BAS Science Summaries

2022-2023 Antarctic field season

British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

POLAR SCIENCE FOR PLANET EARTH

Contents

Cover: *BAS Twin Otter aircraft flying over Fuchs Ice Piedmont, Adelaide Island with MASIN turbulence probe fitted*

BAS Science Summaries

2022-2023 Antarctic field season

Introduction

▲ *Dr Anna Jones, BAS Director of Science*

Welcome to the British Antarctic Survey Science Summaries booklet for the 2022-2023 Antarctic field season! This booklet contains summaries of all the field, station, and ship-based science projects that the British Antarctic Survey (BAS) is supporting during the 2022-23 Antarctic field season. There is some fantastic science being done in Antarctica this season; a whole range of projects of different levels of complexity.

BAS excels in delivering field support for big science projects that address the most urgent questions of the day. Many of these projects will ultimately provide information needed by policy-makers and are of the highest societal importance. These large projects are delivered through collaborations involving multiple partners, either UK-only or including international scientists. Let me take a moment to tell you about some of the highlight projects that will be delivered this season.

The International Thwaites Glacier Collaboration (ITGC) is the largest joint UK-US project undertaken in Antarctica in 70 years. It targets one of the most unstable and rapidly-changing glaciers in Antarctica – the Thwaites Glacier in West Antarctica – in order to understand and quantify the processes that are driving this change. Overall, the glacier is the size of Britain, and it straddles some of the deepest bedrock in the southern continent. Warm ocean water from the Amundsen Sea circulates under the ice, causing it to melt. Melting loosens the ice from the bedrock below, causing it to flow faster and eventually to retreat into the deeper and thicker ice areas where it is likely to speed up still more. Over the past 30 years, the amount of ice flowing out of this 120km-wide region has nearly doubled. It's calculated that Thwaites Glacier already contributes about 4% to global sea-level rise. A series of projects, supported by joint UKRI-NERC and NSF funding and delivered over multiple seasons, will be supported in Antarctica in 2022-23. The projects will address specific regions and/or specific processes that will ultimately enable robust projections around the future of this critical area of West Antarctica. These projects are described in more detail on pages 13-15.

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DEFIANT is the wonderful acronym for the project 'Driver and Effects of Fluctuations in sea Ice in the ANTarctic'. While Arctic sea ice has declined steadily over past decades, sea ice in the Antarctic has shown quite different behaviour. Despite global warming, Antarctic sea ice expanded during most of the past 40 years, as shown by satellite observations. However, in 2016 the Antarctic sea-ice area plummeted, at a rate that far exceed the changes in the Arctic, and resulting in a sea-ice area far less than previously observed. The job for DEFIANT is to gather critical evidence that will help explain the unexpected change in sea ice, and cast some light on how Antarctic sea ice may behave in the future. DEFIANT is a £4M NERC-funded programme supported by strategic Highlight Topic funding – more details on page 16.

The Southern Ocean Clouds project, or SOC, is focussed on understanding high-latitude mixed-phase clouds and improving the way that they are represented in climate models. Reports by the Intergovernmental Panel on Climate Change have shown the large contribution, but also the uncertainty, that clouds have on global climate. For the southern hemisphere, climate models currently struggle to reproduce some fundamental climate features. For example, they have errors in sea-surface temperatures which affect heat uptake over the Southern Ocean and therefore predictions of the long-term climate. They do not adequately represent the jet stream in the southern hemisphere and the inter-tropical convergence zone. In short, these problems in the models affect the modelled climate system of the entire southern hemisphere. There is evidence that the problem lies in the way that mixed-phase (water and ice) clouds are described in the models. SOC will provide key data to improve the representation of clouds in models, and hence the model's ability to carry out southern hemisphere-wider climate studies. SOC is one of five projects that make up the UKRI-NERC-funded strategic programme 'The Uncertainty in Climate Sensitivity due to Clouds' – more about SOC can be found on page 17.

Our knowledge of past concentrations of greenhouse gases comes most directly from ice cores. From the iconic EPICA Dome C ice core, we know that concentrations of carbon dioxide in the atmosphere today are almost 40% higher than at any time in the previous 800,000 years; and those of methane, another very important greenhouse gas, have more than doubled. These changes in concentrations are caused by human activities which emit these long-lived gases into the atmosphere. The ice core data helps us to understand just how far we have pushed the Earth system, both in terms of increases in the raw concentrations, but also the speed at which we have caused these changes. The Beyond EPICA project has the ambition to retrieve even older ice – the target is to retrieve ice that is 1.5 million years old, which would be the oldest ice on the planet – and use that to answer key questions around natural variability of greenhouse gases and climate in the distant past. Beyond EPICA is supported with EU funding, and will drill out of Little Dome C – see page 19 for more information.

Finally, a slightly different activity I'd like to tell you about. In our attempt to deliver critically-needed science at a reduced carbon

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Introduction continued

cost, the British Antarctic Survey, together with colleagues across the science community, is exploring and progressing the use of autonomous vehicles. During the 2022-23 field season, BAS's autonomous airborne fixed-wing platform, the Prion, will be flown and tested for the first time in Antarctica. The Prion can support a range of science (e.g. geophysics, atmospheric) and provide data at a fraction of the carbon emissions compared with traditional Twin Otter use. This is an exciting step forward in our use of autonomous technologies and we look forward to learning how the Prion performs on the icy continent. You can read more about the Prion project on page 20.

As you can imagine, 2022-23 will be a challenging and ambitious field season, with a large number and range of projects to be delivered. A fascinating suite of projects is planned, and I hope you enjoy reading more about them in this booklet.

Please note that not everyone involved in each project has been listed in this document, however all those working in the field are included. Principal Investigators appear in capitals and those in brackets are not present on site. Field Guides are indicated with an asterisk and non-BAS personnel are shown in blue. A full list of non-BAS personnel and their affiliated organisations is shown in the Appendix. For more detailed information about individual projects please contact the Principal Investigators.

My thanks to all the authors for their contributions, to Elena Field for the field sites maps, and to Aurelia Reichardt, Mairi Simms, and Thomas Barningham for collating all the material. Thanks also to Jamie Oliver for the editing and production of this handy summary. And very best wishes to all of the teams – I hope you all have a successful and safe 2022-23 field season.

Dr Anna Jones
Director of Science, BAS

September 2022

List of science projects

Highlight projects

Project title ***Location***	**Personnel** PI in capitals and brackets if not present, Non-BAS personnel in blue, *Field Guide	**Page**
International Thwaites Glacier Collaboration (ITGC) – GHOST *Thwaites Glacier, West Antarctica*	SRIDHAR ANANDAKRISHNAN, Robert Bingham, Helen Ockenden, Julien Bodart, Louise Borthwick, Elizabeth Case, Knut Christianson, Andrew Hoffman, Coen Hofstedeg, Florian Koch, Tanner Kuhl, Rebecca Pearce, Nate Stevens, Paul Winberry, Ole Zeisin, [Field Guides]*, [Mechanic/Drivers], [Other Field Support]	**13**
International Thwaites Glacier Collaboration (ITGC) – TARSAN *Thwaites Glacier, West Antarctica*	ERIN PETTIT, Gabriela Collao Barrios, Michelle Maclennan, Emelie Mahdavian, Cecelia Mortenson, Naomi Ochwat, Meghan Sharp, Christian Wild	**14**
International Thwaites Glacier Collaboration (ITGC) – TIME *Thwaites Glacier region – Eastern Shear Margin*	(POUL CHRISTOFFERSEN, SLAWEK TULACZYK), Robin Bolsey, Anna Broome, Lucia Gonzalez, Galen Kaip, Marianne Karplus, Manuel Moncada, Emma Pearce, Andrew Pretorius, Madeline Hunt, Tara Sweeney, TJ Young	**15**
Driver and effects of fluctuations in sea ice in the Antarctic (DEFIANT) *Rothera, aerosurvey over Weddell Sea, RRS Sir David Attenborough*	JEREMY WILKINSON, (many other co-investigators), Alberto Naveira Garabato, Andrew Shepard, [Field Guide]*	**16**
Southern Ocean Clouds (SOC) *Rothera (East Beach Hut) and flying campaign*	TOM LACHLAN-COPE, (Ian Renfrew), Dan Smith, (David Topping), Floorjte van den Heuvel, Jonathan Witherstone	**17**
Beyond EPICA – oldest ice core *Little Dome C, 40km from Concordia Station in East Antarctica*	ROBERT MULVANEY, (Carlos Martin)	**19**
BAS Prion 3 UAS airspace integration, validation, verification and science flying *Rothera*	(MIKE ROSE), William Clark, (Tom Jordan), Carson McAfee, (Carl Robinson)	**20**

Field-based projects

Sledge	**Project title** ***Location***	**Personnel** PI in capitals and brackets if not present, Non-BAS personnel in blue, *Field Guide	**Page**
Alpha	Annual Antarctic Automatic Weather Station servicing *Sites along the Antarctic Peninsula and around Halley*	(STEVE COLWELL), [BAS Met Teams]	**21**
Bravo	Long-term micro-environmental monitoring for terrestrial biology *Rothera Research Station (Anchorage island), Alexander Island (Coal Nunatak, Mars Oasis), Signy Research Station*	(PETE CONVEY, KEVIN NEWSHAM), Aurelia Reichardt, [Field Guide]*	**22**

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List of science projects *continued*

Field-based projects continued

Sledge	Project title ***Location***	Personnel PI in capitals and brackets if not present, Non-BAS personnel in blue, *Field Guide	Page
Charlie, Juliet. November & Zulu	Quantifying West Antarctic mantle viscosity via precise GPS measurement of Earth's response to surface mass balance anomalies *Throughout western Antarctica*	(MIKE BENTLEY, PETER CLARKE, PIPPA WHITEHOUSE, Matt King, Anya Reading, Michiel van den Broeke, Terry Wilson, Bert Wouters), [BAS Engineers]	**23**
Delta	Mars analogue prototype environmental monitoring equipment for testing Mars mission operation *Sky-Blu Field Station*	(JAVIER MARTIN-TORRES, PETER CONVEY, MERVYN FREEMAN), [BAS Engineers]	**24**
Echo	Interglacial collapse of the West Antarctic Ice Sheet revealed by subglacial drilling (INCISED) *Behrendt Mountains, Haag Nunataks and Northern Ellsworth Mountains*	MIKE BENTLEY, (Rob Mulvaney), [Field Guide]*	**25**
Foxtrot	Sub-ice-shelf boundary-layer experiment (SIBLEX) *Larsen C Ice Shelf*	(KEITH NICHOLLS), [BAS Engineers]	**26**
Hotel	Testing smaller-than-present configurations of the Antarctic Ice Sheet using a novel integration of geochronology *Ellsworth Mountains*	DAVID SMALL, Thomas Lees, Stephan Trabucatti, [Field Guide]*	**27**
Kilo	Subglacial bedrock recovery drilling in the Hudson Mountains, West Antarctica *Winkie Nunatak, Hudson Mountains*	(JOANNE JOHNSON), Scott Braddock, Elliot Moravec, Keir Nichols, Ryan Venturelli, Dominic Winksi	**28**
Lima	Low power magnetometer servicing *Polar plateau*	(MIKE ROSE, MERVYN FREEMAN), [BAS Engineers]	**29**
Quebec	Rift propagation for ice-sheet models (RIPICE) *Larsen C Ice Shelf*	ADRIAN LUCKMAN, (Stephen Cornford, Eduard de Souza Neto), Bryn Hubbard, Glenn Jones, Bernd Kulessa, Katie Miles, [Field Guide]*	**30**
Romeo	Ice-shelf instability caused by active surface meltwater production, movement, ponding and hydrofracture *George VI Ice Shelf, Antarctic Peninsula*	ALISON BARNWELL, Becky Dell, (Doug MacAyeal, Laura Stevens), Ian Willis, [Field Guide]*	**31**
Sierra & Tango	Melt rates over Ronne Ice Shelf *Filchner-Ronne Ice Shelf*	(KEITH NICHOLLS), [BAS Engineers]*	**32**
Uniform	Minimum snow-cover aerial survey of Rothera Point	NATHAN FENNEY, Connor Bamford	**33**
Whiskey	The past, present and future of snow algae in Antarctica: a threatened terrestrial ecosystem? *Nobert Island, Nelson Island, Frei Station*	(PETE CONVEY), MATTHEW DAVEY, (Claudia Colesie, Andrew Fleming, Peter Fretwell), Andrew Gray, (Lloyd Peck, Alison Smith), Alex Thomson, Charlotte Walshaw	**34**
X-ray	State and fate of Antarctica's gatekeepers, a high resolution approach for ice-shelf Instability (HiRISE) *Larsen Ice Shelf*	(BERT WOUTERS), Paul Smeets, (Carleen Tijm-Reijmer), [Rothera Met Team]	**35**

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List of science projects *continued*

Field-based projects continued

Sledge	Project title ***Location***	Personnel PI in capitals and brackets if not present, Non-BAS personnel in blue, *Field Guide	Page
N/A	Environmental management visits to Antarctic Specially Protected Areas managed by the UK *Marguerite Bay: Avian Island, Emperor Island; Green Island, Berthelot Island, Ablation Valley and Ganymede Heights*	(KEVIN HUGHES), Aurelia Reichardt	**36**
N/A	Hot-water drilling on Nansen Ice Shelf *Nansen Ice Shelf*	(KEITH NICHOLLS), Pierre Dutrieux, Keith Makinson, Scott Polfrey	**37**
N/A	Ops Traverse *West Antarctica*	Ops: ROB GRANT, Nick Withey, George Allison, [Field Guide]* GHOST: CATRIN THOMAS, David Jameson, Matthew Shepherd, Pete Young, Julie Baum*	**38**

Rothera Research Station

Project title	Personnel PI in capitals and brackets if not present, Non-BAS personnel in blue, *Field Guide	Page
Aliens in the polar region	STEF BOKHORST, (Pete Convey, Hans Cornelissen)	**39**
Annual Rothera Ramp survey	ANDY SMITH, [Rothera Science Coordinator and Field Guide*]	**40**
Assessment of Antarctic colonisers across a depth gradient	NADIA FRONTIER, SIMON MORLEY, (Ben Robinson)	**41**
Biological long-term monitoring – IBIS (Iceberg impact study)	(DAVID BARNES), Hollie London, Emma Stuart, [Rothera Marine Team]	**42**
BRUV (Baited Remote Underwater Video)	MELODY CLARK, SIMON MORLEY, LLOYD PECK, [Rothera Marine Team]	**43**
Comparative survey of shallow soft-bottom benthic communities in Ryder Bay	(DAVE BARNES, LLOYD PECK), ADRIANA GILES, SIMON MORLEY	**44**
Degradation dynamics of Antarctic macroalgae	SIMON MORLEY, (LLOYD PECK), Nadia Frontier	**45**
Differences in the trophic ecology, distribution and foraging success of crabeater seals across a latitudinal gradient	(LUIS HUCKSTADT, Dan Costa), Connor Bamford, Nathan Fenney, (Jaume Forcada, Peter Fretwell)	**46**
Phosphorus scavenging from plastic as phosphate source by Antarctic cyanobacteria	JAPARENG LALUNG, (Pete Convey)	**47**

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List of science projects *continued*

Rothera Research Station continued

Project title	Personnel PI in capitals and brackets if not present, Non-BAS personnel in blue, *Field Guide	Page
Pole to pole exchange – climate facilitated cyanobacterial parasite pressure and mat ecosystem response	DANIEL R. DIETRICH, (Antonio Camacho, Pete Convey, Kenneth Dumack, Ian Hawes, Lucy Hawkes, Svenja Heesch, Anne Jungblut), Eva Riehle, (Antonio Quesada, Susanna Wood)	48
Predicting DMS(P) production in a high CO_2 world	JAQUELINE STEFELS, Mareike Bach, Maria van Leeuwe	49
Repair and maintenance of the Rothera MF radar masts	(NEIL COBBETT, ANDREW KAVANAGH), [BAS Estates and Engineers]	50
Rothera Oceanographic and Biological Time Series (RaTS)	DAVID BARNES, MICHAEL MEREDITH, HUGH VENABLES, Alex Brearley), Alice Clement, Hollie London, Emma Stuart	51
Rothera skua long-term monitoring and AIMP bird monitoring for wind turbines EIA	(RICHARD PHILLIPS, Kevin Hughes), Aurelia Reichardt, Paul Whitelaw	52
Seaweed physiology	NADIA FRONTIER, SIMON MORLEY	53

Halley VI Research Station

Project title	Personnel PI in capitals and brackets if not present, Non-BAS personnel in blue, *Field Guide	Page
All-sky camera	(TRACY MOFFAT-GRIFFIN), David Goodger, Hessel Gorter	54
Auroral cameras – conjugate measurements of isolated proton auroras, red aurora, and pulsating auroras at subauroral latitudes – Optical	(TRACY MOFFAT-GRIFFIN, MITSUNORI OZAKI), Hessel Gorter, (Keisuke Hosokawa), Dominic Jaques, Carson McAfee, (Yasunobu Ogawa, Kazuo Shiokawa)	55
Clean Air Sector Laboratory (CASLab)	(ANNA JONES, FREYA SQUIRES, MARKUS FREY), Sabina Kucieba	57
Discovering reasons for atmospheric methane growth using deuterium isotopes (MethaneDH)	(REBECCA FISHER, Grant Forster, James France), Hessel Gorter, Dominic Jaques, (Anna Jones, David Lowry), David Maxfield, (Euan Nisbet), (Freya Squires)	59
Electro-Magnetic Quiet Area	(MARK CLILVERD, MERVYN FREEMAN, RICHARD HORNE) Sebastian Gleich, Dominic Jaques, David Maxfield	60

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List of science projects *continued*

Halley VI Research Station

Project title	Personnel PI in capitals and brackets if not present, Non-BAS personnel in blue, *Field Guide	Page
Glaciological monitoring of the Brunt Ice Shelf	OLIVER MARSH, (James Byrne), Sebastian Gleich, Dominic Jaques, David Maxfield	63
Halley Automation Project	(THOMAS BARNINGHAM, MIKE ROSE), [Halley Automation Project Team]	64
Infrared camera	(TRACY MOFFAT-GRIFFIN), Hessel Gorter, Dominic Jaques, Corwin Wright	65
Meteorology and ozone monitoring	(STEVE COLWELL), Sabina Kucieba	66
Sky radiometer	(STEVE COLWELL), Sabina Kucieba	68

Bird Island Research Station

Project title	Personnel PI in capitals and brackets if not present, Non-BAS personnel in blue, *Field Guide	Page
Bird Island marine predators LTS	RICHARD PHILLIPS, Ash Bennison, Marcia Blyth, (Mike Dunn), Rosie Hall, Imogen Lloyd, Marine Quintin, Erin Taylor, Mark Whiffin	69

King Edward Point Research Station

Project title	Personnel PI in capitals and brackets if not present, Non-BAS personnel in blue, *Field Guide	Page
Cetacean monitoring in Cumberland Bay	(PHILLIP HOLLYMAN, Martin Collins), Meghan Goggins, Carrie Gunn, (Jennifer Jackson), Kate Owen, George Perry	70
Higher predator monitoring at Cumberland Bay	(PHILLIP HOLLYMAN, Martin Collins), Meghan Goggins, Carrie Gunn, Kate Owen, George Perry	71
Initiating monitoring support for the SGSSI-MPA Research and Monitoring Plan	(PHILIP TRATHAN), Jamie Coleman, (Martin Collins), Nathan Fenney, (Adrian Fox, Phillip Hollyman)	72
Long-term monitoring of plankton communities in South Georgia waters	(MARTIN COLLINS), Meghan Goggins, Carrie Gunn, Kate Owen, George Perry	73
South Georgia groundfish survey 2023	(PHILLIP HOLLYMAN, Martin Collins), Simeon Hill, Patrick Keith	74
Spatial segregation of seabirds at South Georgia	VICTORIA WARWICK-EVANS, Richard Phillips, [KEP ZFA]	75

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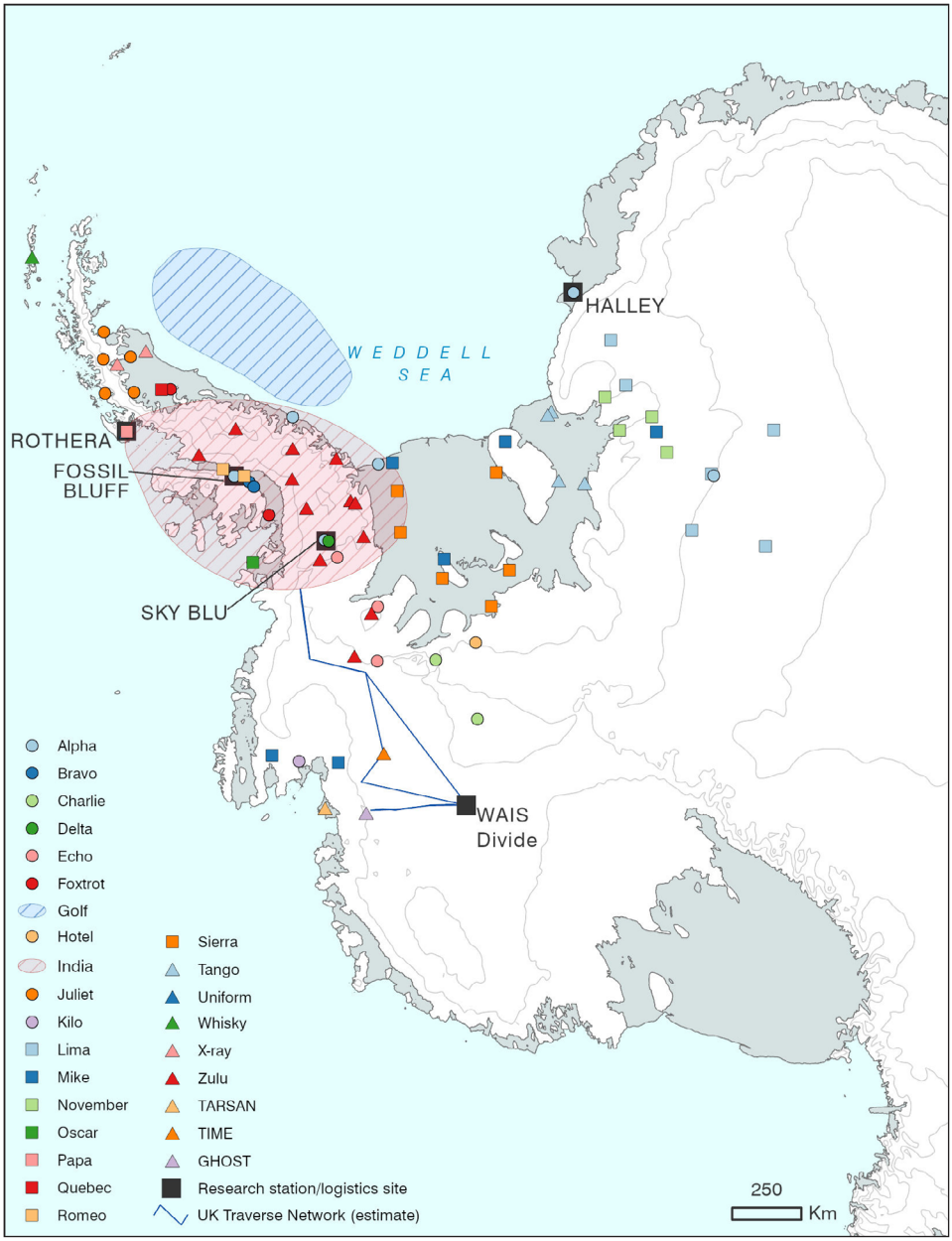
List of science projects *continued*

Signy Research Station

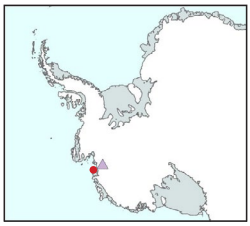
Project title	Personnel PI in capitals and brackets if not present, Non-BAS personnel in blue, *Field Guide	Page
Consistency of chinstrap penguin migration from the South Orkneys and South Shetlands	(NORMAN RATCLIFFE), Derren Fox	**76**
Mechanisms of adaptation to terrestrial Antarctica through comparative physiology and genomics of Antarctic and sub-Antarctic insects	(SCOTT HAYWARD, NICHOLAS TEETS), Monica Aquilino, (Pete Convey, Andrew Michel)	**77**
Signy Island marine predators long-term monitoring and survey programme	(RICHARD PHILIPS, Mike Dunn), Derren Fox	**78**
Summer-monthly collections of the intertidal bivalve Lissarca miliaris at Shallow Bay, Signy Island	(KATRIN LINSE, Mike Dunn), [Signy Station Leader]	**79**
The Antarctic Biota Count (ABC): a functional trait-based approach to scale biodiversity from plot to region	(STEF BOKHORST, Pete Convey, Hans Cornelissen), Seringe Huisman, Ingeborg Klarenberg	**80**
Vegetation and cryosphere (permafrost and glaciers): impacts of recent and past climate change in maritime Antarctica and Antarctic Peninsula	NICOLETTA CANNONE, (Mauro Guglielmin, Francesco Malfasi)	**81**

Map of field-based project locations

2022-2023 Antarctic field season



Highlight project



International Thwaites Glacier Collaboration (ITGC) – GHOST

SRIDHAR ANANDAKRISHNAN, Robert Bingham, Helen Ockenden, Julien Bodart, Louise Borthwick, Elizabeth Case, Knut Christianson, Andrew Hoffman, Coen Hofstedeg, Florian Koch, Tanner Kuhl, Rebecca Pearce, Nate Stevens, Paul Winberry, Ole Zeising, [Field Guides]*, [Mechanic/Drivers], [Other Field Support]

Location: Thwaites Glacier, West Antarctica

Timing: November 2022 to February 2023

More information: *https://thwaitesglacier.org/projects/ghost*

Understanding the bed of Thwaites Glacier is critical to predicting how it will evolve in the future and the consequent impacts on global sea level. The models used to make these predictions must incorporate the glacier bed, but different bed characteristics result in very different glacier responses. Hence, GHOST is a combined observation-based and modelling-based project that will examine the bed of Thwaites Glacier. We will investigate the sediment, hydrology and bedrock beneath the glacier and assess the impact of these on the glacier's dynamics.

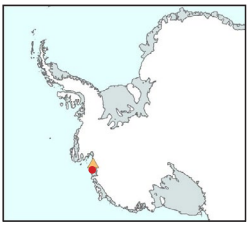
The 2022-23 field season is the first of two major field campaigns. An international team of 24 researchers and support staff will begin at the downstream end of the glacier and work steadily back upstream acquiring a number of different data sets en route, including seismic, radar and other geophysical techniques. One part of the team will use the BAS Tractor Train infrastructure, PistenBullys and containerised accommodation, the other part will mainly use snowmobiles and tents.

Input to WAIS Divide from McMurdo Station (USA) is scheduled for mid-November 2022, followed by deployment to Lower Thwaites Glacier, a roughly 60-day period of data acquisition, then uplift from WAIS Divide at the end of January 2023.

▲ *GHOST project team members getting to grips with a glacier at Sólheimajökull in Iceland during a project meeting*

Highlight project

International Thwaites Glacier Collaboration (ITGC) – TARSAN



ERIN PETTIT, Gabriela Collao Barrios, Michelle Maclennan, Emelie Mahdavian, Cecelia Mortenson, Naomi Ochwat, Meghan Sharp, Christian Wild

Location: Thwaites Glacier, West Antarctica

Timing: December 2022 to January 2023

More information: *https://thwaitesglacier.org*

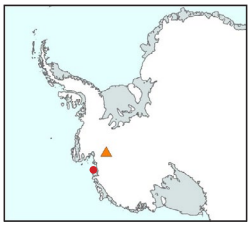
TARSAN (Thwaites-Amundsen Regional Survey and Network) is a part of ITGC (International Thwaites Glacier Collaboration), a multi-disciplinary effort led by the US and UK Antarctic programs. TARSAN has both ocean and ice components and has as its goal an assessment of regional climate, ice, and ocean conditions and processes that are governing the retreat and acceleration of Thwaites Glacier. The project combines extensive ocean data from casts, moorings, and instrumented seals. On the land ice side, the AMIGOS installations (Automated Meteorology-Ice-Ocean Geophysics Systems) measure ocean, ice, and weather conditions, with Iridium uplink for most of the acquired data. A set of geophysical surveys of two of the major ice shelves in the Amundsen Sea embayment – Thwaites Eastern Ice Shelf (TEIS) and Dotson Ice Shelf, are characterising the ice-shelf stability and sub-ice-shelf structure. The geophysical surveys include radar profiles, phase-sensitive radar vertical profiles (ApRES), seismic profiles, and detailed GPS measurements.

The first field season (2019-20) for the land-ice component of TARSAN focussed on installation of two AMIGOS stations on the TEIS, and geophysical surveys (radar and active seismic) on both the TEIS and Dotson Ice Shelf. The second season (2021-22) we visited the sites for just day trips, removed some instruments, repaired some components of the AMIGOS and resurveyed some ApRES sites. This season, we will resurvey the ApRES and radar, recover AMIGOS components (after downloading the remaining data stored in the ocean sensors), making observations of the firn column, collecting precision surface topographic data, and leave a subset of AMIGOS station in place for future monitoring. We will also conduct additional seismic surveys using Distributed Acoustic Sensing laser-stimulated fibre methods (installed as part of the AMIGOS DTS+DAS cable in the first season).

INTERNATIONAL
THWAITES
GLACIER
COLLABORATION
TARSAN

Highlight project

International Thwaites Glacier Collaboration (ITGC) – TIME



(POUL CHRISTOFFERSEN, SLAWEK TULACZYK), Robin Bolsey, Anna Broome, Lucia Gonzalez, Galen Kaip, Marianne Karplus, Manuel Moncada, Emma Pearce, Andrew Pretorius, Madeline Hunt, Tara Sweeney, TJ Young

Location: Thwaites Glacier region – Eastern Shear Margin

Timing: November 2022 to March 2023 (Season 4 of 5)

More information: *https://thwaitesglacier.org*

BAS scientists and support staff will continue working on the Thwaites Glacier this season with our partners at the US Antarctic Programme (part of NSF). Thwaites Glacier is one of the most unstable glaciers in Antarctica and the amount of ice flowing from this region (roughly the size of Britain) has almost doubled in the past 30 years. The ITGC TIME project is investigating the Eastern Shear Margin of Thwaites Glacier – the boundary between the fast-flowing ice of Thwaites Glacier and the surrounding slow-flowing ice sheet. This season is the fourth of five for the ITGC TIME project and will be the main scientific data collection season across the Eastern Shear Margin T2 site.

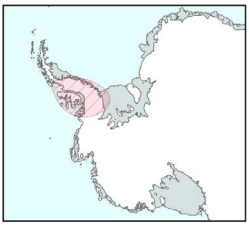
This season, 12 scientists from the US and the UK will deploy through the USAP McMurdo Research Station, travelling via WAIS Divide Camp (USAP) to reach the T2 site. The team will perform 2D and 3D seismic reflection surveys as well as radar measurements across the shear margin. This will be the first time 3D seismic reflection data have been acquired in Antarctica. The technique uses sound waves generated at the ice surface to image the structure of the ice and the sub-glacial material beneath the ice. It works much like and ultrasound scan one might have in hospital to see what is happening inside the body, but here we are giving the ice a 'health scan' to try and understand what is happening inside and beneath the ice at this crucial boundary. Radar sounding data will be collected with an impulsive low-frequency radar to provide complementary data on internal ice structures and basal conditions. If the Thwaites Glacier Eastern Shear Margin moves further east, towards the neighbouring Pine Island Glacier, the two glaciers could combine, rapidly increasing ice loss from this part of Antarctica into the surrounding oceans. The observations we make will be fed into predictive computer models to improve forecasts of future sea-level contribution from the Thwaites Glacier region.

▲ *A wireless Magseis Fairfield seismic node (sensor and data logger) deployed in a small pit at the glacier surface – several hundred of these will be deployed in a grid on Thwaites Glacier as part of the 3D seismic survey*

▲ *Example of a Poulter shot – an explosive set off at the surface of the glacier to generate sound waves, which travel into the ice and reflect of the ice-bed interface and other sub-surface layers, before travelling back to the surface, where we record them to build up our seismic image of the glacier*

Highlight project (Sledge India)

Driver and effects of fluctuations in sea ice in the Antarctic (DEFIANT)



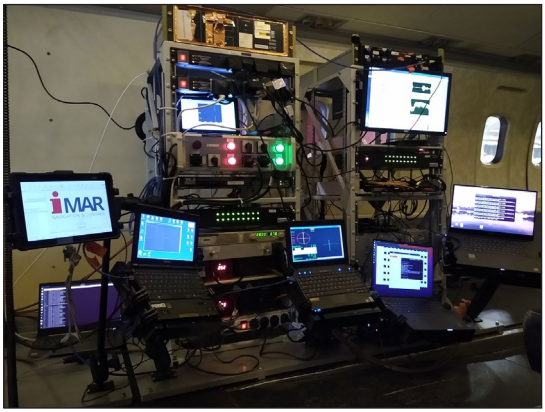
JEREMY WILKINSON, (many other co-investigators), Alberto Naveira Garabato, Andrew Shepard, [Field Guide]*

Location: Rothera, aerosurvey over Weddell Sea, RRS *Sir David Attenborough*

Timing: December 2022

The aim of the DEFIANT project is to better understand the atmospheric and oceanic processes controlling seasonal and longer-term trends in sea ice in the Southern Ocean around Antarctica. To do this we are collecting new ship, airborne, and ground-based measurements and combining these with new computer models and satellite observations to (a) identify what drove the extreme loss of sea ice in 2016, (b) ensure that these drivers are accurately represented in models, (c) predict the seasonal and longer-term evolution of Antarctic sea ice, and (d) to better understand the impacts of these extreme events. Our observational programme focuses around three distinct BAS logistics platforms, these are (i) Rothera: observations of sea ice and snow properties on local fast ice, (ii) Twin Otter/Dash 7: flights over sea ice within the Weddell Sea, and (iii) RRS *Sir David Attenborough*: sea ice and ocean observations as well as the deployment of on-ice assets.

The BAS Dash 7 aircraft hasn't flown science since the 1996-97 season where she flew magnetic and gravity surveys over the Weddell Sea. This season marks the return of the Dash 7 flying for science after over 25 year since she last flew science sensors, the Dash 7 long range capability and large 1.5m-long science equipment bay allows for the long DEFIANT science missions over the Weddell Sea to be flown. During this season the Dash 7 will stop flying passengers for two weeks while she is reconfigured and flies science missions. A wide range of science sensors including multiband 2GHz to 38GHz radar, lidar, cameras, gravimeters and radiometers will be flown.

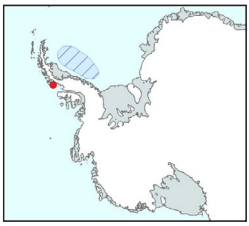


▲ *Multiple science sensor systems installed in racks on the Dash 7*

▲ *DEFIANT science sensors in the Dash 7 instrument bay*

Highlight project (Sledge Golf)

Southern Ocean Clouds (SOC)



TOM LACHLAN-COPE, (Ian Renfrew), Dan Smith, (David Topping), Floorjte van den Heuvel, Jonathan Witherstone

Location: Rothera (East Beach Hut) and flying campaign

Timing: Mid-January to mid-February 2023

More information: *https://cloudsense.ac.uk*

The overall objective of this project is to address the climate model cloud bias over the Southern Ocean and coastal Antarctic regions, thus evaluating the impact that clouds representative of the region may have on the surface radiation balance, surface mass balance, and the global climate. Determine the main sources of aerosols, Cloud Condensation Nuclei (CCN) and Ice Nucleating Particles (INP) over the Southern Ocean and Antarctica. During the 2022-23 season, in addition to taking ground-based measurements and the East Beach Hut, there will be an airborne campaign with instrumented Twin Otter (MASIN). The aims of this airborne campaign will be:

1. To determine the link between the detailed aerosol measurements taken on the ground with the microphysical properties of the clouds.
2. To investigate the role secondary ice production plays in Southern Ocean clouds. Secondary ice production is a process that allows a single ice crystal, in a relatively warm cloud (around -8°C), to start a cascade that eventually glaciates the entire cloud, affecting the lifetime of the cloud and the radiation balance.

continued ▷

▲ *Twin Otter fitted with cloud probes on each wing and turbulence probe installed on a boom*

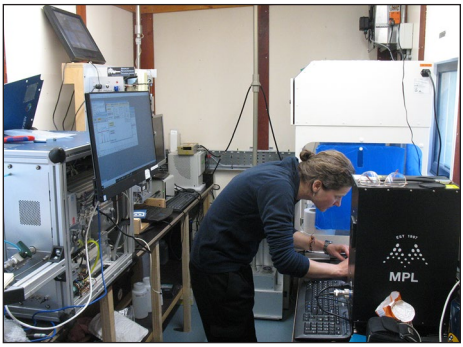
Highlight project (Sledge Golf)

Southern Ocean Clouds (SOC) continued

The Southern Ocean is an area where the biases in climate model representations of incoming solar radiation and temperatures at the surface of the Earth are larger than anywhere else – and this has a fundamental impact on the ability of these models to predict climate globally. It is thought that this is due to the poor representation of the mixed phase clouds (clouds containing both water and ice) which are typically found over these high latitudes.

The project will involve making measurements in this region over a variety of spatio-temporal scales and from various platforms (land, ship and aircraft-based). The aim is to identify the compositions and sources of the aerosols that act as cloud-forming nuclei, to improve understanding of aerosol and cloud microphysics as well as the representation of clouds in numerical models. This season we will be performing several flights over the Southern Ocean with a specially equipped Twin Otter so that we can make measurements directly inside the clouds.

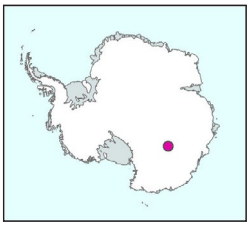
▲ *The Rothera Clean Air facility at East Beach was built in the 2021-22 season and will be measuring cloud and aerosol properties for at least four years*



▲ *The inside of the hut is full of instruments to measure the physical and chemical properties of aerosol as well as their cloud-forming ability*

Highlight project

Beyond EPICA Oldest Ice



ROBERT MULVANEY, (Carlos Martin)

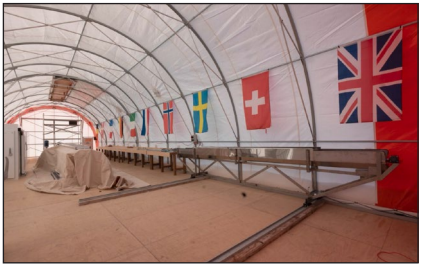
Location: Little Dome C, 40km from Concordia Station in East Antarctica

Timing: 2021-2026

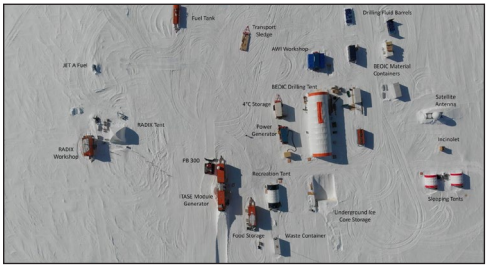
More information: *https://www.beyondepica.eu/en*

The longest record of global climate and atmospheric greenhouse gases comes from the EPICA ice-core drilling at Concordia Station. The ~3,200m deep ice core, reaching the bed of the ice sheet in 2004, gave us 800,000 years of information about climate and greenhouse gases. During this period, the global climate has cycled between cold glacial periods and warmer interglacial periods, such as the one we live in today, with a consistent period of around 100,000 years.

We recognise this as being driven by the Earth's elliptical orbit around the Sun changing the amount of energy received at the Earth's surface. But, from deep ocean sediment records, we suspect that earlier than one million years, the climate cycle was 41,000 years, linked to the tilt in the Earth's orbit, yet we are not sure why this change happened. The likely explanation lies in the levels of greenhouse gases in the earlier period, and the only way to measure these is with an even older ice-core record. The 'Beyond EPICA Oldest Ice' project is drilling a new ice core at 'Little Dome C' where we hope the ice will be as old as 1.5 million years at the bottom.



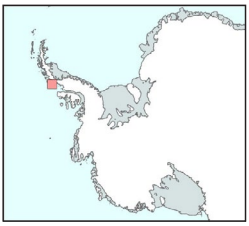
▲ *Main drill tent housing the deep ice core drill with the flags of the participant nations in this EU-funded project*



▲ *Aerial photo of the Little Dome C drilling camp*

Highlight project (Sledge Papa)

BAS Prion 3 UAS airspace integration, validation, verification and science flying



(MIKE ROSE), William Clark, (Tom Jordan), Carson McAfee, (Carl Robinson)

Location: Rothera

Timing: Early March 2023 to mid-April 2023

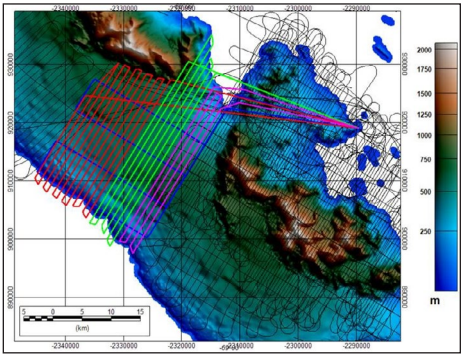
More information: *https://www.uave.co.uk/prion.php*

Uncrewed Aircraft Systems (UAS) will play an important role in allowing science data to be collected with a lower carbon footprint. UAS use considerably less fuel compared to a Twin Otter's 1,500 litres of fuel per flight. In the future, scientists will be able to collect aerial data in winter, at the Antarctic islands and previously awkward or inaccessible areas in Antarctica using various dedicated large science UAS.

Prion 3 UAS are a 3.8m wingspan platform capable of <1,000km/12-hour flights using just 6.5 litres of fuel. Scientists can fit 10kg of science sensors to collect aerial data. Prion 3 is either catapult launched on skis or takes off on wheels, and is piloted by a crew of two, one safety pilot who can take manual control and a ground station pilot who controls the flying from a computer.

The aims this season are to complete airspace integration to give BAS familiarity with large UAS operations, validate the performance and operation of the Prion 3 in Antarctica, and conduct science gravity and magnetics concept demonstration flights to enable future grants use of large UAS. Flying will start local to Rothera Research Station and progressively fly for longer and further away from Rothera.

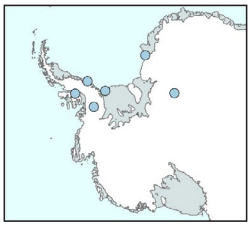
▲ *Fixed -wing unmanned aircraft system*



▲ *Prion science flying*

Field-based project (Sledge Alpha)

Annual Antarctic Automatic Weather Station servicing



(STEVE COLWELL), [BAS Met Teams]

Location: Sites along the Antarctic Peninsula and around Halley

Timing: Opportunistic throughout the season (multi-seasonal)

More information: *https://www.bas.ac.uk/project/meteorology-and-ozone-monitoring/#about*

BAS runs a network of eight Automatic Weather Stations (AWS) on the Antarctic Peninsula and in the Halley region. They are Fossil Bluff, Butler Island, Sky-Blu, Site 8, Baldrick, Halley VIa, CASLab and TT03. The BAS AWS are part of an international network of over 100 stations covering Antarctica.

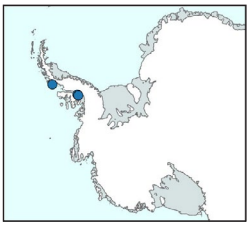
The BAS Met Team collaborates with scientists from all over the world to ensure the best possible coverage of Antarctica to meet the needs of the scientific and forecasting communities. In addition, BAS services stations for the Universities of Utrecht and Wisconsin. Data is sent via satellite link to meteorological offices around the world so that it can be used immediately for weather forecasting. As well as being vital for forecasting, the data from these stations is the very data that has provided scientists with the incredible climate statistics of the last five decades. It is therefore essential that we visit the stations as regularly as possible to ensure that this invaluable data continues to be recorded.

Every year the Rothera Met Team visits the Peninsula sites, while the Halley Met Team visit the Halley sites and Baldrick. A site visit involves collecting high-resolution data from the last year, raising the instruments and power systems above the previous year's snow accumulation, and carrying out necessary repairs and updates. A station service can typically take up to six hours. This project will be supported out of Rothera and Halley.

▲ *Servicing Butler Island Automatic Weather Station*

Field-based project (Sledge Bravo)

Long-term micro-environmental monitoring for terrestrial biology



(PETE CONVEY, KEVIN NEWSHAM), Aurelia Reichardt, [Field Guide]*

Location: Rothera Research Station (Anchorage Island), Alexander Island (Coal Nunatak, Mars Oasis), Signy Research Station

Timing: Opportunistic throughout the season

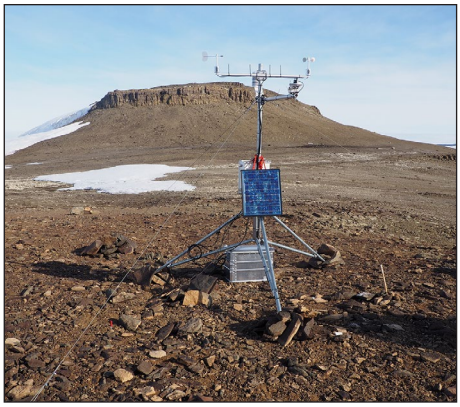
BAS has operated three terrestrial microclimate monitoring stations at sites accessed from Rothera since the mid to late-1990s and one at Signy since the early 1990s. The stations span almost the entire extent of the biological region known as the maritime Antarctic, which has been one of the fastest-warming regions of the planet over recent decades.

Routine site and equipment visits, downloading, and maintenance work, and one-off sampling requests, originally the responsibility of the Rothera Terrestrial Assistant, have been carried out by management agreement by the Bonner Lab Manager since the creation of that post – currently Aurelia Reichardt. Such visits are typically now carried out within a full 'away-day'.

All three Rothera-accessed stations have had substantial maintenance and upgrading in the last three-to-four seasons, and the Signy station has been replaced and relocated close to the station.

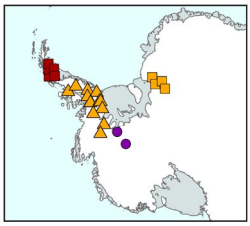
In addition to the maintenance, targeted soil/peat collections supporting NSF-NERC grant will be carried out at Signy Island, targeting the invasive midge *Eretmoptera*, from standard introduction sites immediately adjacent to station buildings.

▲ *The AWS on Anchorage Island is easily accessible by boat from Rothera Research Station. Reptile Ridge can be seen here in the background*



▲ *Coal Nunatak is on Alexander Island and only a short flight away from Fossil Bluff. The AWS overlooks King George VI Sound*

Field-based project (Sledges Charlie, Juliet, November and Zulu)



Quantifying West Antarctic mantle viscosity via precise GPS measurement of Earth's response to surface mass balance anomalies

(MIKE BENTLEY, PETER CLARKE, PIPPA WHITEHOUSE, Matt King, Anya Reading, Michiel van den Broeke, Terry Wilson, Bert Wouters), [BAS Engineers]

Location: Throughout West Antarctica

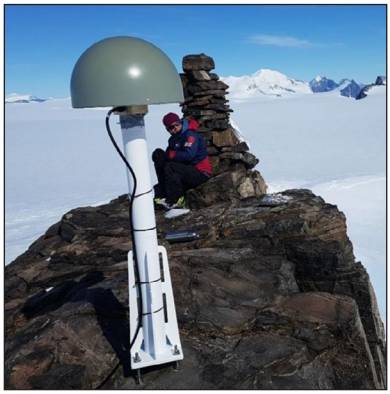
Timing: Opportunistic throughout the season (multi-seasonal)

More information: *https://ukanet.wixsite.com/ukanet*

Satellite measurements of ice-sheet change provide insight into current and future sea-level rise, but they are contaminated by a phenomenon known as Glacial Isostatic Adjustment (GIA). GIA is the ongoing response of the solid Earth to past ice-sheet change. GIA can be measured wherever we have access to bedrock, but due to the lack of outcrops across much of Antarctica, spatial variations in GIA are poorly known and we are forced to rely on mathematical models to interpret the satellite data. These models are calibrated and validated using precise measurements of Earth deformation made by continuous GPS receivers sited on bedrock.

A fundamental property that must be quantified within the models is the rheology of the solid Earth (how it behaves when a surface load is applied). The Earth's mantle displays viscous behaviour over long timescales, but it behaves elastically in the short term. Recent studies have identified large spatial variations in mantle viscosity across Antarctica, but at present the magnitude of such variations is not known. We are pioneering a new approach to determining spatially-variable mantle viscosity that involves analysing the GPS-measured viscoelastic response of the solid Earth to episodic surface mass balance (SMB) anomalies across Antarctica.

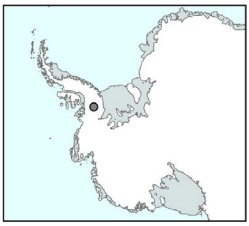
▲ *Preparing to upgrade the instruments and power supply at Welch Mountains, Antarctic Peninsula*



▲ *GPS monument and antenna at Traverse Mountains, Antarctic Peninsula*

Field-based project (Sledge Delta)

Mars analogue prototype environmental monitoring equipment for testing Mars mission operation



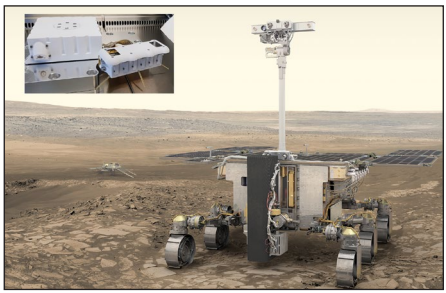
(JAVIER MARTIN-TORRES, PETER CONVEY, MERVYN FREEMAN), [BAS Engineers]

Location: Sky-Blu Field Station

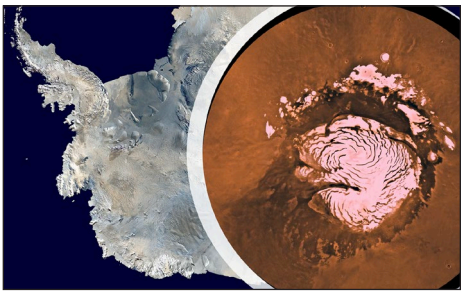
Timing: Opportunistic throughout the season

The Department of Planetary Sciences at the University of Aberdeen is focused on the study of the Moon, Earth and planetary sciences and the development of space and environmental instruments. The team is part of current and future missions to Mars such as Curiosity, ExoMars TGO, ExoMars Rover, ExoMars Surface Platform and Perseverance. The Department is leading a project sending the instrument HABIT (HAbitability: Brine, Irradiation and Temperature) on a mission due to land on Mars and generate data from the planet. The HABIT project is funded by the UK Space Agency. The Department is running in parallel an educational program that started in September 2021. The HABIT research and outreach activities will be disseminated through the web page of the group, and the communication pages of the Space Agency/Agencies responsible of the mission where HABIT will be hosted.

The current OSPQ is to support installation and operation of a 'standalone' equivalent HABIT instrument at Sky-Blu in the 2022-23 season, building on long-standing recognition that Antarctic environmental conditions provide the closest analogue for Martian conditions available on planet Earth (namely hyper-arid, cold environment, with negligible biological aerial dispersal and minimal liquid water activity levels throughout the year). This would be configured to return data by an Iridium antenna, with a direct download each season as a backup option. Continual operation from summer 2022-23 would allow identification of any major issue or required update which could if needed be addressed in the 2023-24 season. The operation would then continue through the 2024 austral winter in order to operate it during same time that the instrument will be operated on Mars. The instrument would be installed at Sky-Blu in a suitable location to avoid snow coverage (e.g. on top of an existing structure, or on one of the locally accessible small nunataks) by a member of Mervyn Freeman's team who is scheduled to pass through Sky-Blu in order to install a magnetometer further south as part of BAS programme work. The Aberdeen instrument also includes a magnetometer.



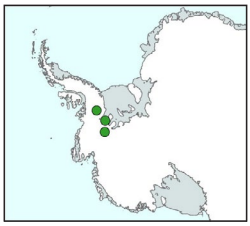
▲ *HabitAbility: Brine Irradiation and Temperature instrument*



▲ *Antarctica is closest analogue for Martian conditions available on Earth*

Field-based project (Sledge Echo)

Interglacial collapse of the West Antarctic Ice Sheet revealed by subglacial drilling (INCISED)



MIKE BENTLEY, (Rob Mulvaney), [Field Guide]*

Location: Behrendt Mountains, Haag Nunataks and Northern Ellsworth Mountains

Timing: Early January to early February 2023

The aim is to test the hypothesis that the West Antarctic Ice Sheet (WAIS) has collapsed, perhaps multiple times, in past interglacial periods. This will be done by retrieving rock cores from bedrock located beneath the ice sheet and analysing this rock for cosmogenic isotopes that are only produced when the rock has been exposed to the atmosphere. Using a combination of innovative drilling technology, sophisticated chemical analysis and computer modelling I will show if, when, and how often the WAIS has collapsed during warmer periods in the past, and provide estimates of the sea-level contribution each time.

▲ *Ice radar system at Leverett Glacier, Greenland with pulks containing radar transmitter and receiver. Green 'hoses' are the radar antennas*

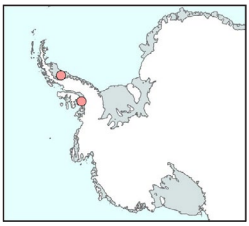
Field-based project (Sledge Foxtrot)

Sub-ice-shelf boundary-layer experiment (SIBLEX)

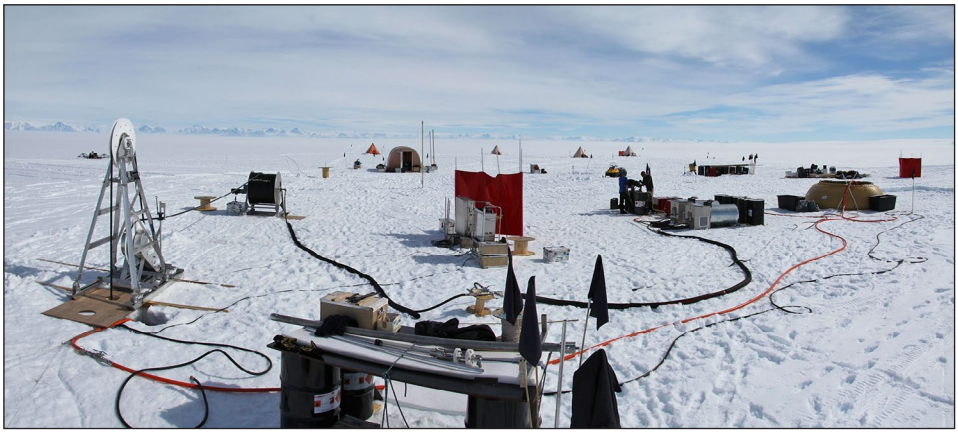
(KEITH NICHOLLS), [BAS Engineers]

Location: Larsen C Ice Shelf

Timing: Final season



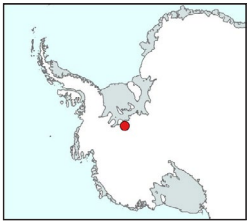
Instruments were originally deployed beneath Larsen C and George VI Ice Shelf as part of a grant-funded project. The aim was to provide data from the ice-ocean boundary layer in an attempt to characterise the dynamics of the layer beneath two different ice shelves. Data were successfully collected for the year of the experiment, but the secondary aim was to continue the time series as long as possible to monitor the oceanographic conditions beneath the ice shelves. We are now in a position where most of the instruments have finally failed, and so the aim this season is to clear the site, recovering the batteries, data logger, cabling and site markers.



▲ *The BAS ice shelf hot-water drill, as used during the deployment of instruments on Larsen C and George VI Ice Shelves*

Field-based project (Sledge Hotel)

Testing smaller-than-present configurations of the Antarctic Ice Sheet using a novel integration of geochronology



DAVID SMALL, Thomas Lees, Stephan Trabucatti, [Field Guide]*

Location: Ellsworth Mountains

Timing: Mid-December 2022 to end of January 2023

The Antarctic ice sheets are losing mass at an increased rate meaning they are heading to a smaller-than-present configuration. To understand how such a configuration is reached it is vital to understand ice-sheet behaviour in the past when they were smaller-than-present. This project will collect subglacial samples from a key region of West Antarctica, the Weddell Sea, where previous work suggests the ice sheet has undergone recent change. Specifically, that the ice sheet has expanded over the last few hundreds of years following a period where it was smaller-than-present.

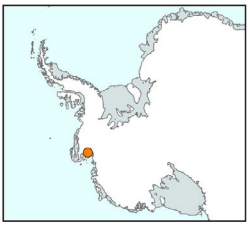
This project will use a portable drill system to drill through ice close to present-day mountains that protrude above the ice sheet. Over two Antarctic field seasons the drill will be used to collect a series of subglacial rock cores. A novel combination of geochronological methods will be employed to establish if the rock has previously been exposed due to the ice sheet being smaller. Combining different techniques improves the constraints that can be obtained; thus not only can it be established if the ice sheet was smaller in the past but also when, and for how long, this was the case.

▲ *The Winkie Drill set up during training at the US Ice Drilling Programme warehouse, Madison, Wisconsin in February 2022*

▲ *The Winkie Drill set up for use in the Ohio Range, West Antarctica during its first season with the US Ice Drilling Programme in 2016/17*

Field-based project (Sledge Kilo)

Subglacial bedrock recovery drilling in the Hudson Mountains, West Antarctica



(JOANNE JOHNSON), Scott Braddock, Elliot Moravec, Keir Nichols, Ryan Venturelli, Dominic Winksi

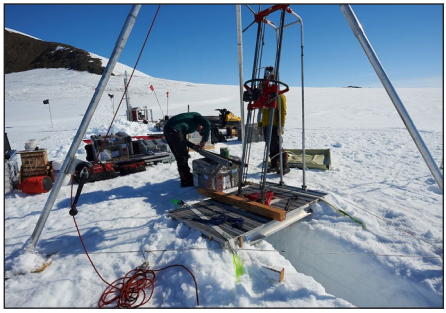
Location: Winkie Nunatak, Hudson Mountains

Timing: Late December 20022 to early February 2023 (5 weeks)

More information: *https://thwaitesglacier.org/projects/ghc*

As part of the US-UK International Thwaites Glacier Collaboration, the Geological History Constraints team are travelling to Winkie Nunatak in the Hudson Mountains to study the history of Pine Island Glacier. Winkie Nunatak sits next to Pine Island Glacier, a large ice stream that is, along with Thwaites Glacier ~200km to the west, retreating quickly and adding to global sea-level rise.

Whilst some of Winkie Nunatak is ice-free and pokes up above the Antarctic Ice Sheet, part of the mountain extends beneath ice of the Thwaites-Pine Island catchment. The team will use ground-penetrating radar to find the ridge where it extends beneath the ice sheet and will drill through about 40-60m of ice to collect cores of bedrock. By measuring a range of isotopes in the cores, we will be able to tell if Pine Island Glacier was ever smaller than it is at present in the last few thousand years, and when. This will place the ongoing thinning and retreat of Pine Island Glacier into context and help to determine if it may be reversible.



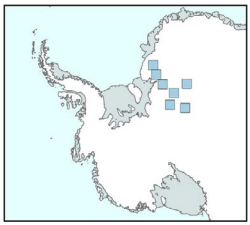
▲ *The US Winkie rock drill, in use at Mt Murphy, near Thwaites Glacier, in the 2019-20 season*

▲ *A core collected with the Winkie rock drill at Mt Murphy (in the 2019-2020 season) being inspected in the field by Brent Goehring*

Field-based project (Sledge Lima)

Low power magnetometer servicing

(MIKE ROSE, MERVYN FREEMAN), [BAS Engineers]



Location: Polar plateau

Timing: Throughout the season

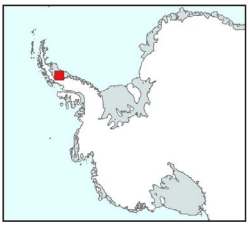
The Low Power Magnetometers (LPMs) operate unmanned all year round, including the long winter, when continuous periods of darkness and temperatures as low as -80°C prohibit human intervention. This has been made possible by new technology which allows the magnetometers to use very little power and survive the winter on solar power stored during the summer. The network measures magnetic fluctuations over a wide area. The data can be used to produce maps of space weather in the region around the Earth where satellites orbit.

Information is recorded by the instrument and removed once a year during servicing. This project will be supported out of Halley and Rothera.

▲ *BAS scientist checking the solar power unit for one of the remote low power magnetometers*

Field-based project (Sledge Quebec)

Rift propagation for ice-sheet models (RIPICE)



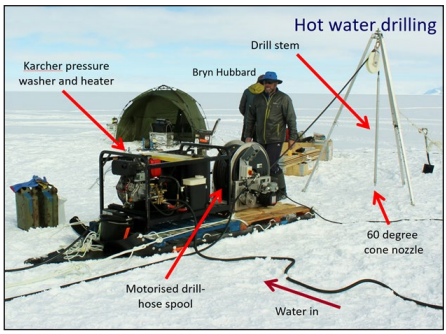
ADRIAN LUCKMAN, (Stephen Cornford, Eduard de Souza Neto), Bryn Hubbard, Glenn Jones, Bernd Kulessa, Katie Miles, [Field Guide]*

Location: Larsen C Ice Shelf

Timing: November to December 2022

Modelled projections of the contribution of the Antarctic ice sheets to sea-level rise over this century vary from a few centimetres to more than one metre – a huge uncertainty which undermines the credibility of sea-level rise projections. The reasons for this uncertainty lie in the treatment of ice shelves – the floating extensions of ice sheets which constrain the flow of ice from the interior to the ocean. Assuming that ice shelves will disintegrate leads to a much higher estimate of ice discharge than assuming they remain in place. No forecast so far, however, has included the processes of ice fracture and rift propagation that led to ice-shelf disintegration. These processes disrupt the normal assumptions of continuity inherent in ice-sheet models and are highly dependent on the heterogeneous nature of ice shelves. We will overcome this fundamental limitation in sea-level rise projections by explicitly representing heterogeneity in ice shelves and pioneering the inclusion of rift processes in an ice-sheet model. We will meet these challenges by collecting new field and satellite data to quantify ice-shelf heterogeneity and developing a fracture physics approach to simulate rift propagation.

During a field program in 2022-23, we will collect geophysical data from the Joerg Peninsula suture zone – a zone of warmer ice which currently prevents existing rifts from propagating across the ice shelf. Our field methods will include surveys of surface radar, seismic reflections, and passive seismic activity, and we will drill boreholes to directly investigate and instrument ice several hundred metres below the surface. RIPICE will enable a new generation of ice-sheet models to achieve a step-change improvement in quantifying and reducing uncertainties in sea-level rise projections.

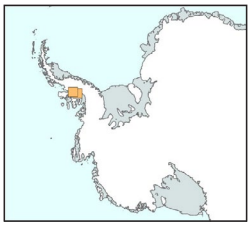


▲ *Drilling system on Larsen C Ice Shelf, 2014. The RIPICE system will be similar*

▲ *Drill water production*

Field-based project (Sledge Romeo)

Ice-shelf instability caused by active surface meltwater production, movement, ponding and hydrofracture



ALISON BARNWELL, Becky Dell, (Doug MacAyeal, Laura Stevens), Ian Willis, [Field Guide]*

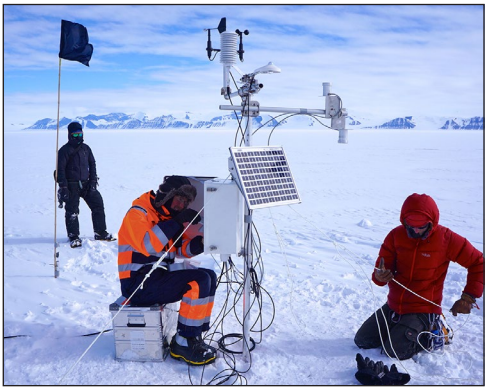
Location: George VI Ice Shelf, Antarctic Peninsula

Timing: Early November to Early December 2022

The evolution of surface and shallow subsurface meltwater across Antarctic ice shelves has important implications for their (in)stability, as demonstrated by the 2002 rapid collapse of the Larsen B Ice Shelf. It is vital to understand the causes of ice-shelf instability because ice-shelf buttressing controls inland ice discharge, and therefore contributions to sea-level rise. Ice-shelf break-up may be triggered by stress variations associated with surface meltwater movement, ponding and drainage, causing ice-shelf flexure and fracture.

This four-year project will provide key geophysical observations on the George VI Ice Shelf (GVIIS) of the Antarctic Peninsula, where hundreds of surface lakes form each summer, that will improve understanding of ice-shelf meltwater and its effects on (in)stability. Over a 27-month period (late 2019 to December 2022), global positioning systems, water pressure transducers, Automatic Weather Stations, and in-ice thermistor strings are being deployed to record ice-shelf flexure, water depths, and surface and subsurface melting, respectively, in and around several surface lakes, within ~30km from BAS's Fossil Bluff Station. Field data will be used to validate and extend the team's existing approach to modelling ice-shelf flexure and stress, and possible 'Larsen-B style' ice-shelf instability and break-up.

▲ *Meltwater lakes on George VI Ice Shelf in January 2020*

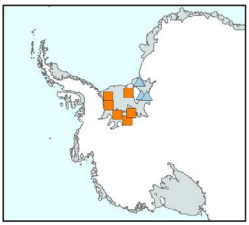


▲ *Installing an automatic weather station on the George VI Ice Shelf in November 2019*

Field-based project (Sledges Sierra and Tango)

Melt rates over Ronne Ice Shelf

(KEITH NICHOLLS), [BAS Engineers]*



Location: Filchner-Ronne Ice Shelf

Timing: Opportunistic throughout the season

This is a continuation of an activity in support of Shelf Seas NC-SS. During the Filchner Ice Shelf System (FISS) project, 14 ApRES were sited at carefully selected locations over the Filchner-Ronne Ice Shelf in order to monitor time series of basal melt rates. These devices are downward-looking radars that are able to detect the basal melting of the ice shelf at time scales of oceanographic interest. This provides us with an indication of the oceanographic processes active beneath the ice shelf, without going to the time and expense of drilling an access hole and deploying expensive instrumentation. When the FISS project ended, five of the sites were selected for long-term monitoring, yielding information about the way the sub-ice shelf cavity responds to external oceanographic forcing from the ice front. In addition, ApRES are being maintained at three sites where boreholes were made to deploy sub-ice-shelf ocean instrumentation: Site 5a, and at two sites on the northern Filchner Ice Shelf, sites FNE1 and FNE3.

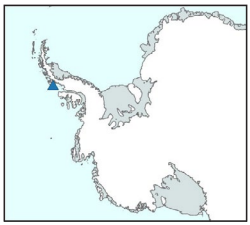
▲ *Measuring melt rates on the Ronne Ice Shelf*

Field-based project (Sledge Uniform)

Minimum snow-cover aerial survey of Rothera Point

NATHAN FENNEY, Connor Bamford

Timing: March to April 2023



The last complete aerial survey of Rothera Point was undertaken back in March 2019. With the rapid pace of development at Rothera there is a significant requirement to collect up-to-date high -resolution aerial imagery of the station. Due to snow cover, the data ideally needs to be collected between the beginning of February and the middle of March each year.

Unlike previous surveys which were conducted from a Twin Otter aircraft, this survey will be undertaken using a fixed-wing remotely-piloted aerial system (RPAS), specifically the SenseFly eBee X. The eBee X was deployed south for the first time during last season as part of a Darwin Plus project to undertake a baseline reference survey of key indicator species across South Georgia.

The 1.2m-wide delta wing design has an endurance of up to 90 minutes and is flown autonomously. The autonomous nature of its operation allows the platform to operate 'beyond visual line of site' (BVLOS) at much greater distances from the pilot.

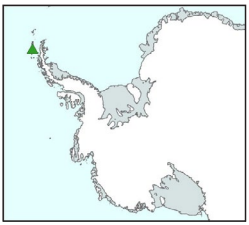
There are a number of secondary objectives for the project, including collecting imagery of the traverse, ski-way and McCallum Pass to support operational activities in the area and to conduct an aerial survey of the ramp as part of the long-term monitoring programme.

▲ *SenseFly eBee X, Hound Bay, South Georgia*

▲ *Launching the eBee X at Hound Bay, South Georgia*

Field-based project (Sledge Whiskey)

The past, present and future of snow algae in Antarctica: a threatened terrestrial ecosystem?



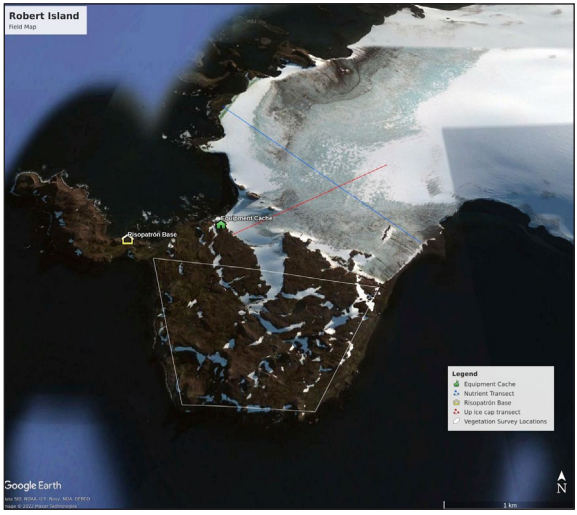
(PETE CONVEY), MATTHEW DAVEY, (Claudia Colesie, Andrew Fleming, Peter Fretwell), Andrew Gray, (Lloyd Peck, Alison Smith), Alex Thomson, Charlotte Walshaw

Location: Nobert Island, Nelson Island, Frei Station

Timing: December 2022 to February 2023

Snow algae live on snow fields in Antarctica and may well be the most abundant primary producers in these regions. Despite their ecological importance, our knowledge of their distribution and growth is limited to a few locations. This project will use satellite imagery, coupled with field measurements to estimate the area and biomass contributed by snow algae blooms. The aim of this NERC standard grant awarded to Dr Davey (PI) is to carry out detailed sampling of the blooms during a full season at one location, measuring variation at a seasonal, altitude and nutrient gradient scale. If our findings are proven typical of wider Antarctic terrestrial communities, it will challenge current thinking of how primary productivity is achieved in this region.

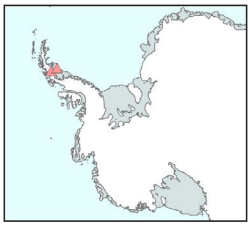
Our fieldwork requires a large snow algae bloom over which to take hyperspectral imagery. The largest identified in satellite imagery is on Robert Island (near KGI). We will conduct work on the Northern aspect (-62.36, -59.67) of Robert Island in 2022-23, arriving December 2022 and leaving end of February 2023. We will be based out of Refugio Luis Risopatrón on Robert Island. We will carry out drone imagery of the location, looking at blooms and other vegetation at a nutrient and altitude gradient. We will also take samples for metabolite and genomic analysis and measure photosynthetic rates of the vegetation over the season.



▲ *Robert Island field map*

Field-based project (Sledge X-ray)

State and fate of Antarctica's gatekeepers, a high resolution approach for ice-shelf instability (HiRISE)



(BERT WOUTERS), Paul Smeets, (Carleen Tijm-Reijmer), [Rothera Met Team]

Location: Larsen Ice Shelf

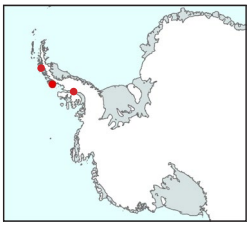
Timing: November 2022

Mass loss from the Antarctic Ice Sheet is the largest uncertainty in current sea-level rise projections and this uncertainty is largely related to the response of ice shelves. Ice shelves are the gatekeepers of Antarctica as they buttress the contribution of grounded ice to sea-level rise. Although several processes have been identified that are key for future ice-shelf instability and retreat, assessing how much, how fast ice-shelf instability will contribute to future sea-level rise remains a major uncertainty that hampers coastal protection policies in The Netherlands and abroad.

The HiRISE consortium, consisting of TUDelft, IMAU, KNMI, NIOZ and ULB and led by junior scientists, aims to develop high-resolution remote sensing and modelling approaches to assess ice-shelf weakening. The results of the different models and remote sensing indicators will be merged in future projections of Antarctic mass loss and translated into sea-level rise to quantify the observationally constrained impact of Antarctic ice-shelf instability in a future changing climate. During the upcoming 2022-23 season, in-situ measurements dedicated to monitor the surface mass balance for WP1 will be installed at Larsen C at two locations.

▲ *iWS18 at Cabinet Inlet*

Field-based project



Environmental management visits to Antarctic Specially Protected Areas managed by the UK

(KEVIN HUGHES), Aurelia Reichardt

Location: Marguerite Bay: Avian Island, Emperor Island; Green Island, Berthelot Island, Ablation Valley and Ganymede Heights

Timing: Opportunistic throughout the season

More information: *https://www.bas.ac.uk/about/antarctica/environmental-protection/special-areas-and-historic-sites-of-antarctica/antarctic-protected-areas-proposed-by-the-uk*

The Antarctic Protected Areas System comprises 75 Antarctic Specially Protected Areas (ASPA) and six Antarctic Specially Managed Areas (ASMAs) distributed across the continent. The UK is the proponent, or managing Antarctic Treaty Party, for 13 ASPAs and one ASMA (ASMA No. 4 Deception Island). Under Annex V to the Protocol on Environmental Protection, managing Parties must commence the review of ASPA and ASPAs and ASMAs management plans every five years, including environmental management visits to these locations to inform the review. Several ASPAs, for which the UK is the proponent, need to be visited in the next two-to-three years on behalf of the FCDO. These are mostly clustered around Marguerite Bay, but there are also a few in other locations (the date that the management plans revision has to be submitted to the CEP/ATCM is provided in brackets).

- Marguerite Bay: ASPA 117 Avian Island (2023); ASPA 107 Emperor Island (2023)
- Others: ASPA 108 Green Island, Berthelot Island (2023); ASPA 147 Ablation Valley and Ganymede Heights (2023)

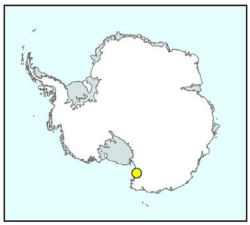
Recent work by the Committee for Environment Protection has identified Signy Island as an International Bird Area, with one of the highest concentrations and greatest diversities of avifauna in Antarctica. As such it is considered one of the most appropriate locations in Antarctic for designation as an ASPA to protected wildlife. Added to this, the vegetation is extremely diverse and merits protection. It would be useful to visit the island a some point to make preparations for the development of a new ASPA that take into consideration the needs of all stakeholders.

There is also the need to erect some ASPA signs on Lagoon Island and Leonie Island (ASPA 177).

▲ *Lagotellerie Island, Marguerite Bay (ASPA 115)*

Field-based project

Hot-water drilling on Nansen Ice Shelf



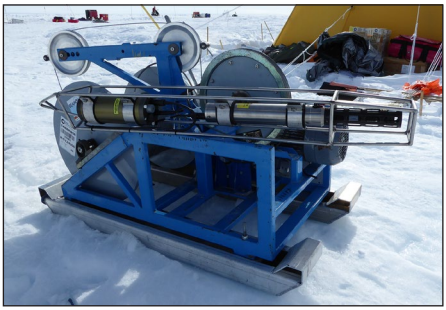
(KEITH NICHOLLS), Pierre Dutrieux, Keith Makinson, Scott Polfrey

Location: Nansen Ice Shelf

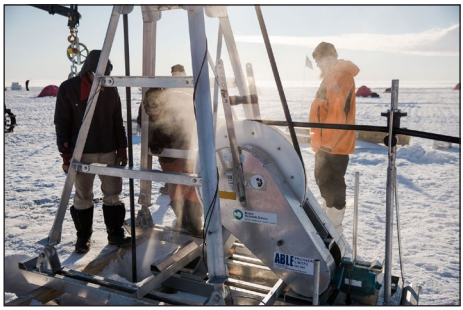
Timing: November 2022 to February 2023 (two-to-three weeks on the ice shelf in December)

The interaction between Antarctic ice shelves and the Southern Ocean is an important part of the climate system. Conversion (cooling and freshening) of water masses beneath ice shelves affects the ocean climate, particularly in the deep ocean; and the changing thickness of ice shelves resulting from changes in the rate at which the ocean melts them at their base has an influence on the degree to which they can 'buttress' the grounded ice sheet. A reduction in buttressing will tend to increase the contribution of the ice sheet to global sea level.

The aim of the project is to visit Nansen Ice Shelf, a small ice shelf in the western Ross Sea, make an access hole using a hot-water drill, and deploy an ocean instrumentation in the water column beneath. Downward-looking radars (ApRES) will be installed at the ice surface to measure the melt rate. Although important aspects are to test a new hot-water drill, train Korean colleagues, and to trial instrumentation to be used in 2023-24 under Thwaites Ice Shelf, we will also be studying the influence a basal channel has on the rate the ocean melts the ice in this, an oceanographically cold ice-shelf setting.



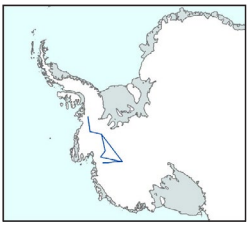
▲ *CTD oceanographic profiler resting on its winch. Used to measure vertical profiles of salinity and temperature beneath the ice shelf*



▲ *Hot-water drill on Filchner Ice Shelf*

Field-based project

Ops Traverse



Ops: ROB GRANT, Nick Withey, George Allison, [Field Guide]*
GHOST: CATRIN THOMAS, David Jameson, Matthew Shepherd, Pete Young, Julie Baum*

Location: West Antarctica

Timing: October 2022 to February 2023

The BAS Tractor Traverse, consisting of a convoy of PistonBulley 300s and various cargo and fuel sledges as well as mobile living cabooses, will be conducting a logistics and science traverse in support of numerous projects and crucially the International Thwaites Glacier Collaboration (ITGC) between the United States Antarctic Program (USAP) and BAS.

All the various traverse assets will traverse from their current overwinter position at SB9(b) at the base of the Peninsula down through Castle to WAIS Divide in West Antarctica. Here the traverse will split into two independent traverse platforms. One will continue as the BAS Ops Logistics Traverse while the other will become the GHOST Traverse and provide a travelling science traverse platform for GHOST, part of ITGC. The BAS Ops traverse will then continue on to LTG, providing further safety support for GHOST, raising various depots and supporting the wider ITGC collaboration. Thereafter the traverse will return via WAIS Divide and TIME sites raising and moving cargo and fuel as necessary before heading north towards SB9(b) and Sky-Blu. Here the many hundreds of tonnes of uplifted cargo will be positioned on berms ahead of the next ship call so as to remove said cargo from the continent and mark the completion of various projects.

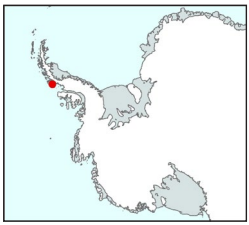
This season the BAS Ops traverse will cover in excess of 3,000km over a period of around three months (~100 days in field) with a core team of four personnel.

▲ *PistenBullys pulling loads across the ice*

Rothera Research Station

Aliens in the polar region

STEF BOKHORST, (Pete Convey, Hans Cornelissen)



Location: Rothera, Anchorage Island

Timing: January to February 2023

A lot of effort and money is being spent on limiting alien invasions and eradication and mitigation programs in the Arctic and Antarctic regions. Given the ever-increasing anthropogenic activities and ongoing rapid climate warming in parts of the Polar Regions, it is unavoidable that alien species will reach these ecosystems, as some already have. However, we currently do not know what the impacts of these species will be for polar terrestrial ecosystems, despite the vital roles and services these ecosystems play in regional and global processes. In this proposal, we aim to quantify and measure the impact of alien species on Arctic and Antarctic terrestrial ecosystems.

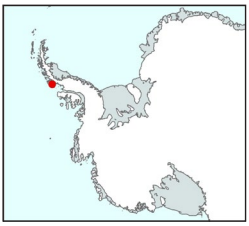
This knowledge will add focus and impetus for efforts to restrict alien species from reaching the polar regions, and in particular those biological groups with the largest ecosystem impacts. Furthermore, we recognise that there are both native and alien species whose ecosystem contribution can facilitate the invasion success of other new arrivals, for instance by providing shelter (e.g. tall shrubs) or nutrients (e.g. penguins). Identifying such 'invasion engineers' and their roles will greatly help in pin-pointing and identifying particularly vulnerable areas where alien species are likely to be successful, and provide key data on the functioning of polar ecosystems.

▲ *An artificial 'invasive species' deployed on Anchorage Island to monitor its affects on the surrounding ecosystem*

Rothera Research Station

Annual Rothera Ramp survey

ANDY SMITH, [Rothera Science Coordinator and Field Guide*]

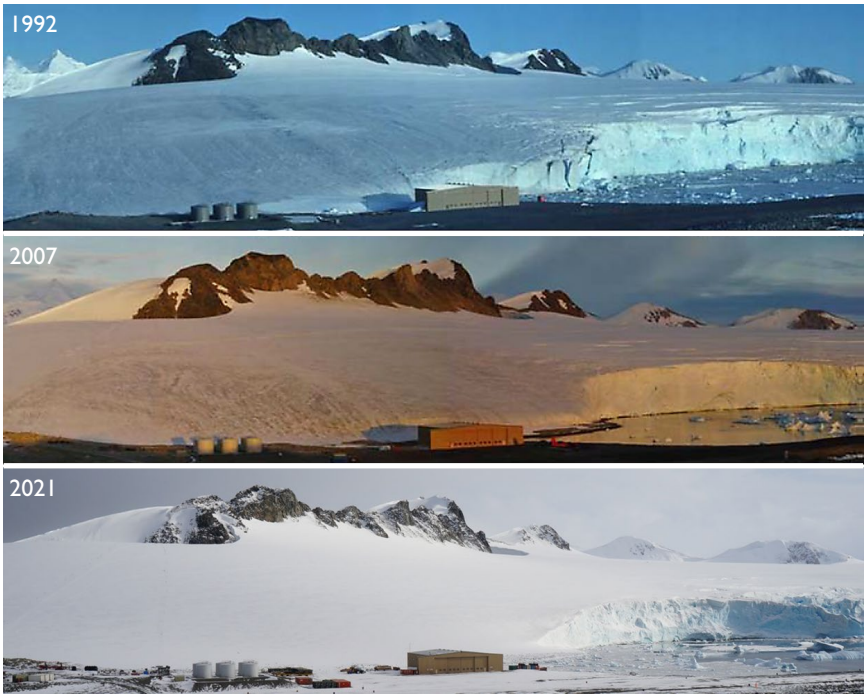


Timing: February or March 2023

The ice ramp at Rothera is disappearing before our eyes! At the end of every summer the surface profile of the ramp is surveyed to see how much it is changing. Over the past 30 years the bottom has gone back well over 100m, and has lowered by almost 20m. The top hasn't changed much, which means that the ramp is slowly getting steeper.

A comparison of photographs taken between 1992 and 2021 is interesting. The survey line is located well to the left of the fuel farm, but the most striking change seen in the photographs is behind and right of the hanger; high ice cliffs in 1992 had become a nice gentle slope by 2021.

The ramp is affected by the Antarctic Peninsula's regional climate. We can compare the amount of ice that melts each year with the Rothera Met data and it correlates well with air temperature. More ice is lost in warmer years, but occasionally there'll be a cooler year and the ramp actually thickens slightly. This long-term co-location of ice measurements and Met records is probably unique, so it's a valuable data set for studying actual ice changes under a changing climate.



▲ *The changing face of The Ramp at Rothera from 1992 (top), to 2007 (middle) and 2021 (bottom). The bottom of the ice has retreated well over 100m*

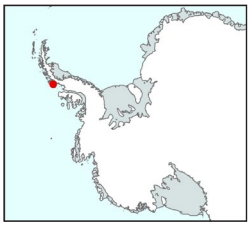
For more information, please visit: **www.bas.ac.uk**

Rothera Research Station

Assessment of Antarctic colonisers across a depth gradient

NADIA FRONTIER, SIMON MORLEY, (Ben Robinson)

Timing: June to October 2022

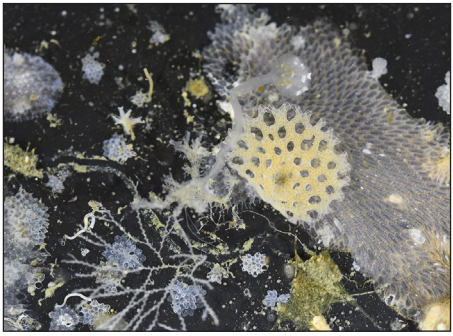


DEBRA, short for Deep Environment Benthic Research Apparatus, is a Remotely Operated Vehicle (ROV) and an extremely useful tool to operate at depths inaccessible to divers. This project aims to collect samples in the form of settlement panels and rocks to assess the colonisation of sessile invertebrates across a four-year period across a depth gradient; 30, 60 and 100m. A comparison can be made between species that settle on artificial substrates compared to natural substrates.

Samples are directly processed in the Bonner laboratory and species are identified to the highest taxonomic resolution. This is fascinating for small animals such as bryozoans. Bryozoans are a simple invertebrate, living in sedentary colonies. The colonies operate together and cooperate to perform basic life functions. The shape of the body wall and certain features varies between species and must therefore be identified under a microscope once dried. Some colonies can be aged using concentric rings where growth is ceased seasonally and then restarts again.

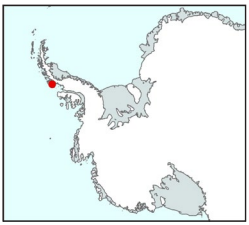
This project will provide unique dataset across a large temporal scale. In situ experiments are subject to a high frequency of iceberg impact in the shallows, but experimenting at deeper depths with the assistance of an ROV, opens the avenue to new research questions.

▲ *Deploying the ROV from small RIBs requires practice and coordination*



▲ *Multiple species of bryozoans forming colonies on a recovered settlement panel*

Rothera Research Station



Biological long-term monitoring – IBIS (Iceberg impact study)

(DAVID BARNES), Hollie London, Emma Stuart, [Rothera Marine Team]

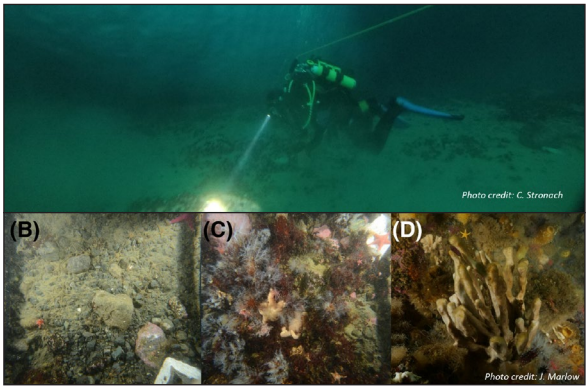
Timing: Ongoing

Since the austral summer of 2002-03, BAS has monitored the shallow seabed adjacent to Rothera Research Station. There are three grids of 25 concrete markers at each of 5, 10 and 25m on the seabed of South Cove, which are surveyed annually in December by the Rothera Marine Assistant. Each block that is hit is noted and replaced, so we have a detailed history of disturbance of the seabed for nearly 20 years. Linked to the Rothera oceanographic Time Series (RaTS) this is a powerful tool to investigate climate, ice and biology in the polar shallows.

It is one of the longest, continually-monitored areas for disturbance anywhere in the global ocean. Initially it allowed us to investigate how often the seabed was hit by icebergs and what impact this had on megabenthos. Crucially it was found that the duration of seasonal sea ice (fast ice) cover was related to how often the seabed was pummeled by icebergs. Sea ice is changing drastically in both Polar Regions and Rothera is in the hotspot of sea-ice losses in time and space – what does this mean for life on Antarctica's seabed?

Researchers at the Argentinian research station of Carlini (formerly Jubani) became interested and, collaboratively working with BAS, set up a series of similar iceberg scour monitoring grids at King George Island.

Life in the Polar Regions is thought to be vulnerable to even small changes, and the coastal shallows are the fastest-changing part. Onward monitoring of the Rothera iceberg grid (IBIS) together with that at Jubani should prove to be an important part of the toolset to enable us to understand the wider picture of how the many aspects of climate changes holistically influence life at the far ends of our planet.

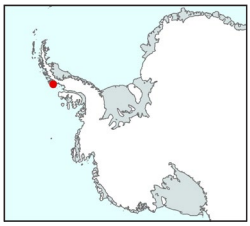


▲ *Impact of icebergs and stages of recovery: Photos show (A) a grounded iceberg frozen immobile in the sea-ice and the state of benthic communities (B) immediately after impact, (C) 11 years post-impact and (D) sheltered from ice-scouring impact*

Rothera Research Station

BRUV (Baited Remote Underwater Video)

MELODY CLARK, SIMON MORLEY, LLOYD PECK,
[Rothera Marine Team]



Timing: Ongoing

More information: *https://www.gov.uk/government/publications/the-blue-belt-programme*

https://www.uwa.edu.au/news/article/2021/april/worlds-largest-ocean-monitoring-protects-marine-biodiversity

We are partnering with the UK Government Blue Belt program's Global Ocean Wildlife Analysis Network, deploying BRUVS in the British Antarctic Territory (BAT). We hope that BRUVS will add an additional capacity to our research, allowing us to monitor the animals living in the surface waters. We hope to add this missing information to the monitoring of the near shore marine environment in Ryder Bay that has been conducted for more than 20 years.

The duration of winter sea-ice cover in Ryder Bay is extremely variable, with the overall warming trend recorded on the Western Antarctic Peninsula since the 1970s affecting winter sea-ice duration. Mid-ocean research cruises have been monitoring krill and fish populations further north in the Southern Ocean for many years and have shown marked reductions in krill numbers. The early life stages of krill rely heavily on algae living on the underside of the sea ice for food and so changes in the winter sea ice are expected to have a marked effect on krill populations. We want to use BRUVS to learn how the annual variation in oceanography and sea ice affects these species.

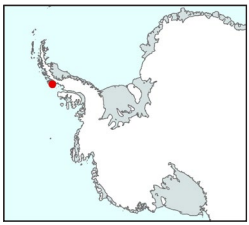
The value of life in the oceans is increasingly being recognised, not just for the intrinsic value of biodiversity, but for the key ecosystem services it provides to human society. One of the emerging questions is to better understand how healthy marine ecosystems capture carbon from the atmosphere and store it into the seafloor. Partnering with Blue Belt and the University of Western Australia will allow us to investigate specific questions about the pelagic marine system in Ryder Bay.

Being part of this global network gives us an excellent opportunity to compare different oceans and understand more about our changing oceans.

▲ *A BRUV (Baited Remote Underwater Video) system being assembled on the boat for deployment*

▲ *View of the bait box underwater. Notice the notothenioid fish in the right bottom corner*

Rothera Research Station



Comparative survey of shallow soft-bottom benthic communities in Ryder Bay

(DAVE BARNES, LLOYD PECK), ADRIANA GILES, SIMON MORLEY

Timing: November 2022 to March 2024

More information: *https://www.bas.ac.uk/data/our-data/publication/spatial-and-temporal-dynamics-of-antarctic-shallow-soft-bottom-benthic-communities*

Marine soft sediments are some of the most widespread habitats in the ocean, playing a vital role in global carbon cycling, but are amongst the least studied with regard to species composition and ecosystem functioning. This is particularly true of the Polar Regions, which are currently undergoing rapid climate change, the impacts of which are poorly understood. Compared to other latitudes, Polar sediment habitats also experience additional environmental drivers of strong seasonality and intense disturbance from iceberg scouring, which are major structural forces for hard substratum communities.

Soft sediment assemblages around Ryder Bay will be surveyed in both South Cove and Hangar Cove at various depths. Animals and algae will be identified, counted and both skeletal and organic mass converted into mass of carbon. Sediment cores will be collected to estimate the depth at which carbon is sequestered. This information will be compared to data collected 10 years ago and will be used to improve estimates of carbon storage and sequestration along the Antarctic Peninsula.

The loss of ice and retreat of glaciers is opening up new habitats for benthic colonisation which could be an important negative feedback mechanism against climate change.

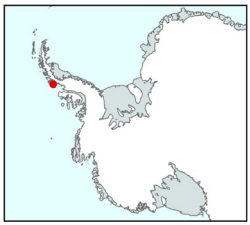
▲ *Soft sediments around Rothera are inhabited by a diverse community of species, some of which are well camouflaged, such as these amphipods*

Rothera Research Station

Degradation dynamics of Antarctic macroalgae

SIMON MORLEY, (LLOYD PECK), Nadia Frontier

Timing: January 2021to March 2023



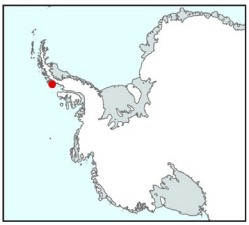
Marine plants are being increasingly recognised for their role in removing carbon dioxide from the atmosphere and storing it in ocean ecosystems. Globally, marine plants, such as macroalgae, play an incredibly important role in supporting food webs, providing shelter for an array of organisms and stabilising the sediment locally. Marine plants are eroded and senesce. As a result, some of this carbon is transferred through the ecosystem in the form of detritus. The rest of the plant material remains in situ where carbon is remineralised by invertebrate grazers and bacteria. Plant material can be exported from shallow, coastal habitats into deeper sediments, known as carbon sinks, where they are buried.

This project aims to quantify the breakdown of different Antarctic macroalgae species to explore the ways in which this resource supports the food web. Experimental detrital accumulations are sampled at different time points in order to understand the succession of the invertebrate community. We will employ stable isotope analysis (SIA) to provides information about the range of species that directly consume macroalgae as part of their diet.

Studies across multiple ocean ecosystems have already shown that macroalgae species generally break down at different rates and therefore contribute differently to carbon storage. However, research about the degradation rates of Antarctic macroalgae detritus remains in its infancy. Colder temperatures may slow their breakdown relative to temperate algae but this topic deserves further attention.

▲ *Macroalgae, such as this brown algae Desmarestia menziesii, form an important part of the food web. Their contribution to carbon sink in the Antarctic bears further investigation*

Rothera Research Station



Differences in the trophic ecology, distribution and foraging success of crabeater seals across a latitudinal gradient

(LUIS HUCKSTADT, Dan Costa), Connor Bamford, Nathan Fenney, (Jaume Forcada, Peter Fretwell)

Timing: March to April 2023

Our fieldwork is part of a joint NERC/NSF-funded project to investigate the differences in the ecology, distribution and foraging success of crabeater seals across the latitudinal gradient of the western Antarctica Peninsula. Our study will enhance our ability to understand how the entire krill-dependent community of large predators (whales, penguins, and seals) are responding to ongoing environmental change in the region.

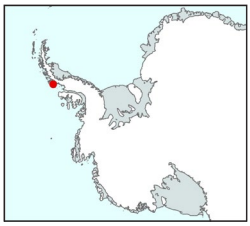
This year's fieldwork will assess crabeater seal abundance and distribution using a variety of survey techniques. BAS will fly aerial survey in Marguerite Bay and Crystal Sound to count seal numbers. This will be compared to synoptic VHR satellite surveys of the same areas. Additionally, repeat fixed-wing UAV surveys will be flown from Rothera point to assess haul-out patterns and variability in distribution patterns. Our NSF colleagues, supported by US logistics, will be attaching tracking devices to seals in Marguerite Bay to assess movement and behaviour.

These new data will be compared to ecological baseline data from 20 years ago when the last comprehensive survey was conducted. This will provide us with a unique opportunity and advantageous position to detect changes in the ecology of this conspicuous Antarctic higher-predator and the extended predator community.

▲ *Crabeater seals on an ice floe in Ryder Bay*

Rothera Research Station

Phosphorus scavenging from plastic as phosphate source by Antarctic cyanobacteria



JAPARENG LALUNG, (Pete Convey)

Timing: March to April 2023

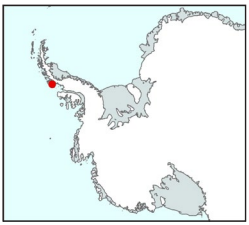
Cyanobacteria are key primary producers in Antarctic terrestrial and freshwater ecosystems. Both phosphorus and nitrogen are essential for cyanobacterial growth. However, a nitrogen-limited environment is typical of oligotrophic maritime Antarctic freshwaters and soils. Some cyanobacterial taxa such as *Nostoc sp.* and *Anabaena sp.* can fix nitrogen directly from the atmosphere through the formation of thick-walled cells called heterocysts. However, without any parallel mechanisms for fixing phosphorous, this often becomes the limiting factor for their growth. With the prevalence of phosphorus limitation in Antarctica compared to other continents globally, we hypothesise that Antarctic cyanobacterial strains may have evolved the capability to scavenge phosphorus from very limited sources.

The proposed study will determine the ability of Antarctic cyanobacterial strains to scavenge phosphorus from phosphorus-containing plastics. This will be achieved by determining the presence and expression of phosphorus-cycling-related genes within available isolated strains of cyanobacteria originally obtained from the Rothera area, Adelaide Island, maritime Antarctic. The presence of solubilising enzymatic activity will be determined to evaluate the ability of the cyanobacteria to scavenge phosphorus from the plastic. The removal of phosphorus from these plastics may lead to their disintegration and the algae can potentially be used in plastic breakdown/remediation of plastic pollution.

We have secured funding from YPASM to carry out the laboratory studies in Malaysia of phosphate scavenging on frozen samples previously collected several years ago on Signy Island. This application is aimed to generate fresh material for that funded study, as fresh material is likely to have greater potential for contained cyanobacteria to be brought into culture. We could possibly also expand the sample range through access to existing material from BAS (BEA Team) frozen soil collections from Alexander Island.

▲ *The photosynthetic cyanobacterial strains might possess the ability to scavenge phosphorus from plastic. The picture was taken at Lab 148, School of Industrial Technology, Universiti Sains Malaysia*

Rothera Research Station



Pole to pole exchange – climate facilitated cyanobacterial parasite pressure and mat ecosystem response

DANIEL R. DIETRICH, (Antonio Camacho, Pete Convey, Kenneth Dumack, Ian Hawes, Lucy Hawkes, Svenja Heesch, Anne Jungblut), Eva Riehle, (Antonio Quesada, Susanna Wood)

Timing: January to February 2023

Previous research of our group comparing the cyanobacterial mat species diversity from the North Pole with those of the Antarctic Peninsula demonstrated a surprisingly high species overlap. As serendipitous and simultaneous development of these cyanobacterial species appears highly unlikely, it is assumed that cyanobacteria are transported from the Arctic to Antarctica via birds or aerosols. Investigating the effect of climate change on polar cyanobacteria, prior studies showed a change in cyanobacterial species diversity and toxin production after exposure of Antarctic cyanobacterial mats to increased temperatures, indicating higher toxin production rates and a general shift towards more toxin-producing species during elevated temperatures.

Further, the continuously-reduced ice coverage and corresponding weakening of biogeographical boundaries may lead to increased invasion with non-endemic cyanobacteria and their endogenous and exogenous pathogens (viruses and fungi) and thus increased infection rates of endemic cyanobacteria in Antarctica. Consequently, more temperate-tolerant species may overtake endemic cyanobacterial mat populations and increasing temperatures could further facilitate a general shift towards more toxic cyanobacterial species. This project investigates the possible exchange of cyanobacteria, cyanobacteria parasitic fungi and viruses between the poles and the impact of climate change on the establishment of more temperate tolerant (parasitic) species in Antarctica.

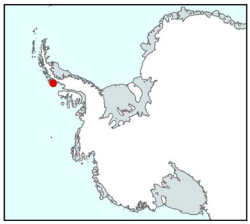
▲ *Plexiglass chambers on cyanobacterial mats to increase temperature and radiation for climate change simulation experiments at Rothera Research Station, Antarctica*

Rothera Research Station

Predicting DMS(P) production in a high CO_2 world

JAQUELINE STEFELS, Mareike Bach, Maria van Leeuwe

Timing: November 2022 to January 2023

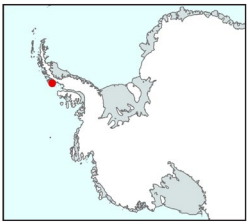


The West Antarctic Peninsula (WAP) is undergoing the most rapid climate change of any region in the Southern Hemisphere, with ocean acidification and sea-ice retreat as major actors. The consequences of these changes are still largely unknown. How algae are going to respond to increased levels of CO_2 and lower pH values of seawater is under debate. Likewise, studies on the relation between DMS(P) and CO_2 are not straightforward: increases as well as decreases in DMSP concentration upon elevated CO_2 have been recorded.

In this proposal we will study how ocean acidification and dynamics of sea-ice retreat impact on entangled carbon and sulphur cycles in the Southern Ocean, by combining controlled laboratory experiments with field studies at Ryder Bay, located at the southern part of the WAP. The sea ice that is present in winter and spring makes an excellent natural laboratory to study both carbon and sulphur dynamics under ambient conditions of CO_2, light and temperature. It provides the opportunity to study carbon acquisition mechanisms and its relationship with DMSP production in sea-ice communities, during various phases of ice melt and during pelagic bloom periods of various algal communities.

▲ *A: Sea-ice floe flipped over and reveals large algal biomass within the bottom layers. B: Sea-ice diatoms under the microscope. C: Sea-ice cores for pigment and community analysis as well as DMS(P) content. D: Cultures of algae used in laboratory experiments to investigate coupling of DMSP production and primary production*

Rothera Research Station



Repair and maintenance of the Rothera MF radar masts

(NEIL COBBETT, ANDREW KAVANAGH), [BAS Estates and Engineers]

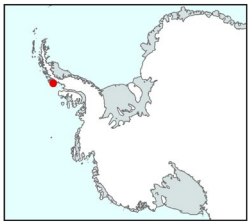
Timing: Opportunistic throughout the season

The MF radar at Rothera measures winds in the mesosphere. It is used for studies of atmospheric vertical coupling and space weather and long-term monitoring. Measurements of winds above Rothera extend back to 1997 and have been quasi-contiguous since 2002. There are known cracks in the antenna masts on East Beach. In the 2021-22 season these were fully assessed to determine the level of repair/replacement that will be required in the 2022-23 season.

▲ *MF radar array at Rothera Research Station*

Rothera Research Station

Rothera Oceanographic and Biological Time Series (RaTS)



(DAVID BARNES, MICHAEL MEREDITH, HUGH VENABLES, Alex Brearley), Alice Clement, Hollie London, Emma Stuart

Timing: 1997 to present (ongoing)

More information: *https://www.bas.ac.uk/project/rats*

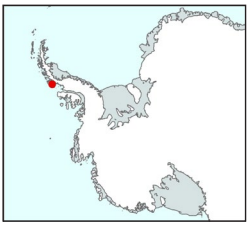
The glaciers, sea ice, ocean physics and biology along the Antarctic Peninsula are very closely linked, with strong feedbacks between ice and ocean through winter mixing. These changes then strongly affect the growth of phytoplankton, which underpins both the food web and carbon uptake and sequestration. There is also very significant interannual variability in the region, from strongly varying local weather patterns, which are in part affected by wider scale processes linked to Southern Ocean winds, El Niño and the Ozone Hole. It is therefore extremely important to monitor the system throughout the annual cycle and on a decadal timescale to cover the large-scale variability.

The Rothera Time Series has and continues to do this and is the only such time series to cover winter sampling. The sampling is carried out 4km from base, using the small boats or a sled. It has shown many interesting feedbacks leading from changing winter sea ice, with less ice in winter leading to more heat and carbon loss, a loss of stratification which follows into the summer and then leads to more mixing, greater heat uptake (which can exceed the original heat loss) and reduced phytoplankton growth and carbon uptake.

▲ *Water sampling in all conditions*

▲ *Deploying a CTD on the hand winch to 500m depth*

Rothera Research Station



Rothera skua long-term monitoring and AIMP bird monitoring for wind turbines EIA

(RICHARD PHILLIPS, Kevin Hughes), Aurelia Reichardt, Paul Whitelaw

Timing: December 2022 to March 2023

More information: *https://www.bas.ac.uk/project/skua-monitoring-at-rothera*

The small population of south polar skuas (up to 25 pairs) at Rothera Point has been studied since the late 1990s. The initial intention was to monitor possible impacts of the station, but the data also provide useful indicators of local prey availability at sea, effects of changes in sea-ice coverage, etc. Up until 2005, the monitoring was of population size and breeding success (chicks fledged per pair). Subsequently, the breeding parameters that are collected include laying dates, clutch size, egg dimensions, hatching success, fledging success, chick condition and adult attendance (which provides an index of foraging effort) of each pair. In addition, since the 2007-08 season, monitoring has included resighting of colour-ringed adults, which can be used to estimate adult survival, breeding frequency and divorce rates, and to determine the breeding histories of individuals and the effects of mate change. In addition, there is some monitoring of birds on nearby Anchorage Island, which act as controls.

A further addition to this routine monitoring is the need for flight-path analysis of skuas and other bird species over Rothera Point to inform decision-making with regard to site selection for potential wind turbines (AIMP project). This will involve research by a PhD student for the 2022-23 seasons (and possibly the 2023-24 season). Methods will include laser tracking, visual observation and deployment of GPS loggers on birds.

A final element of the monitoring will be the collection of any dead birds found in the vicinity of Rothera Research Station to allow the quantificiation of environmental persistant pollutants.

▲ *South polar skua and Antarctic shag captured together whilst monitoring the shag colony on Mucklescarf Island*

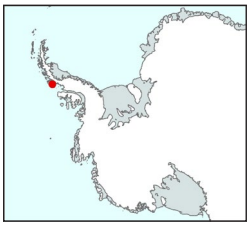
▲ *This adult pair of Antarctic shags were caught at the nest so at to deploy a GPS logger on its back (to track its summer movements), GLS light-level logger attached to its leg (to record its winter distribution) and a TDR (Time Depth Recorder) on its other leg (to record its foraging activities while it dives to extraordinary depth to catch prey) as seen in the photo*

Rothera Research Station

Seaweed physiology

NADIA FRONTIER, SIMON MORLEY

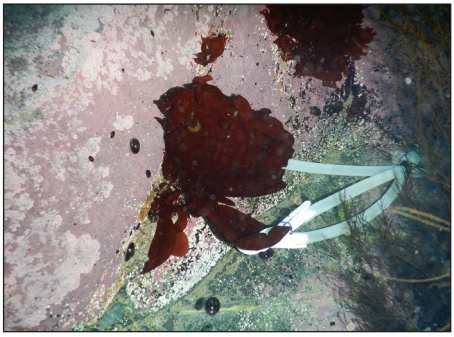
Timing: October 2022 to March 2023



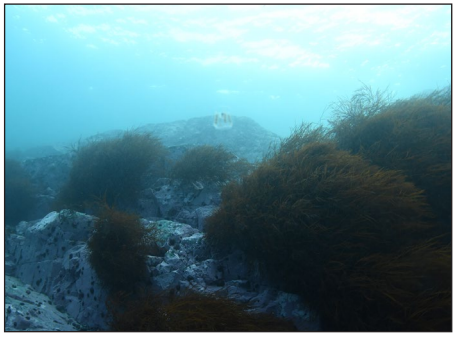
Antarctic ecosystems are understudied relative to other ocean basins. Questions about the timing of senescence and photophysiology of certain species are particularly relevant as Antarctic macroalgae 'die-back' similarly to the annual nature of temperate kelps. However, there is a lack of in situ studies regarding macroalgae photophysiology in response to strong seasonal forces operating in the Polar Regions.

This project will involve the repeated sampling of a targeted macroalgae community in Ryder Bay to provide an insight into photophysiological processes at the cellular level using PAM (Pulse Amplitude Modulation) fluorescence. Site surveys using a combination of divers and ROVs to map detrital accumulations. The accumulations will subsequently be sampled to compare photosynthetic performance measurements between standing macroalgae and detached macroalgae.

This topic of research will contribute towards our knowledge of blue carbon in Antarctic habitats. Inferences and predictions can be made about the sequestration potential of different Antarctic macroalgae species. Antarctic habitats are changing and research at Rothera has demonstrated that sea-ice cover is reducing in spread and frequency of occurrence. New habitats are open to the colonisation of marine plants and therefore the role of macroalgae is increasingly important although the sequestration potential of Antarctic macroalgae remains largely unknown.



▲ *PAM measurement*

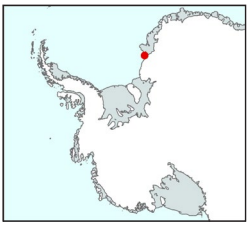


▲ *Macroalgae forest*

Halley VI Research Station

All-sky camera

TRACY MOFFAT-GRIFFIN, David Goodger, Hessel Gorter

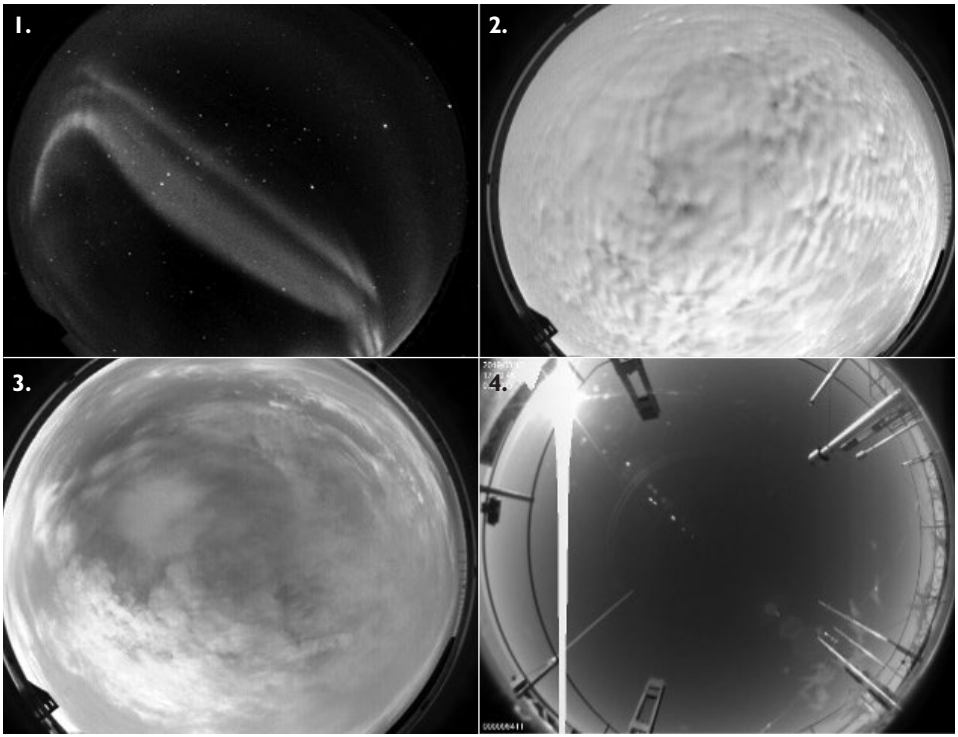


Timing: 2018-ongoing

More information: *https://www.bas.ac.uk/polar-operations/sites-and-facilities/facility/all-sky-camera-black-and-white*

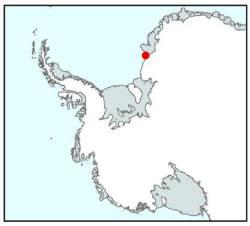
This instrument takes regular, visible light images of the sky using a fisheye lens. This data is used to determine the cloud cover levels at a given site. It is normally used to aid the analysis of mesopause (upper middle atmosphere, 87km) airglow spectra measurements (cloud equals poor airglow spectra) which are used to calculate mesopause temperatures. It also can be used to observe aurora.

This instrument has been engineered to run autonomously over the unmanned Halley winter period.



▲ *Figures (1-3) are from Halley in previous years, one of the aurora, two of cloud cover. Fig 4 is an image taken by the camera during its unmanned operation in March 2019*

Halley VI Research Station



Auroral cameras – conjugate measurements of isolated proton auroras, red aurora, and pulsating auroras at subauroral latitudes

(TRACY MOFFAT-GRIFFIN, MITSUNORI OZAKI), Hessel Gorter, (Keisuke Hosokawa), Dominic Jaques, Carson McAfee, (Yasunobu Ogawa, Kazuo Shiokawa)

Timing: 2020-ongoing

We have three small auroral cameras at the Halley Research station that have run autonomously. These cameras are used to observe:

Proton auroras

Energetic protons striking the upper atmosphere can cause isolated bursts of light from the upper atmosphere known as proton auroras. One curious aspect is that the bursts of light occur in the northern and southern hemisphere but not at the same time. One theory suggest that the bursts of light are due to an ultra-low frequency wave packet that travels along the geomagnetic field and bounces between the northern and southern hemisphere. Theory suggests that each time the wave packet crosses the equator it causes a burst of energetic protons that travel along the magnetic field into the atmosphere – so causing the burst of light. However, satellite observations provide inconclusive support for this idea. The optical instrument at Halley is designed to measure these bursts of light and compare the timing with signals at Nain in the northern hemisphere. The intention is to combine the optical measurements with measurements of the wave packets using the search coil magnetometer at Halley and Nain and hence test the theory more carefully.

Red aurora

Red aurora are sometimes observed at Halley after a large geomagnetic storm. They can last for hours but the chain of events leading to the red aurora is very complicated and not well understood. Satellite data suggest that ions trapped in the geomagnetic field are the ultimate source of energy for the red aurora. The ions are heated and then somehow transfer this heat to electrons which travel down into the atmosphere and collide with oxygen atoms which emit the light we see as the red aurora.

continued ▷

▲ *Red aurora taken by Kazuo Shiokawa*

Halley VI Research Station

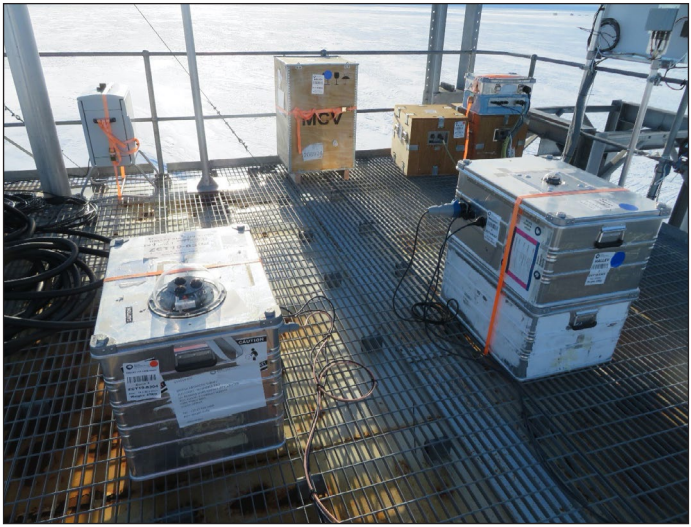
Auroral cameras continued

The object of this project is to deploy a special type of camera that can measure the red aurora across the whole sky so we can understand this energy transfer process. The camera has been built by our Japanese colleagues at Kanazawa University in Japan as part of a new and longer-term collaboration with BAS.

This project is important since high-energy ions which power the red aurora also cause damage to satellites in orbit. By understanding the red aurora and measuring how long it lasts we can help determine how long satellites may be at risk of damage.

Pulsating auroras

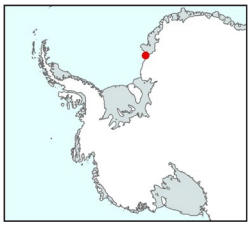
Observations show that the intensity of the aurora can vary as if there is a switch turning it on and off every second or so. As energetic electrons striking the atmosphere cause the bright auroral patches, the suggestion is that wave-particle interactions modulate the flow electrons coming down the field line into the atmosphere. It is thought that the waves responsible are very low frequency plasma waves, which originate in space but which also travel along the geomagnetic field and can be detected at Halley. The intention is to combine the optical observations with measurements of very low frequency waves at Halley to test some of the theories.



▲ *The auroral camera system (left) on the roof of the CASLab, adjacent to the All-Sky Camera system (right)*

Halley VI Research Station

Clean Air Sector Laboratory (CASLab)



(ANNA JONES, FREYA SQUIRES, MARKUS FREY), Sabina Kucieba

Timing: 2012-ongoing

More information: *https://www.bas.ac.uk/polar-operations/sites-and-facilities/facility/halley/clean-air-sector-laboratory-caslab/#about*

The laboratory has run successfully over the winter period, albeit cold, powered by the microturbine. This has allowed the collection of priority data streams that advance our understanding of reactive chemistry in the Polar Regions – observations of tropospheric ozone and the number of particles, or aerosols, in the atmosphere.

Tropospheric Ozone

The laboratory-based TEi 49i ozone monitor currently runs continuously in the CASLab. These measurements not only help us to understand the mechanisms of reactive chemistry in the seasonal sea-ice zone, but also contribute to our commitments of being a background monitoring station for the WMO's Global Atmospheric Watch programme.

Aerosol loading

The Automated Condensation Particle Counter (CPC) instrument measures the concentration of particles (>0.01 µm) in the atmosphere. These particles are produced from a variety of processes relating to the production of reactive halogen oxides and sulphur compounds from the seasonal sea-ice zone and contribute to local aerosol loading. These measurements therefore make a complimentary addition to those made by the TEI 49i ozone monitor.

▲ *The Clean Air Sector Laboratory (CASLab) at Halley Research Station*

▲ *The CASLab is located away from the main station*

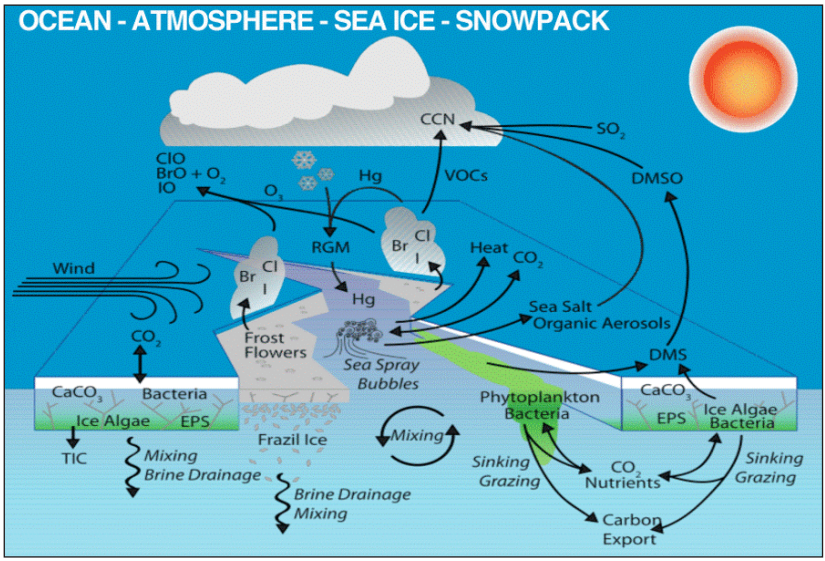
continued ▷

Halley VI Research Station

Clean Air Sector Laboratory (CASLab) continued

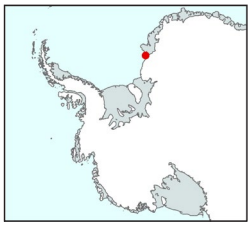
Greenhouse gas observations of CH_4 and CO_2

We have developed two autonomous systems centred on the Picarro instrument, which measure the atmospheric methane (CH_4) and carbon dioxide (CO_2) mole fraction. We are currently running one of these systems with our international colleagues at the Alfred Wegener Institute's (AWI) Neumayer Station III. Measurements of CH_4 and CO_2 contribute to two NERC-funded projects; the SONATA – RoSES programme, the aim of which is to assess the current state of the Southern Ocean carbon cycle, and also the MOYA project, aimed at improving quantification the global budget of atmospheric methane.



▲ *Schematic showing the physical, chemical and biological interactions in the sea-ice zone*

Halley VI Research Station



Discovering reasons for atmospheric methane growth using deuterium isotopes (MethaneDH)

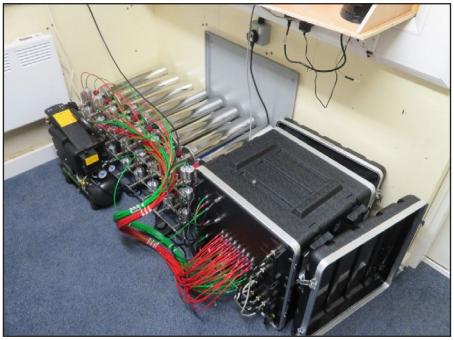
(REBECCA FISHER, Grant Forster, James France), Hessel Gorter, Dominic Jaques, (Anna Jones, David Lowry), David Maxfield, (Euan Nisbet), (Freya Squires)

Timing: 2021-2023

Atmospheric methane levels are growing rapidly with a 70ppb (an extra ~4% of total atmospheric methane) rise in atmospheric methane mole fraction observed over the last decade. The reasons behind the growth since 2007 are not well known. The changing 13C/12C isotopic signature of atmospheric methane can give us some insight into the reasons for the change because, concurrent with the atmospheric methane rise, it has become depleted in 13C. There have been several proposed reasons for the increase and corresponding isotopic shift and we need additional tracers of the sources to explain it. This proposed work will use measurements of the deuterium/hydrogen (D/H) isotope ratio of methane to constrain the source distribution of methane globally.

New instrumentation for high-precision multiple-sample measurement of D/H isotopes in methane in ambient air has recently been developed and this will be used to analyse air samples collected close to sources. The isotopic signatures of the major sources will hence be characterised, including wetland, waste, biomass burning, fossil fuel, ruminants and rice agriculture. A focus of the field campaigns will be on tropical Africa and East Asia, parts of the world with high emissions of methane, but with very few measurements of methane isotopic signatures. Measurements at remote locations, such as Halley, will act as baseline information, and latitudinal transects will inform on global distributions. The results will then be used to identify regional source signatures for the main source categories. Understanding the causes of the current rise in methane is critical to driving policy for greenhouse gas reduction globally and the desire to remain within the 2°C temperature change outlined in the Paris Agreement.

The engineering teams at BAS have built an automated flask sampler that will run unattended through the Halley winter collecting air samples that will be shipped out for analysis the following season.

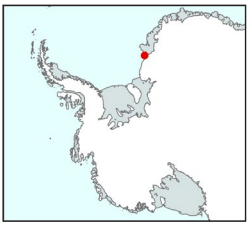


▲ *The automated methane flask sampler in the CASLab*

Halley VI Research Station

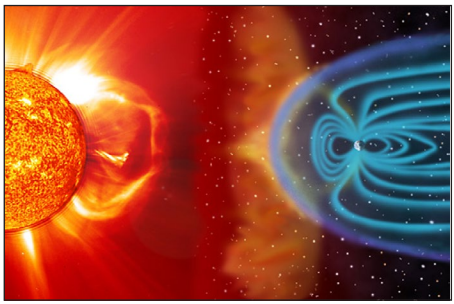
Electro-Magnetic Quiet Area

(MARK CLILVERD, MERVYN FREEMAN, RICHARD HORNE)
Sebastian Gleich, Dominic Jaques, David Maxfield

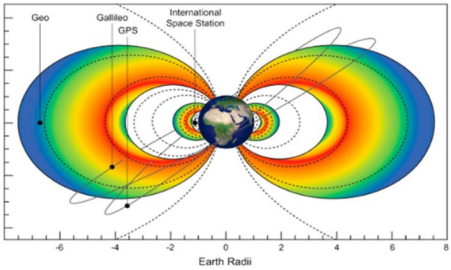


Timing: 2012-ongoing

The Electro-Magnetic Quiet Area (EMQA) at Halley is a region of the station that is packed with very sensitive instrumentation that detects very slight disturbances in the Earth's magnetic field and variations in one of the upper most layers of our atmosphere – the ionosphere. These instruments run automatically throughout the year without the need for human intervention. This season we will be carrying out some minor maintenance on some of the equipment.



▲ *The solar wind pushing on Earth's magnetic field (Image: NASA)*



▲ *Earth's Van Allen radiation belts*

Search coil magnetometer

This instrument is designed to measure ultra-low frequency waves. These waves are generated in space by natural processes during geomagnetic storms and other active periods driven by solar disturbances. Some of the waves are guided along the geomagnetic field and are able to penetrate the atmosphere and reach the ground. We want to find out more about these waves since we think they cause a depletion in the Earth's radiation belts – i.e., we think they remove high-energy charged particles that circulate around the Earth and which cause damage to satellites. The Halley and Rothera search coil magnetometers are part of an international network of magnetometers called MICA-S (Magnetic Induction Coil Array – South). By making measurements over a network of instruments at different locations we can get a better information on where the waves originate, where they propagate to, and thus gain a better understanding on the region in space where they deplete the Earth's radiation belts.

Fluxgate magnetometer

This instrument measures perturbations in the Earth's magnetic field caused by electrical currents in the ionosphere and beyond. Periods of particularly large and variable magnetic perturbations are known as magnetic storms during which electrical power distribution networks across the globe, such as the National Grid, can be disrupted or damaged.

continued ▷

Halley VI Research Station

Electro-Magnetic Quiet Area continued

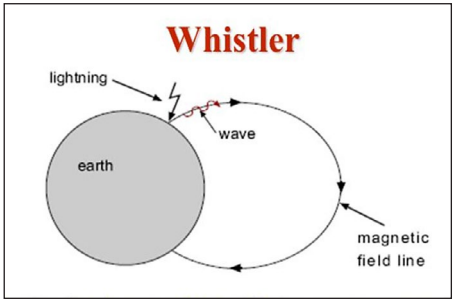
Very Low Frequency (VLF) receiver

The Halley VLF receiver listens to very low frequency radio waves as part of several networks of receivers located all over the Polar Regions. The data gathered by these networks are used by more than 35 institutions around the world to:

- Record and map, in real-time, lightning strikes around the world (WWLLN instrument – University of Washington, Seattle, USA)
- Listen to powerful VLF communication transmitters located in mainland USA, Hawaii, Europe (including the Lake District). This technique uses the upper atmosphere as a gigantic energetic particle detector to find out about interactions between our atmosphere and solar flares, solar eclipses, explosions on other stars, and particles effects from the solar wind – the aurora (AARDDVARK instrument – University of Otago, New Zealand)
- Record electromagnetic waves from space – these waves are responsible for the harsh conditions for satellites as they orbit through the Van Allen Belts (VELOX instrument – BAS, Space Weather Observatory)
- Record and analyse whistling tones originating from lightning in America – this inputs into space weather models used to protect satellites from the harsh radiation environment of space (AWDA instrument – University of Eotvos, Budapest, Hungary).

As part of the Halley Automation Project we also run one Low Power Very Low Frequency (VLF) wave receiver. These instruments provide back up to two of our higher power experiments, known as AARDDVARK and VELOX.

▲ *The Halley VLF receiver*



▲ *Schematic showing the generation and detection of a 'whistler' from a lightning strike at the WWLLN instrument*

MOSAIC

The Mesospheric Ozone Spectral Analysis Instrument Chain (MOSAIC) is a chain of spectrometers running from pole to pole at about the longitude of Europe/Africa. The chain is a joint collaboration between the Massachusetts Institute of Technology, Lancaster University, the South African National Space Agency, and the British Antarctic Survey. This experiment will map the concentration of high altitude ozone from pole to pole and identify the changes caused by space weather. The instrument

continued ▷

Halley VI Research Station

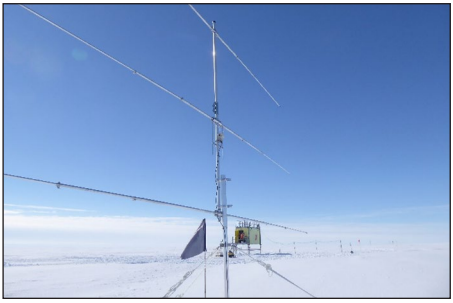
Electro-Magnetic Quiet Area continued

is a passive, low-cost spectrometer for detecting ozone at altitudes of ~100km (about the same height as the aurora). The instrument uses a satellite TV dish and a low noise block converter (LNB) to monitor the line radiation at 11.072GHz generated by ozone. By fitting the shape of the ozone line radiation very accurately we can determine the concentration of ozone with altitude, especially from 50-100km altitude. At these high altitudes the concentration of ozone is affected by chemistry reactions induced by energetic particle impacts on the atmosphere, such as those that cause the aurora.

Riometer

This instrument looks straight up and measures the noise coming from the galaxy at a frequency of 30MHz. The noise is almost constant, with just small variations occurring as the stars rotate across the sky each day. Space weather events cause changes in the transmission of the galactic noise signal through the Earth's ionosphere around 50-100km up. We can measure these changes in radiowave opacity using the riometer, and calculate what is happening to the levels of ionisation. This information tells us about the geophysical processes going on during solar storms, it indicates the presence of the aurora directly over Halley (even during daylight hours), and indicates the levels by which local radiowave propagation conditions could be affected – like polar radio blackouts.

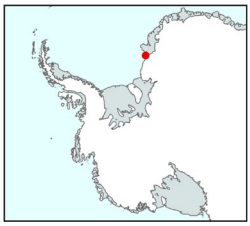
▲ *The Halley MOSAIC spectrophotometer is located on top of a container*



▲ *The riometer at Halley Research Station*

Halley VI Research Station

Glaciological monitoring of the Brunt Ice Shelf



OLIVER MARSH, (James Byrne), Sebastian Gleich, Dominic Jaques, David Maxfield

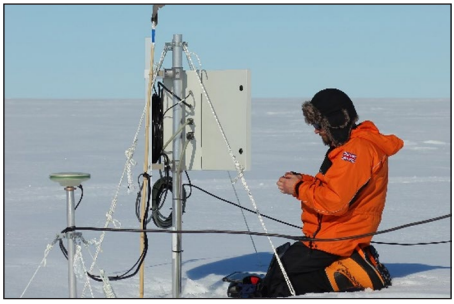
Timing: 2011-ongoing

More information: *https://www.bas.ac.uk/project/brunt-ice-shelf-movement*

The project uses data from a variety of in situ instruments on the ice shelf, satellite data, and numerical modelling to understand the changing risk to our operations and infrastructure on the Brunt Ice Shelf. In 2012, satellite monitoring revealed the first signs of growth in a chasm (Chasm 1) that had lain dormant for at least 35 years. In 2016-17, the Halley technical, vehicle, science and operational teams successfully moved the Halley VI station to a new, safer location on the ice shelf.

In February 2021, the first of several large icebergs (now called A74) calved from the northern part of the ice shelf. Two other rifts (Chasm 1 and Halloween Crack) continue to widen, and will soon produce additional icebergs. As a result of the project, the Brunt Ice Shelf is the most closely and thoroughly observed ice shelf on Earth. A network of 17 GPS instruments measures the deformation of the ice shelf around Halley VI and the movement of icebergs, sending data to Cambridge every day. Satellite imagery from ESA, NASA and the German Aerospace Agency along with ground penetrating radar, on-site drone footage and specially-configured range-finding equipment provide additional information on any growth of the cracks to inform operations during the summer season.

▲ *Chasm 1 on the Brunt Ice Shelf*

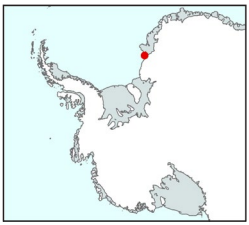


▲ *Maintaining a GPS station on the Brunt Ice Shelf*

Halley VI Research Station

Halley Automation Project

(THOMAS BARNINGHAM, MIKE ROSE), [Halley Automation Project Team]



Timing: 2017-2023

More information: *https://www.bas.ac.uk/project/halley-automation*

This innovative, multi-year project aims to provide a micro-turbine power supply and datalink to a suite of autonomous scientific instrumentation around Halley VI Research Station and on the Brunt Ice Shelf. This system enables data collection throughout the Antarctic winter when the station may be unoccupied.

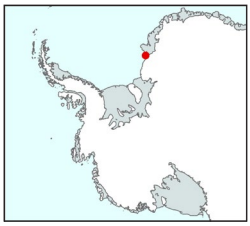
The microturbine and the automated instruments it powers are now entering the fifth year of operation. Each year we learn more about the operation of the system and make improvements where we can. We have encountered some challenges in recent years that have required us to really examine how we control the temperature of the microturbine container and how we interact with the microturbine remotely from Cambridge. We're also now looking ahead to the delivery of the second microturbine to Halley in the following season, 2023-24. This will mark the end of the project and will see 'Automated Halley' become Ops normal for BAS.

The number of experiments we have now re-established at Halley through automation is substantial, although there is still room (and power) for much more. We currently have ~30 individual experiments being powered through the winter period. This season we're focusing on maintenance of existing systems, rather than adding more. In 2023-24 we will be looking to build capacity to bring in larger radar systems and more all-sky imagers to be powered autonomously.

▲ *The Automation platform with four bulk fuel tanks that the containerised microturbine system autonomously fuels from throughout the unmanned winter*

Halley VI Research Station

Infrared camera

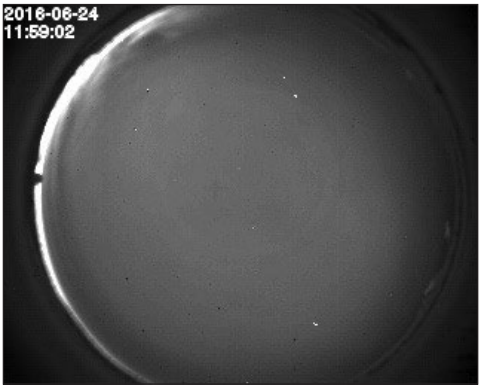


(TRACY MOFFAT-GRIFFIN), Hessel Gorter, Dominic Jaques, (Corwin Wright)

Timing: 2021-ongoing

More information: *https://www.scar.org/science/angwin/angwin*

This all-sky imager observes infrared airglow emissions at ~87km during the night and operates on a high temporal cadence (an image every 10 seconds). This enables short period atmospheric gravity waves (thought to carry most of the energy and momentum in the gravity wave spectrum) to be observed. It is operated jointly by BAS and Bath University and is part of ANGWIN (ANtarctic Gravity Wave Instrument Network). Understanding gravity waves in Antarctica is important because they are the main driver of upper atmospheric circulation in this region.



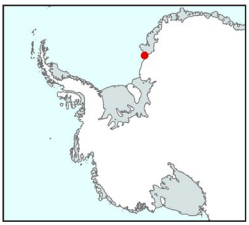
▲ *An image taken by the infrared camera in 2016 at Halley when the station was occupied throughout the winter*

Halley VI Research Station

Meteorology and ozone monitoring

(STEVE COLWELL), Sabina Kucieba

Timing: 2012-ongoing



Stratospheric ozone measurements

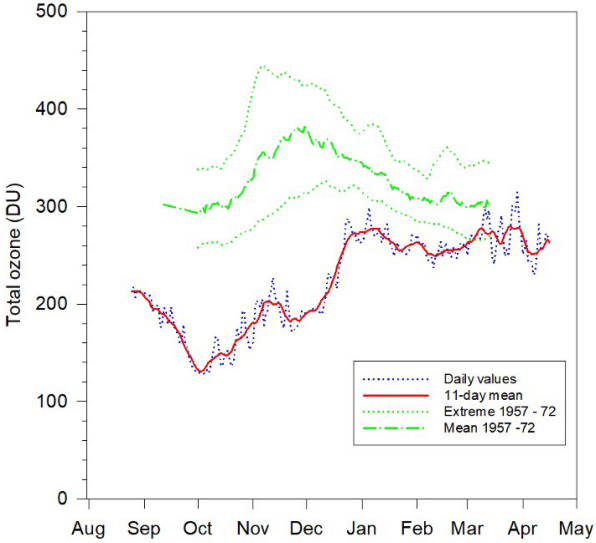
Stratospheric ozone shields the Earth's surface from more than 90% of harmful solar ultraviolet radiation. The Antarctic Ozone Hole was discovered in 1985 by BAS scientists using Halley's unique data set of Dobson spectrophotometer observations which now spans 60 years. Maintaining these observations, at Halley and elsewhere, is crucial to monitoring the slow recovery of stratospheric ozone following the banning of CFCs.

The destruction of ozone by CFCs in the stratosphere requires extremely cold temperatures, and energy from sunlight. Antarctic ozone therefore begins to decrease in the spring with the end of polar night and recovers during the dark winter months when ozone is replenished by atmospheric mixing.

The automated Dobson has been running successfully at Halley for four years now. Alongside this, we have the SAOZ instrument (SAOZ (Système D'Analyse par Observations Zénithales). This is another instrument that measures stratospheric ozone that we can then compare the automated Dobson against, as well as Nitrogen Dioxide, which plays a key role in the global ozone distribution.

The discovery of the ozone hole provides a prime example of the importance of investing in long-term observational science.

continued ▷



▲ *Unmanned, automated ozone measurements collected over the 2020-21 period. The formation of the ozone hole is visible in the data in the austral spring*

Halley VI Research Station

Meteorology and ozone monitoring continued

Radiosonde launches

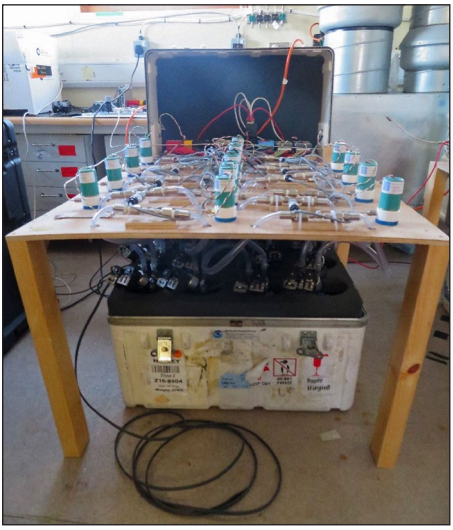
This year, we will resume our daily launch of radiosonde balloons as soon as personnel return to Halley in late November. These radiosondes measure temperature, humidity, wind speed and wind direction from the Earth's surface, through the troposphere (10km) and high up into the stratosphere (~25km). Each set of measurements provide a snapshot of the state of the atmosphere above Halley at the time of the launch. This information is then fed into global weather forecasting models.

Automated air sampling

We have an automated system for collecting air samples throughout the unmanned winter months. These air samples are collected monthly and sent to the US National Oceanic and Atmospheric Administration (NOAA) in the following summer. They will measure a range of greenhouse gases and atmospheric pollutants, thus maintaining these important global data sets that were first established at Halley in 1986.

Snow sampling campaign

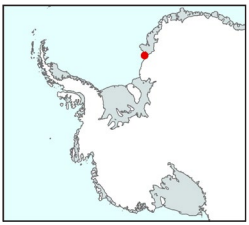
Snow samples are collected that are then melted down for water samples. These are sent to the IAEA-WMO Global Network for Isotopes in Precipitation (GNIP) which has been in operation since the 1960s and is comprised of hundreds of observation stations located around the world.



▲ *Our automated air sampling system running in the CASLab*

Halley VI Research Station

Sky radiometer



(STEVE COLWELL), Sabina Kucieba

Timing: 2022 onwards

More information:
https://legacy.bas.ac.uk/met/jds/turbidity/index.html

http://www.euroskyrad.net/index.html

https://www.bas.ac.uk/data/our-data/publication/long-term-1995-2018-aerosol-optical-depth-derived-using-ground-based-aeronet

The POM-01 sky radiometer is an instrument which will be installed this season at Halley after maintenance in Japan. It was operated at the station between 2009 and 2016 and manual measurements were made prior to this back to 1972. It uses a single detector and a rotating filter wheel to measure solar radiation intensity at seven wavelengths (315, 400, 500, 675, 870, 940, 1020nm). The dedicated sun tracker enables measurement either directly from the Sun or at user-defined angles away from the Sun.

This allows us to calculate the size and density of the particles that are scattering the light (mainly things like sea salt, volcanic dust and man-made pollutants).

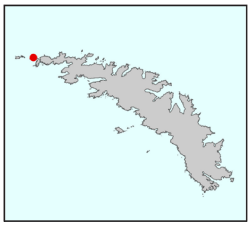
This scattering effect can vary – for example following a large volcanic eruption – and can have a major effect on climate by altering how much of the Sun's radiation reaches the surface and how much is trapped once it gets there.

The POM is part of a network of similar instruments around the world. As the air at Halley is much less polluted than in more populous parts of the world, it provides a really useful comparison.

▲ *The POM-01 sky radiometer at Rothera Research Station*

Bird Island Research Station

Bird Island marine predators LTS



RICHARD PHILLIPS, Ash Bennison, Marcia Blyth, (Mike Dunn), Rosie Hall, Imogen Lloyd, Marine Quintin, Erin Taylor, Mark Whiffin

Timing: Ongoing

More information: *https://www.bas.ac.uk/project/higher-predators-long-term-science/higher-predators-bird-island-albatrosses-and-giant-petrel-monitoring*

British Antarctic Survey carries out a Long-Term Science (LTS) project that measures changes in Antarctic ecosystems and seeks to understand the underlying drivers and processes. Marine predators are sensitive to changes in the ecosystem, some of which are natural (e.g. climate variability), whereas others are caused by humans (e.g. fishing). Monitoring breeding populations of seabirds and seals is an important part of the LTS programme, providing scientists and conservationists with indicators of change in the Scotia Sea and elsewhere in the south-west Atlantic. These indicators include estimates of population size and trends, breeding frequency, reproductive success, and the composition of predator diets.

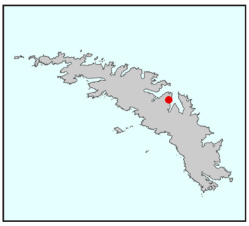
Scientists have carried out targeted research projects on most of Bird Island's breeding species over recent decades. Survival and breeding histories are recorded for wandering, black-browed and grey-headed albatrosses, northern and southern giant petrels, macaroni penguins, and Antarctic fur and leopard seals. BAS also monitors population size and breeding success of light-mantled albatrosses and gentoo penguins, and a range of other parameters that reflect annual changes in food availability in the wider environment. These data help inform the regional conservation management authority for Southern Ocean fisheries, the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR).

▲ *Macaroni penguin colony on Bird Island, South Georgia*

▲ *Fur seal pups are monitored each year*

King Edward Point Research Station

Cetacean monitoring in Cumberland Bay



(PHILLIP HOLLYMAN, Martin Collins), Meghan Goggins, Carrie Gunn, (Jennifer Jackson), Kate Owen, George Perry

Timing: Ongoing

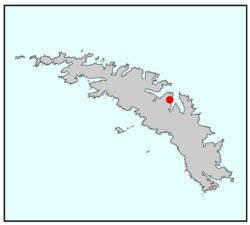
An increase in the number of both humpback and blue whales foraging around South Georgia has been observed in recent years. During November to December 2019, humpbacks were regularly visible from KEP, foraging in Cumberland Bay and a blue whale spotted from Maiviken. The regular presence of whales in Cumberland Bay provides an opportunity for the KEP science team to collect valuable data in support of broader efforts to understand the abundance, behaviour and ecology of cetaceans.

The aim of this project is to establish long-term whale monitoring in Cumberland Bay East, as agreed in the KEP Science Plan. BAS KEP scientists will monitor (i) numbers and (ii) identity (with photo-ID using existing photo catalogues), (iii) multi-seasonal presence of whales in Cumberland Bay. The work will be supported by Jen Jackson (BAS cetacean specialist) and contribute to regional efforts to better understand the distribution and abundance of whales and the recovery of populations at a former whaling site.

▲ *A blue whale was spotted off the coast of South Georgia*

King Edward Point Research Station

Higher predator monitoring at Cumberland Bay



(PHILLIP HOLLYMAN, Martin Collins), Meghan Goggins, Carrie Gunn, Kate Owen, George Perry

Timing: Ongoing

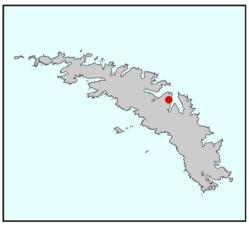
King Edward Point Research Station is operated by BAS on behalf of the Government of South Georgia & the South Sandwich Islands (GSGSSI) and the Foreign, Commonwealth & Development Office (FCDO) under a tripartite MoU. In accordance with the MoU, the purpose of the research station is to carry out an agreed scientific programme primarily focused on the sustainable management of fisheries (toothfish, icefish and krill) in the South Georgia Marine Protected Area. Research at KEP provides key inputs into the toothfish stock assessment and the evaluation of the impacts of the fishery on habitats and non-target species.

A survey of the fish stocks of the South Georgia is undertaken on a biennial basis, to support the icefish stock assessment and provide valuable data on the status of other species. An environmental monitoring programme is operated from the station, focussing on the breeding success of the krill-dependent fur seals and gentoo penguins at nearby Maiviken. Whales in the locality of KEP are also monitored and, when possible, photographed for comparison to established catalogues of identifiable images. The station also supports the CCAMLR fishery observer programmes and undertakes and regular sampling of plankton (for larval fish) in Cumberland Bay and Bay of Isles (using the *Pharos* SG).

▲ *An environmental monitoring programme is operated on the breeding success of the krill-dependent fur seals and gentoo penguins at Maivken*

King Edward Point Research Station

Initiating monitoring support for the SGSSI-MPA Research and Monitoring Plan



(PHILIP TRATHAN), Jamie Coleman, (Martin Collins), Nathan Fenney, (Adrian Fox, Phillip Hollyman)

Timing: October 2022 to January 2023

The Southern Ocean, including around South Georgia, is experiencing significant environmental and climatic change, including: increasing ocean temperatures, regional loss of sea ice and widespread glacial retreat. Key to developing a comprehensive understanding of such changes, is the establishment of a series of rigorous baseline datasets from which change over time can be established, so that management policies can be updated. However, monitoring represents a significant challenge in many UKOTs, due to funding, logistic support, and challenging terrain.

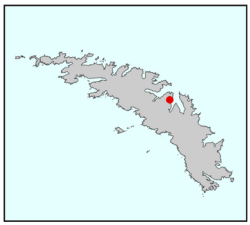
Unmanned multi-copter aerial vehicles offer solutions but are limited by operational conditions. This project therefore proposes the introduction of a new generation of fully autonomous fixed-wing survey drones, coupled with sophisticated image analysis software. These open up possibilities for large-scale, high-resolution repeatable aerial surveys in locations otherwise too remote to be accessed by manned aircraft and too large to be captured by multi-copter drones. Such a methodology represents a significant step change relative to existing practices. This project proposes to conduct a multi-species baseline reference survey to help inform both national and international policy, while providing GSGSSI with an established workflow that can be used as part of the SGSSI MPA Research and Monitoring Plan, an exemplar for other UKOTs.

▲ *Fully autonomous fixed-wing survey drone*

▲ *Monitoring the pre-programmed flight*

King Edward Point Research Station

Long-term monitoring of plankton communities in South Georgia waters



(MARTIN COLLINS), Meghan Goggins, Carrie Gunn, Kate Owen, George Perry

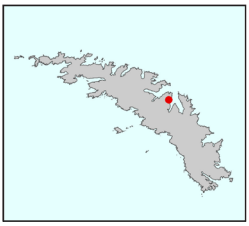
Timing: Ongoing

The aim of this project is to maintain a long-term data set on seasonal patterns in the abundance and size of fish larvae in Cumberland Bay and the Bay of Isles (north coast of South Georgia). This is a long-term monitoring project that has been carried out in Cumberland Bay from 2001 and at Cumberland Bay and Rosita Harbour since 2008. It provides data on the inter-annual changes to the larval fish assemblage at South Georgia which in turn may provide information on adult stock status. More recently this sampling effort is also being used to monitor krill and other zooplankton.

▲ *Towing an RMT-1 plankton net using the Pharos SG to collect fish larvae and other plankton*

King Edward Point Research Station

South Georgia groundfish survey 2023



(PHILLIP HOLLYMAN, Martin Collins), Simeon Hill, Patrick Keith

Timing: January to February 2023

The South Georgia Maritime Zone (SGMZ) supports fisheries for Patagonian toothfish *(Dissostichus eleginoides)*, mackerel icefish *(Champsocephalus gunnari)* and Antarctic krill *(Euphausia superba)*. The main source of fishery-independent data on mackerel icefish and toothfish stocks are the South Georgia groundfish surveys, which have been undertaken on an approximately biennial basis since the late 1980s (with a period of annual surveys from 2006-11).

The surveys provide an estimate of the standing stock and length (age) structure of the mackerel icefish population, which is used directly in the stock assessment. The surveys also provide information on the abundance of pre-recruit toothfish, the abundance of non-target species, and provide samples for a range of other projects including dietary and phylogenetic studies of fish. Most surveys have been conducted during the austral summer.

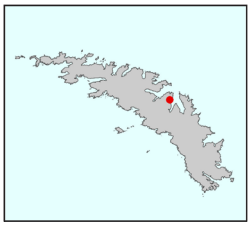
▲ *Groundfish surveys have been undertaken since the late 1980s*

King Edward Point Research Station

Spatial segregation of seabirds at South Georgia

VICTORIA WARWICK-EVANS, Richard Phillips, [KEP ZFA]

Timing: December 2022 to January 2023



Seabirds are amongst the most globally-threatened birds, often as a consequence of incidental mortality (bycatch) in fisheries. Understanding where and when they are vulnerable is vital to conservation management. South Georgia holds globally-important populations of white-chinned petrels and these are the most common species bycaught in Southern Ocean fisheries. Tracking from Bird Island (the only populations tracked to-date) indicates that during the nonbreeding season white-chinned petrels overlap with multiple fisheries within Exclusive Economic Zones (EEZs) and in the High Seas. However, birds at breeding colonies elsewhere in South Georgia may encounter risks from different fisheries. We will deploy tracking devices simultaneously at Bird Island and KEP. The devices will collect real-time fine-scale data during the breeding season, and broad scale data over the non-breeding season.

By enhancing our understanding of the variability in marine distributions and identifying the factors that drive inter-colony variation, we can better understand colony-specific bycatch risk. By improving our understanding of critical risk areas at-sea, we can advise the relevant fisheries regulatory bodies on changes to management that better focus bycatch monitoring and mitigating at appropriate spatial and temporal scales.

▲ *A black-browed albatross feeding its chick*

Signy Research Station

Consistency of chinstrap penguin migration from the South Orkneys and South Shetlands

(NORMAN RATCLIFFE), Derren Fox

Timing: January to March 2023

Understanding animal migration patterns is important due to its links with population processes. The conditions experienced along migration routes and in the wintering areas can affect overwinter survival of animals, or their body condition upon return to the breeding grounds which goes on to affect their reproductive success. The degree to which discrete breeding populations of animals share wintering areas can therefore have profound effects on how their population trends are coupled, and identifying these wintering areas can assist with diagnosis of factors driving population change.

Chinstrap penguins are found across the Scotia Arc and Antarctic Peninsula, including the South Orkney and South Shetland Islands. Tracking of migrations using geolocator tags has shown that birds from the South Shetlands tend to migrate to the Pacific Ocean or remain locally, while those from the South Orkneys move to the north-east of the South Sandwich Islands. The consistency of these migratory strategies, both at the population and individual level, are poorly understood. This project aims to track chinstrap penguins from multiple colonies across the South Shetland Islands and Signy Island on the South Orkneys over three consecutive migrations to better understand migration paths and the degree of individual and population fidelity to wintering areas.

▲ *Chinstrap penguins*

Signy Research Station

Mechanisms of adaptation to terrestrial Antarctica through comparative physiology and genomics of Antarctic and sub-Antarctic insects

(SCOTT HAYWARD, NICHOLAS TEETS), Monica Aquilino, (Pete Convey, Andrew Michel)

Timing: January to March 2023

Insects are the most diverse and abundant terrestrial animals, yet few are capable of surviving in Antarctica's harsh terrestrial environments. The midge *Belgica antarctica* is the only species endemic to the continent and the southernmost free-living insect. Our work over the past several years has characterised some of the physiological and genetic mechanisms that permit survival in its cold, dry habitats. However, a lack of information from closely-related species has hindered our ability to pinpoint the precise evolutionary processes that drive adaptation to Antarctic climates. In this proposal, we will use a comparative approach to identify population and species-level adaptations across three closely-related species of Antarctic and sub-Antarctic insects. The species are the chironomid midges, *B. antarctica*, which is endemic to the west Antarctic Peninsula, E*retmoptera murphyi*, an endemic native of sub-Antarctic South Georgia that has been accidentally introduced to Signy Island in maritime Antarctica, and *Halirytus magellanicus*, which is native to intertidal habitats in the 'Magellanic sub-Antarctic' ecoregion of Tierra del Fuego. Our team of researchers from the US and UK, with our collaborator from Chile, provide complementary expertise and access to remote collecting sites to make this novel and exciting comparative project possible.

Our specific aims are as follows:

Aim 1: Characterise conserved and species-specific adaptations to extreme environments. These experiments will allow us to identify shared and distinct mechanisms that contribute to survival in harsh Antarctic and sub-Antarctic environments.

Aim 2: Compare the genomes of Antarctic and sub-Antarctic midges. This aim will complement our existing data for *B. antarctica* and create a powerful platform for investigate evolutionary adaptations to Antarctic environments.

Aim 3: Investigate patterns of diversification and local adaptation in all three species. All three species of midges are flightless, suggesting population isolation could occur across relatively small spatial scales. This isolation likely leads to unique adaptations that have left distinct signatures in their respective genomes.

▲ *Collecting larvae of the Antarctic midge, Belgica antarctica, on the Antarctic Peninsula*

Signy Research Station

Signy Island marine predators long-term monitoring and survey programme

(RICHARD PHILIPS, Mike Dunn), Derren Fox

Timing: January to March 2023

More information: *https://www.bas.ac.uk/project/higher-predators-long-term-science/higher-predators-signy-island-penguin-monitoring*

The British Antarctic Survey carries out Long-Term Monitoring and Survey (LTMS) on marine predators, including seals, penguins and flying seabirds. These are valuable bioindicators of changes in Antarctic ecosystems, both natural (such as climate variability), and those brought about by humans (such as fishing). The long-term studies provide data on population sizes and trends, reproductive success, adult and juveniles survival, timing of breeding, chick and pup condition, and diet of seabirds and seals. These data can be used to understand the key drivers of environmental variability and to predict future changes in Antarctic ecosystems.

Recent analyses show that modes of climate variability, for example the Southern Annular Mode and the El Niño Southern Oscillation, affect upper-trophic-level predators (including seals and penguins) in different ways. The Antarctic is unique in that scientists and policy-makers from many nations have adopted an ecosystem approach for managing fisheries. Analyses of the LTMS data inform the regional conservation and management authority for Southern Ocean fisheries, the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR).

BAS data on albatrosses, giant petrels and white-chinned petrels are also used by the Agreement on the Conservation of Albatrosses and Petrels (ACAP) to understand and highlight reasons why these species are declining. This information is used to develop strategies to minimise or eliminate the major threats, including campaigning for the wider use of mitigation to reduce the currently high rates of incidental mortality (bycatch) of seabirds in many fisheries.

▲ *Blue-eyed shags*

▲ *Gentoo penguins*

Signy Research Station

Summer-monthly collections of the intertidal bivalve Lissarca miliaris at Shallow Bay, Signy Island

(KATRIN LINSE, Mike Dunn), [Signy Station Leader]

Timing: January to March 2023

Lissarca miliaris is a small, up to 5mm-long, reddish-brown bivalve that lives on red and brown seaweed in the intertidal of Signy Island. Specimens previously collected between 1972 and 2011 were analysed for growth and reproduction and showed changes in growth performance correlating with a 40-year warming event of air temperatures, suggesting local adaptation to increasing temperatures. They also showed changes in reproductive efforts with more but smaller juveniles being brooded and released. Since then, we continued the bivalve collections to monitor further growth and reproductive changes and since 2014 we monitor the annual intertidal, subtidal, and terrestrial temperatures, a key environmental factor, with TinyTag temperature loggers. In our dataset until 2019, we can see that times without broken winter sea-ice increase and intertidal bivalves are experiencing colder winter temperatures.

For the bivalve collections a handful of seaweeds is picked at monthly intervals during the summer season from the stepping stones in 'Shallow Bay' and checked for the presence of the small bivalves. The bivalves (~50 individuals) will be removed either in the field or in the lab from the seaweed and fixed in ~70% ethanol.

The measurements from the TinyTag loggers, deployed at one intertidal, one subtidal and four terrestrial sites, will be downloaded once per year and at the same time have their batteries replaced.

▲ *Lissarca miliaris on seaweed*

Signy Research Station

The Antarctic Biota Count (ABC): a functional trait-based approach to scale biodiversity from plot to region

(STEF BOKHORST, Pete Convey, Hans Cornelissen), Seringe Huisman, Ingeborg Klarenberg

Timing: January to March 2023

Protection of Antarctic biodiversity is a key founding principle of the Antarctic Treaty, today achieved through the Environmental Protocol. However, Antarctica's terrestrial ecosystems are not well represented in any form of Systematic Conservation Plan due to a lack of spatially-explicit data on vegetation composition and abundance and its associated biodiversity. This project will deliver such terrestrial biodiversity data along the Antarctic Peninsula to inform the evidence-based designation of new Antarctic Specially Protected Areas. This will be achieved by quantifying vegetation cover, and the functional groups supporting biodiversity, on the ground and linking this to satellite images for upscaling.

▲ *Different mite species associated with contrasting vegetation. What role does the vegetation play in ecosystem functioning and biodiversity along the Antarctic Peninsula? Can we scale these functions from local scales (1-100 m) across the length of the Antarctic Peninsula (>1,000 km)?*

Signy Research Station

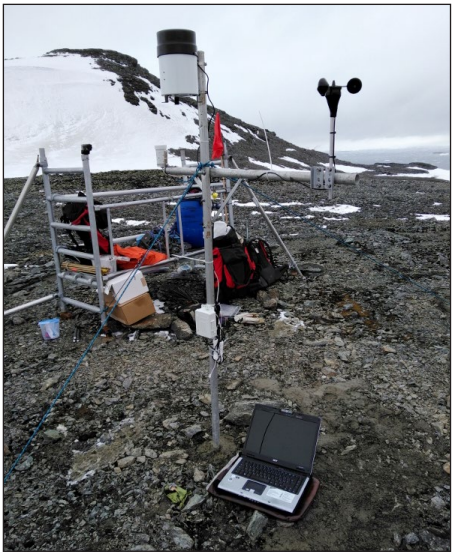
Vegetation and cryosphere (permafrost and glaciers): impacts of recent and past climate change in maritime Antarctica and Antarctic Peninsula

NICOLETTA CANNONE, (Mauro Guglielmin, Francesco Malfasi)

Timing: January to March 2023

Antarctica is extremely vulnerable to increasing threats from climate change, with vegetation, and cryosphere (e.g. glaciers, permafrost and active layer) being highly-sensitive components of the terrestrial ecosystems. The impacts of recent climate change are already evident both in maritime Antarctica (MA), where in response to warming, a large increase of the two native vascular plants was detected at Signy Island since the 1960s and in the Antarctic Peninsula (AP), which has been among the fastest-warming regions of the planet, and despite a short cooling, now is showing a striking increase in the last decade in response to climate change acceleration.

CRYOVEG is a multidisciplinary and international project focusing on the impact of past and recent climate change on the sensitive system vegetation – cryosphere (permafrost and glaciers) across an established long-term monitoring network of the sensitive system vegetation – permafrost established since 2001 in MA, AP and continental Antarctica. In MA and AP the network was developed in collaboration with the British Antarctic Survey at Signy Island and Rothera Point. For these aims the research activities include long-term monitoring of permafrost, active layer, vegetation and soils, as well as manipulative field experiments simulating the impacts of potential future climate change established since 2014.



▲ *Automatic weather station for the long-term monitoring of climate and the assessment of climate change impacts on terrestrial ecosystems*

Appendix

List of non-BAS personnel and their associated institutes

Highlight projects

Name	Institute
Sridhar Anandakrishnan	*Penn State University, USA*
Robert Bingham	*Edinburgh University*
Julien Bodart	*Edinburgh University*
Robin Bolsey	*University of California Santa Cruz, USA*
Louise Borthwick	*Temple University, USA*
Anna Broome	*Stanford University, USA*
Elizabeth Case	*Columbia University, USA*
Knut Christianson	*University of Washington, USA*
Poul Christoffersen	*University of Cambridge*
Gabriela Collao Barrios	*University of Colorado, USA*
Lucia Gonzalez	*University of Texas at El Paso, USA*
Andrew Hoffman	*University of Washington, USA*
Coen Hofstedeg	*Alfred Wegener Institute (AWI), Germany*
Madeline Hunt	*PASSCAL, USA*
Galen Kaip	*University of Texas at El Paso, USA*
Marianne Karplus	*University of Texas at El Paso, USA*
Florian Koch	*Alfred Wegener Institute (AWI), Germany*
Tanner Kuhl	*Ice Drilling Program, University of Wisconsin-Madison, USA*
Michelle Maclennan	*University of Colorado, USA*
Emelie Mahdavian	*University of Utah, USA*
Manuel Moncada	*University of Texas at El Paso, USA*
Cecilia Mortenson	*N/A*
Alberto Naveira Garabato	*National Oceanography Centre*
Naomi Ochwat	*University of Colorado, USA*
Helen Ockenden	*Edinburgh University*
Emma Pearce	*University of Leeds*
Rebecca Pearce	*Swansea University*
Erin Pettit	*Oregon State University, USA*
Andrew Pretorius	*University of Leeds*
Ian Renfrew	*University of East Anglia*
Meghan Sharp	*Oregon State University, USA*
Andrew Shepard	*University of Leeds*
Dan Smith	*University of Manchester*

continued ▷

Appendix *continued*

List of non-BAS personnel and their associated institutes continued

Highlight projects continued

Name	Institute
Nate Stevens	*University of Madison, USA*
Tara Sweeney	*University of Texas at El Paso, USA*
David Topping	*University of Manchester*
Slawek Tulaczyk	*University of California Santa Cruz, USA*
Paul Winberry	*Central Washington University, USA*
Christian Wild	*Oregon State University, USA*
TJ Young	*University of Cambridge*
Ole Zeising	*Alfred Wegener Institute (AWI), Germany*

Field-based projects

Name	Institute
Alison Barnwell	*University of Colorado, USA*
Mike Bentley	*Durham University*
Scott Braddock	*University of Maine, USA*
Peter Clarke	*Newcastle University*
Claudia Colesie	*University of Edinburgh*
Stephen Cornford	*Swansea University*
Matthew Davey	*Scottish Association for Marine Science (SAMS)*
Becky Dell	*University of Cambridge*
Eduard de Souza Neto	*Swansea University*
Andrew Gray	*University of Edinburgh*
Bryn Hubbard	*Aberystwyth University*
Glenn Jones	*Swansea University*
Matt King	*University of Tasmania, Australia*
Bernd Kulessa	*Swansea University*
Thomas Lees	*Durham University*
Adrian Luckman	*Swansea University*
Doug MacAyeal	*University of Chicago, USA*
Javier Martin-Torres	*University of Aberdeen*
Katie Miles	*Aberystwyth University*
Elliot Moravec	*University of Wisconsin-Madison, USA*
Keir Nichols	*Imperial College London*
Anya Reading	*University of Tasmania, Australia*

continued ▷

Appendix *continued*

List of non-BAS personnel and their associated institutes continued

Field-based projects continued

Name	Institute
David Small	*Durham University*
Paul Smeets	*University of Utrecht, Netherlands*
Alison Smith	*University of Cambridge*
Laura Stevens	*University of Oxford*
Alex Thomson	*Scottish Association for Marine Science (SAMS)*
Carleen Tijm-Reijmer	*University of Utrecht, Netherlands*
Stephan Trabucatti	*3D Drilling Ltd*
Michiel Van Den Broeke	*University of Utrecht, Netherlands*
Ryan Venturelli	*Colorado School of Mines, USA*
Charlotte Walshaw	*University of Edinburgh*
Pippa Whitehouse	*Durham University*
Ian Willis	*University of Cambridge*
Terry Wilson	*Ohio State University, USA*
Dominic Winksi	*University of Maine, USA*
Bert Wouters	*University of Utrecht, Netherlands*

Rothera Research Station

Name	Institute
Stef Bokhorst	*VU Amsterdam, Netherlands*
Mareike Bach	*University of Groningen, Netherlands*
Antonio Camacho	*University of Valencia, Spain*
Hans Cornelissen	*VU Amsterdam, Netherlands*
Dan Costa	*University of California Santa Cruz, USA*
Daniel Dietrich	*University of Konstanz, Germany*
Kenneth Dumack	*University of Cologne, Germany*
Ian Hawes	*University of Waikato, New Zealand*
Lucy Hawkes	*University of Exeter*
Svenja Heesch	*University of Rostock, Germany*
Luis Huckstadt	*University of California Santa Cruz, USA*
Anne Jungblut	*Natural History Museum, London*
Japareng Lalung	*Universiti Sains Malaysia, Malaysia*
Antonio Quesada	*University Autonoma Madrid, Spain*
Eva Riehle	*University of Konstanz, Germany*
Jaqueline Stefels	*University of Groningen, Netherlands*

Appendix *continued*

List of non-BAS personnel and their associated institutes continued

Rothera Research Station continued

Name	Institute
Susanna Wood	*Cawthron Institute, New Zealand*
Maria van Leeuwe	*University of Groningen, Netherlands*

Halley VI Research Station

Name	Institute
Rebecca Fisher	*Royal Holloway University of London*
Grant Forster	*University of East Anglia*
James France	*Royal Holloway University of London*
Keisuke Hosokawa	*University of Electro-Communications, Japan*
David Lowry	*Royal Holloway University of London*
Euan Nisbet	*Royal Holloway University of London*
Yasunobu Ogawa	*National Institute of Polar Research, Japan*
Mitsunori Ozaki	*Kanazawa University, Japan*
Kazuo Shiokawa	*Nagoya University, Japan*
Corwin Wright	*University of Bath*

King Edward Point Research Station

Name	Institute
Patrick Keith	*Essex University*

Signy Research Station

Name	Institute
Monica Aquilino	*University of Birmingam*
Stef Bokhorst	*VU Amsterdam, Netherlands*
Nicoletta Cannone	*University of Insubria, Italy*
Hans Cornelissen	*VU Amsterdam, Netherlands*
Mauro Guglielmin	*University of Insubria, Italy*
Scott Hayward	*University of Birmingham*
Seringe Huisman	*VU Amsterdam, Netherlands*
Ingeborg Klarenberg	*VU Amsterdam, Netherlands*
Francesco Malfasi	*University of Insubria, Italy*
Andrew Michel	*Ohio State University, USA*
Nicholas Teets	*University of Kentucky, USA*

Feedback and further information

We welcome your feedback and comments on this document. These should be addressed to:

Mairi Simms

British Antarctic Survey
High Cross, Madingley Road
Cambridge, CB3 0ET, UK

Tel: +44 (0)1223 221400
Email: rscico@bas.ac.uk

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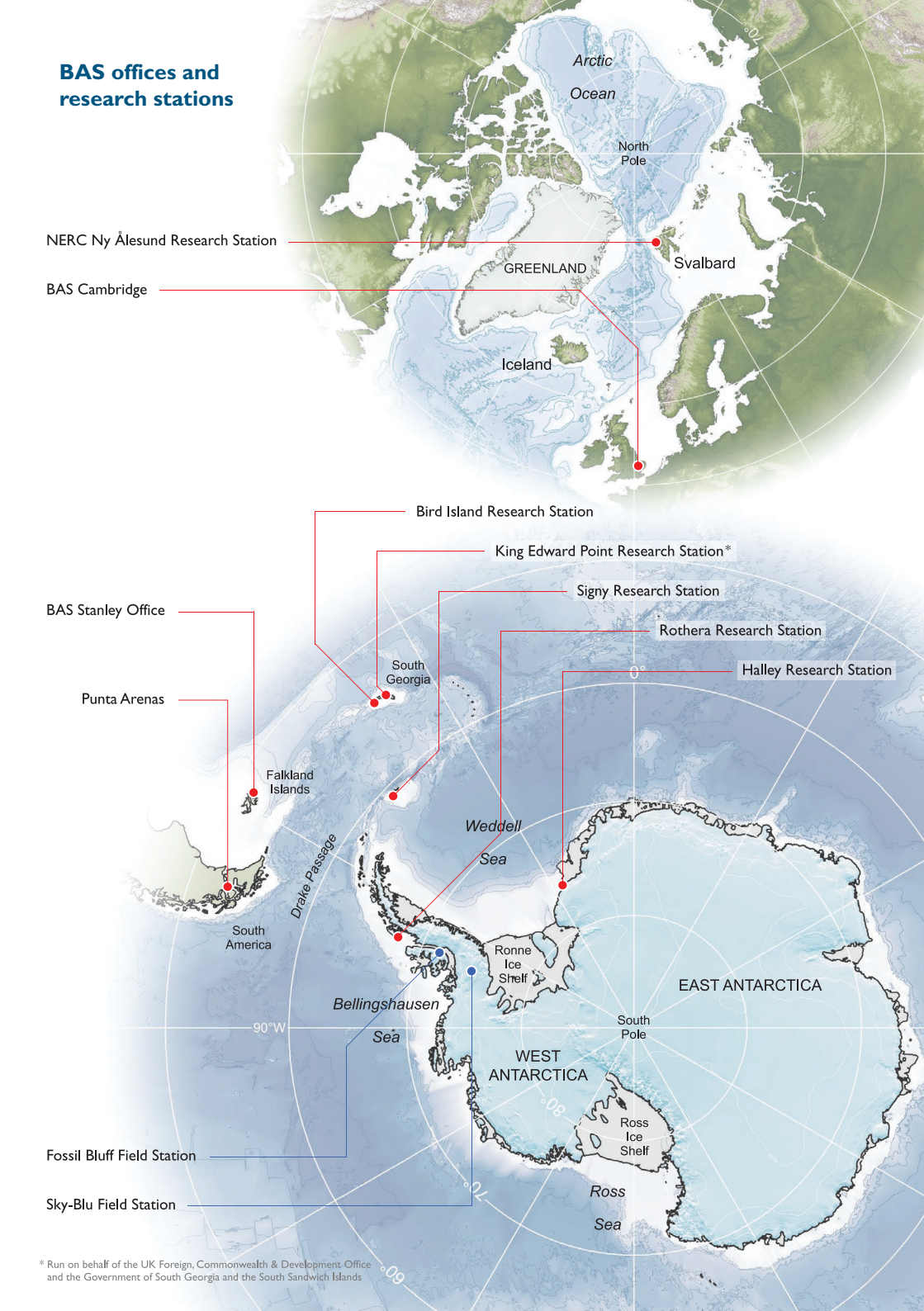
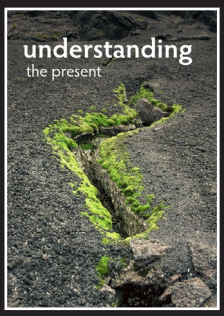
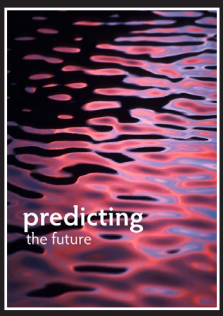


* Run on behalf of the UK Foreign, Commonwealth & Development Office and the Government of South Georgia and the South Sandwich Islands





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