Institution:
University of Cambridge

Unit of Assessment: UoA14 Geography and Environmental Studies

Title of case study: The Scott Polar Research Institute's Polar Museum: engaging new audiences to increase knowledge, understanding and awareness of the polar regions and environmental change

Period when the underpinning research was undertaken: 2014 to date

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Dr N.S. Arnold	University Senior Lecturer	1996-present
Dr M. Bougamont	Senior Research Associate	2007-present
Dr M.T. Bravo	University Senior Lecturer	2000-present
Dr P. Christoffersen	University Reader in Glaciology	2007-present
Professor J.A. Dowdeswell	Professor and Director of SPRI	2002-present
Dr R.C. Powell	University Lecturer	2017-present
Dr W.G. Rees	University Senior Lecturer	1991-present
Dr I.C. Willis	University Reader in Glaciology	1990-present

Period when the claimed impact occurred: 2013 to 2020

Is this case study continued from a case study submitted in 2014? N

1. Summary of the impact (indicative maximum 100 words)

Polar research at the Scott Polar Research Institute (SPRI) is accessible to wider audiences through its Polar Museum (the UK's only museum dedicated to the Arctic and Antarctic). Museum displays communicate SPRI research to general, non-specialist audiences; for example, showing the public how research is deepening understanding of environmental problems such as climate change and global sea-level rise. SPRI research in polar sciences and humanities underpins museum displays that project the significance of the rapidly changing polar environment - climatic, social and cultural - to diverse audiences (c. 375,000 in the REF period) with international reach. Innovative new programmes since August 2013 have engaged new audiences, focused on outreach to schools and encouraged audiences to understand climate change in new ways.

2. Underpinning research (indicative maximum 500 words)

SPRI research is explicitly multidisciplinary, including polar natural sciences (especially ice and environmental change), northern peoples and cultures, polar geopolitics and historical archival records. SPRI's Archive and Picture Library is a unique resource for research, representing the most comprehensive documentary and photographic collection in the world on British polar exploration (Archive around 50m^3; Picture Library around 100,000 images), and its holdings have been integrated closely with evolving museum displays. The selection of research-led displays was guided by several objectives: i) to demonstrate the significance of the Arctic and Antarctic in a global context (e.g. climate change, sea-level rise, ocean-circulation change); ii) to explain and clarify areas of public debate or uncertainty; e.g. about polar environmental change and global warming; iii) to mesh with key topics in the National Curriculum to maximise educational impact (e.g. Key Stage 1, Famous Britons – Captain Scott, Sir Ernest Shackleton; Key Stage 3, ice and environmental change).

Four exemplars of underpinning research by returned SPRI/Geography staff projected through the Polar Museum follow – many more have populated the Museum's dynamic displays. SPRI is a sub-department within the Department of Geography. Dowdeswell is Director of both SPRI and the Polar Museum.

Sociology and culture of the Arctic and its peoples

Bravo and Powell have both published books that deal with wide-ranging issues concerning the Arctic, its indigenous peoples and cultures, its geographical and scientific exploration by Europeans (e.g. the search for the Northwest Passage and the North Pole), and its post-war geopolitical significance [**R1**] [**R2**]. Archival, photographic and museum-artefactual material (e.g. maps and scientific instruments) from SPRI's broad and deep collections have been a significant part of this research.

Basal properties of ice sheets

SPRI has been a world leader in this area since SPRI staff developed ice-penetrating radars in the 1960s. NERC and ERC projects have supported Dowdeswell and Christoffersen to undertake airborne and ground-based data acquisition over polar ice (field campaigns in 2014, 2015, 2017, 2018, 2019). Our data on ice thickness and basal ice-sheet properties are unique, providing critical boundary conditions to ice-sheet numerical modelling by Bougamont [**R3**]. The nature of radar returns from glacier beds enables detection of subglacial conditions (e.g. recent discovery of hypersaline lakes beneath the Devon Ice Cap, Arctic Canada [**R4**]).

Glacier and ice-sheet hydrology

SPRI staff have been at the forefront of the measurement and modelling of ice mass surface and basal hydrology for more than 20 years (Arnold, Rees, Willis, [**R5**]). Field and satellite-derived observations of surface water flow and lake drainage have been combined with borehole and dye-tracing experiments on water flow rates within glaciers and their effects on glacier velocity [**R6**]. Innovative numerical modelling of ice mass thermal structure, water flow and ponding has also been undertaken [**R5**], relating to both ice sheets on Earth and to those at the Martian poles.

Submarine glacial landforms

Dowdeswell has undertaken eight NERC-funded cruises on the UK ice-strengthened research vessel *James Clark Ross.* Much of this work, and that of 200 other scientists from 20 countries, has been brought together in a definitive volume that records the full variety and significance of submarine glacial landforms for ice-sheet reconstruction and understanding of key glaciomarine processes. The volume, edited by Dowdeswell [**R7**] is the standard reference for both academics and industry and data from multibeam echo-sounding of the Antarctic seafloor have been used, for example, to test the theory of catastrophic ice-sheet collapse through marine ice-cliff instability [**R8**].

3. References to the research (indicative maximum of six references)

1. **Powell, R.C.**, 2017. *Studying Arctic Fields: Cultures, Practices, and Environmental Sciences*. McGill-Queen's University Press, 264 pp.
2. **Bravo, M.T.,** 2018. *The North Pole: Nature and Culture*. Univ. of Chicago Press, 260 pp.
3. **Bougamont, M.**, **Christoffersen, P.**, Hubbard, A.L., Fitzpatrick, A.A., Doyle, S.H., Carter, S.P., 2014. Sensitive response of the Greenland Ice Sheet to surface melt drainage over a soft bed. *Nature Communications*, **5**, 5052 doi:10.1038/ncomms6052.
4. Rutishauser, A., Blankenship, D.D., Sharp, M., Skidmore, M.L., Grima, C.; Schroeder, D.M., **Dowdeswell, J.A.,** Young, D.A., 2018. Discovery of a hypersaline subglacial lake complex beneath Devon Ice Cap, Canadian Arctic. *Science Advances*, **4**, doi: 10.1126/sciadv.aar4353.
5. **Arnold, N.S.,** Banwell, A.F., **Willis, I.C.**, 2014. High-resolution modelling of the seasonal evolution of surface water storage on the Greenland Ice Sheet. *The Cryosphere,* **8**, 1149-1160.6.
6. **Banwell, A.**, Hewitt, I., **Willis, I., Arnold, N.**, 2016. Moulin density controls drainage development beneath the Greenland Ice Sheet. *Journal of Geophysical Res.*, **121**, 2248-2269.
7. **Dowdeswell, J.A.**, Canals, M., Jakobsson, M., Todd, B.J., Dowdeswell, E.K., Hogan K.A., (eds), 2016. *Atlas of Submarine Glacial Landforms: Modern, Quaternary and Ancient. Geological Society, London, Memoirs*, **46**, 618 pp.

8. Wise, M.G., **Dowdeswell, J.A.**, Larter, R.D., Jakobsson, M., 2017. Iceberg-keel plough marks provide evidence for rapid calving and retreat of the West Antarctic Ice Sheet resulting from marine ice-cliff instability. *Nature*, **550**, 506-510, doi:10.1038/nature24458.

Outputs are peer-reviewed. All books have received strong reviews in academic journals and the wider media. A total of 12 major funding awards are associated with the research over the period, including ERC €4.5 million (2 awards); NERC £2.25 million (8 awards); Horizon 2020 £380,000 (2 awards).

4. Details of the impact (indicative maximum 750 words)

Since August 2013 the Polar Museum has received over 375,000 visitors (recorded by calibrated footfall counter and reported to the Association of Leading Visitor Attractions; museum entry is free). Its core mission is to deliver SPRI's research findings to general audiences in accessible and engaging ways, and it continues to fulfil this role and renew its approach and materials. The Museum has developed innovative new programmes and events during the REF period, which focus on two main areas: diversifying the audiences with whom the Museum engages and stimulating understanding and learning with different groups around the polar regions and environmental change.

Diversifying museum audiences

The Polar Museum's Education and Outreach team routinely work with a range of under-represented audiences to share SPRI research with people of all ages and backgrounds. These include running short courses for people living with dementia and their carers, partnering with local charity 'Portals to the World' (78 people engaged since 2015), museum tours especially for young parents, and tours for homeless people with local charity 'Winter Comfort' (one group of around 10 for each reporting year). University of the Third Age (U3A) activities also take place regularly, 396 individuals reached directly by staff talks or tours, plus weekly lectures hosted at SPRI during term-time throughout the reporting period), demonstrating that the impact of SPRI research has considerable reach across the generations. The annual event *Twilight at the Museum* specifically targeted people living in areas of high deprivation around Cambridge and in 2018 was notable for 51% of attendees visiting for the first time, 50% visiting with the target audience of children aged 6-11, and 47% of Cambridge visitors from areas ranked as of 'Higher Socio-Economic Deprivation' (postcodes CB2, CB4, CB5).

LGBTQ+ tours of the Museum were piloted in January 2019. The innovative tours were reviewed favourably in the New York Times: 'Tours like this are important to the future of museums' [**S1**]. In 2015 and 2017, respectively, Antarctic and Arctic tactile maps were designed and produced by textile artist Jenny Langley in collaboration with research students, Museum and research staff for use with blind and partially sighted people (research featured includes permafrost erosion and treeline retreat (Rees), glacier retreat (Arnold, Willis), and surface melt lakes (Christoffersen). The tactile maps have been used by a range of audiences, including 'Antarctica Live' at the Science Museum (1,675 people engaged; August 2018) as well as smaller ad hoc groups of blind and partially sighted visitors. Museum team-member Naomi Chapman received a University Impact and Outreach Award for this work in 2019. Further blind and partially sighted resources relating to Shackleton were developed through 2019, including audio-descriptions of objects and tactile models. The Museum team collaborated with Simon Clark, a popular blogger, on his YouTube series 'Crash Course Cryosphere'. The series featured Rees and introduced the principles of studying the icy world. Published in 2017, the series has attracted difficult-to-reach young adults and late-teen audiences of 54,000 viewers, 54% aged 18-24, with an average view duration of 4:59 minutes. User comments on the videos include, '*This is a terrific series, it feels like this is what has been missing from those hundreds of lessons on global warming' and 'I would love to become a climate change researcher and benefit the environment. I saw your video… and that really inspired me.'*

Bringing Museum collections to new sites

Exhibitions organised by Polar Museum staff held at Bonhams' Bond Street auction house in London in 2016 and 2018 attracted over 2,500 visitors. The exhibitions featured both SPRI research (e.g. Christoffersen's Greenland work) and collections (e.g. Ponting's fine-art prints of

Scott's last Antarctic expedition), and work by our Artists in Residence (a formal programme sponsored by Bonhams, running since 2015 and supported through ship-berths in the Antarctic and Arctic from the Royal Navy and One Ocean Expeditions). Artist Dr Kat Austen discussed the work from her Arctic SPRI residency on BBC Radio 3 alongside Bravo in an episode of *Free Thinking* on the theme of 'ice' (December 2018). The Museum's exhibition *By Endurance We Conquer* toured venues in Ireland, the Falkland Islands and Chile, and was seen by over 15,000 visitors. The museum's education team undertook external outreach including regular attendance at the Lyme Regis Fossil Festival (30,340 people engaged from 2016 to 2018), and handling collections have been taken to patients in the Kidney Dialysis Unit at Addenbrookes Hospital (over 100 people engaged since 2016).

Secondary outreach for SPRI research includes substantial media coverage in UK and overseas broadsheets, BBC Online, TV and radio (e.g. Dowdeswell on Radio 4 *Today Programme* (April 2018, February 2019) and *Inside Science* (January 2019) on his Antarctic research). The Polar Museum is a regular venue for filming of news items and documentaries about polar history (e.g. *Antiques Roadshow Detectives*, April 2015; BBC2's *Icons*, January 2019 - Dowdeswell) and contemporary polar science issues (BBC and foreign documentaries) which often include SPRI academics.

Engaging audiences around environmental change

The Polar Museum has undertaken a number of stand-alone or one-off activities about climate change in the Polar regions. The 'Climate Hack', a SPRI-led Cambridge Museums initiative, invited 24 members of the public with skills in science communication or design skills to form four teams, each of which built a prototype exhibit in one of the University's museums over the course of the three-day event held in January 2018. The museum exhibit, developed by Rees and SPRI PhD student Praveen Teleti, enabled visitors to explore how sea ice in the Arctic has changed year on year since the 1850s. Visitor feedback showed that 88% agreed that the exhibit had '*inspired them to think differently about climate change*.' The exhibit has since been developed into a permanent display, where visitors have left written feedback commenting on '*a super idea, simple and good resource… shows the impact of global warming on the polar ice cap* (written visitor feedback, April 2019). The 'Climate Hack' was recently shortlisted for a 2019 'Museums and Heritage Award' for 'Limited Budget Project of the Year.'

In summer 2019 the Museum invited twelve Year 12 students, through a national competition, to co-curate an exhibition about climate change. The project enabled engagement with researchers including Arnold, Christoffersen, Rees and Willis, who shared their learning with the students. Participants were selected for academic attainment and targeted schools with below average Cambridge application rates; all showed marked increases in their understanding of climate change and confidence to consider Cambridge as a place for them [**S2**]. Feedback included: '*I'm more confident and have increased my knowledge in climate change; I have become a better speaker and listener; I can work in a team better; The project was successful in allowing me to speak to professors and expand my knowledge'*. The project concluded with an exhibition (Dec 2019 to March 2020). The students spent a residential week at the university, were supported in learning about applying to Cambridge and encouraged to feed back to their teachers and fellow pupils about their experience.

School visits are a major element of learning provision. The Museum offers several different workshops which are informed variously by remote-sensing research (Rees), glaciology research (Arnold, Christoffersen, Willis), and the marine record of past change (Dowdeswell). In the REF period, 14,200 pupils attended workshops taught by museum staff, and a further 8,300 have taken part in teacher-led workshops. Nearly 7,000 pupils have accessed museum handling collections in their schools since the introduction of this outreach activity in 2015. Feedback from both children and teachers demonstrates that the Museum has developed a reputation for high-quality communication of research to school groups [**S3**] [**S4**]. A Key Stage 1 teacher commented: '*Thank you for our first class visit. The children loved the day and they came back with a lot of new knowledge'* [**S4**]. The Museum has provided teacher training for over 100 teachers since 2017, and has welcomed over 1,000 teachers as part of Museum workshops since 2016. Newly developed digital resources, including short films designed for classroom use and accompanying teacher packs, were launched in 2017 and have been

accessed over 40,000 times each year. The Chief Executive of the UK Antarctic Heritage Trust commented [**S5**]: '*The unique nature of the Polar Museum, underpinned as it is by a world-class research institute, makes for a compelling and expert organisation with a richness to its activities. The quality and range of the displays and exhibitions delivered by the museum are peerless*'. The Director of the British Antarctic Survey wrote [**S6**]: '*The exceptionally important topic of climate change and the impact on the peoples and landscape of the polar regions is brought to life in the SPRI Polar Museum'.*

To make SPRI's academic work accessible to general audiences, researchers regularly contribute material through physical exhibits and captions, text and illustrations for interactive touch screens in the Ice and Climate gallery, and verbally for audio-guides. These have focused on environmental change in the current period. For example, museum displays show ice-penetrating radar equipment and explain how the method works, and interactive screens provide explanations of the significance of ice-sheet mass loss for global sea-level rise [**R3**] [**R4**]. Special exhibitions with accompanying displays have shown the scientific evidence for and significance of ice-melting on Greenland [**R5**] [**R6**] together with artists' paintings and drone-derived photographs of melt lakes and streams (e.g. Timo Liber's photographic exhibition *Thaw*, 2016; and *Ummannaaq: a Century of Exploration in Greenland*, 2018, featuring fieldwork carried out by Christoffersen in Greenland, with over 24,000 visitors). The Head of the Polar Regions Dept. at the Foreign and Commonwealth Office (FCO) wrote [**S7**]: '*The museum has been rightly recognised for its role and impact in terms of education and outreach; in particular the museum has demonstrated innovative use of primary research in well thought-out displays on the polar environment in a warming world*'. The SCAR Executive Director [**S8**] wrote: *'The opportunity to visit the Polar Museum is always highly valued by our visitors, be they government officials, policy makers or researchers. Such visits have a lasting impact.'*

Special Museum events to engage families, including the *Cambridge Science Festival,* the *Festival of Ideas* and *Twilight at the Museum,* take place annually (total attendees exceed 21,000 in the REF period). Over 1,400 visitors came to the Museum for the 2018 *Science Festival* family day, of which an estimated 900 were children. Demonstrations by researchers included: the differing properties of frozen salt water and fresh water; using a quadrant and the pole star to measure latitude (Bravo's work on the history of the North Pole) and hands-on experiments on how ice scatters light (Rees's use of spectroscopy methods in mapping penguin populations). Comments include: '*Amazing museum and the interactive exhibit on ice extent was very informative and thought provoking, and educational'* (visitor exit interview, 29 March 2019). Interactive screens have proved popular across a wide age range, and are particularly well used by one of our main target audiences; young people aged 12-16.

Books written for an informed general audience and based on staff research are sold in the Museum Shop and on the internet. Dowdeswell has co-authored four books on the science and history of the polar regions: *Islands of the Arctic* (2002, 6,500 sold) and *The Continent of Antarctica* (2018, 2,200 sold) as popular science books for adults (reviews in [**S9**]); *Scott of the Antarctic* (2012, 7,400 sold) and *Sir Ernest Shackleton* (2014, 2,200 sold) for children at Key Stage 1. Sir Ranulph Fiennes commented on *The Continent of Antarctica*: '*Wide-ranging and extremely well-illustrated, this authoritative yet accessible book is a must for anyone interested in the Antarctic'*.

5. Sources to corroborate the impact (indicative maximum of 10 references)

1. Review of LGBTQ+ tours at the Polar Museum in the New York Times, 17 Jan 2019
2. Comments on Co-curation Climate Change project, Aug 2019, by Year 12 participants
3. Comments on the Polar Museum by Primary School Children after school visits
4. Comments on the Polar Museum by Teachers after school visits
5. Chief Executive of the UK Antarctic Heritage Trust, Dr Camilla Nichol
6. Director of the NERC British Antarctic Survey, Prof Dame Jane Francis
7. Head of Polar Regions Department, Foreign and Commonwealth Office, Dr Jane Rumble
8. Executive Director, Scientific Committee on Antarctic Research (SCAR), Dr Chandi Nath
9. Reviews of 'The Continent of Antarctica': *Nature* 563, 332; SCAR President Prof S. Chown