OF HMS *EREBUS*

5.1 SITE DESCRIPTION AND ENVIRONMENTAL SETTING

The wreck of *Erebus* lies at a depth of 11 m. The surrounding seafloor consists of hard-packed flat cobblestone with intermixed gravel and sand. Given the firm substrate that this represents, the wreck has not become substantially embedded in the seabed. There is however a scour pocket around the footprint of the hull where it makes contact with the bottom. The most prominent scouring is found along the run of the hull on both the port and starboard stern quarters, where quantities of detached wreck debris have become entrapped (Figure 5.1.1).

Farther afield, the sea floor is generally featureless save for the occasional shoal, some of which approach within 2 m of the surface. One of these shoals situated directly north of the site may possibly have been implicated in the original wrecking event for the vessel, as it seems very unlikely that the ship, even if only partially laden, could conceivably have cleared it if swept over it by the

ice while drifting and/or conned to the southeast. This shoal should be inspected at some point for any signs of vessel grounding or stranding.

In general, there are no signs of seafloor scouring caused by ice in this area, likely attributable to the protective barrier of surrounding islands which appear to prevent anything but in situ ice formation and generally static ice dynamics thereafter. Recent Radarsat 2 backscatter imagery shows the ice in this area as being typically very smooth in surface appearance with no evident signs of rafting or upheaval.

The wreck is heavily colonized with marine overgrowth in the form of unidentified seaweed and kelp (Figure 5.1.2). The latter is the most conspicuous with large fronds seen streaming away from the sessile roots which anchor the prolific vegetation to the wreck. This is found in abundance on the top of the hull and all along the sides and at the stern. Not enough time has been spent on site at this point, however, to comment meaningfully on its distribution. It can be said that marine growth is not observed on the seafloor itself, nor on many timbers that lie flat on the bottom.



Figure 5.1.1: Scour pocket under the starboard stern quarter of the wreck of *Erebus*. Mussels growing on the outside hull planking can also be seen (Photo: T. Boyer, Parks Canada; 89M0737EF).



Figure 5.1.2: Marine growth on upper deck beams and planking (Photo: T. Boyer, Parks Canada; 89M00505EF).

Kelp is observed inside the ship as well, where it is found atop the lower deck planking directly below the exposed upper deck beams along the port side

(where a large section of deck has been peeled away by the ice). The kelp does not appear farther inside the wreck where the decking overhead is still intact.



Figure 5.1.3: Filippo Ronca at forward face of the end post of *Erebus* covered with a layer of mussels of as yet unidentified taxonomy (Photo: T. Boyer, Parks Canada; 89M00439EF).

In the stern, the hull is thoroughly covered with a layer of mussels of as yet unidentified taxonomy (Figure 5.1.3). Whether these particular mollusks are indigenous to this part of the Arctic or not is entirely unknown, but the faint possibility that they were in fact introduced by the *Erebus* itself in the mid-19th century should be investigated.

Water temperature was typically observed in the order of +2 degrees Celsius. While a discernible current on the site was certainly noted in the course of the two-day diving operation, the strength and prevailing direction of this current cannot presently be quantified. Given the lack of collected tide data for this part of the Arctic, it is entirely unknown during which part of the tide cycle the diving operations were in fact conducted. A noticeable surface current was occasionally encountered, this appearing to set from the north or northwest, being a relatively negligible ground current observed on the seafloor below at the time. As such, this observation may have indicated a current swing coinciding with high or low water. Efforts will be made during future site visits

to deploy both tide and current gauges in order to establish a reference baseline of water movement around the site.

5.2 VISUAL HULL INSPECTION

The wreck is oriented almost perfectly east-west, with the bow pointing 272 degrees. The multi-beam data indicates that the hull lies more or less upright on the seafloor, with no clear heel evident to either side. The wreck measures 36 m in overall length by 9.75 m in maximum breadth, with the hull standing a full 5 m proud of the seafloor in the bow and 4.5 m in the stern (Figure 5.2.1).

Overall, the wreck survives in remarkably sound condition despite clear evidence of ice occasionally grounding on the site. This has seen the gradual collapse of most of the surrounding bulwark and transom structures, with a more prominent impact discernible at the eastern extremity of the wreck where the ice has taken a pronounced bite out of the starboard stern quarter. This particular impact has resulted in much debris including, it would appear, the two bronze 6-pounder cannons found on the site, falling directly down to the seafloor. Otherwise the hull is generally preserved to the height of the upper deck, with substantial portions of the weather deck still surviving in situ,

and where missing, revealing intact deck beams below. A large section of upper decking originating from along the port side railing has been lifted up by the ice and deposited right-side-up on the seafloor immediately alongside the wreck just off the southern side. This 13 m long detached section clearly shows the double-planked laminate construction typical of Royal Navy ships modified for Arctic service in the mid-nineteenth century. On the upper deck, this amounts to a layer of diagonal softwood planking being laid atop the existing longitudinal deck planking (Figure 5.2.2). This produced a herringbone pattern, as the port and starboard planks each angle forward and outward at a roughly 45 degree angle. This pattern can be seen quite clearly all along the starboard side of the upper deck, particularly in the waist and farther forward in the bow where the deck planking survives relatively intact. In the vicinity of the quarter deck (not an actual deck per se but rather the aft portion of the upper deck typically reserved for officers and those directly involved in the navigation of the ship), the upper deck beams have all been snapped mid-length. It can be assumed that this resulted from a large ice keel having once pressed down on the wreck, with the deck now depressed into a shallow V shape readily apparent in the multi-beam imagery. While many of the exposed beams observed on the port side appear to still be stepped on the underlying beam shelf, a few have clearly pulled away allowing them to sag.

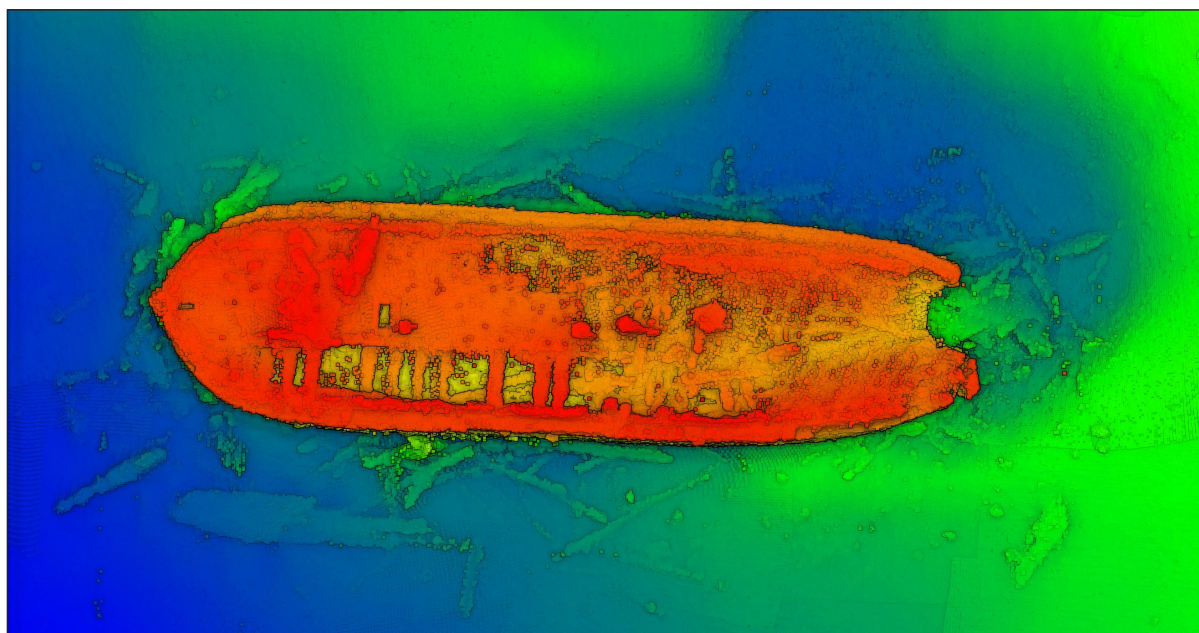


Figure 5.2.1: Multi-beam echosounder image of *Erebus* as it lies at the bottom of Wilmot and Crampton Bay (Image: CHS and UAT, 2014 CHS data).



Figure 5.2.2: Detached section of upper decking lying right-side up on the seabed off the port side of the shipwreck. Diagonal planking can be seen, as well as the round opening for an illuminator (centre) and the hole for a rectangular deck prism (top right) (Photo: T. Boyer, Parks Canada; 89M00381EF).

A number of deck fittings and features associated with the upper deck are preserved on site. This includes the windlass up forward, which has been dislodged by the ice from its centreline position and shifted over to the starboard side of the deck. Its port side warping head has snapped off and is now found to lie down below on the lower deck, having apparently fallen through the open forward hatchway. The most prominent vertical feature on

the site is the capstan, which is intact but heeled over slightly to starboard, likely as a result of the aforementioned damage sustained by the upper deck beams in this area (Figure 5.2.3). The broken stubs of both the forward- and main-masts can be seen where the ice has sheared them away above deck level. The bowsprit and mizzenmast were also carried away, but no fragments of either spar have been observed above deck height. Their



Figure 5.2.3: Capstan covered by marine growth (Photo: T. Boyer, Parks Canada; 89M00633EF).



Figure 5.2.4: Copper alloy ring bolts located on the starboard side of the mizzen mast partner and the square heel end of the tiller (Photo: T. Boyer, Parks Canada; 89M00605EF).

respective partners can be identified in the upper deck, however: the rectangular outline of the bowsprit partner being found directly abaft the stem, and the circular mizzenmast partner appearing in the stern. The latter is indicated by an enclosing circle of in situ mast wedges with a series of ring bolts for anchoring rigging tackle offset to either side (Figure 5.2.4). These bolts are clearly depicted on the 1839 upper deck plan for *Erebus*. The rectangular outlines of both the forward and main hatchways can be identified, as can the rectangular deck coaming of the wardroom skylight. Just aft of the forward hatchway coaming, one of the two suction pumps for evacuating bilge water from the forward watertight compartment in the

bow survives for its full height (about a metre above deck). Its starboard counterpart is missing entirely, an empty hole in the deck indicating its original location.

Highly visible fixtures in the area around the mainmast are the copper alloy bilge pumps. A pump head is lying on its side, on the port side of the mainmast stump, next to copper alloy tubes still standing upright, at their original location (Figure 5.2.5). These are Massey patent bilge pumps, a new type of pump at the time of their installation during the refitting of the ship in preparation for the 1839-1843 Antarctic expedition. This port side pump head is positioned slightly offset from the longitudinal axis of the ship, between the stub of the mainmast and the capstan, that are still close to their original locations.

The external hull appears largely intact to the height of the ice channels which survive for their entire length on both port and starboard sides (Figure 5.2.6). These prominent shelf-like projections, more or less triangular in section, are typical features on the British polar exploration ships of the period, which served to defend from ice push cutting down the shrouds. Above the height of the ice channels, broken top timbers generally survive to the height of the waterway or slightly beyond in better preserved areas. At this height in the bow, the fragmented stub of the diminutive knee of the head can also be identified.



Figure 5.2.5: Partially disarticulated Massey patent bilge pump on the port side of the mainmast atop the wreck (Photo: T. Boyer, Parks Canada; 89M00496EF).



Figure 5.2.6: Starboard side of the wreck with spars (left) lying on the seafloor. The full height of the hull above bottom can be sensed (Photo: T. Boyer, Parks Canada; 89Mo706EF).

The stern exhibits more damage than other parts of the ship, but still maintains much of its original integrity, and with it, valuable information about the 1845 stern modifications completed under the supervision of Master Shipwright Oliver Lang at Woolwich Dockyard to accommodate steam screw propulsion (Figure 5.2.7). The sternpost is intact to the level of the lower deck transom timber, a height at which counter timbers can be seen to either side. Some of the longer counter timbers exhibit broken upper extremities, while others are shorter and evenly bevelled off in pairs where the stern gallery window frames would have seated. Immediately aft of the sternpost, the end post (or rudder post) has been knocked from its position above the extended keel, and is now displaced slightly to port, leaning up at an angle against the stern (Figure 5.2.8). The space between the sternpost and end post once formed the propeller aperture. While no trace of the rudimentary two-bladed propeller was found, the mechanism for hoisting the screw up through a well in the

deck when not in use was identified. This amounted to a pair of bronze tracks seen on the opposing faces of the sternpost and end post, representing guide rails for easing the prop in and out of position (Figures 5.1.3 and 5.2.8). Between the closely spaced rails in each case, an intervening U-shaped recess for seating the propeller shaft could also be seen on the respective posts. Large iron gudgeons appear on the aft face of the end post where they would originally have received the corresponding pintles for swinging the rudder, which was not in position and not observed.

A localised debris field can be identified all about the perimeter of the wreck; this situated in close proximity to the hull and found to contain substantial quantities of disarticulated rigging material including various chain plates, blocks, and spars. All three masts and the bowsprit have been carried away by the ice, and some or all may have been transported a considerable distance away from the site.

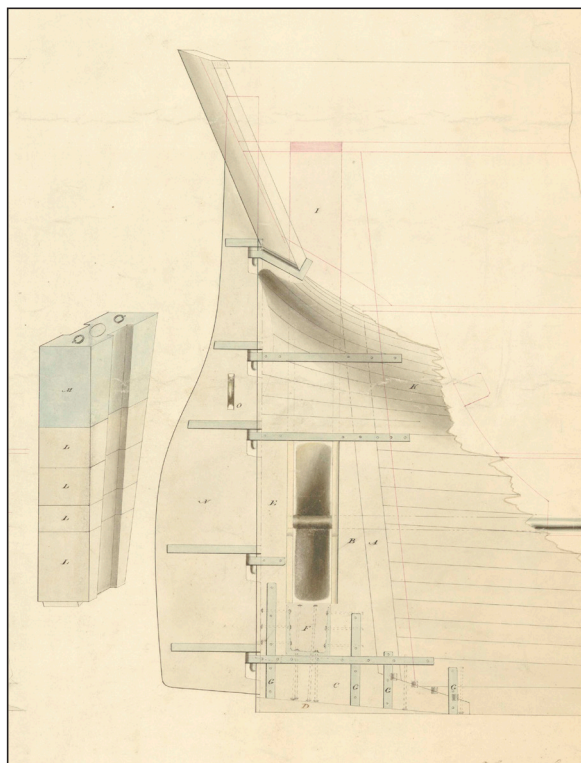


Figure 5.2.7: Detail, stern modifications made to HMS *Erebus* at Woolwich Dockyard to accommodate the adoption of auxiliary steam screw propulsion for the 1845 Arctic expedition (Courtesy: National Maritime Museum, Greenwich, London ZA25683, J1529).



Figure 5.2.8: The end post (right, facing starboard aft) has been displaced from its original location atop the keel. Cast bronze guide rails for lowering and retracting the propeller can be seen on the forward face of the timber (Photo: T. Boyer, Parks Canada; 89Mo592EF).

ARTEFACT POTENTIAL

One of the objectives of the preliminary investigations by the UAT following the discovery of the wreck was to determine the artefact potential of the site. This aspect of the site assessment is critical to prepare subsequent field operations and to help construct a sound research design. The objective of this assessment is to understand the number and nature of the artefacts that could potentially be found and recovered during advanced archaeological work. This can be extrapolated from observations of artefacts that are visible on the seabed surface in the debris field and on the hull structure itself. The following section provides observations on the artefact potential, but it is important to understand that these observations are preliminary and will be re-evaluated during subsequent archaeological work.

For the site of *Erebus*, observations will be presented in three zones: hull; hull periphery; and interior.

HULL

Direct and detailed observations of artefacts lying on the upper deck were made difficult by the presence of heavy marine growth directly attached to the hull structure. Therefore, a relatively small number of artefacts could be identified during four dives that saw divers inspect this area of the site. All of the objects that were observed were related to the operation of the ship.

The only artefact that was recovered from the site was a ship's bell. The bell was identified at the end of the first dive and was archaeologically mapped and recovered on the last dive of the season. The bell was lying on the deck unattached, adjacent to the aft side of the displaced windlass (Figure 5.2.9). It seems that the windlass has taken the bell with it when it was detached from its original position and displaced aft and to starboard, very likely by ice. The bell shows two raised markings that are still visible: "1845" and a broad arrow, but unfortunately it was not marked with a ship's

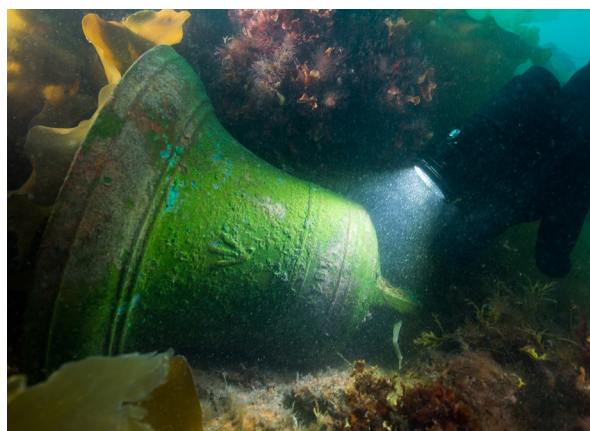


Figure 5.2.9: The bell of *Erebus* in situ, next to the windlass, as an underwater archaeologist shines a dive light on the bell's raised markings (Photo: T. Boyer, Parks Canada; 89M00528EF).

name (Figures 5.2.9 and 5.2.10). It measures 38 cm in diameter, and its total height is 39 cm. It was recovered on the last dive of the operations, after discussion with Dr. Doug Stenton, representative of the GN who was on board the CCGS *Sir Wilfrid Laurier* at the time and who agreed with the proposed recovery (Figure 5.2.11). Consultation also



Figure 5.2.10 Detail photos of markings on the bell of *Erebus*: (top) 1845; and broad arrow (bottom). The photos are not at the same scale (Photos: T. Boyer, Parks Canada; 89M00863EF and 89M00871EF).



Figure 5.2.11: Dr. Doug Stenton (left) and Parks Canada underwater archaeologists Ryan Harris and Jonathan Moore examine the bell of *Erebus* after its recovery, in the forward lab of the CCGS *Sir Wilfrid Laurier* (Photo: T. Boyer, Parks Canada; 89M00886EF).

took place with Parks Canada conservator Flora Davidson in Ottawa. The bell is now under treatment in Parks Canada's laboratories.

Towards the stern of the vessel, the ship's tiller lies unattached on the starboard side of the coaming for the ward room skylight (Figure 5.2.12). The large single-piece tiller is made of a copper alloy, likely bronze, and is circular in cross section except at the aft extremity. Here the tiller assumes a square cross-section where the shaft would have notched into a corresponding mortise set in the rudder head. The forward extremity shows two raised annular lips, wider than the shaft, where the tackle used to control the tiller by way of the ship's helm would have been secured. The presence of the raised lips would have prevented the tackle from slipping off the tiller head or along the shaft. The tiller was measured at 3.65 m in length. This tiller was almost certainly fitted as part of the stern modifications made to the *Erebus* under the supervision of Master Shipwright Oliver Lang at Woolwich Dockyard in 1845. No other loose artefacts were observed on the upper deck.

It is believed that the removal of the kelp on the wreck will yield other objects either relating to the ship's operation, the rigging and even possibly life on board and personal possessions. However, the upper deck has been impacted by the ice in many places, and even peeled off in certain areas, and this will certainly limit the number of objects to be found on deck.



Figure 5.2.12: Head of the tiller on the upper deck (Photo: T. Boyer, Parks Canada; 89M00484EF).

HULL PERIPHERY

Because vegetation limited the capacity to locate artefacts on the hull (mainly the upper deck) and because penetration into the various openings through the upper deck was limited, more time was spent looking at the artefacts in the hull periphery. These were numerous and for the most part readily available as a great number were lying directly on the seabed and with limited sealife coverage (Figure 5.2.13).

Two dives were dedicated to documenting the overall debris field around the hull, one with video, the other with photography. On both occasions, an archaeologist accompanied the camera operator as they inspected the site and made observations.

Generally speaking, the artefact and debris scatter does not extend far from the intact hull structure: very few timbers can be observed at a distance greater than approximately 5 m. This observation has been made directly by divers, but can also be noted on various side-scan and multi-beam sonar images taken at different ranges and on various passes by Parks Canada's UAT or by the CHS. The

exception to this seems to be off the starboard bow, where one timber (possibly part of the bowsprit) lies further away, and off the stern where a greater number of items can be seen spread over a greater area.

Preliminary observations indicate that there is limited siltation around the hull structure. The seabed is composed of hard-packed sand and gravel allowing for limited penetration once objects fall on the bottom. One exception to this is the mid-starboard side where one large anchor lies at an angle with the uppermost extremity exposed but with approximately half of its shank and both arms and flukes completely buried in sand (Figure 5.2.14). This is also the case, although to a lesser extent, for another similar large anchor on the port side of the wreck, seemingly in a comparable longitudinal location, and for the large bower anchor standing upright just under the stem, slightly to starboard. In both instances, the arms and flukes are buried in sand, although they are more upright than the starboard anchor. The evaluation of the siltation around the wreck will need to be investigated further with test excavations.

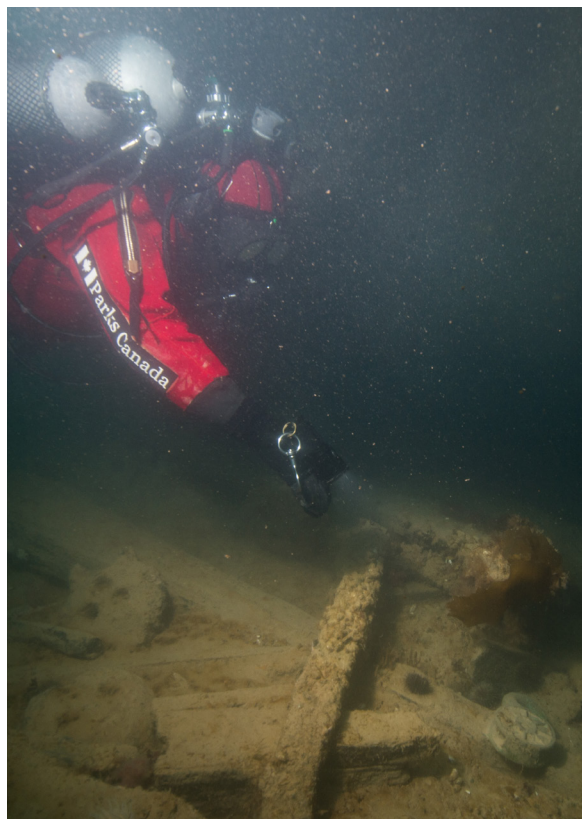


Figure 5.2.13: Rigging material on the seabed off the port stern quarter showing minimal sediment cover (Photo: T. Boyer, Parks Canada; 89M0434EF).



Figure 5.2.14: Anchor lying off the starboard side. The flukes and lower part of the shank are buried leaving only the upper part of the shank and shackle exposed (Photo: T. Boyer, Parks Canada; 89M00696EF).

The great majority of the objects identified in the debris field originate from the standing rigging, the running rigging, the upper deck, and upper structures. A number of anchors, apparently stored on the ice channel are also present and easily identified. The area at the starboard stern includes a number of objects that appear to have come from inside the vessel. This area lies just under, or close to, the damaged portion of the hull that is clearly visible on the sonar images.

Working our way from the bow towards the stern on the starboard side, the first element visible past the bower anchor is a large spar or mast component. Further investigation is required at this point to confirm the exact identity of this very large feature. Adjacent to this timber is an interesting block of wood pierced with what seems to be three lead scuppers.

Moving towards the stern we observe among the debris one ice chock that would have been attached to the side of the vessel to defend against the ice, as well as a lead sheet, evidence of cordage of various sizes and other anchors, rope, and chain.

Further aft of the anchors, two large spars or yards lie very close to and parallel with the hull, the smaller slightly on top of the other. Immediately aft of these spars is a portion of a mast that still has its mast cap in place. The mast section is inserted in the circular opening of the cap but the square opening is empty. The cap has a copper alloy sheave embedded on the exposed side. Aft of this item, a deadeye and a small anchor lie among other objects.



Figure 5.2.15: Turned furniture leg and attached stretcher lying next to the shipwreck off the starboard stern quarter (Photo: T. Boyer, Parks Canada; 89M00740EF).

As we come closer to the stern itself, the amount of debris increases. This is due to the more substantive damage to the stern of the vessel higher up on the structure. It seems that the starboard upper portion of the stern, around the great cabin, was impacted to a greater degree by the ice and that the components of this area have fallen directly to the seafloor. Almost directly below the stern structure lies a segment of hull showing the upper ends of the top timbers as well as a leg of what seems to be a low table (Figures 5.2.15 and 5.2.16).

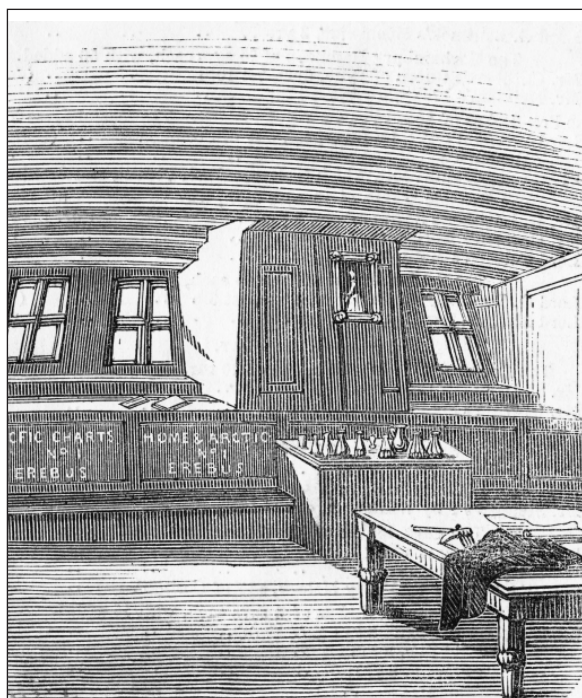


Figure 5.2.16: Interior of Captain Sir John Franklin's cabin aboard HMS Erebus showing a small table with legs similar to that found on site (Drawing: *Illustrated London News*, 24 May 1845).



Figure 5.2.17: Muzzle of one of the two bronze cannons lying on the seafloor astern of the wreck. The second cannon lies underneath (Photo: T. Boyer, Parks Canada; 89M00453EF).



Figure 5.2.18: Underwater archaeologist Filippo Ronca measuring the muzzle bore diameter of one of the two bronze cannons. (Photo: T. Boyer, Parks Canada; 89M00472EF).

Aft of the hull structure, and slightly to the starboard side are two bronze cannons, one lying partly on top of the other (Figures 5.2.17 and 5.2.18). Both appear to be of the same size and the bore of one has been measured at 9 cm. Around the guns lie numerous timbers and timber assemblages, including a section of what seems to be deck planking.

Moving from bow to stern on the port side, a first concentration of debris can be seen close to the stem. A chain still attached to a bower anchor standing on the starboard side runs over scattered timbers. A little farther off to port, the above-mentioned large section of deck planking lies approximately 5 m from the hull (see Figure 5.2.2). An elongated pyramid-shaped glass deck prism, likely to have been embedded in a rectangular-shaped opening, lies on the deck section, forward of its opening (Figure 5.2.19). Another deck prism is still in place in the planking. Forward of the deck section lies a large timber that may be a portion of the bowsprit, but this will need to be confirmed.

Lying slightly forward of amidships, after a string of debris is the afore-mentioned large anchor. Two smaller anchors lie flat on the seafloor closer to the stern, in the port quarter. They just precede a grouping of elements that would have been associated with the mizzenmast channel assembly as at least three deadeyes lie in proximity one to the other (Figure 5.2.20). A small copper alloy block with a hook shows a decorative pattern



Figure 5.2.19: An elongated pyramid-shaped glass deck prism lying on the dislocated deck section on the port side of the wreck (Photo: Thierry Boyer, Parks Canada; 89M00391EF).



Figure 5.2.20: Rigging elements on the seabed next to the shipwreck. A few deadeyes lie next to chainplates and a copper alloy tackle block (Photo: T. Boyer, Parks Canada; 89M00753EF).

resembling a sun. Finally, the last element to mention is a large piece of metal sheet (possibly lead) that seems to correspond to some sort of metal box that has been flattened during its deposition on the seabed.

The general observation is that the debris field around the wreck is significant and is generally composed of rigging elements and structural elements from the upper structure and some section of deck. The exception to this is in the starboard stern section where a larger portion of hull structure has been deposited, and some items originating from inside the ship.

HULL INTERIOR

The interior of the vessel, between the remaining decks, is clearly where the artefact potential is the highest, not only for variety and preservation, but also in view of the better preserved context. Two areas were briefly investigated.

First the video camera was inserted in the forward hatch. The brief video recorded shows a deck area heavily covered with disarticulated timbers. Two deck stanchions are clearly visible amongst the debris as well as a crate and an unidentified frame. Forward at midship, the edge of what is believed to be the iron galley stove was visible. There seems to be very little siltation in this area.

Second, some of the underwater archaeologists gently lowered themselves into one of the large openings on the port side, in the bow quarter, where most of the deck planking had been peeled off. Without moving into the wreck, it was possible

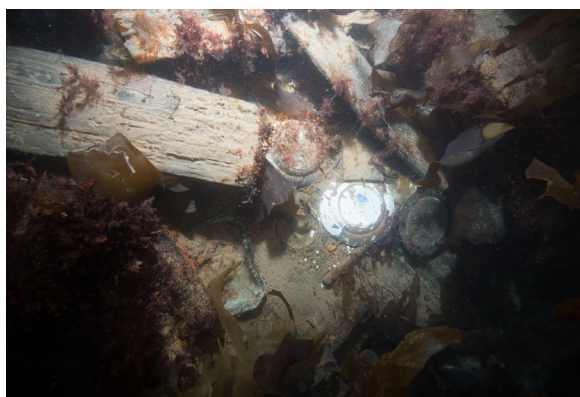


Figure 5.2.21: A scatter of artefacts visible inside the wreck, atop the lower deck, including ceramic plates, an illuminator and a serving platter (Photo: T. Boyer, Parks Canada; 89M00512EF).

to make some observations even though the curtain laid by the large bands of kelp limited the extent of visible areas. Here again, there seems to be limited siltation as the main deck planking observed was for the most part devoid of sediment. Many artefacts were seen in this particular area including, at least two whiteware plates, one serving platter and one small intact glass bottle (Figure 5.2.21).

5.3 IDENTIFICATION

The conclusive identification of the wreck was not made until the end of September 2014, well after the UAT had returned to Ottawa and only after careful analysis of the reams of site data that had been accumulated up to that point. Even during the initial side-scan sonar survey, however, the evidence seemed to be hinting more towards *Erebus* given the observed 33 m (108.27 ft) length of the wreck taken from the leading edge of the stem to the trailing edge of the stern post, which presented a close match with the 108 ft (32.9 m) length indicated on the 1839 starboard profile of *Erebus* – bearing in mind that the *Vesuvius* class bomb vessels were built three feet shorter than the subsequent *Hecla* class bomb vessels. This could not be considered definitive, however, given the limitations in spatial accuracy inherent to towed side-scan sonar data.

In preparation for the inspection dives, consequently, the respective ship plans for the *Erebus* (1839) and *Terror* (1836/45) were thoroughly indexed for subtle distinguishing features that might be encountered underwater and which

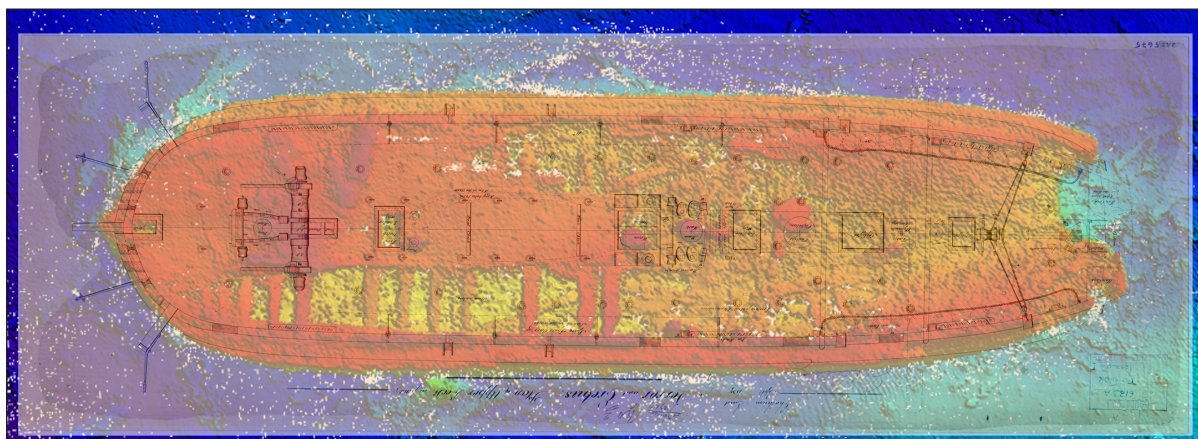


Figure 5.3.1: Overlay of 1839 HMS *Erebus* upper deck plan with the 2014 CHS multi-beam echosounder image of the wreck (Image: Ryan Harris, Parks Canada; Ship plan “*Terror* and *Erebus*, Plan of Upper Deck (as fitted)”, National Maritime Museum, Greenwich, London, ZAZ5675, J1409; CHS, 2014).

might potentially serve to identify the wreck one way or another. The immediate application of this approach was hindered somewhat by the limited number of dives that were ultimately possible, due to the advanced state of the navigation season and deteriorating weather, as well as the extensive marine growth on the wreck which conspired to conceal many of these diagnostic features from view. Nevertheless, the dives served to visually confirm where exactly the necessary length and breadth measurements on the sonar data were in fact being referenced to, particularly in the stern where the partially collapsed structures were difficult to interpret on sonar.

Between dives, the UAT made way for the CHS to access the site in order to image the wreck structure with multi-beam echosounders deployed on their survey launches. The post-processed 400 kHz multi-beam data provides vivid 3D imagery that is very accurate geospatially, allowing precise and reliable hull dimensions to be extracted, while also showing the relative arrangement of prominent topographical features in scalable real-world coordinates. This works in perfect complement to the higher structural detail offered by the 2D side-scan imagery, to provide a faithful digital representation of the site.

In the end, dimensional information obtained from the multi-beam, structural information obtained from the side-scan, and visual land marking and other diagnostic detail identified in the course of the inspection dives combined to yield a positive identification of the site as *Erebus*. This data demonstrated a close correlation with the 1839 upper deck plan and starboard profile

of *Erebus* preserved in the ship’s plans collection of the National Maritime Museum, Greenwich, while presenting clear discrepancies with those of *Terror* (Figure 5.3.1).

Positive correlations included the aforementioned stem to sternpost moulded length measurement, the moulded breadth, the length and breadth of the ice channels, the locations of the forward and main hatchways, the position of the forward suction pumps, the position of the bowsprit partner, as well as that of the foremast and mainmast, all of which align perfectly with the upper deck plan for *Erebus* when rendered to the same scale.

A correlation was also observed in the morphology of the warping heads from the windlass as well as the fastening of the iron davit pintles. The detached warping head found on the wreck was seen to match the complex ogee shape depicted on the *Erebus* plan as opposed to the simple concave shape shown for *Terror*, while the davit pintle recovered in the course of the terrestrial survey seemingly indicates a simple compression fitting to the bottom of the wooden davit stanchion consistent with those shown on *Erebus* whereas those depicted for *Terror* are shown as having been secured by a pair of iron bolts.

Any single correlation considered in isolation wouldn’t necessarily prove compelling, but it can reasonably be stated that an overwhelming preponderance of evidence in this case very clearly supports the identification of the Ugjulik Wreck in Wilmot and Crampton Bay as being that of Sir John Franklin’s flagship *Erebus*.

6 CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

The wreck of *Erebus* presents an extraordinary opportunity to learn more about the final stages of the disastrous 1845 Sir John Franklin Expedition. After six field seasons spent looking for the remains of the *Erebus* and *Terror*, the survey will now enter a new and compelling phase largely focused on comprehensive documentation and investigation of the Ugjulik Wreck. The research to come will hopefully be able to identify who the last survivors on *Erebus* were, who was in command (if anyone) at this time, what factors may have contributed to the demise of the expedition, if the ship was indeed remanned at some point subsequent to April 22nd 1848 when it was deserted off Victoria Point, and by extension, whether the ship drifted passively with the ice or was deliberately conned to its present location in Wilmot and Crampton Bay. It is also hoped that clear archaeological traces of Inuit visitation to the site will eventually be identified, and the mechanism of the vessel's sinking determined. As an example of a ship modified by the Royal Navy for Arctic service, the wreck provides a stunning case study for innovative Victorian industrial technology during a period of rapid evolution in marine engineering and naval design. Along with *Terror*, these were the first ships to be equipped with steam screw propulsion for purposes of polar navigation, this at a time when marine steam power was still very much in its infancy.

At the same time, the search for *Terror* will also continue in parallel with the ongoing work on *Erebus*, as a full archaeological understanding of the failed expedition in particular and mid-nineteenth century British polar exploration in general should ideally draw upon the potential evidence available from both ships. Furthermore, as both vessels were designated together as a National Historic Site of Canada, it is incumbent upon Parks Canada to locate the second vessel in order to ensure its commemorative integrity.

6.2 RECOMMENDATIONS

In consultation with the Director of Culture and Heritage for the GN, it is agreed that precise site coordinate information will not be included in reporting materials at this time in the interest of protecting the anonymity of the site location until more comprehensive site protection measures are implemented. For the same reason, a site report form will not be submitted at this time either. It is the intention of the Parks Canada UAT to return to the site as soon as possible, as early as April 2015, to resume site documentation efforts.

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APPENDIX 1: MEMORANDUM OF UNDERSTANDING

MEMORANDUM OF UNDERSTANDING

BETWEEN THE GOVERNMENTS OF

GREAT BRITAIN AND CANADA

PERTAINING TO THE SHIPWRECKS *HMS EREBUS* AND *HMS TERROR*

This Memorandum of Understanding between the Government of Great Britain ("Britain") and the Government of Canada ("Canada") pertains to activities surrounding the exploration, recovery and disposition of the *HMS Erebus* and *HMS Terror*, two wrecked ships of Her Majesty's Royal Navy within Canada ("the wrecks") that have been designated by the Minister of Canadian Heritage to be National Historic Sites.

1. The Parties desire to ensure the commemorative integrity of the wrecks through the orderly and scientific exploration, recovery and disposition of the wrecks and their contents. The Parties further intend that proper archaeological research and disclosure shall prevail over interests of financial gain and media coverage.

2. Britain, as owner of the wrecks, hereby assigns custody and control of the wrecks and their contents to the Government of Canada, and acknowledges Canada as its agent for purposes of this Understanding. In so doing, Britain does not waive ownership or sovereign immunity with respect to the wrecks or their contents while they are on the seabed, but accepts that any site investigation, excavation or recovery of either of the wrecks or their contents will be under Canada's control.

3. In exercising custody and control, Canada has the discretion to take any actions with respect to the wrecks and their contents that it considers appropriate. Canada may accordingly deny at any time permission for investigation, excavation or recovery of the wrecks or their contents, and will seek to ensure that any such permission will only be granted to approved organizations or persons in accordance with an approved plan and procedure.

4. Once either of the wrecks has been positively located and identified, Britain will assign to Canada ownership of everything recovered from that wreck and its contents, except that

a) any gold recovered from the wrecks, apart from coins considered to have been in private ownership, will after deduction of any share which may by law be due to any third party be shared equally between Canada and Britain, and

b) any recovered artifacts identified by Britain as being of outstanding significance to the Royal Navy will be offered to Britain for display in an appropriate museum. Britain will assume responsibility for all reasonable costs associated with the recovery, conservation and transportation of such artifacts.

- 2 -

5. Canada will seek to ensure that any recovered contents are dealt with in accordance with applicable Canadian law and with a plan and procedures approved by marine archaeologists of the Government of Canada, and are properly conserved and made available for public display or other museological purposes, education or research. British historians and archaeologists will be given reasonable access for research purposes to information derived from site investigations, to artifacts raised, and to all reports produced.

6. Canada will seek to ensure that anyone dealing in any way with either of the wrecks and their contents treat reverently, and refrain from disturbing or bringing to the surface, any human remains that are discovered at the sites of the wrecks or in their vicinity. Any human remains that must be removed in order to conduct archaeological work, or that are inadvertently recovered, will be re-interred with proper respect and reverence, and in consultation with Britain.

7. Canada will keep Britain apprised on a regular basis of developments relating to the recovery of the wrecks.

8. In order to facilitate the implementation of, amendments to, or the resolution of any dispute arising under this Understanding, either Party may request consultations to be held between their representatives, including any of their concerned institutions.

9. This Understanding may be amended on the mutual consent of the Parties.

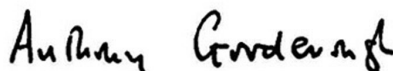
10. This Understanding will take effect when it is signed by both Parties, and will remain in effect until one of the Parties provides thirty days notice in writing of its intention to terminate.

Signed this 5th day of August, 1997.

Signed this 8th day of August, 1997.

For the Government of Canada:

For the Government of Great Britain:



Philippe Kirsch
Legal Adviser
Department of Foreign Affairs and
International Trade

His Excellency Sir Anthony Goodenough
High Commissioner to Canada

