SPITSBERGEN
RETRACED

UNIVERSITY OF OXFORD

Expedition Report

January 2017

In memory of Jamie Gardiner
1994 - 2017
“We left punters and returned Arctic Legends”

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Expedition Leader's Foreword

From skiing through the peak district on the May bank holiday weekend to being reprimanded for pulling a pulk through the Front Quad of The Queen's College, it is safe to say that this has not been an ordinary year at university for any of us. The 'Spitsbergen Retraced' project has been far more than just spending 32 days on an ice cap and we have all developed a huge amount, both as individuals and as a team. At times the scale of our undertaking seemed insurmountable but the hundreds of hours of planning, preparation and training were ultimately a small price to pay for what was a once-in-a-lifetime expedition.

We are greatly indebted to the countless people who provided support, advice and much needed encouragement throughout the project.

James GC Lam
Expedition Leader
30th January 2017

Introduction

1923 - 2016

In the summer of 1923 the *SS Ternigen* sailed from Tromsø bound for the island of Northeastland in the High Arctic. Under the student leadership of George Binney, the Merton College (Oxford) Arctic Expedition intended to circumnavigate the archipelago of islands now known as Svalbard and to cross the unexplored interior of Northeastland. As it happened a build-up of pack-ice in the Hinlopen Strait forced a last-minute revision of this second objective. Instead, on 29 July a sledging party landed on the East Spitsbergen ice cap with a view to making the first east−west crossing of this section of the island. Over the course of thirty days they overcame terrible conditions to achieve both their goal and a detailed topographical survey of the unexplored interior.

Ninety-three years later to the day, another Oxford expedition arrived on the eastern shores of Svalbard's 'cold coast'. The genesis of the 'Spitsbergen Retraced' project to repeat the 1923 journey lay in the original maps and photos from the expedition, discovered in the archives of Merton College and the Royal Geographical Society. After nine months of planning, fundraising and training for the expedition, the team are pleased to report that it was a resounding success.

A Note on Using the Report

This report is intended to provide a comprehensive account of how we put together an Arctic expedition. It provides comparatively technical details which we hope would be useful and specific for future expeditions. This is something we found reading reports of expeditions to the region when in the planning stage ourself.

Therefore, for a more high-level account of the trip, it is recommended that would-be readers focus on the *Aims: Overview* section and the *Expedition Diary*.

Expedition Members

The team upon their safe return to Longyearbyen harbour, 29th August 2016. ***Left to right:*** *Endre, Jamie, Will, James, Liam.* ***Below:*** *Bris.* ***Behind:*** *The Kit.* ***In the UK:*** *Giles*

James Lam - Expedition Leader

James had climbed extensively around the UK, the Picos de Europa, the Dolomites, the Alps and India by the time he went to Spitsbergen. In 2015 he went on an expedition to Kyrgyzstan, making a number of first ascents on 4,000 and 5,000 metre peaks. He had also trekked in Nepal, Tibet, Iceland and The Pyrenees. He served as President of the Oxford University Mountaineering Club and became a member of the Alpine Club in early 2016.

Although he had never been to polar environments, much of this time spent mountaineering and trekking in cold climates provided transferable skills that were invaluable in Svalbard. In the pre-expedition phase James was responsible for overseeing the planning and worked closely with all the other team members to ensure the necessary preparations were made, he also organised the majority of in-country logistics. He was principally in charge of the science projects and was the main drone pilot.

Will Hartz - Medical Officer

Prior to the expedition, Will had taken part in mountaineering, climbing and ski touring ventures across the UK, Alps, Pyrenees and Norway. This included mountaineering in Scotland and the Mont Blanc massif, climbing up to “Hard Very Severe” at a variety of UK

crags and teaching Nordic touring on the Hardangervidda. Further afield, he had trekked in Myanmar, Oman and Ethiopia. He has an interest in wilderness medicine and has completed the Advanced Mountaineering First Aid qualification up to level two. He is currently President of the Oxford University Exploration Club, recipient of the 2016 Wallace Watson Award and is an undergraduate Chemist at St Catherine's College.

Will's primary role was the Medical Officer. Beyond sourcing medical supplies and first aid training, he oversaw and assisted in planning many aspects prior to departure. These included organising a training expedition to Norway, firearms training, sourcing specialist equipment, insurance and fundraising.

In addition to his role as Medical Officer, Will was principally involved with navigation in Svalbard, as well as locating photographs. He worked with Liam to secure twenty repeat photographs, recorded sound for the film and collected DNA plant samples.

Liam Garrison - Expedition Photographer and Filmmaker

Liam had climbed extensively in the UK and further afield. That included everything from Scottish winter mountaineering to competently leading up to HVS on rock. His previous expedition experience included climbing in Morocco, Canada and the USA. In 2014 he cycled 2300 miles down the Pacific coast of the USA. He had produced several short films about his various expeditions prior to Svalbard and was thus asked to take the role of photographer and filmmaker for the trip.

For the pre-departure phase, Liam was the expedition marketing/PR officer. He photographed and videoed the training, made promotional videos and oversaw the design of the website. He enlisted the help of mark-making*, a branding agency, to create the Spitsbergen Retraced 'brand'. Such efforts allowed the team to come across as a serious and professional bunch when approaching people for money.

During the trip, Liam was in charge of photographing and filming events as they happened, working alongside his co-director Jamie. This took up much of his time; working with cameras in such a harsh environment was no easy task!

Jamie Gardiner - Expedition Historian and Filmmaker

In 2015 Jamie had organised a small expedition to Nuuk Fjord in West Greenland. Over the course of two weeks, he made attempts on peaks, sailed through the complex fjord system and completed the annual 120km Nuuk-Kapissillit race over tundra and glacier. He had extensive experience of multi-day treks in the UK and further afield in Albania and Vietnam. His mountaineering experience was comparatively modest, though included some Scottish winter climbing, several alpine routes in the European Alps and Greenland and leading trad climbs up to Severe. His nordic touring experience derived from a week long expedition to the Hardangervidda in the March prior to departure

He studied history at St Hugh's College, specialising in polar exploration in the 1930s. He had also edited the student TV channel, making a number of smaller features as well as filming his time in Greenland.

A late-invite, Jamie joined the team in January 2016. He was principally responsible for all things historical, but this spilt over to playing a key part in publicising the expedition through film, articles and websites to secure grants and gear sponsorship, notably from Montane. His background in outdoor retail enabled him to advise on the dreaded Kit List too. Once in Svalbard, he focused on co-directing the filming alongside Liam, locating re-photographs and managing the archive materials taken with the team. He was also responsible for communications with the UK-based Home Agent, and monitoring stove output and fuel.

Endre - Local Guide

Endre has a PhD in geology and has lead several extensive scientific field campaigns to many of the most remote and alpine areas of Svalbard - campaigns often involving technical climbing of virgin peaks. His research has focused on alpine landscape evolution and the configuration of past ice sheets on Svalbard, and some of his work has been published in the highly renowned scientific journal Nature. Two documentaries on his fieldwork have been featured on national TV. He also holds a M.Sc. in glaciology and knows the glaciers of Svalbard as his own backyard.

In addition to scientific field campaigns he has lead innumerable explorative expeditions to the most remote and steep areas on the archipelago involving steep skiing, alpine climbing and paragliding/speedriding. Endre has lived on Svalbard continuously for the last 10 years, and has in total spent 1 year(!) in tents on numerous locations all around the archipelago. With a friend he also spent 3 dark winter months isolated on a trapping station in northern Svalbard, encountering daily polar bear visits. Endre has been climbing and skiing for his entire life, and masters all types of climbing. His passion for alpine environments have also taken him to many corners of the world, from high-altitude climbing in China to alpine climbs in New Zealand and to the walls of Yosemite valley in USA. He has also been used as a consultant for guide education on Svalbard and for giving advice to the Svalbard's alpine rescue group.

Giles Colclough - Home Agent

Giles has organised treks in the Pyrenees, the Alps, Morocco and Borneo over the last 10 years. His love of hiking and mountains has gradually morphed into a broad love of mountaineering, and an involvement with the climbing community. He got to know James, Will and Liam well as the treasurer of the Oxford University Mountaineering Club.

Giles was the team's point of contact and coordinator back in Oxford throughout the expedition. He provided a central point of communication, and released updates on the team's progress to close relatives as they made their way across the island.

Aims: Overview

It is fair to say that with a project of this size and time in the planning, there has been some evolution in its aims and identity. During the early planning phases, it was commented on by all members of the group that there were too many different 'strands' to the expedition and no single overarching identity. This initially made 'selling' the project as a compact and concise entity to potential sponsors much harder.

On this point, we are very grateful to mark-making* for their part in providing an impetus to refine the expedition's identity to one principally concerned with:

- **'Retracing' the 1923 Route** from Duym Point on the East Coast, to the terminus of the Nordenskiöld Glacier in the West.

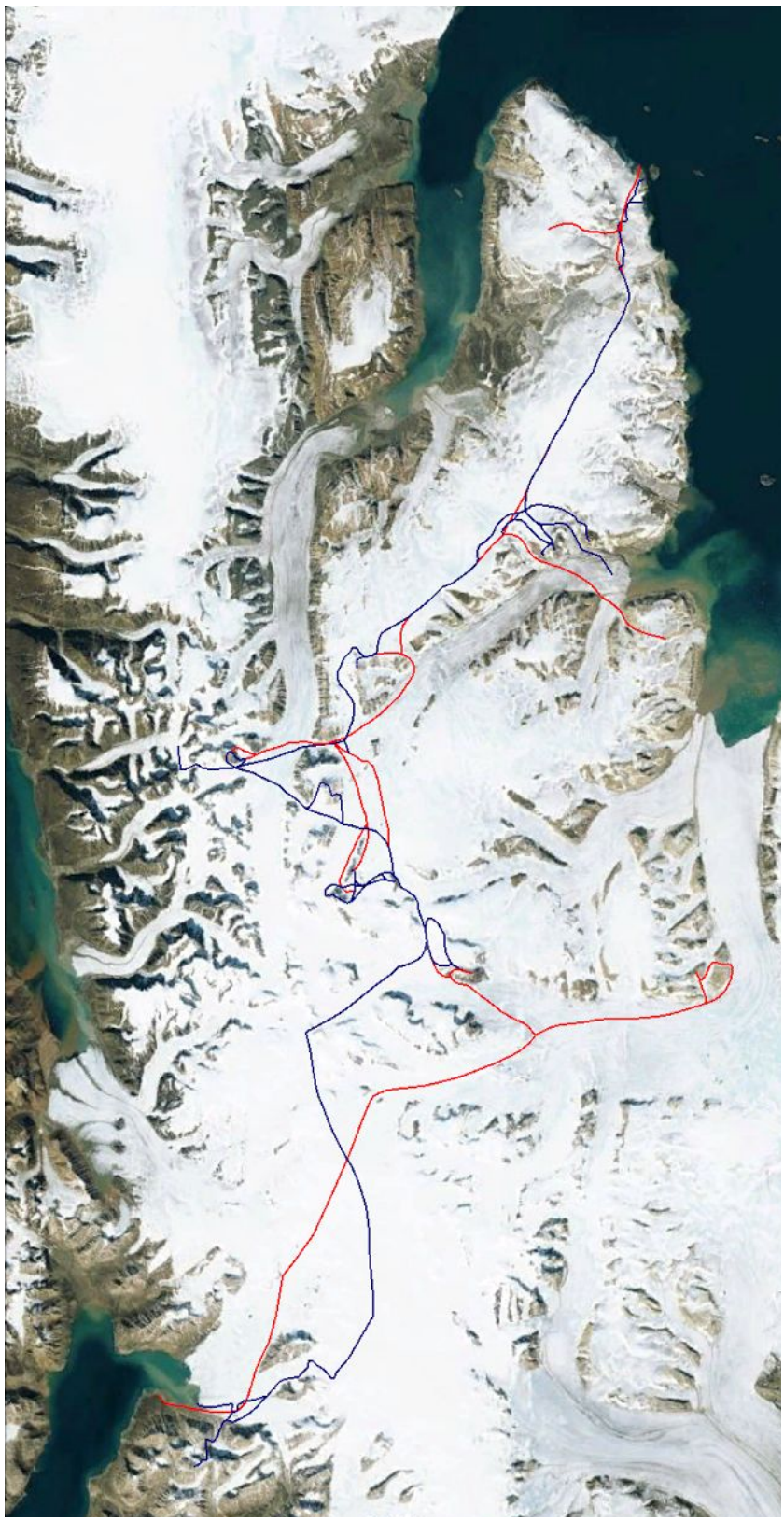
In addition to this central aim, there were three subsequent, related objectives which emerged from it and aimed to capture the spirit of the 1923 expedition. They were first published on our expedition website on 27th January 2016. Whilst there was some inevitable and subsequent tinkering, broadly-speaking the following were either achieved in the field, or are in the process of completion.

- **Historical Documentary:** Three of the four members of the sledging party kept a diary of their time on the ice, subsequently publishing papers in the Alpine and Geographical journals. In addition, they took tens of large-scale landscape photographs. We have already completed extensive archive research at the Royal Geographical Society, Scott Polar Institute and Merton College, Oxford, to piece together the events of ninety three years ago. All that remains is to match those stories to the landscape.
- By producing a documentary film-feature in the field, we will be able to compare these two contrasting polar narratives.

- **Scientific Research:** We are working closely with researchers at Oxford University and the University Centre in Svalbard (UNIS) to collect a variety of data throughout our journey. The Ny-Friesland area of East Spitsbergen has received very little attention from researchers, especially compared to other areas of the archipelago. The only recordings of biological samples ever made in this area were by the 1923 expedition and we will record, photograph and collect DNA samples from the species of vascular plants we encounter en route.
- We will be using photogrammetry, the science of measurements through photography, to investigate glacial change in the Arctic. By using a drone as well as a ground mounted camera we hope to be able to create accurate 3D maps of selected glaciers and their surroundings. Fixed-point repeats of the original photos taken on the 1923 expedition will add a powerful comparative element to the study.

- **Mountaineering:** Svalbard boasts some of the most dramatic peaks in the Arctic. Indeed, the name Spitsbergen derives from the Dutch phrase, ‘pointed mountains’, chosen by the Frisian navigator Willem Barentsz in 1596.
- The 2016 team aims to summit a number of ultra-prominent peaks climbed on the original expedition, including Poincarétoppen, Mount Irvine and Svalbard’s highest, Newtontoppen (5666 feet). Most importantly, the underlying motivation for the 1923 expedition was to scale hitherto unclimbed mountains. Following in the same spirit, it is our intention to carve out new routes and lines in the remote Stubendorff/Atomfjella range.

Route



The 1923 route (red) and the 2016 route (blue) are illustrated on a satellite image of Svalbard. The start point (Duym Point in the Hinlopen Strait) is at the top right and the finish (Nordenskiold) is at the bottom left. Core route length: 149km.

Retracing

The 1923 Expedition

In 1921, a precocious undergraduate at Merton College, Oxford - George Binney - succeeded in leading an expedition to reach the remote archipelago of Svalbard. Anchoring in Klaas Billen Bay, the expedition's foray into the interior of the island had failed, however, to make significant improvements on the territory explored by the famous nineteenth century adventurers Sir Martin Conway and Professor Garwood. Severe blizzards and under-provisioning forced an emergency, twenty-five hour march to safety.

Two years later, Binney prepared another expedition, this time with the dual aims of circumnavigating the island and sledging across the unexplored interior of Eastern Spitsbergen. Remaining on the ship himself, Binney chose Noel Odell, a respected mountaineer as the leader of his four-man sledging party. The overall expedition of fourteen men left Newcastle on the 14th July, arriving in Tromsø on 21st July after a less than sedate crossing. Here they acquired a Norwegian crew and boarded the *Ternigen*, a propeller-driven sealing-yacht equipped with a reinforced-hull to break through the Arctic pack-ice.

The original plan had been to put a sledging party ashore on the virtually unexplored island of Northeastland. However, an impenetrable build-up of ice-floes in the Hinlopen Strait forced Binney to switch his objective once again to the main island of Spitsbergen. Just after midnight on 30th July, a team of four were put ashore at Duym Point on the East coast under the leadership of the experienced mountaineer and geologist Noel Odell. Their plan was to make the first-ever crossing of this part of the island, to map it properly and conduct a geological field survey to boot. What followed was an epic, thirty-day crossing of the East Spitsbergen ice cap. Dragging two wooden sledges, each weighing in excess of 500lbs, the party's only contact with the outside world was a temperamental wireless connection which petered out for days at a time.

Their route took them up through the difficult ice falls and waist-deep morass of the Lomme Glacier onto the ice cap proper. Diverting only to summit outlying and often unclimbed peaks, including the highest in Spitsbergen, the team proceeded to map the topography and geology of the lands lying between the Chydenius and Stubendorff (Atomfjella) ranges. The mountaineering had a specific significance for one particular member of the expedition. 21 year-old undergraduate Sandy Irvine's name would later acquire renown in tragic circumstances after his disappearance on the North-East ridge of Everest the next year with George Mallory. From the diaries and journals of the four members it emerges that Irvine's passion for mountain and wilderness was catalysed in the frozen ranges of Spitsbergen.

Their journey was beset with difficulties, not least on account of primitive ski and camping equipment prone to breaking. The need to ferry the sledges one-by-one, in effect trebled their 184-mile journey. With temperatures hovering between -8°C and 0 °C, poor visibility and high winds, the ultimate sting in Svalbard's tail hit the team a mere twelve miles from the

west coast and safety. A protracted blizzard swept in from the ocean and pinned the expedition to their tents for three days and three nights. Despite the partial collapse of one shelter on the 30th of August, all four members emerged unscathed to complete the final twelve miles to Klaas Billen Bay and the safety of the *Ternigen*.

Researching the 1923 Expedition

Most of the research into the original 1923 expedition was conducted in the Bodleian Library using either journal articles published by the original expedition, or their informal, personal accounts. There was a considerable dearth in secondary material, with the notable exception of Julie Summer's excellent account of Andrew Irvine's life: *Fearless on Everest*. However, this absence is a reflection of the scanty literature covering inter-war polar exploration more generally.

Valuable forays were additionally made to the Scott Polar Research Institute in Cambridge and the archives of the Royal Geographical Society. Noel Odell's diary, arguably the most colourful of the extant primary accounts, was studied at the former. The latter yielded the exceptional collection of Robert Frazer's original landscape photographs, which became the (literal and metaphorical!) focal point of our rephotographic efforts.

We were also lucky enough to correspond with various relatives of the original expedition and those involved with exploration in that region at the time. Thanks must be offered in particular to Julie Summers, Peter Odell and Jamie and Julia Korner.

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The following provides a useful but not exhaustive summary of key sources.

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Key Discoveries in the Field

'Retracing' is of course not in any sense an established or systematic research activity. We wanted to find an expedition which leant itself to a clear objective and a potentially continual source of interest to boot. With this caveat in mind, it may still be said that the expedition yielded two distinct types of discovery, one of a strictly archaeological sort and the other a more general historical awareness.

Archaeological Discoveries

On a robustly tangible level, the expedition was extremely fortunate to find a number of original artefacts left in situ from the 1923 expedition. Our most exciting discovery was of the remains of the original 'carpet camp' from 1923. On 5th August, intending to repeat the photo of Sandy Irvine *sans vêtements*, Will spotted what appeared to be a wooden cross wedged into a cracked rock on the patch of moraine we had correctly identified as the location of the 'carpet camp' (79.2790°N, 18.1125°E). On closer inspection, these transpired to be a trio of wooden pegs, akin to those used for large, canvas scout tents. They were surrounded by several tin cans, fragments of circular metal like the outside part or rim of the lid of a paint pot, matches, string and a piece of stuffed, wire-rimmed material which resembled part of a bonnet or padded strapping. If any further evidence were needed that these were the bona fide remains of the original camp, then it was the discovery of the faint letters 'Oxo' and 'Primus' on a tin lid and scrap of metal; both brands which sponsored the 1923 expedition.

We naturally left these items where they were, not least because it is illegal to pick up anthropological remains in Svalbard dating prior to 1945. On return to Longyearbyen, we reported our findings to the Sysselmannen who noted that no record of the site existed. This appeared to suggest that ours was the first, or at least the first recorded, return to this particular spot, and possibly particular valley, since 1923.

As fascinating as it was, the discovery of the 'carpet camp' posed a paradox. The artefacts discovered were almost invariably litter, their presence in the landscape obvious and unmistakeable. Why, we wondered, had such early enthusiasts for the wilderness and polar travel ostensibly behaved in a manner which a presentist analysis might consider disrespectful? Several theories were advanced. Firstly, and compellingly, the sledging party arrived at the Carpet Camp just as the weather improved after a harrowing and damp crossing of the Loven Plateau. Pictures and diaries attest to the fact that the team chose this campsite as a location to dry out their equipment. It is conceivable that amidst the piles of kit laid out, the artefacts we found had simply been forgotten. But this seems harder to believe given the obviously throwaway nature of some of the items. It seems more plausible that, in the context of such an ambitious venture, for which the outcome was always uncertain, the team had little choice but to jettison deadweight when it no longer served a purpose. The sledges had been bogged down in the mires and 'snow-swamps' of the Loven Plateau to the extent that Odell had at one point been forced to abandon one until Milling and Irvine miraculously rescued it the following day. In the context of East Spitsbergen in 1923, it is

easier to see how what may appear today as an act of callous vandalism would not have seemed so adversely consequential in 1923, and instead entirely necessary. This could be taken further, as a comment on the changed and vulnerable perception of wilderness today.

Further archaeological discoveries were made on a smaller scale on 23rd August near the Geodetic Beacon on Mount Chernishev (78.9581°N, 17.9816°E), constructed by the 1901-2 Russo-Swedish expedition. Firstly, a tin can with a label in cyrillic. Royal emblems suggested this was from the pre-Communist era and thus the original 1901 expedition.

Perhaps more interesting, though we were expecting to find it, was the max/min thermometer left in 1901-2 and explicitly visited by the 1923 expedition. Opening the insulated cannister, we were amazed to find letters and notes from a number of different expeditions, including from Oxford and Cambridge in the 50s, Norway in the 60s and the 2014 Russo-Swedish Meridian expedition. Most startling, and totally unprecedented, of all was a note left by the 'Topographical Party of the Merton College (Oxford) Expedition', dated 21st August 1923 and signed by all four members of the sledging team. We added our own note in the same format.

Will and Jamie attempt to locate the position of several 1923 photographs before heading out to retake them. This was a common sight in the tent: laptops and ring binders out reviewing the 1923 diaries and photographs, comparing our progress to theirs.

Historical Revelations

On a more cerebral level, it was commented on by a number of team members that the opportunity to visualise the landscape around them rendered the diaries and accounts of the original expedition much easier to interpret. From a purely practical point of view, it was often

hard to determine exactly in what order and where certain things happened on the original expedition when reading the source material in the abstracted setting of an Oxford library.

By allowing us to visualise the features, many of which were named descriptively, and the sequence in which they must have were encountered, 'retracing' the route actually furnished us with a more accurate exposition of the detail conveyed in the sources. More tenuously, the opportunity to experience the landscape and the hardships of modern polar travel may provide some modicum of insight into the possible motivations and, in albeit very diluted form, the ordeals of early Arctic exploration. Though entirely unhistorical, it should also be noted that there was a certain, sometimes moving and emotive effect derived from travelling in the shadow of the same mountains and landscapes as such distinguished early pioneers. In the historian's opinion, this effect was most pronounced climbing the '1923 Route' on Mt Irvine which may have inspired the young Sandy to undertake his last, tragic climb on Everest a year later.

It was generally agreed that the best means by which to inculcate a sense of 'retracing' was for all members of the team to gain a basic understanding of the history of the 1923 trip prior to departure. Once in the field, the team historian offered formal and informal 'briefings' on how our progress and experience compared with that in 1923. By carrying electronic copies of diaries from 1923 and key articles into the field, it seemed the team was generally very well informed and interested in the events of 93 years prior.

Rephotography

Since it was the stunning landscape photographs taken by the 1923 expedition that had initially piqued our interest, and the prospect of going back to '*re*-take' them that set in motion plans for an expedition to return to the island 93 years later, '*re*-photography' was thus established as one of the central aims.

Methodology

Put simply, rephotography involves the comparison of one or more photographs taken at *different* points in time, but from the *exact* same physical position (i.e. exactly the same GPS position and altitude). For example, it has been used to study the changing face of our cities and to show the changing landscape of the American West (*Second View,* Klett, 1984). One of the benefits of this simple methodology of repeating a photograph is that, provided it is done well, the viewer can immediately see the differences in the scene of interest. One of its primary applications is to demonstrate glacial retreat, in attempt to engage the public with climate change. After all, a picture speaks a thousand words.

The most important thing to get right is to ensure the camera locations between the two images are *identical*. This is crucially important, especially when there is foreground in the image as a small deviation in camera position from the original image can lead to large parallax effect. This can be noticed when features in the foreground do not line up with those in the background as they did in the historical photograph. When the location of a historical image is not known exactly, the photographer must make efforts to locate it. This is often a very challenging process and what takes the most time.

Once the historical camera location has been estimated, it can be fine tuned by a fairly simple process. Firstly, by drawing a vertical line in the centre of the historical photograph, one can line up a feature in the foreground with one in the background. The photographer can then line these features up in real life. Then, by moving along a line keeping and these features lined up, one can easily line up the features to the sides of the image. This takes some practice, but can achieve fairly good results. When there is no foreground in the historical image, things become harder as there is no parallax effect to guide the photographer to the true camera location. In these cases, it is up the one's best judgement as to where the camera location could be. In our case in Svalbard, obvious places were at the summit of peaks on flat ground where a tripod could be set up.

Since we did not have a panoramic camera, panoramas were created by taking a series of wide-angle photos from that point and then stitching them in Photoshop upon our return. It was important to ensure we covered enough of the view in order to create the panorama later, and as such we allowed for a lot of overlap between images and made sure captured enough vertical content (sky and ground). Having the camera in manual exposure mode and with constant settings for all the images for a particular panorama ensured constant exposure across the panorama.

It was important to have clear weather, for the scene can change quite significantly with the presence of clouds. Also, in an ideal situation, the sun's angle would be the same in both photos so as not to confuse the viewer with different shadow angles. However, a compromise had to be struck between getting a photo that might not be perfect and holding out for the identical conditions to the historical image.

Results

Our expedition was able to locate and re-take over 20 photographs from the 1923 expedition. The results from the rephotography were on the whole very good. Of the photos we were able to retake, around a dozen are excellent, shot at a variety of locations with a very accurate repetition of the historical camera location.

Below are some examples of our work:

North East Shoulder of Mt. Newton, as viewed from the summit of Makarovtoppen. ***Above:*** *1923.* ***Below:*** *2016.*

Duym Point, the lagoon where the 1923 began their journey. ***Above:*** *1923.* ***Below:*** *2016. Note the difference in the ice cliffs to the left of the image.*

Chernyshev Beacon, built by the Russians in 1901. ***Left:*** *1923.* ***Right:*** *2016. Note Frazer's highly fashionable kitchen apron (left).*

The terminus of the Bear Bay Glacier, as viewed from Raudberget. ***Above:*** *1923.* ***Below:*** *2016. Note the changing direction of the medial moraine and the retreat of the glacier.*

The Nordenskiöld Glacier, as viewed looking north from Mt. Robert. Klaas Billen Bay is to the left of the scene. ***Above:*** *1919* ***Below:*** *2016. Taken on the First Scottish Spitsbergen Expedition, 1919.*

Conclusion

While we have managed to obtain very accurate repeats of the historical panoramas from 1923, the true value of our work has yet to be realised. We set out to use the methodology of rephotography to 'see how the landscape has changed over the course of a century'. While performing this task is interesting in itself, the conclusions we can draw about the state of the glacier are less clear-cut. We expected to see the glaciers in a significantly different state today. While the termini can be seen to have retreated, the glacial levels in the interior of Svalbard look fairly similar. This might be due to snow conditions, or it may well be due to the lack of sensitivity of the rephotography method in measuring subtle changes. However, we do believe that this is a simple and useful method that can be replicated in other parts of the world where historical photographs are available but scientific data is not. In that respect, we believe that our work has been a worthwhile endeavour.

Scientific Research

Biological research

Our biological research was conducted in collaboration with Prof. Pernille Eidesen at the University Centre in Svalbard (UNIS).

Background

Ocean islands are claimed to be ideal model systems for studying universal processes as they are isolated geographical spaces characterized by often comparable conditions; this allows observations to be replicated at regional scales. Nunataks within glacier systems can be regarded as such replicated island systems.
Saxifraga oppositifolia L. is a circumpolar arctic-alpine species with probably the widest global distribution in the family Saxifragaceae (Webb & Gornall, 1989), and thrives in a wide range of habitats, from early-melting, extremely dry ridges with long growing seasons, to moist snow beds with short growing seasons (Teeri, 1973; Crawford, Chapman & Smith, 1995; Kume et al., 1999; Larl & Wagner, 2006). Two main ploidy levels are recorded (2n = 26 and 52, functionally diploid and tetraploid) (Elven et al., 2011).

Previous investigations suggest extensive gene flow among populations of *Saxifraga oppositifolia* within the two ploidy levels. No spatial differentiation or genetic variation due to environmental factors has been found except some environmental filtering of ploidy levels at local scales.

All populations investigated thus far have been sampled along the coast at lower altitudes, and investigated by AFLPs, which are dominant molecular markers, possibly masking genetic variation.

Populations found on nunataks within the ice might represent islands within the island of Spitsbergen and show more restricted gene flow, allowing for better investigations of dispersal patterns. In addition, dispersal and colonization can be related to environmental factors as populations are collected along various environmental gradients.

Aim

Our aim was to collect leaf and flower samples of *Saxifraga oppositifolia* at different altitudes (low-high), along a latitudinal gradient and a precipitation (east-west) gradient. We would then analyse these together with reference populations from other locations around Spitsbergen to decipher local, regional, and long-distance dispersal frequencies in diploid and tetraploid individuals of *Saxifraga oppositifolia*.

We also aimed to sample additional species in similar manner, in order to evaluate whether glaciers should be regarded as dispersal barriers, or dispersal corridors (along prevailing wind directions).

With this data, we also hoped to evaluate whether environmental filtering affects composition of ploidy levels at a regional scale.

Methodology

Sampling of *Saxifraga oppositifolia:*

A population is defined as the plants of one species that occur within an area of approximately 100 x 100 m. From each population, we selected and sampled 5 individual plants that were separated by at least 5-10 m. The two populations (low and high altitude) from each main geographic location were sampled with as large an altitude difference as possible.

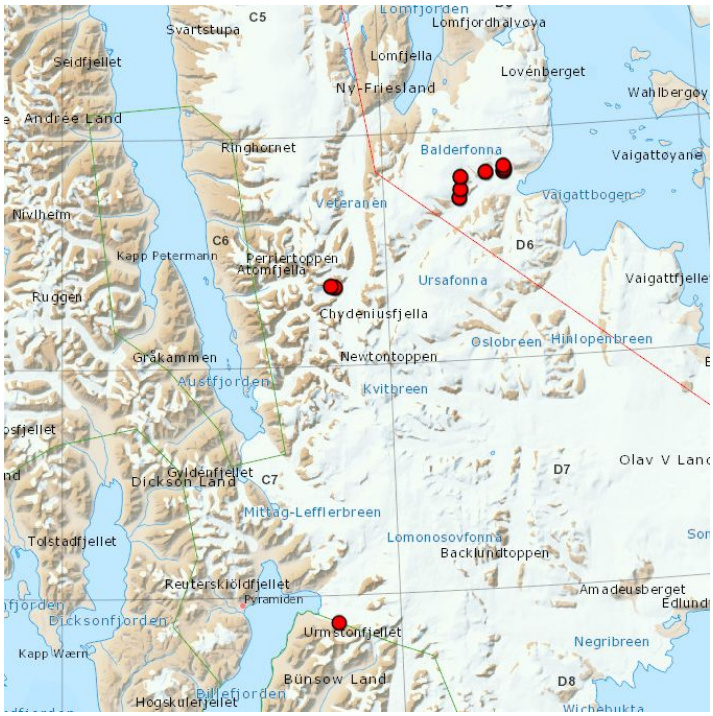
From each population, we recorded information on location, date, habitat, coordinate, growth form (trailing or cushion) and assigned a population number. We selected healthy, typical specimens and avoided insect-damaged plants. Each sample consisted of ca. 5 cm2 of leaves placed in filter paper with a sample number recorded on each. The 5 samples from each population were placed in an airtight 'ziploc' bag. Finally, we collected photographs of the plant samples in situ. If the weather was bad (raining), the leaves were instead put into numbered plastic bags and then dried out in the tent at night before being placed into the dry filter papers for storage.

The plant material collected for this project was to be used for DNA analysis, and so in order to preserve the DNA, we used silica gel to dry the plant samples. Two tablespoons of silica gel was placed into each ziploc bag in the evening in the tent. The bags were shaken such that the filter-paper packages and the silica gel mixed.

When possible, whole plant samples were taken and pressed in a portable flower press and carried with us back to Longyearbyen.

Results

Below is a map indicating the locations of the plan samples we took. It was very hard to find *Saxifraga oppositifolia* in the central section of the route and so we were unable to collect samples from this area.



The samples were deposited with Prof. Eidesen at UNIS at the end of the expedition. We are awaiting the results from the DNA analysis.

Drone Mapping

Background

A Digital Elevation Model (DEM) is a 3D representation of a surface. DEMs of the earth's surface can be used by scientists such as glaciologists as a tool to understand the precise topography of an area of interest. Modern computing technology now allows scientists and others to easily gain tremendous insight into the terrain of a landscapes in the form of hi-resolution virtual 3D models.

Fundamentally, DEMs are created using 2D images of a region to reconstruct the topology in question; traditionally, this was done using a pair of 'stereo-pair' of images, where the location of the camera is well defined. These images could be captured using satellites, aeroplanes, or ground mounted cameras and also today with drones.

With the advent of faster computing and more intelligent algorithms, it is now also possible to use Structure from Motion (SfM) (Westoby et al.,2012) to construct DEMs, which relies on a larger series of overlapping photos to define the internal camera positions automatically, without them needing to be accurately pre-defined. It has been hailed as an inexpensive, effective, and flexible approach to capturing complex topography.

The North East corner of Spitsbergen is covered by DEMs created by the Norwegian Polar Institute from data collected by aeroplanes, as well as LiDar data from ICEsat satellites. However these data are very sparse and of low resolution. Approx. 10m/pix. In this project

we collected photos from the drone and processed them using SfM software, and were able to produce DEMs of far greater resolution.

Our thanks go to Dr Austin Elliot from the Oxford Earth Sciences department who provided much of the guidance with this project, both before departure and after return from the field.

Aim

Our aim was to map sections of Chydeniusbreen (The Bear Bay glacier) at different altitudes along its length, primarily in the same regions as the ICEsat transects so that we could compare our DEMs with the previous data.

We also aimed to create a new benchmark of ultra-high resolution imagery in the region so that later research could make comparisons to our data.

To this end, we tried to develop and optimise the mapping technique, maximising the area covered and resolution of our model.

Methodology

The drone used was a DJI Phantom 4, with a quoted flight time of 28 minutes and 12.4 MP camera. An iPad Air was used to control it.

In order to maximise the flight time and area covered, a 3rd party app ('Drones Made Easy' for iOS) was used to control the flight path of the drone. The user was able to draw a desired area to cover and the app would define a flight path according to the following, user defined, parameters: altitude, speed, required front and side overlap between pictures. The area covered in each flight was limited by the battery life of the drone, in light winds it was able to travel approximately 8km.

While capturing images the camera was pointed between 5°-10° off nadir to maximise the texture of the surface that was observed.

Flying the drone was not possible in strong winds (~5-7m/s) or in any precipitation. The batteries also had to be warmed to above 15°C before the drone could take off which often meant warming them in a jacket.

In order to cover the desired area it was often necessary to conduct multiple flights. We ensured that there was an adequate overlap of >20m to ensure that the processing software could link up subsequent flights.

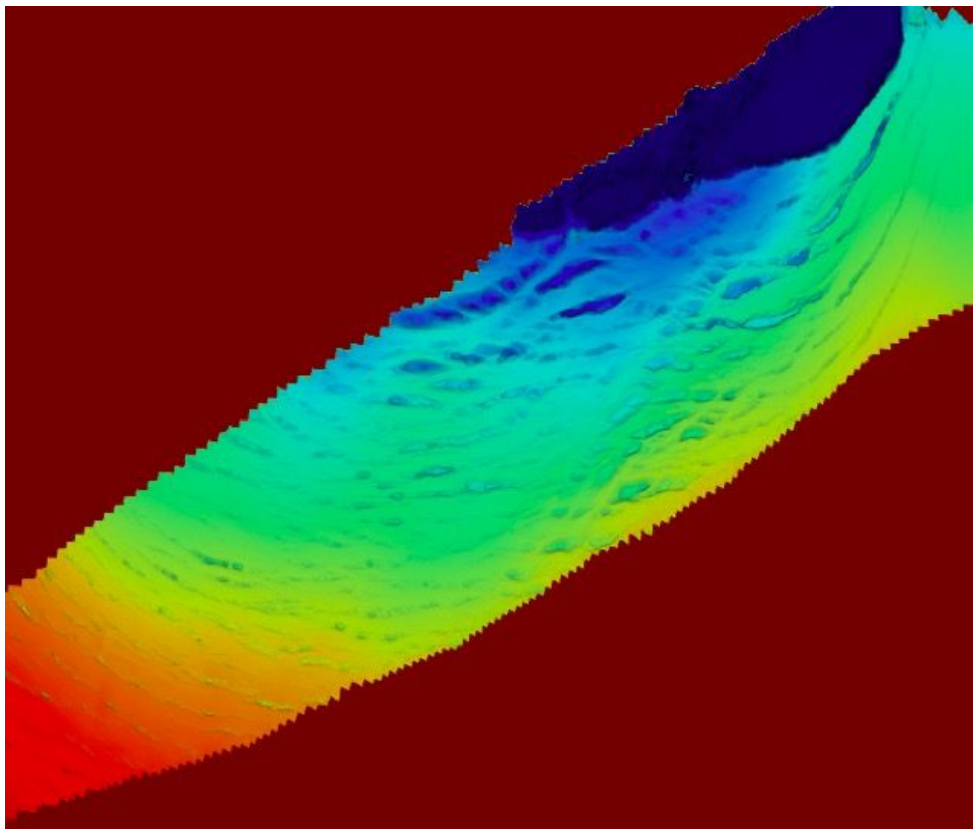
Ground control points were used in an attempt to increase the accuracy of the geographic registration of the DEMs. A distinctive object that could be identified from the aerial images was used to mark the control point and their location was then measured using a handheld GPS with an accuracy of ±3m. Due to time and other practical limitations the ground control points were extremely sparse with approx. 3 per flight. The drone also had an inbuilt GPS which geotagged each individual photo.

Upon return to the UK, the raw photographs and GPS data were processed in the Oxford University Earth Sciences department in collaboration with Dr Austin Elliot. The professional edition of Agisoft Photoscan was used to align the photos, create sparse and dense point clouds, integrate the ground control points, create the DEMs and create the orthophotos.

Results

The preliminary data has been processed into DEMs at 3 locations on the glacier, as well as orthophotos for the same areas. The resolutions for the DEMs and orthophoto are 10cm/pix and 2cm/pix respectively.

These DEMs and orthophotos can be found here: https://goo.gl/SZJojy.



***Above**: DEM represented as a heat map of elevation of the terminus of Chydeniusbreen with the sea in the top right hand corner. **Lower**: a composite orthophoto of the same area.*

Discussion

Despite using ground control points, the georegistration of the models was poor and there was a large discrepancy between the drone GPS data and the ground control points. This was partly due to the sparsity and relatively low accuracy of the handheld GPS readings. One possible solution to this would be to find permanent features on the ground such as bedrock, which would also appear in previous DEMs and align them so that the glacial elevation can be better compared. However, this may only be possible in two of the locations. Until this has been completed it will not be possible to meaningfully compare our new data with previous data.

The resolution of the DEMs exceeded our initial expectations. We have been able to create DEMs of **two orders of magnitude** higher resolution than any previous data which will allow us to examine the fine surface structure of the glacier at different altitudes.

We continue to collaborate with the Oxford University Earth Sciences Department and Norwegian Polar Institute to continue the analysis.

Mountaineering

Given the success of the 1923 expedition in summiting a number of peaks along their journey, we were keen to both repeat the routes that they had climbed as well as building on their legacy by climbing our own new routes. We successfully re-climbed all six of the peaks summited in 1923, while putting up a new route on Newtontoppen and also making an ascent of Robertfjellet.

Poincarétoppen, 1448m

Poincarétoppen, known in 1923 as Mt Deception, was the first mountain we climbed on the expedition. It presented no major difficulties up our chosen route up the east face. Endre and Liam were able to stay on skis up the 30 degree snow field until the rocky summit ridge, while Jamie, James and Will walked the upper sections. After spending time on the summit enjoying the sun and retaking 1923 photos a ski descent was made down the route we had come.

Irvinefjellet, 1561m

Irivnefjellet, or Mount Irvine, arguably had the greatest historical significance of the routes we climbed. The mountain itself was named after the their return to the UK and subsequently the adjacent mountain was named after Mallory after the fateful events in 1924.

In Irvine's diary, he describes the route:
'...we reached the foot of the peak which we intended to ascend by a pinnacle ridge running S.S.E. as the fine precipice face some 2000 ft high showed too great difficulties to attempt in the time we could afford. We started up at 1240 and had a very fine rock climb up the crest of the ridge some pitches being of considerable difficulty. The rock gave very good climbing being hard melamorphine rock & Odell declared the whole character of the climb, very reminiscent of the Tower Ridge of Ben Nevis. It gave about 2800ft climbing.'

With this as our only guide, James, Jamie and Endre set off to make a second ascent of the SSE Ridge on Irvinefjellet. The rock was indeed very compact in places and we roped up to protect the steeper sections. With the sun out and warm temperatures, fast progress was made up the ridge. None of us having done Tower Ridge we were unable to make a direct comparison however it was certainly an extremely fine climb.

The imposing SSE ridge on Irvinefjellet, as climbed for the first time by Sandy Irvine and Noel Odell in 1923. The ridge starts at the centre at the glacier level and heads leftwards before rising to the flat summit.

Laplacetoppen, 1584m

Laplacetoppen, also known as Mt Hope was climbed in 1923 at midnight with panoramic photos taken over the whole of the previous section of the route.

Being keen to re-take the photos while still making progress, it was decided that James and Will would make a quick ascent of the mountain while Endre, Liam and Jamie would continue to a suitable campsite with all of the pulks. Trying to ski up a couloir on the the west face of the mountain we soon found it too icy and steep so reverted to scrambling up a buttress to the summit ridge. After repeating the photos in gale force winds we continued along the ridge and descended on skis via the east face to the camp.

Newtontoppen, 1712m

For Newtontoppen, we split into two groups to climb the mountain. Liam and Will skied from the East side, up the snow field to the summit, known for being able to drive a snow scooter to the summit in winter. They were able to repeat a number of photos before skiing down and climbing Makarovtoppen.

James, Jamie and Endre headed to the West of Newtontoppen to climb the West Ridge, which has had no previously recorded ascents. The rock itself was compact red Granite, being both extremely solid and textured it made for fantastic climbing. A number a steep steps added some complexity to the route but despite some snow cover we were able to make good progress.

The ridge eventually flattened off and with a snow slope leading from the west summit to the higher main summit.

Grade: PD

Makarovtoppen in the foreground with the lower and upper summits of Newtontoppen behind. The west ridge ascends to the lower summit from the far right of the image in the distance. Photograph taken from the drone at midnight.

Makarovtoppen, 1534m

Having attempted rather unsuccessfully to fly the drone to the top of Makarovtoppen to obtain repeat photographs some three days earlier, we decided to make a more personal ascent of the mountain with the hope of re-taking the fantastic panoramas of Newtontoppen and the Atomfjella. Will and Liam ascended the peak on skis from the col between it and Newtontoppen. The snow was very wind-blown and icy, making progress quite tricky. Leaving skis at the top of the snowfield, we walked along the rocky ridge and found the location of four historical photographs, which we proceeded to repeat successfully. The descent was icy and required a great deal of attention.

Černyševfjellet, South East shoulder, 1220m

We knew that the south east shoulder of Černyševfjellet was home to a Swedo-Russian geodetic beacon constructed in 1901 although we were not sure of it's exact location. The entire team made an ascent via a snow field on the west side of the mountain. With a slope of around 30 degrees and a particularly cold spell, the snow field was extremely icy and even Bris was slipping in places. At the top of the snow field we left our skis and walked almost 2km along the rocky shoulder until we reached the beacon. We descended by traversing to the north side of the mountain where the gradient was much less steep.

The team atop the Russian geodedic beacon on Černyševfjellet braving the sub-zero temperatures and chilling wind to get a selfie

Robertfjellet, 1122m

Robertfjellet was the only mountain climbed that was not also summited in 1923. We did, however, have a photo taken on the mountain from a 1919 expedition that showed the terminus of the Nordenskiöld glacier which we were keen to repeat. Being significantly further south that the other peaks we had climbed, it was more typical of the mountains seen around Longyearbyen with even sides caused by the accumulation of scree.

Being so close to the end of the route and with time running out, it was decided that James and Endre would try and complete the climb while Liam, Will and Jamie made progress down the glacier towards our collection point. The steep scree slopes required delicate climbing, especially higher up where a covering of soft snow obscuring the particularly loose rocks.

The scree slopes finished at a plateau 600m below Robertfjellet. The large crevasses on the glacier upper glacier leading to the summit had been hidden from the view below but fortunately they were avoided by sticking to the steep north ridge. To our surprise there was a small hut on the top that looked like it could be a VHF repeater. After retaking the 1919 photo we descended the way we came.

Expedition Diary

29th July

We left from Longyearbyen harbour at 9am, expecting a boat journey around 14 hours long to get to the original 1923 starting point on the coast. Two hours out of the harbour, we were hit by extraordinarily rough seas. The captain informed us that it was very unlikely we would make the start point of the expedition, but that he would press on to the refuelling station at Ny-Ålesund. We arrived there at 6pm and the captain announced that he was happy to press on though the weather would be terrible.

It was like being in a washing machine, bouncing over 5m waves in a boat which was only rated up to 8m waves. Will was very sea sick, almost continuously for 12 hours.

The boat journey was tough. Will, James and Bris were all very sick. We were not sure at this stage whether we would ever make it to our starting point.

30th July

We arrived at Duym Point at 4am, after nearly 19 hours at sea. It was impossible to reach the original landing place, so we were forced to ferry equipment to the shore using a rib. We dragged kit up to the first camp, and began the first bear watch and retired to the tents at 8am.

31st July

Slept for almost two days. By the end of the 31st James, Will and Endre headed off on foot to explore the route ahead.

In the evening, Jamie and Liam headed down to the original landing place in 1923 to retake a photo. It took a very long time to locate the original photo, and we were continually worried about a polar bear ambush after finding a clump of fur.

Eventually Liam found the photo, which showed a huge reduction in the extent of the ice cap and explaining why the 1923 landing site was now unsuitable due to the huge expanse of moraine that would have to be crossed.

1st August
We dragged the pulks further inland to a spectacular glacial lake, negotiating various meltwater obstacles. This same lake had stopped the 1923 expedition in their tracks, forcing them up onto the storm-wracked Loven Plateau.

En route we repeated another photo.

2nd August
The morning was spent drone-filming the ice lake and conducting interviews. In the afternoon, we dragged the pulks up onto the Loven Plateau. Perhaps more for practice using the set-up with pulks than out of necessity, we roped up for a section of the approach to the plateau. That evening we decided to abandon polar bear watches, which would only resume again on 27th August.

3rd August
With good weather and surprisingly firm snows we were able to cross the plateau in just eight hours. This journey had taken the 1923 expedition nearly four days due to terrible storms and poor equipment. We set up camp a 2km from the edge of the Bear Bay Glacier (Chydeniusbreen).

4th August
Jamie, Liam and Will headed off for an initially frustrating, and eventually very successful repeat photography session around the Bear Bay glacier. James and Endre began mapping their first of three transects on the Bear Bay Glacier. That evening it transpired that Jamie had ‘jettisoned’ one of two InReach communication devices on the summit of Raudberget.

5th August
We hoped to repeat a number of photos taken at the 1923 ‘carpet camp’, after recovering the undamaged InReach. Skiing down on arrival, Jamie, Liam and Will were amazed to discover the remains of the original camp, including tent pegs, Oxo cans, fragments of clothing and even part of the original stove.

The original photo from 1923 shows Sandy Irvine with his clothes off, and the diaries suggest that this was the first camp where the sun came out after a terrible crossing of the Loven Plateau. The expedition would have dried their kit out on the rocks at carpet camp, and presumably left some of it either by accident or to save weight.

James and Endre returned very late to camp after a successful day mapping and collecting biological samples.

6th August
A rest day spent making minor repairs (to Jamie's skis), playing chess and eating.

7th August
Visited the 1923 camp once again with Endre and James. By now the weather was turning, diminishing visibility to levels not seen since landing. Set up a new camp further along the glacier, the most successful to date after Endre showed us how to dig a sit-down 'snow kitchen'. Jamie, Will and Liam searched unsuccessfully for a repeat photo that evening.

8th August
Skied down to the Bear Bay glacier to conduct drone-mapping of the ice. In order to get the most accurate map, we had to cross the glacier from one side to the other, which required roping up and negotiating dangerous meltwater torrents and crevasses. Will and Endre followed up the previous day's uncompleted rephotography and then collected a plant sample transect down to the glacier from Carpethøgda. The drone mapping party returned utterly exhausted, after dragging the pulk back uphill through whiteout conditions until midnight.

9th August
The temperature had plummeted in the night and we woke to very bad weather. The 'freezing fog' that lasted until the evening would become a regular feature. Dragged pulks up the length of the Bear Bay Glacier in almost whiteout conditions. A compass proved the most reliable means of following a bearing, but not without considerable concentration. On arrival at the base of Poincarétoppen ('Mt Deception', climbed in 1923) the sun came out and we did the first of several sponsor photos with the flag.

10th August
Skied up Poincaré to repeat photos, which proved tricky at times, even with full skins. We were rewarded with spectacular views of the Atomfjella mountains which were our destination for the coming week. Will, Endre and Liam skied down the East face of Poincaré, and James filmed them with the drone.

En route to Glasgowbreen, we encountered the most seriously crevassed terrain to date. Our first experience of skiing, downhill, roped up with pulks. It was chaotic at the best of times, and Jamie, who had not yet learnt how to downhill ski properly fell over a lot. We camped on the edge of Glasgowbreen, a tributary of the Bear Bay Glacier.

11th August
The morning was spent mapping the final transect on the Bear Bay Glacier. En route to the Atomfjella, we crossed a large number of difficult meltwater streams in order to reach the proposed campsite on Gallerbreen on the other side of the Lomme Bay Glacier. The fog was frequently freezing, but since it was comparatively thin it frequently momentarily lifted to reveal the imposing sight of Mount Irvine – first climbed in 1923 by Noel Odell and Sandy Irvine.

12th August
A rest day was spent on Gallerbreen, waiting for the weather to improve for mountaineering.

13th August
Jamie, James and Endre climbed the SSE ridge on Mt Irvine, which took roughly 6 hours in ascent and 1 ½ in descent, via a steep South-facing couloir. This was a very special moment and most likely a second ascent via this route. Liam and Will filmed the climb from our camp with the drone.

Throughout the day, conditions deteriorated from wall-to-wall blue skies to overcast and windy – a harbinger of things to come.

14th August
A storm swept in and pinned us to the tent for 18 hours. Whilst the tents did shake violently, occasionally impeding sleep and frequently requiring us to peg-down errant guys, there was no real sense (yet) that the tents faced any serious structural damage.

15th August
We emerged to discover the previous 18 hour blizzard has almost totally buried our pulks (and, as it transpires, Will's ice axe).

Jamie, Liam and James climbed the col between Gallerbreen and Tryggvebreen, then skied down onto the latter. Most of the journey from the col downwards was conducted roped-up, inspired not least by a fairly formidable set of crevasses on the western side of the glacier. The initial objective was a new route on Pallasfjellet, but the rock appeared too poor. After a circuit of Tryggvebreen, we settled on the North Ridge of Vestafjellet, racking up at 17.30. After two hours on the ridge, progress was too slow, the technical difficulties ahead too great and the rock too poor to carry on.

Endre and Will climbed Mt Irvine, this time in mixed conditions, and repeat the photo Noel Odell took from the top looking east.

The Gallerbreen storm. James tries to dig out the stoves so we can make dinner.

16th August

We leave the Atomfjella, and James and Will climb Laplacetoppen to repeat key photos before joining the others at camp on Tilleybreen. Throughout the day, the weather was exceptional, but according to the InReach forecasting service it was not meant to hold. At 11pm, we are too exhausted to face a 12km round trip to Makarovtoppen to repeat photos of Mount Newton, so James flew the drone out to repeat photos. Unfortunately in the low temperatures the battery rapidly drained and the drone made a crash-landing 2km from camp on the Bear Bay Glacier. Jamie and Liam skied out to recover it, remarkably completely intact.

17th August

Awoke to the promised bad weather. After building a substantial lee-wall, the day was spent in the tents with the exception of a short ski that evening to a buttress at the base of Makarovtoppen. Dreams of new routing were rapidly crushed by the low temperatures and the rain.

18th August

Skied to the 'Citadel' camp, beneath a huge granite cliff discovered in 1923 that we had hoped to climb. That evening a huge storm rolls in, with winds so strong we can't stand up, let alone put the tent up. Digging a huge lee-wall proved virtually useless since the temperature was hovering just over freezing and the blocks melted almost as fast as we could cut them. At 11.30pm we were forced to get into the emergency survival shelter.

19th August

It was estimated from the forecast that we only might be able to put the tent up as late as 12pm the next day, however, at 8am the wind subsided sufficiently. After 9 hours, we are able to escape from the survival shelter and get the tent up. Liam was quite worried about his toes which he thinks had begun to freeze. We quickly warmed up, and spent the day gradually drying out the kit.

NB: On return to the UK, both Jamie and James complained of acute numbness and some pain in their toes. It's hard to say exactly when this began, but the storm seemed a likely cause.

20th August

The storm returned and we were repeatedly forced to get out and secure guys. After 45 minutes holding the sagging, badly bent poles of the Keron 4GT up, Jamie, Endre and James improvised a series of supportive struts made from walking poles and boots to reinforce the tunnel structure. By contrast, the smaller Nammatj 3GT had come out of the storms relatively unscathed.

21st August

We skied out towards Newtontoppen and split into two parties. Jamie, James and Endre successfully climb Svalbard's highest mountain by a new route up the unclimbed West Ridge, in an attempt to capture the 1923 spirit of exploratory mountaineering. From racking up to putting skis back on, the route took around six hours. Meanwhile, Liam and Will skinned up the South-Eastern flank repeating key photos from 1923 and Andrew Croft's expedition in 1936, returning via Makarovtoppen and the Citadel for more rephotography

Both parties encountered Vincent Colliard and his clients on a guided expedition to summit Newtontoppen run by Ousland Expeditions. Their team had chosen to camp at the base of Newtontoppen's North Face for summit day. Incidentally, they had chosen to use trip-wires without a dog.

That evening we shot long-overdue team interviews.

The Atomfjella Mountains, as viewed from Makarovtoppen in the fierce evening sun.

22nd August

We dragged on to the next campsite, beneath Mount Chernishev. En route, Will took a series of photos of the Citadel with a view to constructing a 3D model using photogrammetry. That evening the sun set for the first time in three months and the moon rose clearly over Chernishev, heralding a bout of good weather.

23rd August

Skinned up the South West face of Mt Chernishev in excellent visibility, and then traversed the south ridge to reach the 'geodetic' beacon built in 1901 by Russians and first visited by the 1923 expedition. En route we discovered a tin can ostensibly left by the original 1901 Russian expedition.

Here we also discovered, as expected, a max-min thermometer left in 1901. Folded inside was a note written by the 1923 expedition and about five other expeditions, to which we added our own.

In the evening we conducted an intensive staged shoot of general camp and travel activities to use as a bank of stock footage.

24th August – 25th August

During two days of hard-dragging against the clock in the direction of the coast, we camped first just below the col between Lomonosovfonna and Millingbreen and then just within sight of Terrierfjellet. The weather was gradually improving after a mild but heavily overcast day on the 24th leading into a bitterly cold, sunny conditions on the evening of the 25th. On each

day, we pulked for between 6 and 8 hours and drags only rivalled in duration when crossing the Loven Plateau almost three weeks earlier.

26th August
After around four hours of dragging through freezing fog, we arrived at the top of the Nordenskiöld Glacier as the weather began to improve. James and Endre set off to climb the ridge between the first and second most southerly glaciers feeding into the main terminus to scout a route down. It was decided that the second (more northerly) glacier offered a clear route through in places vast crevasse fields.

That evening we resumed bear watch now that we were closer to the coast. The same morning we had also learnt via satphone that three bears had been sighted at Nordenskiöld's terminus.

27th August
Faced with a very small window of good weather, we were extremely keen to repeat a photograph from the summit of Mt Robert showing the terminus of the Nordenskiöld Glacier. Since time was against us, the group split in two. James and Endre successfully climbed Mt Robert and rephotographed the Nordenskiöld glacier, whilst Jamie, Liam and Will ferried pulks through difficult terrain to a lower camp on the glacier. Route-finding advice offered by the team on Mt Robert was invaluable, as too was a technique whereby the pulks were lowered down steeper sections on a fixed line.

28th August
After a leisurely morning recovering after a big day previously and shooting interviews, we moved the pulks down to a lower camp about a kilometre from the terminus. James and Endre recced the final stage on foot.

29th August
After around three hours sleep, we struck camp at 6am to begin the final descent. This was conducted with the pulks clipped in tandem, with one front-man steering and two or three at the back taking the weight. The steepest section required a lowering system to reach the beach. Having stopped only to shoot sponsor photos in front of the terminus, we were down by 9am and ready for the 12pm pick up. Kit was ferried laboriously by hand the final hundreds of metres from the glacier to the fjord.

Training

Though the expedition was technically accompanied by a guide, all members of the team resolved that they should be adequately trained for polar travel independent of Endre. The guide was there to provide a supplementary level of safety and local knowledge, rather than as an essential presence. The bar was therefore high, not least given that none of the undergraduate members of the team had ever been to any even comparable environment.

Broadly speaking, training fell into two categories. That which could be routinely conducted in Oxford and specific trips to external locations which included:

Brecon Beacons (2 days, December 2015): General campcraft and team bonding.
Lochaber, Scotland (3 days, February 2016): Winter climbing and mountaineering.
Cairngorms, Scotland (2 days, February 2016): Winter camping and nordic skiing.
Hardangervidda Plateau, Norway (7 days, March 2016): Winter camping and nordic skiing.
Dartmoor (2 days, April 2016): Campcraft and specific polar travel theory (including managing the bear risk) with Jim McNeill from Ice Warrior.
Peak District (2 days, May 2016): General campcraft, and bizarrely, nordic skiing!
French Alps (7 days, June 2016): Mountaineering and glacier travel.
Snowdonia (3 days, July 2016): General campcraft, ropework, mountaineering.
Nottingham (1 day, July 2016): Firearms training organised through Icebear Alarms.
Longyearbyen, Svalbard (1 day, July 2016): Firearms training with Endre.

Back in Oxford, in addition to regular planning sessions which honed our teamwork, with three months to go we were meeting three to four times a week for physical and skills training. A typical week would include:

Strength training: Circuit training run by the University Athletics club, or hill sprints.
Aerobic: A 45-minute run or longer cycle.
Tyre-dragging: We usually dragged for up to one hour, covering as much as 8km with two tyres each.
Skills: Ropework, drone-flying, camera-work etc.

Generally, it may be said that the training programme was successful for the undergraduate members. In particular, the Norwegian training expedition and a rigorous fitness programme stand out. The latter gave participating members a taste of what might be expected, far enough in advance to mentally and physically prepare. The latter probably significantly reduced the risk of fatiguing in the field.

One criticism may be that, whilst all the bases were eventually adequately covered, training was generally organised on a rolling basis, and with the exception of certain camp skills, no concrete mountaineering or skiing goals were set. In the end, mutual enthusiasm, rather than an especially structured, long-term programme was probably the driving force.

Another observation might be that we were relatively uncertain as to exactly what challenges to expect beyond certain ‘givens’ like pulk-dragging and winter camping. This probably explained, along with our comparative inexperience, why such a thorough programme emerged. On the other hand this could also lead to a tendency to spend more time agonising over alien or uncertain risks than was really useful. This was especially true of our earlier, less-informed discussions about polar bears.

Filming

Early on in the planning stages, we decided to make a film of the journey as a way to tell the story of how both the landscape and the nature of polar exploration had changed over the course of century. While the production of a film would increase our equipment costs, it did help us raise money from sponsors as we promised that they would be included in the credits of the final film.

Liam was in charge of selecting and familiarising himself and the team with the most appropriate camera equipment for the conditions. What we eventually brought was the result of a lot of research. For the most part, the kit worked very well given the conditions.

Jamie was the director in the field and would work with Liam to determine the shot list and conduct footage reviews to see what we still needed to capture.

In the field

Our main camera for film and stills was a Canon 5D Mark II with a 24-105mm f/4 EF L lens, which turned out to be a very good body/lens combination for the conditions. We had this in a Ortlieb Aqua Zoom waterproof case, which was very good at keeping the camera dry in the wet conditions. Most of the time, we kept a microphone (Rode Videomic Pro) handy in the case for improved sound when filming with the 5D. The microphone was plugged into the camera, the sound was set to manual and the output on the microphone at maximum in order to maximise the signal to noise ratio.

Our secondary camera was a GoPro Hero4 Silver, which we used as both an action camera and for selfie filming. We carried several spare batteries, as one would often not be sufficient for our filming needs for the day. The head mount was most useful, but we also carried a chest mount and a pole mount for various shots.

The drone was a very valuable asset for improving production value in our shots. We used a DJI Phantom 4 with and carried a total of three batteries, which allowed us to do several flights. An iPad Air was used with the controller. A major advantage of this drone was its ability to shoot in 4K, thus resulting in the ability to crop footage while still maintaining a resolution greater than 1080p. This was especially useful for cropping out rotor blades from the shot which often appeared.

A DJI Osmo was taken for stabilised footage, though the gimbal did not work and so was fairly useless.

We brought sound recording equipment in order to improve the audio quality of our shots, especially the interviews. This consisted of a Zoom H4n field recorder into which we plugged a Rode NTG-1 XLR shotgun microphone on a Rycote pistol grip. Deadcats were used on the H4n and on the microphone. We also brought a Rode SmartLav+ which we could put on the subject's clothing. This was plugged into either a phone or into the H4n (with an adapter).

The H4n warm up time was less than ideal at over two minutes, and made for a lot of waiting around in the cold. Additionally, the device would occasionally freeze and say the card was full, even when it was not. The Tascam DR-40 would be worth looking into as an alternative.

We used a Manfrotto 190 3-section tripod and a Manfrotto MVH500AH Fluid Video Head. While the combination was heavy, it provided a stable platform for interviews and timelapses.

We ensured that all our footage and stills were backed up each night. We brought a laptop (MacBook Air 11 inch) and two rugged hard drives (Transcend StoreJet) to which we transferred the data each night.

Production in the UK

We shot approximately 60 hours / 700GB of footage in the field. Following our return to the UK, work to produce a feature-length documentary has begun. At the time of writing, we are exploring a potential route to national broadcast, working in concert with a TV production company. However, the are also plans to produce a feature either in place of or in addition to the broadcast. Our aim would be to submit this to film festivals by mid 2017.

Logistics

Local guide

Early in the planning stage we decided we would bring a local guide with us on the expedition as none of us had any experience in such polar environments. The driving reason behind taking a local guide was to help mitigate the polar bear risk. All of the other necessary skills for the expedition could be practiced in the UK and mainland Norway but we felt that the skills required to deal with polar bears could not be learned to a sufficient standard before we left.

After talking to a number of potential guides the Spitsbergen Guide Service put us in touch with Endre. His combination of skills and experience with research, filming and fieldwork in the Atomfjella made him an ideal candidate.

On the expedition itself he integrated extremely well into the team as a core member rather than an external instructor or advisor. Any preconceptions that a guide would try to lead the expedition were ill-founded as we spoke to Endre in great detail about what we were expecting before departure.

Field Agent

Our field a in Longyearbyen was Ellinor Falkgjerdet, Endre's partner. She was able to provide an alternative weather forecast from the resident weatherman at the airport as well as being a key part of our emergency communication plan.

Transport

Flights

Our flights were very generously organised and provided for us by DialAFlight. We travelled with Scandinavian Airlines (SAS) from London Heathrow to Longyearbyen, via Oslo without any major problems.

Excess baggage

Instead of sending any of our gear up in advance by freight, we took all of it with us as excess baggage. On the outbound flight we had 19, 23kg bags and 13 bags on return. SAS were very accommodating with our oversized baggage, which included a ski bag, solar panels and our pulks.

The team with 19 bags at Heathrow Terminal 2 including solar panels, a drone and 4 pulks.

Boat transport

From Longyearbyen, the only way to get to the start of our route was by boat. We also looked into skido and helicopter transport which turned out not to be feasible due to conditions and regulations, respectively. After talking to most of the boat charter companies in Svalbard we decided to go with the Spitsbergen Guide Service (SGS) and their Targa 42, the *Spitsbergen Express*. This was a double hulled glass fiber boat with sufficient space for the team, Bris, and all the equipment. Despite a storm that produced a sea swell of over 6m, the boat was very well suited to our needs and the SGS did everything in their power to safely deliver us to the start of our route.

Permits

The first was for extended independent travel outside of management area 10 - the area around Longyearbyen. We applied for this permit through the Sysselmannen by providing details of our route, experience and safety equipment we would be carrying. Once this permit was granted our SAR-insurance cover was set at NOK 175,000. This was well below the £100,000 cover provided by the University's insurers.

We also required a permit to sample the plants along our route, particularly in the restricted areas. The application for this permit at the same time as the previous one.

Navigation

For navigation we relied on both a Garmin Montana 610 and Oregon 450 loaded with TOPO Explorer Svalbard. We also carried a Garmin Etrex 20 as a reserve. Should a GPS fail when splitting up, each team would still be carrying a InReach SE that can be linked with the Delorme Earthmate App and mobile phone loaded with the Svalbardguiden App, which include maps for the whole of Svalbard. Indeed the mapping on this app is more detailed than the TOPO Explorer Svalbard on the GPS.

Traditional map and compass work was not possible due to the relatively featureless terrain, only 1:100,000 maps being available and the great magnetic variation in Svalbard. Thus we relied on the GPS's for all day to day navigation. We also carried the relevant maps from the Norsk Polarinstitutt's Svalbard S100 series and printed satellite imagery from the very functional toposvalbard.npolar.no. This allowed for planning precise route choice during group meetings on the expedition. Ordering maps in the UK was problematic, this is best left until arrival in Longyearbyen where one can purchase them readily and cheaply from the Svalbard Museum Shop. The Bodleian Library also has a selection of the S100 series on closed stacks.

The GPS's also proved themselves essential when marking waypoints and collecting the position of particular drone mapping control points, plant sampling and rephotography sites.

To move efficiently around the landscape when pulking, it is important to minimise the height gain and loss. When taking turns to break trail in otherwise featureless terrain, the leading skier often found themselves pulling off to one side, despite their best attempts.

Ground Conditions

Given the few expeditions each year that travel in mid-summer to the inland ice areas of Svalbard, little is known about the state of the inland areas during these months. Previous expeditions, such as those undertaken by Børge Ousland and Vincent Colliard have encountered vast areas of standing water on the glaciers due to poor drainage, so called 'snow swamps'. Indeed an expedition undertaken by Imperial College in 2011 could not progress any further north up Ny-Friesland due to the excess of standing water on Veteranen that summer. Satellite imagery also assisted in second guessing what conditions on the ground would be.

However what we encountered as we navigated from east to west was remarkably in our favour. We had prepared for the 'snow swamps' by carry two lightweight drysuits that would then by combined with sandals and crampons! Fortunately this was never tested due to the excess of snow and generally colder conditions than expected. Indeed our rephotography points towards there being a higher snowline in 2016 compared to 1923.

We met the snow line at about 500m whilst ascending the snow dome east of Staupvatnet and did not encounter dry glacier again until making our descent south of Terrierfjellet 24 days later. Following a storm on 18th August, the snow line receeded and upper reaches of

Oslobreen began to run with water. Fortunately we were headed south on higher ground. Nonetheless, when viewed from Černyševfjellet, the condition of Hinlopenbreen had no doubt deteriorated as a result. Indeed this was one of the reasons why we adapted our route to pass up Keplerbreen and not Gruzdevbreen.

We also encountered a number of melt water streams, these were found on Glasgowbreen, while crossing Veteranen to the Atomfjella and on the ice between Tommelpynten and Staupvatnet. None were too serious, but they significantly slowed our progress whilst we search for a safe crossing point and then shifting five pulks. Similarly crossing moraine was a nuisance, this a number of times on the ice between Duym Point and Staupvatnet, and whilst descending Nordenskiöldbreen.

Weather

In the haste of our packing we failed to bring an anemometer and thermometer, luckily these were the only items that were forgotten from the kit list. We therefore do not have accurate wind speed or temperature measurements.

The majority of the time the temperature was between +5°C and -5°C without windchill. It never exceeded this maximum of this range but the minimum temperature experienced was approximately -20°C and colder with windchill.

Day to day wind speeds varied, but were always manageable. However the maximum wind speed experienced was during a storm and we estimate the maximum gusts were over 100kph.

Carbon Offsetting

In order to minimise our impact on the planet we decided to try and offset the carbon dioxide associated with the expedition. As it would have be nearly impossible to track the emissions produced by the manufacture of the equipment we purchased, we decided to offset carbon dioxide released due to all our transport and fuel burned with an additional 100% margin to cover the equipment. We purchased 15 tonnes of carbon dioxide offset credits through Climate Care's diverse portfolio. See appendix 4.

Equipment and Campcraft

Skis

The question of how to move about inland ice most effectively took some time to decide. An alpine touring set up was quickly ruled out, but a question as to whether to take snowshoes or Nordic skis lingered. An Imperial College Expedition in the summer of 2011 to a similar area successfully used snowshoes and spoke highly of them. Børge Ousland and Vincent Colliard had successfully used Nordic skis on a number of expeditions on summer inland icecap crossings. In the end the more efficient nature of a lightweight Nordic backcountry setup proved very successful, and even if conditions had not been so kind, it still would have been superior to snowshoes we believe. Bjørn Moa at Piteraq in Oslo offered us a good group discount plus a tax rebate. With his advice we chose to take Åsnes Nansen skis with Rottefella NNN BC Magnum bindings. Both the beefed up binding and ski offered additional support to the weaker skiers and the greater side cut assisted on descent. The Nansens thrived on the undulating terrain. Both the narrower Åsnes Amundsen and Fischer E99 would have been viable alternatives, indeed Endre took Amundsen skis with 3 pin bindings. Prior training with the skis on the Hardangervidda was essential given our mixture of previous skiing experience.

For boots we choose Alfa Quest A/P/S with a built in gaiter that proved very helpful. The snug nature of the heel meant we were more at risk to blisters. Given the conditions were generally colder than expected, future expeditions could also consider the Alfa Polar A/P/S. For poles we took a mixture of MSR Flight 3 and Gipron 797 Fliplock.

In conclusion, given we spent only five days moving on crampons, the manner in which we travelled on snow-covered areas was vital and the lightweight Nordic setup offered an efficient and seamless way of moving around the landscape.

Tents

We chose to go with the well known Swedish manufacture, Hilleberg, and their black label series. Future expeditions would also do well to consider the Norwegian brand Helsport. The first decision surrounding tents was to take ones that had a greater than stated capacity. Given rest days and the two storms we encountered, this small cost in weight proved a great luxury. Hence the team of two took a Nammatj 3GT and the team of three took a Keron 4GT. The Nammatj's smaller profile gave it the edge structurally whilst the Keron suffered in high winds. In the second half of the expedition, despite digging in and building walls 270° around the camp, the Keron’s poles bent beyond repair. Thus an improvised internal structure was made some days. Both tents had great ventilating capabilities and there was little if no moisture issues. Given the Keron 4GT’s reputation in polar regions we were disappointed with our experiences and would hence recommend future expeditions consider the Keron 3GT or Helsport tents.

Our tents after the storm at the 'Citadel' camp. Note the Keron in the foreground with bent poles and the intact Nammatj behind.

The tents proved very easy to pitch and use. We almost always dug in and built lee walls as conditions required. Digging out the spacious GT porch allowed for the additional luxury of added storage and living space. This was not possible in the Keron 4GT as we opted to use a groundsheet. For pegs we carried both the pegs provided and the very capable MSR Blizzard Tent Stake. These were the supplemented with skis and axe when available, and on dry glacier we used ice screws and abalakovs. Usually skis and axes were being used for their intended uses, but burying a horizontal Blizzard Stake proved exceptionally secure for guy lines.

Campcraft

The water for drinking and meal preparation was boiled in two 5L Kirtley Kettles on two MSR XGK-EX stoves mounted on plywood stove boards. This setup allowed a lot of snow volume to melted easily. Optimus titanium long spoons were used as our cutlery and Optimus heat pouches were very useful for keeping our freeze-dried pouches warm. Purified petrol was taken as fuel and carried in the 5L containers it was purchased in. All rubbish was carried out with us and we found it useful to have dry bags to store it in. When the fuel bottles were empty we also stored rubbish in them too.

A so-called 'table and chairs' set up was made most nights when the weather was good and snow conditions permitted. This gave the team a place to cook, eat and socialise together. Two facing benches were dug with a table in the middle for the stoves and a lee wall for wind protection (see below).

A typical 'table and chairs' set up. In good weather this would be our hanging out spot

In order to maintain good hygiene, a 'clean' side and a 'dirty' side were allocated to the camp. The dirty side was the half from which we had come and the clean the other half. All toilet activities were taken on the dirty side and snow for melting was taken from the clean side to make sure our drinking water was never contaminated. The dog had his own area on the dirty side and was tethered with either a deadman or an ice screw attached to a chain.

Two toilet areas were designated at camp. Excrement was to be buried at least 50m from camp on the dirty side, with toilet paper being burned or carried out. A 'urinal' was often dug (snow conditions permitting) closer to camp on the dirty side and consisted of steps down to a trench where one could urinate away from the wind and cold. Pee bottles were carried by each team member and allowed urination inside the tent. Food scraps and toothpaste residue were deposited in the toilet areas or pee bottles. Wet wipes were a welcome addition to our daily hygiene routines

Food and Fuel

5000 kcal per person per day was our target intake, at the recommendation of expedition nutritionists. In reality, around 4500-5000 kcal was brought and found to be largely adequate. Each person's food for each day was vacuum-packed to make life easy the field and we aimed to have such "day-packs" weighing less than 1 kg each. In reality, the actual weights were 1.05-1.34 kg per day, accounting for packaging and personal food choices.

2000-3000 kcal of the 5000 kcal target was obtained from freeze dried, pre-packaged meals sourced mostly from Expedition Foods, but also from Trek n Eat and LYO Food. Most people had one freeze-dried packet for breakfast and two for dinner. We found that Expedition Foods had the best overall meal selection, calorie density and taste and therefore they made up the bulk of our meals. They were simple to prepare, as only boiling water was required compared to preparing meals from scratch. This was very useful as it saved us time, required no washing up and were more hygienic.

The remaining 1000-2000 kcal for the day depended on personal preference and often included foodstuffs such as instant couscous, soup powder, trail mix and cereal bars and Pepperami. Oils such as coconut oil and chili oil were a very welcome addition for extra calories and taste.

In order to boil the water required to cook our food, we budgeted 250mL of unleaded petrol per person per day (40L in total). This turned out to be a huge excess. Even when we tried to use up the spare fuel to heat the tents and dry kit after the storm, we were still left with over 10L spare.

Power generation

Charging of camera equipment and other electronics took place with two solar panel ‘rigs’. Each rig consisted of a 100W flexible solar panel plugged into a waterproof Peli 1170 case which contained a 10A solar regulator and 7Ah 12V $LiFePO_4$ battery. A cigarette/USB charger was used as the load and allowed charging of devices. Most devices were USB powered but some (like the drone, laptop and 5D) used the cigarette charger. No AC inverter was used. The solar panels were placed on top of pulks during travel and left on the ground or stood up in camp. We found 200W to be more than sufficient for our power needs, though the drone batteries often required a full rig battery and bright sunlight to be charged as their capacity is very high.

Our magic box on which we depended for electricity. Designed and built by James and Liam, it provided with enough power to have movie nights!

Finances

Fundraising

Fundraising took place from November-June and came from three main sources: grants, private donations and corporate sponsorship. Discounted gear also saved us a large amount of money. Costs incurred in Svalbard and paid in NOK prior to departure were higher than initially expected due to the fall in Sterling prior to the expedition.

Grants

Much of the grant application deadlines are at the end of January, so the initial efforts were spent filling in the sometimes lengthy applications. In total we applied for thirteen grants and were successful with four. Individuals were also successful with the college travel grants. Namely the Wallace Wason Award of St Catherine's College, Alice Horsman Scholarship of Somerville College and The Queen's College 650th Anniversary Trust Fund. We are very grateful to all the overwhelming support of the various grant bodies and it has been a pleasure working to support their values this year.

Gifts in Kind

These were generally successful. Gear sponsors were always keen to support initiatives where both environmental scientific research and exciting potential first ascents were on the cards. Their support came both in the way gifts in kind and/or a discount on trade price. Whilst we were able to offer a number of marketing initiatives in return, they were particularly keen on our social media presence and being seen in the film. We enjoyed working with local branding agency mark-making* who helped create an image for ourselves and assisted in logo and web design. Cascade designs assisted us in acquiring top quality MSR stoves and Thermarests. Montane were great in helping provide us with a variety of clothing that continues their links with the Arctic. We sourced these sponsors relatively early on and having their approval gave us a springboard to secure further support.

Corporate sponsors

Success through this avenue was slow and often unsuccessful, even when pursuing personal connections. That said, Hughmans Solicitors were one of our earliest supporters. Having been successful with local branding agency mark-making*, we attempted to engage other local businesses in the project, including a telethon which we ran. Despite contacting many businesses, our efforts were in vain. We did have some success pursuing bigger more well known corporates, however when being considered by internal committees these fell through. However tides changed when we secured mid-market private equity firm, Inflexion. We are thankful to both Hughmans and Inflexion for their generous support of the initiative.

Crowdfunding

With the help of Somerville College (Liam's college), we launched a crowdfunding campaign to raise £10,000. This was largely successful, though it did require a lot time spent asking

people to donate. We used promotional videos and social media posts to help build a following and reassure people that the expedition would go ahead.

Rewards were used to incentivise giving, though we aimed for them to only cost us <5% of the donation amount. Rewards included a thank you postcard, framed prints, a thank you phone call from the Arctic and an opportunity to come and sign our pulks. What we found in the end was that while the rewards were a nice gesture, people primarily wanted to show their support for the project and thus most were not claimed.

Private Donors

Merton College kindly agreed to host us for dinner and this was a great opportunity to thank our most generous supporters including individuals who has supported the project financially. We were also able to thank those who had supported the project through their valuable time and knowledge.

Personal Contributions

There was always an expectation that we too would contribute to the project. The Expedition Council recommends that your personal contributions should be equivalent to the same costs one would include if living in Oxford for the equivalent time.

Budgeting Strategy

Budgeting was taken to be an ongoing exercise for the team. Over the course of the planning period, the budget varied quite dramatically depending on the progress of our fundraising efforts and the cost of equipment as we managed to secure discounts. It was only by sitting down and writing out every cost that we were able to come up with an accurate budget.

Contingency

A contingency fund of 10% was allocated for unexpected costs. Primarily, we kept this in reserve for the unlikely scenario whereby the boat was unable to drop us off and we required a second charter. It also gave a buffer for exchange rate fluctuations and the higher than expected cost of equipment.

Safety

Communications strategy

Our strategy had to address both external communications with the ‘outside world’ and internally, between sub-teams when the group split up.

External communications were conducted via the Home Agent, on a daily basis using the InReach messaging and tracking system. Via Delorme explore software, Giles could see our progress whenever we were moving, assuming the InReach was switched to tracking mode

(a couple of times, we forgot). When we stopped moving, this was a prompt for him to message us with a weather-forecast and a general check in. He would then acknowledge our reply, and relay the contents via email twice weekly to a select group in the UK. Other than this, we had opted for a ‘radio silence’ approach, even for sponsors. The reasoning behind this was firstly; that we wanted to enjoy the expedition free from social media, and secondly; that in the event of any incidents, information already in the public domain might be subject to unwanted scrutiny. Our sponsors were very understanding of this.

In the event that Giles was unable to make contact with us after a period of 42 hours after our last message, he was to contact the Sysselmannen who would then take necessary steps in the field. The Home Agent would then continue to liaise with those interested parties in the UK and the University (our insurers). If we were unable to communicate with Giles, including after attempts by sat phone, we would then switch to updating our Field Agent in Longyearbyen.

Internal communications relied on a series of devices, decided in a hierarchical fashion. General communications took place over the intergroup radio. As a back-up, and in areas separated by distance or mountains, an InReach was always carried for the purposes of regular check ins which both teams would acknowledge. This could also be used to get weather forecasts, which were generally inaccurate in absolute terms, but did give a general sense of meteorological trends.

A satellite phone and/or personal locator beacon was also always carried by any party and kept at basecamp in the event that immediate contact with Longyearbyen was required. Unless communications with Giles had broken down as above, it was understood that we would be the ones who would call a rescue. The phone was the preferred means of organising this, but the PLBs were a back-up. Finally, we had a 16 channel VHF radio, primarily for communicating with the Spitsbergen Guide service (our boat charter) at the beginning and end of the expedition.

In sum then, the following communications devices were carried by the group: three intergroup radios, three InReaches, a 16 channel VHF radio, one satellite phone and two personal locator beacons.

Insurance

We were covered by the University Travel Insurance through Aon. We also looked into insurance from Endsleigh and the British Mountaineering Council. However we chose to proceed through the University due to its exceptionally good value. Despite the majority of the team graduating before the expedition, they were still covered as they were recognised as a volunteer under the University's policy. We prepared a risk assessment that covered all aspects of the expedition, which then had to be verified by the University Expeditions Council and the University Safety Officers. Once this was completed we filled in the Travel Insurance Application Form and the cover was in place. The Sysselmannen required our expedition to be covered for at least NOK 175,000 Search and Rescue. Our insurance covered us for £100,000 and therefore we were also covered further rescue would we have chosen to continue in the case of someone had been evacuated. The Sysselmannen also

requires that you are covered for one and a half the length of your trip in case of delay. With this in place, insurance cost us just £36 per person.

Medical

Being able to provide first aid and basic medical consultation on such an expedition is essential. We worked with a number of doctors, in particular with one of the University Expedition Council's doctors, Dr Tariq Qureshi, to ensure this was possible. Will and James were Medical Officer and Deputy Medical Officer respectively and already held their Advanced Mountaineering First Aid Levels 1 and 2, taught by Dr Chris Humphries of Wilderness Medical Training. It was also through him that we secured the appropriate prescriptions. Liam already held his AMFA Level 1 and Jamie received training through the St John's Ambulance. Will and Tariq worked together to produce appropriate first aid kits, given the knowledge that a helicopter could be present in three to four hours if conditions allowed whilst also balancing what care was reasonably possible. Will and James also consulted with Dr David Kelly who offered advice surrounding the kit and trauma scenarios.

We choose to carry three types of first aid kit: Personal First Aid kits, two Day First Aid kits and Base Camp First AId Kit. The contents of each are listed in the *Medical Kit List* section. In general the Personal First Aid Kit offered such basics as alcohol hand gel and over the counter painkillers. The two Day First Aid Kits were carried only by James and Will, and accompanied any team leaving base camp. This kit was set to deal primarily with trauma and included prescription painkillers. The Base Camp First Aid Kit was stored in Will's pulk. It included resupplies of all medication and stored antibiotics. We discussed at length whether we should carry IV fluids, however we chose not to take them in the end.

Thankfully no one ever required serious medical attention and most problems could be seen to personally or with the advice of Will and James. Blisters were not as widespread as expected, despite the ski boots putting us at particular risk. Two members of the expedition used blister socks from Basisfot and spoke very highly of them. At the advice of Jim McNeill everyone used mycil antifungal powder, although some more often than others. This also assisted in drying out feet at the end of the day. Most members had a sensation of numbness to varying degrees in their toes upon return to Longyearbyen. One expedition member had symptoms of potential food poisoning one evening, possibly indicating a lapse in hygiene along the chain. No one suffered any serious sunburn, although how much suncream one thought they needed for a month varied wildly!

Polar Bears

With a polar bear population of 3000 on Svalbard, it was very important to have a safety strategy in place should we encounter one. They are a predatory animal that has been known to attack humans on Svalbard, with some recorded deaths over the years. It was therefore very important that we thought long and hard about how we would deal with this objective risk.

After lengthy consultation with a variety of parties such as Arctic Expert Jim McNeill, our local guide (Endre) and the Sysselmannen, it was decided that we take follow the following

strategy to minimise the polar bear risk: (a) two rifles, pen flares for each team member and one revolver would be carried at all times, (b) a polar bear dog would be taken and (c) polar bear watch would be performed at night in the high risk areas (mainly at low altitudes and near the coast) in accordance with Endre's recommendation.

We carried two Tikka .308 rifles which were half loaded at all times and carried in waterproof canvas sleeves. At night, each tent would have one rifle out of the sleeve in the porch. Endre carried a Magnum revolver by his side at night. Each person carried a pen and pen flares on their person during the daytime. At night, they were loaded and stored in the tent pocket.

Bris, our polar bear dog, was never truly tested as we did not encounter any bears. However, he had lived on trapping stations for many years with frequent polar bear encounters and Endre had assured us that he would make a lot of noise upon a bear's approach. He was sourced locally in Svalbard through a friend of Endre's. We carried Bris' food (~30kg), though towards the end of the trip his appetite decreased and consequently he lost some weight.

Polar bear watch consisted of a 10-hour rota. Each of the five team members would have a two-hour slot which they would be on watch for. The slots were shifted by two each night so as to achieve a fair cycle (i.e. 1-3-5-2-4 etc…). The first and fifth slots resulted in a solid 8 hour sleep, whereas the other slots involved waking up during the middle of the night which did make us slightly tired. When on polar bear watch, a rifle was carried in its sleeve and we maintained a no-sitting policy to ensure that people stayed awake for the duration of the watch. No problems were had with watchers falling asleep with this method. Most of the time, we had a clear field of view around the camp. However, when the fog rolled in or when we were unavoidably camped in a dip in the terrain, our field of view was reduced. In these situations, it was important to be more vigilant and the rifle was sometimes carried out of the sleeve while the watcher scanned the surroundings more intensely.

Appendix 1: Kit List

Personal

Outer layer

- Waterproof jacket (Montane Fast Alpine Neo)
- Waterproof trousers (Montane Fast Alpine Neo)
- Synthetic Belay Jacket (Montane Ice Guide)
- Softshell trouser/equivalent (Fjallraven Keb)

Optional Layers (3 of the following)

- Wind shirt/softshell
- Lighter Fleece
- Heavier Fleece (Everyone had Montane Volt Alpiniste)
- Lighter Insulated Jacket (e.g. Montane Prism)

Base Layers

- 3 x Merino wool thin top (2 Normal, 1 Emergency)
- 2 x Synthetic/Merino wool long johns (1 Normal, 1 Emergency)
- 3 x Underwear (2 normal, 1 Emergency)
- 4 x Socks (3 Normal, 1 Emergency)
- Liner Socks (optional)

Head

- Synthetic hat
- Eye mask
- Sun hat
- Buff

Feet

- Alfa Quest A/P/S ski boots
- Mountaineering boots, B2 or B3 (e.g. La Sportiva Nepal, Scarpa Charmoz)
- External gaiters
- Tent/Camp booties (Optional)

Hands

- Ski/mountain gloves
- Overmitts (e.g. BD Mercury)
- Liner/lightweight insulated gloves

Eyes

- Ski goggles (cat 4)
- Sun glasses (cat 4)

Sleeping

- Sleeping bag (Synthetic, e.g. Mountain Hardwear Lamina Z)
- Sleeping bag liner (optional)
- Thermarest mattress
- Thin foam mat

Travelling gear

- Pulk & bag (Snowsled HDPE 100Kg)

- Pulk Harness (Snowsled)
- Pulk Hauling shafts (Snowsled)
- Backpack (40-50L mountaineering)
- Ultra light pack (To wear while pulking, 10-15L)
- Backcountry Nordic Skis (Åsnes Nansen)
- Poles (MSR flight 3 and Gipron 797 Fliplock)
- Skins Full (Military surplus)
- Skins Half (Åsnes)
- Ski waxes, scraper, cork, base cleaner
- Dry bags (SealLine and Ortlieb)

Personal travelling rack

- Petzl Crevasse rescue gear
- Mountaineering harness
- 2 Screw PP
- Prussik
- Knife to cut pulk
- Extra screwgates
- Extra 60cm sling

Personal hardware

- Crampons (Grivel AirTech)
- Helmet
- Walking axe
- Belay plate
- Shovel (1 per person)

Eating

- Optimus Spoon
- Optimus heat pouch
- Insulating mug - large plastic
- Thermos (Hercules)
- Water bottle 1L (Nalgene)
- Camelback (Optional)

Group

Sleeping

- Hilleberg Nammatj 3GT
- Hilleberg Keron 4GT
- Tent pegs per tent: Snow pickets x 10, Normal pegs x10
- Survival shelter (Rab, 8 person)
- Egg package mat (1 per group as spare)

Hardware

- 70m Beal Joker
- 60m Beal Cobra
- 30m 6mm cord
- Mammut Rescyou
- Cams

- Nuts
- Quickdraws and extenders
- 240cm sling

Eating/Cooking

- 10L Dromedary
- 3 x XGK-EX Stove
- Stove board
- Stove windshield
- Stove fuel in containers
- MSR fuel bottle (1 litre size)
- 2 x 5L Kirtley Kettle
- 2.5L pot
- Vitamin tablets
- Brew kit (coffee, tea, squash etc)

Navigation/comms/safety

- Garmin eTrex 20
- Garmin Oregon 459
- Garmin Montana 610
- 2 x PLB
- Sat phone
- 3 x InReach SE
- Radio (16 channel)
- 3 x VHF/UHF radios (Baofeng)
- Transceiver (1 per person)
- Norsk Polar Institutt S100 (Maps C6, C7, C8, D5, D6, D7 and D8)
- Aerial and satellite photos from toposvalbard.npolar.no
- 1 x Binoculars
- 2 x Tikka Rifles .308 cal
- Ammunition
- Pen flares (1 each plus)
- Magnum Revolver .50 cal
- Dog, dry food and sausage
- Whistle and spares
- Signal mirror
- 2 x Survival suits

Tools

- Small metal saw
- Small adjustable spanner
- Allen key
- Mini clamp for ski repair
- Sleeping mat repair kit
- Sand Paper
- Lighter
- Rubber gloves

Materials

- Gorilla tape
- Wire (steel)

- Low temperature glue (epoxy)
- 4mm cord
- Seam grip
- Superglue
- Cable ties
- Tent pole repair kit (Metal sleeve)
- Pulk spares
- 2 x Stove repair kit/spares
- 2 x Skin Adhesive (skis)
- Self tapping screws
- Tenacious tape
- Buckles

Spares

- Spare straps for use on bags, pulk straps
- 2 x MSR Flight 3
- Spare Flight 3 baskets
- Snowshoes

Cameras

- Canon EOS 5D Mark II and Canon 24-105mm EF L
- GoPro Hero 4 Silver + assorted mounts
- DJI Osmo
- DJI Phantom 4
- Manfrotto Manfrotto 190 Aluminium 3 Section Tripod with MVH500AH Tripod head
- ND 1000x and circular polarising filters
- Spare batteries for all devices
- CF and Micro SD cards (at least 1 per device)

Phones, tablets and computers

- MacBook air 11 inch in Thule protective case
- 2 x Transcend Rugged 1TB hard drives
- Transcend Card reader
- iPad air
- Personal smartphones

Sound equipment

- Zoom H4n Handheld Recorder
- Rode NTG1 shotgun mic with pistol grip
- Rode VideoMic pro
- Rode SmartLav Plus plus adaptor

Chargers

- 2 x Solar 100w panels
- 2 x Peli case containing 7Ah 12V battery, regulator and cigarette/USB socket
- Lightning USB cables
- Micro USB cables
- Mini USB cables
- Car charger for canon battery
- GoPro USB battery charger
- Macbook car charger
- DJI phantom battery car charger

- AA/AAA battery charger
- DJI Osmo USB charger

Miscellaneous

- Sponsorship materials (e.g. flag, banner, patches)
- Union Jack
- 1 x Head torch for group
- Umbrella
- Expedition surprise (max 300g)
    - Tesco tinned Mandarin
    - Bluetooth Speaker
    - Travel Chess
    - Crisps and coke
    - Films on USB stick

Appendix 2: Medical Kit List

Personal First Aid Kit

For each team member to manage and administer themselves.

- Lip salve
- Sun cream
- Toothbrush and paste
- 16 x Paracetamol 500mg
- 12 x Ibuprofen 200mg
- 16 x Chlorphenamine 4mg
- Zinc Oxide tape
- Compeed Blister plasters
- Personal medication
- Dioralyte (rehydration) sachet
- Wet wipes
- Alcohol hand wipe
- Towel
- Loo Roll

Day First Aid Kit

Any team leaving basecamp was accompanied by a Day First Aid Kit. Two such kits were prepared and were carried by only James and Will as they had been trained in the use of its full contents.

Medication

- Spares of any patient's medication
- 8 x Paracetamol 500mg
- 8 x Ibuprofen 400mg
- 8 x Chlorpheniramine 4mg
- 8 x Dihydrocodeine 30mg
- 1 x Epipen
- 1 x Tramadol hydrochloride 50mg/ml 2ml ampoule (also req. 3 x blue needle, 1 x 5ml syringe, 1 x chlorhexidine wipe
- 2 x Oral tramadol hydrochloride 50mg

Wound care

- 10 x Gauze 10cmx10cm 8 ply
- 1 x Triangular bandage
- 1 x Crepe bandage
- 1 x Trauma shears
- 2 x Melolin 10cmx10cm
- 5 x Plasters (variety)

- 1 x Steristrips (pack)
- 1 x Syringe 20ml
- 1 x Superglue
- 3 x Burn gel 4.5g sachet
- 1 x Cotton wool tipped stick (for eyes)
- 1 x CPR pocket mask
- 1 x Adjustable cervical collar
- 1 x Eurosplint
- 2 x Major Haemorrhage bandage

Documentation

- 2 x Emergency patient care sheet
- 2 x Pen

Miscellaneous

- 1 x Zinc oxide tape (1cm x 5m)
- 4 x Disposable gloves (pair)
- 1 x Orange oropharyngeal airway

Base Camp First Aid Kit

Central source of expedition medical supplies, will restock other kits and keep backup of any personal medication. Stored with suitable kit together in tupperware boxes inside lengthways opening dry bag.

Medication

- Spares of any patient's medication
- 1 x Sharps pad
- 388 x Paracetamol 500mg
- 84 x Ibuprofen 400mg
- 128 x Ibuprofen 200mg
- 70 x Chlorpheniramine 4mg
- 12 x Kerala hyoscine hydrobromide 300mg
- 2 x Chloramphenicol 1% eye ointment tube
- 20 x Ciprofloxacin 500mg
- 5 x Clotrimazole 2% cream 20ml
- 42 x Co-amoxiclav 625mg
- 30 x Dihydrocodeine 30mg
- 24 x Dioralyte sachet
- 60 x Docusate sodium 100mg
- 28 x Metronidazole 400mg
- 1 x Otomize ear spray
- 56 x Prednisolone 5mg
- 56 x Promethazine 25mg
- 60 x Senna 7.5mg tablets
- 3 x Tramadol hydrochloride 50mg/ml 2ml ampoule (also req. 2 x blue needle, 1 x 5ml syringe, 1 x chlorhexidine wipe)

- 6 x Oral tramadol hydrochloride 50mg
- 10 x Prochlorperazine 3mg

Wound care

- 50 x Gauze 10cmx10cm 8 ply
- 1 x Triangular bandage
- 5 x Crepe bandage
- 1 x Trauma shears
- 10 x Melolin 10cmx10cm
- 100 x Plasters (variety)
- 6 x Steristrips (pack)
- 1 x Superglue
- 10 x Burn gel sachet 4.5g
- 5 x Syringe 20ml
- 4 x Cotton wool tipped stick (for eyes)

Devices

- First aid dentistry kit
- Cling film roll (for burns)
- Ear Thermometer
- Documentation:
- 25 x Routine patient care sheet
- 2 x Emergency patient care sheet
- 2 x Pencils
- Pre-expedition medicals (stored confidentially)
- Prescription only medicine inventory

Miscellaneous

- 4 x Zinc oxide tape
- 10 x Disposable gloves (pair)
- 1 x Small alcogel (for hands)
- 1 x Tweezers
- 1 x Microporous tape

Appendix 3: Budget Summary

Income

Grants		£18,231.00
Andrew Croft Memorial Fund Grant and Swithinbank Award	£2,000.00	
Arctic Club Award	£2,000.00	
Gino Watkins Grant	£4,000.00	
The Irvine Travel Fund	£4,600.00	
Oxford University Expeditions Council	£1,300.00	
The Queen's 650th Anniversary Trust Fund Grant	£500.00	
Alice Horsman Scholarship of Somerville College	£350.00	
Wallace Wason Award of St Catherine's College	£2,481.00	
The Friends of Adam Thurston Trust	£500.00	
OM Lodge Bursary fund	£500.00	
Crowdfunding		£11,114.08
Crowdfunding Campaign and Donations	£11,114.08	
Sponsorship		£11,500.00
Sponsors	£11,500.00	
Personal contributions		£2,312.60
Personal contributions	£2,312.60	
	Grand total	**£43,157.68**

Expenditure

Item	Description	Cost
Insurance	Oxford University Insurance	£180.00
Boat transport	Spitsbergen Guide Service	£6,105.79
Guide	Remuneration for Endre's time, firearms & ammunition, costs associated to Bris (the dog)	£7,004.30
Fundraising	Sponsors' rewards	£161.72

Food	Freeze dried meals and snacks	£3,144.00
UK training	Gun training, weekend with Ice Warrior, travel etc.	£2,936.14
Norway Training	Flights, ski hire, train	£743.32
Film production	Music copyrights, editing software etc.	£19.81
Administration	Visiting archives, image copyright, carbon offset and research costs	£560.84
Longyearbyen logistics	Accommodation, food, car	£1,096.43

Kit

Personal kit	Sleeping bag, jackets	£1,264.10
Group kit	Tents, all safety equipment etc.	£9,680.80
Medical Kit	inc. prescription drugs	£755.25
Pulk	With Harness, pulk bag and poles	£2,369.81
Skis, boots and skins		£2,451.06
Electronics	Drone, cameras and power generation etc	£4,442.64
Satellite device	Subscription for DeLorme Inreach	£241.67
	Grand total	**£43,157.68**

Appendix 4: Carbon Credits

climatecare

This certifies that

Spitsbergen Retraced

Has offset 15.00 tonnes of carbon dioxide through greenhouse gas reduction projects in order to reduce the rate of global climate change.

ClimateCare

25 January 2017

www.climatecare.org