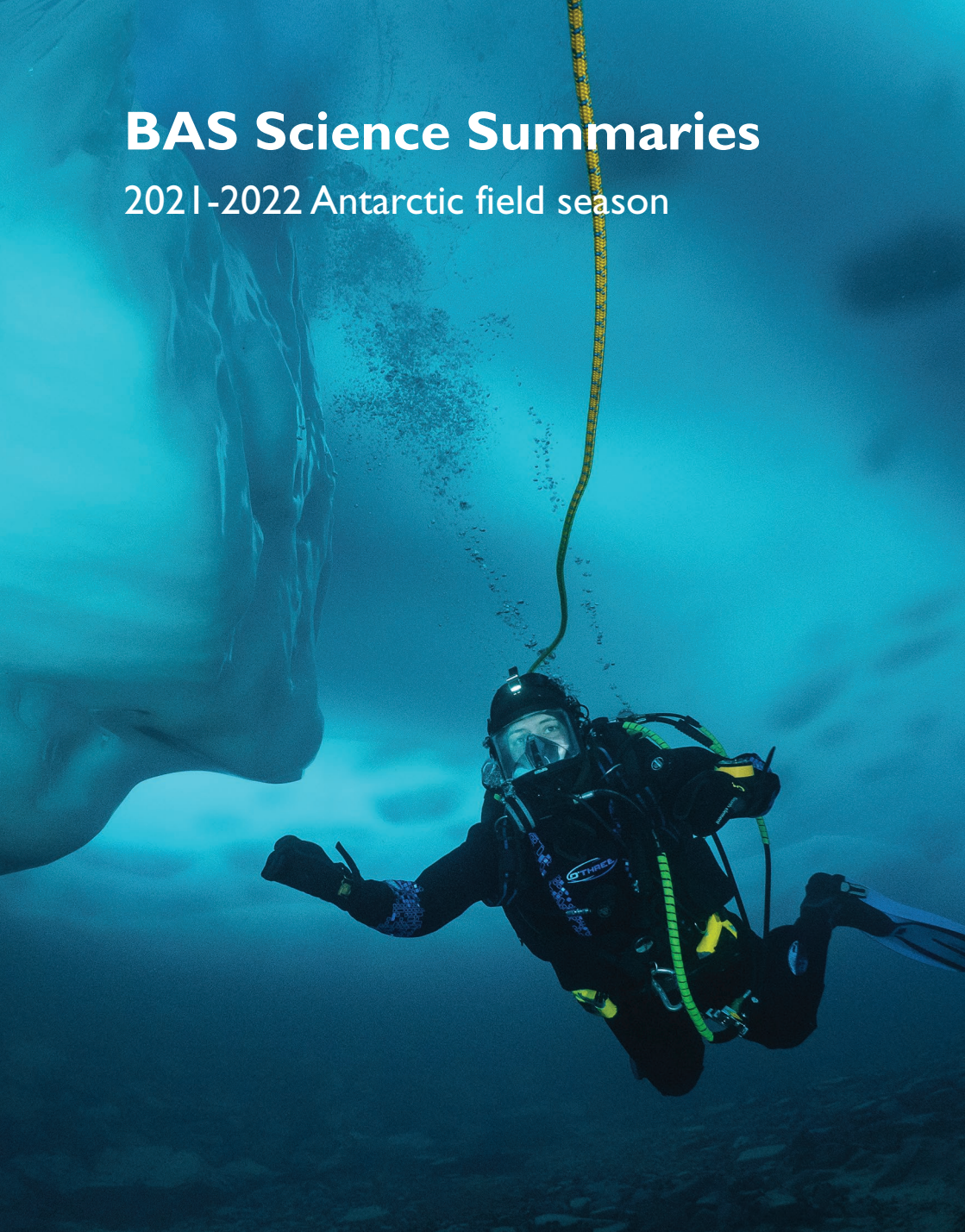


# BAS Science Summaries

2021-2022 Antarctic field season



**British  
Antarctic Survey**

NATURAL ENVIRONMENT RESEARCH COUNCIL

**POLAR SCIENCE**  
**FOR PLANET EARTH**

*Cover: The scientific diving program at Rothera Research Station supports a plethora of projects and important long-term monitoring programmes studying marine biodiversity in a changing world*

# BAS Science Summaries

## 2021-2022 Antarctic field season

### Introduction

This booklet contains the project summaries of field, station and ship-based science that the British Antarctic Survey (BAS) is supporting during the 2021/22 Antarctic field season. After the extensive disruption last season from the Covid-19 pandemic, the projects described in this booklet represent a significant step on our return towards 'business as usual'.

There is no doubt that 2021/22 will be an extremely challenging field season, given the number and range of projects to be delivered, and the geographical stretch. A fascinating suite of projects are planned, tackling questions in climate science, ecosystems and biodiversity, as well as testing out new autonomous science capability through atmospheric chemistry projects at Halley, and BAS's Remotely Piloted Autonomous Systems (RPAS).

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 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. My best wishes to all of the teams. I hope you all have a successful and safe 2021/22 field season.

### Dr Anna Jones

Interim Director of Science, BAS



November 2021



▲ Gentoo penguins are part of the Signy Island marine predators Long-Term Monitoring and Survey (LTMS) programme

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<i>King Edward Point Research Station</i>	<b>10</b>
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# List of science projects

## 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 <i>Sites along the Antarctic Peninsula and around Halley</i>	(STEVE COLWELL), Tom Chitson, Jo Cole, Jack Farr, John Law, Mairi Simms	13
Bravo	Long-term micro-environmental monitoring for terrestrial biology <i>Rothera Research Station (Anchorage island), Alexander Island (Coal Nunatak, Mars Oasis), Signy Research Station</i>	(PETE CONVEY, KEVIN NEWSHAM), Aurelia Reichardt, [Field Guide]*	14
Charlie, Juliet, November & Zulu	Quantifying West Antarctic mantle viscosity via precise GPS measurement of Earth's response to surface mass balance anomalies <i>Throughout western Antarctica</i>	(MIKE BENTLEY, PETER CLARKE, MATT KING, PIPPA WHITEHOUSE, TERRY WILSON, Anya Reading, Michiel van den Broeke, Bert Wouters), [BAS Engineers], [Field Guides]*	15
Delta	December 2021 Eclipse Campaign <i>Mt Johns</i>	(MERVYN FREEMAN, Michael Hartinger, Mike Rose), Jaskiran Nagi	16
Echo	Interglacial Collapse of the West Antarctic Ice Sheet revealed by subglacial Drilling (INCISED) <i>Behrendt Mountains, Haag Nunataks and Northern Ellsworth Mountains</i>	(MIKE BENTLEY), Neil Ross, Ed Luke*	17
Foxtrot	Sub-ice-shelf boundary-layer experiment (SIBLEX) <i>Larsen C Ice Shelf</i>	(KEITH NICHOLLS), [BAS Engineers], [Field Guide]*	18
Golf	ORCHESTRA <i>Airborne observations over the Weddell Sea (day trips from Rothera)</i>	TOM LACHLAN-COPE, Alexandra Weiss, Jonathan Witherstone	19
Hotel	Mars analogue prototype environmental monitoring equipment for a parallel operation to Mars mission <i>Sky-Blu</i>	(JAVIER MARTIN-TORRES, MARIA-PAZ ZORZANO, PETER CONVEY, MERVYN FREEMAN), [BAS Engineers]	20
India	International Thwaites Glacier Collaboration (ITGC) – TIME project <i>Thwaites Glacier region, West Antarctica</i>	POUL CHRISTOFFERSEN, Ronan Agnew, Emma Smith, T] Young, [and others], Julie Baum*, Taff Raymond*	21
Lima	Low power magnetometer servicing <i>Polar plateau</i>	(MIKE ROSE, MERVYN FREEMAN), [BAS Engineers]	22
Romeo	Ice-shelf instability caused by active surface meltwater production, movement, ponding and hydro-fracture (NSFGEO-NERC) <i>Area around Fossil Bluff</i>	ALISON BANWELL, (Doug MacAyeal), Laura Stevens, Ian Willis, Mark Chambers*	23
Sierra	Investigating Ronne Ice Shelf using ground-based radar (ApRES) <i>Ronne Ice Shelf</i>	(KEITH NICHOLLS), Irena Vankova, [Field Guide]*	24

continued ▷

# List of science projects *continued*

## Field-based projects *continued*

<b>Sledge</b>	<b>Project title Location</b>	<b>Personnel</b> PI in capitals and brackets if not present, Non-BAS personnel in blue, *Field Guide	<b>Page</b>
Tango	Field sites serviced from Halley – Filchner Ice Shelf System (FISS) <i>Filchner Ice Shelf</i>	(KEITH NICHOLLS), [BAS Engineers]	<b>25</b>
Uniform	BEAMISH: Data recovery and final site closure <i>Rutford Ice Stream</i>	(ANDY SMITH), [BAS Engineers]	<b>26</b>
Whiskey	Seismic investigation of SLC (Lago Subglacial CECs) <i>Subglacial Lake CECs</i>	ANDY SMITH, JB Chandesris*	<b>27</b>
X-ray	University of Utrecht IMAU Automatic Weather Station in the Antarctic <i>Larsen C Ice Shelf</i>	(CARLEEN REIJMER), Tom Chitson, Jo Cole, John Law, Mairi Simms, (Paul Smeets, Michiel van den Broeke)	<b>28</b>
N/A	ANTSIE (ANTarctic Sea Ice Evolution from a novel biological archive) <i>Princess Elisabeth Station (Belgian Programme), Svarthamaren nunatak (Tor field station)</i>	(ERIN MCCLYMONT, Mike Bentley, Dominic Hodgson), Eleanor Maedhbh Honan, Richard Phillips, (Louise Sime), Ewan Wakefield	<b>29</b>
N/A	Environmental management visits to Antarctic Specially Protected Areas managed by the UK <i>South Orkney Islands: Moe Island, Lynch Island, Southern Powell Island; Marguerite Bay: Lagotellerie Island, Rothera Point</i>	(KEVIN HUGHES), Fran Potheary, Aurelia Reichardt	<b>30</b>
N/A	International Thwaites Glacier Collaboration (ITGC) – TARSAN and THOR projects <i>Thwaites Glacier region, West Antarctica</i>	ROB LARTER, KAREN HEYWOOD [and others]	<b>31</b>
N/A	Ops Traverse <i>West Antarctica</i>	Calum Evans, Zac Gedny, Tyler Gilbertson, Chris Jacobs, Dave Jamieson, Logan Johnson, Dan Lewis, Marek Pazstor, Matt Rowbottom [and others], Rob Grant*, Mark Scales*, Catrin Thomas*	<b>33</b>
N/A	SOCHIC (Southern Ocean Carbon and Heat Impact on Climate) <i>Maud Rise and northern edge of Weddell Sea, onboard SA Agulhas II</i>	(JEAN-BAPTISTE SALLÉE), ALEX BREARLEY, (ANDREW MEIJERS, Povl Abrahamsen), Mark Barham, Natasha Lucas	<b>34</b>
N/A	Spatial segregation and bycatch risk of seabirds at South Georgia <i>Paryadin Peninsula, Cooper Island and Prion Island (South Georgia)</i>	VICTORIA WARWICK-EVANS, (Richard Philips)	<b>35</b>

*continued* ▷

# List of science projects *continued*

## Rothera Research Station

Project title	Personnel PI in capitals and brackets if not present, Non-BAS personnel in blue, *Field Guide	Page
Annual Rothera ramp re-survey	(ANDY SMITH), [BAS Engineer], [Met and Field Guide]	36
ARMS (Autonomous Reef Monitoring Structures)	MELODY CLARK, LLOYD PECK, [Rothera Dive Team]	37
BRUV (Baited Remote Underwater Video)	MELODY CLARK, (SIMON MORLEY), LLOYD PECK, [Rothera Dive Team]	38
Degradation dynamics of Antarctic macroalgae	(SIMON MORLEY), Nadia Frontier, (Ben Wigham), [Rothera Dive Team]	39
IBIS (IceBerg Impact Study)	(DAVID BARNES), Hollie London, Ryan Mathews, [Rothera Dive Team]	40
Modelling marine microbial interactions in the Southern Ocean	JULIA ENGELMANN, Swan Li San Sow	41
Multi-omics analysis of the impacts of climate change and pollution on nitrogen-fixing microbial communities	WAN LUTFI WAN JOHARI, (Mohd Yunus Shukor, Nur Adeela Yasid)	42
Obtaining seasonal growth measures of key benthic species	(SIMON MORLEY, LLOYD PECK), Nadia Frontier, [Rothera Dive Team]	43
Post-construction benthic environmental monitoring of Rothera and KEP wharfs	(SIMON MORLEY, Kevin Hughes), Ben Robinson	44
Rothera Biological Long-Term monitoring – Reproduction	(DAVID BARNES), LLOYD PECK, Melody Clark, Hollie London, (Simon Morley), Ryan Mathews, [Rothera Dive Team]	45
Rothera Oceanographic and Biological Time Series (RaTS)	DAVID BARNES, MICHAEL MEREDITH, HUGH VENABLES, Alex Brearley, Hollie London, Ryan Mathews	46
Rothera skua long-term monitoring and AIMP bird monitoring for wind turbines EIA	(RICHARD PHILLIPS, Kevin Hughes), Ruben Fijn, Aurelia Reichardt, Paul Whitelaw	47
The Antarctic biota count (ABC): a functional trait-based approach to scale biodiversity from plot to region	(HANS CORNELISSEN), Stef Bokhorst, Emma Ciric, (Pete Convey), Seringe Huisman, (Sander Veraverbeke)	48

*continued* ▷



# 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
All-sky camera	(TRACY MOFFAT-GRIFFIN), David Goodger, Hessel Gortner	49
Auroral cameras – conjugate measurements of isolated proton auroras, red aurora, and pulsating auroras at subauroral latitudes – Optical	(TRACY MOFFAT-GRIFFIN, MITSUNORI OZAKI), Hessel Gortner, (Keisuke Hosokawa), Dominic Jaques, Carson McAfee, (Yasunobu Ogawa, Kazuo Shiokawa)	50
Clean Air Sector Laboratory (CASLab)	(ANNA JONES, FREYA SQUIRES), Josh Eveson, [BAS Atmospheric Scientist]	51
Discovering reasons for atmospheric methane growth using deuterium isotopes (MethaneDH)	(REBECCA FISHER, Grant Forster, James France), Hessel Gortner, Dominic Jaques, (Anna Jones, David Lowry, Euan Nisbet), Ross Sanders, (Freya Squires)	53
Electro-Magnetic Quiet Area	(MARK CLILVERD, MERVYN FREEMAN, RICHARD HORNE) Sebastian Gleich, Hessel Gortner, Dominic Jaques	55
Glaciological monitoring of the Brunt Ice Shelf	OLIVER MARSH, DAVID VAUGHAN), James Byrne, Sebastian Gleich, Hessel Gortner	56
Halley Automation Project	(THOMAS BARNINGHAM, MIKE ROSE), [Halley Automation Project Team]	59
Infrared Camera	(TRACY MOFFAT-GRIFFIN), Hessel Gortner, Dominic Jaques, Corwin Wright	60
Meteorology and ozone monitoring	(STEVE COLWELL) Josh Eveson, Hessel Gortner, Dominic Jaques, Ross Sanders, [Halley Atmospheric Scientist]	61
Summertime observations of nitrous acid gas (HONO) concentrations and flux above snow in coastal Antarctica	(MILLIE BOND), Markus Frey, Freya Squires	63

*continued* ▷

## List of science projects *continued*

### *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), James Crymble, (Mike Dunn), Jaume Forcada, Imogen Lloyd, Marine Quintin, Claire Stainfield, Erin Taylor, Mark Whiffin, (Andy Wood)	64
Cable installation for burrow-monitoring system at Bird Island	(RICHARD PHILLIPS), Mark Whiffin, [BI Tech Service]	65
Using dynamic energy landscapes to understand drivers of movement, foraging and life history patterns in albatrosses	(RICHARD PHILLIPS), <a href="#">LESLEY THORNE</a>	66

### *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), Jamie Coleman, (Martin Collins, Jennifer Jackson), Matt Marsh	67
Does rafting allow connectivity across the Antarctic Polar Front? A case study of the direct developing periwinkle <i>Laevitorina caliginosa</i>	SIMON MORLEY, <a href="#">Claudio Gonzalez-Wevar</a> , [KEP staff]	68
Higher predator monitoring at Cumberland Bay	(PHILLIP HOLLYMAN), Jamie Coleman, (Martin Collins), Meghan Goggins, Matt Marsh, Kate Owen	69
Initiating monitoring support for the SGSSI-MPA Research and Monitoring Plan	PHILIP TRATHAN, (Martin Collins), Nathan Fenney, (Adrian Fox, Phillip Hollyman)	70
Long-term monitoring of plankton communities in South Georgia waters	(MARTIN COLLINS), Jamie Coleman, Meghan Goggins, Matt Marsh, Kate Owen	71

### *Signy Research Station*

Project title	Personnel PI in capitals and brackets if not present, Non-BAS personnel in blue, *Field Guide	Page
Signy Island marine predators long-term monitoring and survey programme	(RICHARD PHILIPS, Mike Dunn), Derren Fox, (Andy Wood)	72
Summer-monthly collections of the intertidal bivalve <i>Lissarca miliaris</i> at Shallow Bay, Signy Island and T-logger maintenance	(KATRIN LINSE), Derren Fox, Fran Potheary	73

*continued* ▷

# List of science projects *continued*

## *RRS Sir David Attenborough*

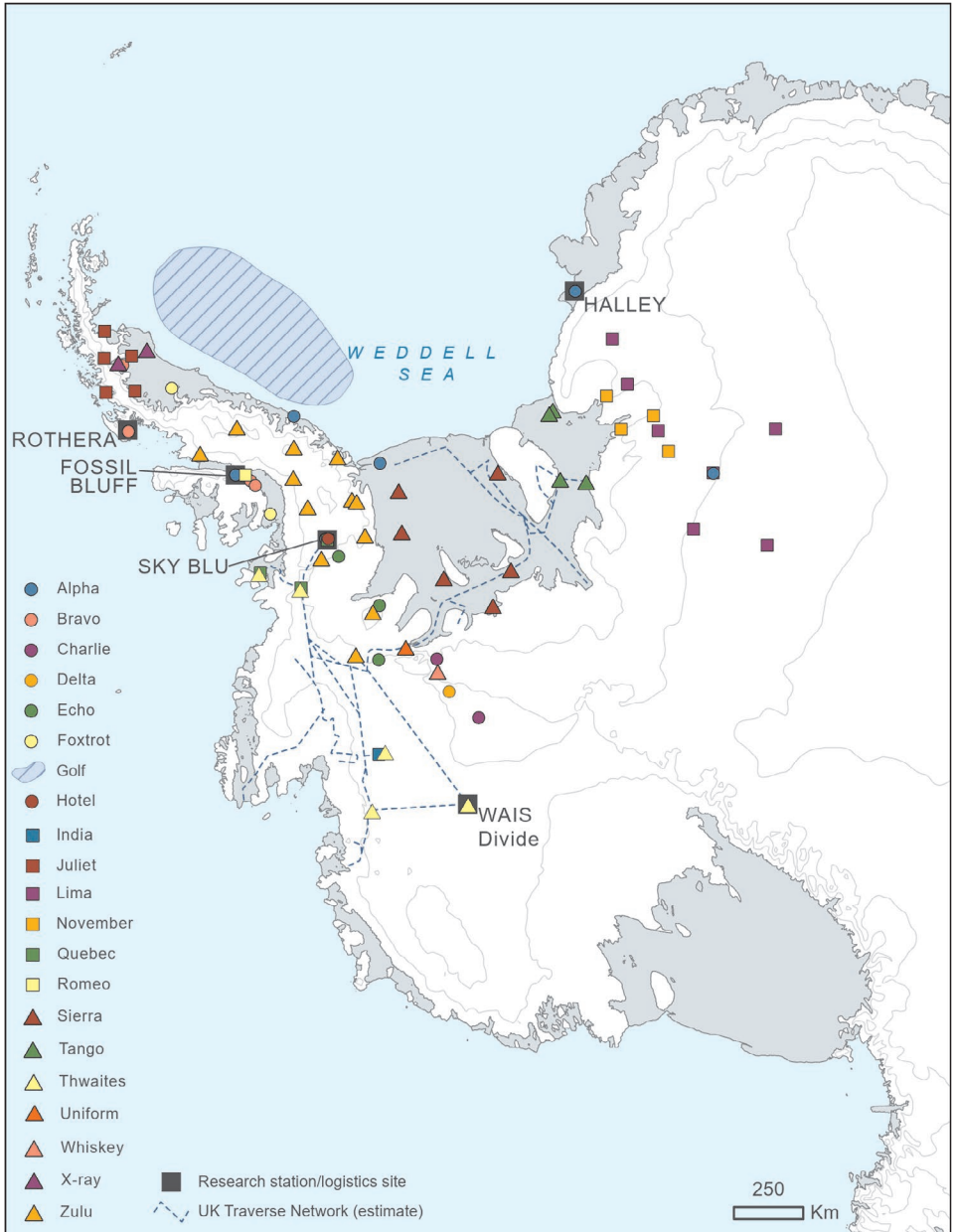
<b>Project title</b>	<b>Personnel</b> PI in capitals and brackets if not present, Non-BAS personnel in blue, *Field Guide	<b>Page</b>
Rothera oceanographic mooring	ALEX BREARLEY, Mark Barham, Gareth Flint, Tom Gillum-Webb, (Clara Manno, Hugh Venables), [SDA Officers and Crew]	<b>74</b>

## *Multiple locations*

<b>Project title</b>	<b>Personnel</b> PI in capitals and brackets if not present, Non-BAS personnel in blue, *Field Guide	<b>Page</b>
Southern Ocean clouds (Long-term measurements) <i>Rothera, Bird Island, RRS Sir David Attenborough</i>	TOM LACHLAN-COPE, (Anna Jones), Floortje Van Den Heuvel, Jonathan Witherstone	<b>75</b>

# Map of field-based project locations

2021-2022 Antarctic field season



# Field Science (Sledge Alpha)

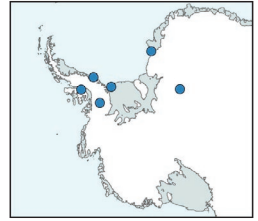
## Annual Antarctic Automatic Weather Station servicing

(STEVE COLWELL), Tom Chitson, Jo Cole, Jack Farr, John Law, Mairi Simms

**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 in order 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 Science (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

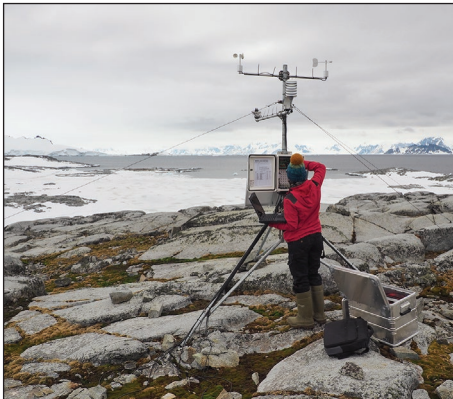
**Timing:** Opportunistic throughout the season

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.

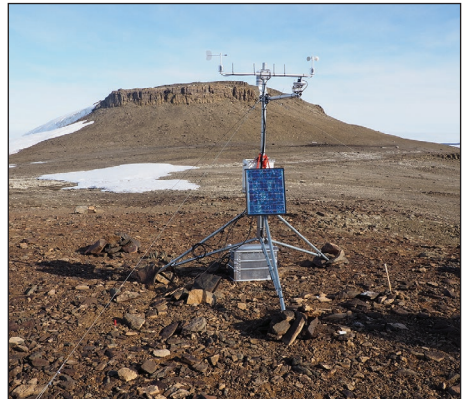
Routine site and equipment visits, downloading, and maintenance work, and one-off sampling requests, originally the responsibility of the Rothera Terrestrial Assistant, have been carried out by management agreement by the Bonner Lab Manager since the creation of that post – currently being Aurelia Reichardt. 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 base itself.

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

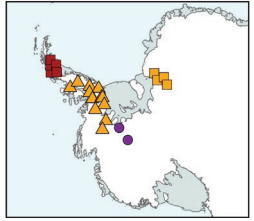


▲ Coal Nunatak is on Alexander Island and only a short fly away from Fossil Bluff. The AWS overlooks King George VI Sound

## Field Science (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, MATT KING, PIPPA WHITEHOUSE, TERRY WILSON, Anya Reading, Michiel van den Broeke, Bert Wouters), [BAS Engineers], [Field Guides]\*



**Location:** Throughout western Antarctica

**Timing:** Opportunistic throughout the season (multi-seasonal)

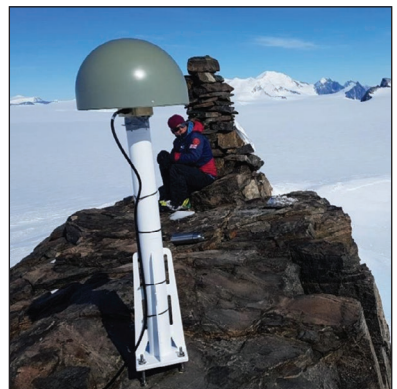
**More information:** <https://ukanet.wixsite.com/ukanet>

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 describes the ongoing solid Earth deformation that takes place in response to past ice-sheet mass change. It can be measured wherever we have access to bedrock, but the extensive ice cover across Antarctica means we must rely on mathematical models of GIA to interpret the satellite data. The models are calibrated and validated against precise measurements of Earth deformation made using 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 deforms in response to a surface load). The Earth's mantle shows viscous behaviour over long timescales, but it behaves elastically in the short term. Recent studies have demonstrated that there are 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 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 Science (Sledge Delta)

## December 2021 Eclipse Campaign

(MERYYN FREEMAN, Michael Hartinger, Mike Rose),  
Jaskiran Nagi

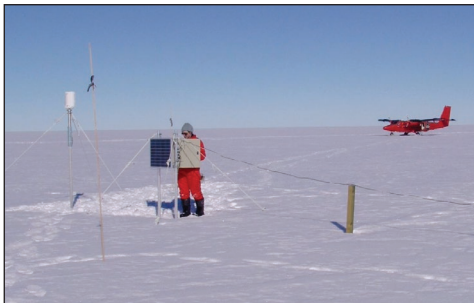
**Location:** Mt Johns

**Timing:** Late-November to early-December 2021

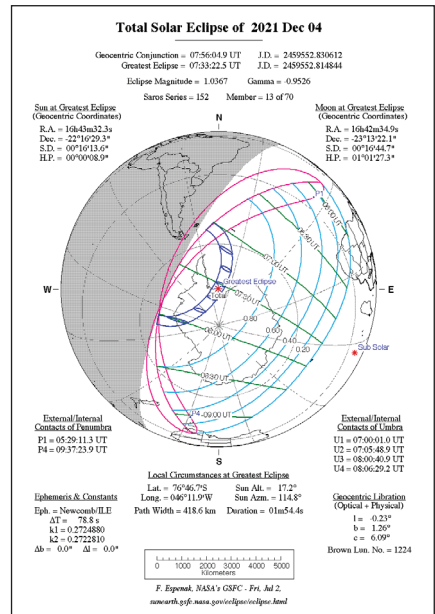


Controlling nature is impossible, but occasionally nature does act in a repeatable way that allows us to perform controlled experiments. One example is a solar eclipse when the Moon casts a moving shadow over some part of the globe, turning day into night more quickly than normal. On 4th December 2021 this will happen in Antarctica and a shadow will sweep across the Ronne Ice Shelf and Ellsworth Land. This eclipse will give us a great opportunity to see how quickly switching the Sun on and off affects space weather.

In this project, we will temporarily redeploy the Rothera Low Power Magnetometer (LPM) under the path of the eclipse as part of an international observing campaign. The magnetometer measures variations in Earth's magnetic field caused by space weather. In other parts of the world these magnetic variations induce unwanted electrical currents in electricity networks like the National Grid, which need to be accurately forecasted so that damage can be avoided. The results from our eclipse experiment will provide a challenging test of our understanding of space weather and whether forecasting models are correct or need to be improved.



▲ Typical LPM setup. From left to right: vertical axis wind turbine (white cylinder on scaffold pole), solar panel and electronics box on twin scaffold poles (with person), wooden catenary support, aluminium tube containing magnetometer. Two wooden marker poles are also seen in the foreground



▲ The path of the total eclipse lies within the dark blue arc region. Contours of 80, 60, 40, 20 and 0% darkness are shown by lighter blue contours



## Field Science (Sledge Echo)

### *Interglacial Collapse of the West Antarctic Ice Sheet revealed by subglacial Drilling (INCISED)*

(MIKE BENTLEY), Neil Ross, Ed Luke\*

**Location:** Behrendt Mountains, Haag Nunataks and Northern Ellsworth Mountains

**Timing:** December 2021 to January 2022 (season 1 of 3)



The work in this season will be over-snow survey work using skidoos and a towed, sledge-mounted ice radar. At each site, the team of Neil Ross and a Field Guide will survey the ice-sheet bed through several hundred metres of ice, to help the planning of future drill sites.

In future seasons we will return and at each location we will drill rapidly through the ice and then retrieve bedrock cores from the bed using new drill technology.

The work forms part of a large European-funded project called INCISED. The aim is to test the hypothesis that the West Antarctic Ice Sheet (WAIS) has collapsed, perhaps multiple times, in past interglacial periods. 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 will allow us to test hypotheses of past collapse. Using a combination of innovative drilling technology, sophisticated chemical analysis and computer modelling we will work out if the WAIS has collapsed during warmer periods in the past and provide estimates of the global 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 Science (Sledge Foxtrot)

### Sub-Ice-shelf Boundary-Layer EXperiment (SIBLEX)

(KEITH NICHOLLS), [BAS Engineers], [Field Guide]\*

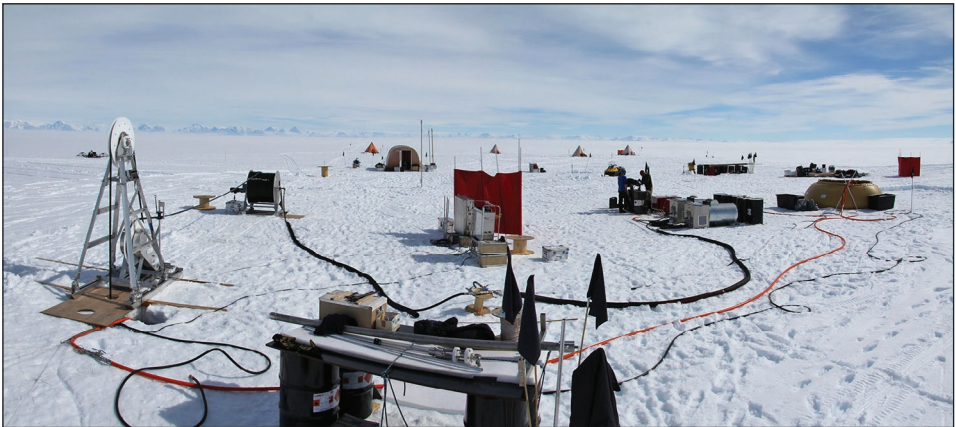
**Location:** Larsen C Ice Shelf

**Timing:** Opportunistic throughout the season (final season)

**More information:** <https://www.bas.ac.uk/team/science-teams/oceans>



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

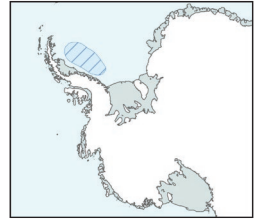
# Field Science (Sledge Golf)

## ORCHESTRA

TOM LACHLAN-COPE, Alexandra Weiss, Jonathan Witherstone

**Location:** Airborne observations over the Weddell Sea (day trips from Rothera)

**Timing:** Late-November to late-December 2021



In the ORCHESTRA campaign from Rothera over sea ice and open water, we plan to measure: airborne observations of; turbulent atmospheric fluxes of sensible and latent heat, momentum, and CO<sub>2</sub>; mean values of air temperature, pressure, humidity, atmospheric stability, sea/ice surface (brightness) temperature SST; radiative in- and outgoing fluxes of longwave and short wave; surface albedo; mean wind speed and direction; mean values of the concentration of atmospheric CO<sub>2</sub>; surface structure or roughness (using laser altimeter); aerosol numbers.

The focus will be on the observations of turbulent heat and CO<sub>2</sub> fluxes as these are the main key parameter of interest over the Southern Ocean in the ORCHESTRA project. We plan to observe and investigate the atmospheric processes of the atmospheric boundary layer over different surface and sea-ice conditions. We will concentrate on observations of sea ice in the Western Weddell Sea in this campaign as observations over sea ice have been sparse during the previous ORCHESTRA seasons.



▲ BAS Twin Otter aircraft 'Ice Cold Katy' (AZ) measuring turbulence over sea ice

## Field Science (Sledge Hotel)

*Mars analogue prototype environmental monitoring equipment for a parallel operation to Mars mission*

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

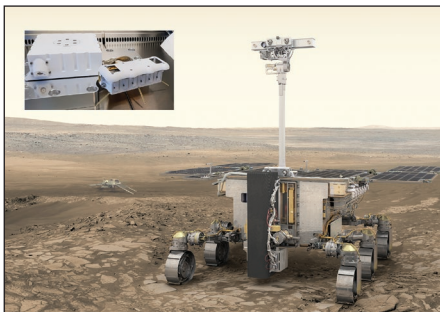


**Location:** Sky-Blu

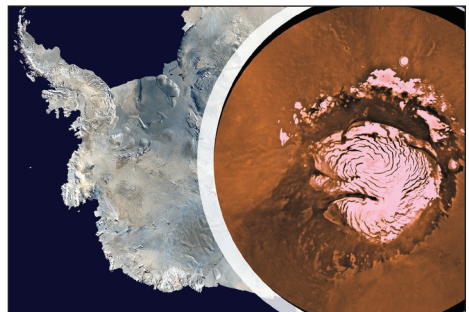
**Timing:** December 2021 (season 1 of 3)

The Department of Planetary Sciences at the University of Aberdeen is focused on the study of 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 the ExoMars 2022 mission due to land on Mars and generate data from the planet in June 2023. The HABIT project is funded by the UK Space Agency. The Department is running in parallel an educational programme that will start in September 2021. The HABIT research and outreach activities will be disseminated through the webpage of the group, and the ESA-ExoMars communication pages.

The current OSPQ is to support parallel installation and operation of a 'standalone' equivalent HABIT instrument at Sky-Blu in the 2021/22 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 direct download each season as a backup option. Continual operation from summer 2021/22 would allow identification of any major issue or required update which could if needed be addressed in the 2022/23 season. The operation would then continue through the 2023 austral winter to give parallel time coverage to the instrument to 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 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 Science (Sledge India)

*International Thwaites Glacier Collaboration (ITGC) –  
TIME project*

POUL CHRISTOFFERSEN, Ronan Agnew, Emma Smith, TJ  
Young, [and others], Julie Baum\*, Taff Raymond\*



**Location:** Thwaites Glacier region, West Antarctica

**Timing:** Early-December 2021 to mid-March 2022 (season 3 of 4)

**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.

This austral summer is the third of four field seasons. Four of ITGC's eight research projects will be deployed in Antarctica focusing on different aspects of the glacier and its environment. This season's expeditions will undertake work for several ITGC projects: Geological History Constraints on the Magnitude of Grounding-Line Retreat in the Thwaites Glacier System (GHC), Thwaites-Amundsen Regional Survey and Network Integrating Atmosphere-Ice-Ocean Processes (TARSAN), Thwaites Interdisciplinary Margin Evolution – The Role of Shear Margin Dynamics in the Future Evolution of Thwaites Drainage Basin (TIME) and Thwaites Offshore Research (THOR).

There will be two teams representing TIME this season at the Eastern Shear Margin, one from BAS (Sledge India) and one from the US program. Both teams are aiming to recover the GPS, ApRES and seismometers installed in the 2019/20 season that were investigating the hydrology and how the conditions at the bed of the glacier influence its behaviour. If the Thwaites Glacier at the Eastern Shear Margin moves towards Pine Island Glacier the two glaciers could combine, both of which are already leading to sea-level contributions. The observations will be fed into computer models to improve future predications of future sea-level contribution from the region.



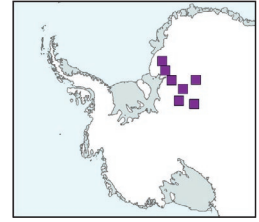
## Field Science (Sledge Lima)

### 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  $-80^{\circ}\text{C}$  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 Science (Sledge Romeo)

*Ice-shelf instability caused by active surface meltwater production, movement, ponding and hydro-fracture (NSFGEO-NERC)*

ALISON BANWELL, (Doug MacAyeal), Laura Stevens, Ian Willis, Mark Chambers\*



**Location:** Area around Fossil Bluff

**Timing:** Late-November to late-December 2021 (season 2 of 3)

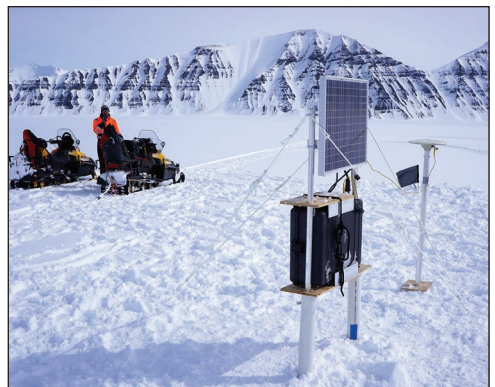
The evolution of surface meltwater lakes across Antarctic ice shelves has important implications for their stability, as demonstrated by the Larsen B Ice Shelf's rapid collapse in 2002. It is vital to understand the causes of ice-shelf instability because ice-shelf buttressing controls inland ice discharge, and therefore contributions to sea-level rise. Ice-shelf break-up may be triggered by stress variations associated with surface meltwater ponding and drainage, causing ice-shelf flexure and fracture. This project will provide key geophysical observations on the George VI Ice Shelf of the Antarctic Peninsula, where hundreds of lakes form each summer, which will improve understanding of surface meltwater-induced and ice-shelf instability.

Over a 27-month period (November 2019 to January 2022)\*, global positioning systems, water pressure sensors, automatic weather stations, and in-ice thermistor strings will be deployed to record ice-shelf flexure, water depths, and surface and subsurface melting, respectively, in and around several surface lakes within ~30km from Fossil Bluff. Field data will be used alongside satellite imagery to develop the team's existing approach to modelling ice-shelf flexure, stress, and 'Larsen-B style' rapid break-up.

\*Due to cancellation of last season due to Covid-19, we expect this project to end in January 2023.



▲ Meltwater lakes on George VI Ice Shelf in January 2020



▲ A GPS station installed on George VI Ice Shelf

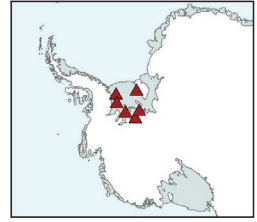
## Field Science (Sledge Sierra)

### Investigating Ronne Ice Shelf using ground-based radar (ApRES)

(KEITH NICHOLLS), Irena Vankova, [Field Guide]\*

**Location:** Ronne Ice Shelf

**Timing:** 2021/22 season



The field project composes three elements: investigating small scale ice shelf basal topography using radar; trialling a new technique using large-offset radar to study ice rheology; revisiting existing borehole and radar sites on Ronne Ice Shelf to service instruments and recover data.

Downward-looking radars (ApRES) were deployed as part of a project to study how the rate of melting at the base of Ronne Ice Shelf varies over time. A very careful study of those datasets has shown how we might use radar experiments to learn about the detailed topography of the ice base, which is thought to have a strong influence on basal melt rates. Specific experiments will be carried out to test the limits of our ability to use radar to study the evolution of the topography.

A variant of ApRES (IQApRES) will be used with a transponder to acquire large-offset polarimetric data. This trial will take place at an existing site on the ice shelf where the vertical variation of ice-crystal structure is thought to be relatively simple. Perfecting a radar-based technique to obtain profiles of preferred ice-crystal orientation is crucial for accurate modelling of ice flow.

Several existing borehole and ApRES sites, originally installed in the 2014/15 and 2015/16 seasons, will be revisited to service instruments and recover data.



▲ An ApRES (phase sensitive) radar system after being raised during a site-servicing visit on Ronne Ice Shelf



# Field Science (Sledge Tango)

## Field sites serviced from Halley – Filchner Ice Shelf System (FISS)

(KEITH NICHOLLS), [BAS Engineers]

**Location:** Filchner Ice Shelf

**Timing:** 2020/21 season

**More information:** <https://www.bas.ac.uk/project/fiss/#about>

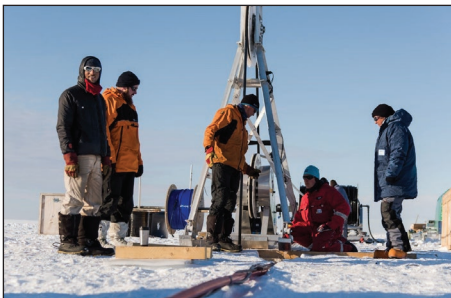


Understanding the contribution that polar ice sheets make to global sea-level rise is recognised internationally as urgent. The mission of this five-year project is to capture new observations to assess the future stability of Antarctica’s Filchner Ice Shelf so that credible projections of the West Antarctic Ice Sheet’s contribution to sea-level change over the next 50 years can be produced. The project is in collaboration with the FISP project of the Alfred Wegener Institute, Germany.

A research outcome from this project includes the acquisition of new knowledge from models and new datasets that are critical to the development of the Hadley Centre’s Global Earth Model. The improved projections that will result are essential to informing policy and business decisions relating to coastal and flood defence planning and investment.

This year, the engineering team from Halley will be servicing several of the FISS sites across the Filchner Ice Shelf. They include:

1. Sites where a hot-water drilled access hole to the ocean has allowed oceanographic observations to be made, and ocean instrumentation to be deployed in the long term. Data loggers at these sites will be raised, and their data cards replaced
2. Sites where ApRES instruments (stationary, active, downward-looking radars) have been deployed to make long-term measurements of the rate at which the ice-shelf base is being melted by the ocean
3. Sites where GPS instruments have been deployed to show how the ice shelf responds to tidal forcing. The ocean beneath the ice shelf is subject to tides, like everywhere else, and the ice shelf goes up and down as a result. It also moves horizontally at tidal frequencies, by up to a few tens of centimetres, as the ice shelf is tipped and slumps down the tidal wave



▲ Hot-water drilling on the Filchner Ice Sheet



▲ Field site for the FISS project

## Field Science (Sledge Uniform)

*BEAMISH: Data recovery and final site closure*

(ANDY SMITH), [BAS Engineers]

**Location:** Rutford Ice Stream

**Timing:** Late-January 2022



Currently, the biggest uncertainty in predicting future sea-level rise comes from the polar ice sheets. The BEAMISH project aims to reduce this uncertainty by understanding two aspects of that uncertainty, the past behaviour of the West Antarctic Ice Sheet, and the flow of the glaciers that drain it.

The main work took place in the 2018/19 season. Using a hot-water drill, we drilled through the ice, more than 2km thick, to reach the bed three times. We collected samples of the bed and from within the ice itself, and we installed instruments into the bed and the ice column. Each hole was deeper than BAS had ever drilled before. As well as the drilling, we carried out extensive seismic, radar and GPS experiments to study the ice motion and the bed underneath it.

The last remaining field task for the BEAMISH Project is the final download of data from the installed instruments, recovery of data loggers and decommissioning of the site.



▲ BEAMISH project location on Rutford Ice Stream

# Field Science (Sledge Whiskey)

## Seismic investigation of SLC (Lago Subglacial CECs)

ANDY SMITH, JB Chandresris\*

**Location:** Subglacial Lake CECs

**Timing:** Late-December 2021 to late-January 2022



Antarctic subglacial lakes contain unique records of ice-sheet history and microbial life; they may also be water sources that lubricate the ice sheet flowing over its bed, and potentially useful analogues in the search for extra-terrestrial life. Hence, subglacial lakes are the subject of much scientific interest, and much effort has been put into investigating them.

To gain the scientific benefits from subglacial lakes requires drilling into them so that lake water and bed sediments can be sampled. Preparations have started between BAS (UK) and the CECs institute (Chile) to drill into a subglacial lake near the Ellsworth Mountains – Lago Subglacial CECs (SLC) – in 2023/24. Prior to this, geophysical surveys can determine its physiography and characteristics, including the water depth, which can be measured using seismic surveys. These involve detonating small explosive charges and recording the echoes that are reflected off the top and bottom of the lake. The seismic data will help to decide the optimum access location.

Three seismic lines were acquired in 2016/17 field season. More lines acquired in 2021/22 will complete the necessary dataset, allowing the lakebed to be mapped in more detail and to determine the exact drill site location.



▲ Detonating a small explosive charge during a seismic survey

## Field Science (Sledge X-ray)

University of Utrecht IMAU Automatic Weather Station  
in the Antarctic

(CARLEEN REIJMER), Tom Chitson, Jo Cole, John Law, Mairi Simms, (Paul Smeets, Michiel van den Broeke)



**Location:** Larsen C Ice Shelf

**Timing:** Opportunistic throughout the season (multi-seasonal)

**More information:** [www.projects.science.uu.nl/iceclimate/aws](http://www.projects.science.uu.nl/iceclimate/aws)

In close collaboration with BAS, UU/IMAU operates Automatic Weather Stations at two sites (AWS14 and AWS18) in the Antarctic Peninsula which are serviced each year by BAS personnel from Rothera. These are part of a project started in 2009 with the overall aim to investigate the changing climate over the Larsen C Ice Shelf. The stations are equipped with sensors to measure temperature, humidity, wind speed and direction, air pressure, snow accumulation, short-wave incoming and reflected radiation, long-wave incoming and outgoing radiation, and snow temperature.

With these observations it is possible to calculate the amount of melt and study the changing snow conditions on the ice shelf. AWS14 is situated in the middle of Larsen C Ice Shelf while AWS18 is close to Cabinet Inlet and the stations were installed in January 2009 and December 2014, respectively. Yearly maintenance is performed by BAS personnel consisting of replacement of the AWS units, re-installing the snow temperature string and extending the telescopic mast whenever necessary due to snow accumulation.



▲ Maintenance of the IMAU AWS on Cabinet Inlet, Larsen C (AWS18) in January 2017

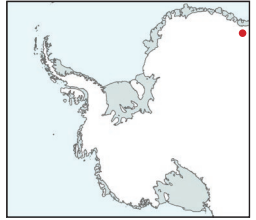


▲ Close up of the sensor yard with on the left the radiation sensors, in the middle the wind speed and direction sensor, and on the right the AWS unit which includes all other sensors except snow temperature

## Field Science

### *ANTSIE (ANTarctic Sea Ice Evolution from a novel biological archive)*

(ERIN MCCLYMONT, Mike Bentley, Dominic Hodgson),  
Eleanor Maedhbh Honan, Richard Phillips, (Louise Sime),  
Ewan Wakefield



**Location:** Princess Elisabeth Station (Belgian Programme),  
Svarthamaren nunatak (Tor field station)

**Timing:** December 2021 to February 2022

The overall aim of this project is to use the deposits of regurgitated stomach oils from Antarctic seabirds (snow petrels), to reconstruct sea-ice conditions over the last ~40,000 years. The snow petrels nest on the mountainsides above the Antarctic ice sheet, but feed in the sea ice offshore. The snow petrels preserve details of their diet (e.g. krill, fish) in their stomach oils, which in turn may tell us about the nature of the sea ice. When the birds return to the nest, these stomach oils are regurgitated and accumulate in front of the nest, ultimately becoming fossilised over hundreds and thousands of years.

The overall project has two components: (1) monitoring living snow petrels and analysing their stomach oil composition (which this fieldwork supports); (2) analysing fossil stomach oil deposits to reconstruct snow petrel diet and sea ice history in the past, using already collected deposits. The project will focus on the detailed chemistry of the modern and fossil stomach oils: we have already demonstrated that the abundance of elements such as copper, iron, and silica can be valuable tracers of diet, alongside the distributions of fatty acids. Our focus is in Coats Land and Shackleton Range, which will provide information on sea-ice conditions in the Weddell Sea, an area of importance for global ocean circulation and yet with sporadic evidence for varying sea ice properties since the last major expansion of the Antarctic Ice Sheet. Our aim is to provide a new, regional perspective on sea-ice conditions and their ecosystems through time.



▲ A snow petrel nesting in a crevice on a nunatak above the ice sheet. In front of the snow petrel is an accumulation of stomach oils, recording snow petrel diet and sea ice conditions back through time

## Field Science

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

(KEVIN HUGHES), Fran Potheccary, Aurelia Reichardt

**Location:** South Orkney Islands: Moe Island, Lynch Island, Southern Powell Island; Marguerite Bay: Lagotellerie Island, Rothera Point

**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 72 Antarctic Specially Protected Areas (ASPAs) 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 FCO. These are mostly clustered around Marguerite Bay and the South Orkney Islands, but there are also a few in other locations (the date that the management plans revision must be submitted to the CEP/ATCM is provided in brackets):

- South Orkney Islands: ASPA 109 Moe Island (2022); ASPA 110 Lynch Island (2022); ASPA 111 Southern Powell Island (2022)
- Marguerite Bay: ASPA 129 Rothera Point (2022); ASPA 115 Lagotellerie Island (2022); 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 Antarctica 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 at some point to make preparations for the development of a new ASPA that take into consideration the needs of all stakeholders.



▲ Lagotellerie Island, Marguerite Bay (ASPAs 115)

## Field Science

### *International Thwaites Glacier Collaboration (ITGC) – TARSAN and THOR projects*

ROB LARTER, KAREN HEYWOOD [and others]

**Location:** Thwaites Glacier region, West Antarctica

**Timing:** December 2021 to mid-March 2022 (season 3 of 4)

**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.

This austral summer is the third of four field seasons. Four of ITGC's eight research projects will be deployed in Antarctica focusing on different aspects of the glacier and its environment. This season's expeditions will undertake work for several ITGC projects: Geological History Constraints on the Magnitude of Grounding-Line Retreat in the Thwaites Glacier System (GHC), Thwaites-Amundsen Regional Survey and Network Integrating Atmosphere-Ice-Ocean Processes (TARSAN), Thwaites Interdisciplinary Margin Evolution – The Role of Shear Margin Dynamics in the Future Evolution of Thwaites Drainage Basin (TIME) and Thwaites Offshore Research (THOR).

This season, 24 scientists and technicians will join RV *Nathaniel B Palmer* for a major cruise associated with the TARSAN and THOR projects. The cruise hopes to undertake intensive oceanographic surveys around, and beneath, the Thwaites Ice Shelf in the Amundsen Sea. The TARSAN marine fieldwork is led by the University of East Anglia (Dr Rob Hall), and will focus on deployments of ocean gliders, Autonomous Underwater Vehicles (AUVs), tagging of seals with miniature sensors, microstructure profiling of ocean turbulence, and traditional surveys of temperature, salinity, and

*continued* ▷



▲ RV *Nathaniel B Palmer*

## Field Science

### *ITGC – TARSAN and THOR projects continued*

current velocity. The other participants in the TARSAN cruise are from the University of St Andrews (seal tagging) and the University of Gothenburg (bringing their Hugin autonomous underwater vehicle Ran), plus a team of National Marine Facilities technicians (bringing Autosub Long Range, a.k.a. Boaty McBoatface).

The THOR marine fieldwork will involve further survey of the seabed using sonar systems and collection of sediment cores.

An additional project, ARTEMIS, is in the process of being funded by NSF and NERC and will bring eight further scientists to add complementary in situ biogeochemical analyses (e.g., chlorophyll, iron, carbonate chemistry) together with additional gliders and seal tags to the TARSAN cruise. The cruise also offers an opportunity to collaborate further with the ITGC project THOR. Together, the three projects will be about 60 days at sea, from early January until mid-March 2022.

TARSAN will deploy two AUVs (Autosub Long Range and the Hugin Ran) beneath an ice shelf for the first time. We hope to assess the ocean conditions in the Thwaites cavity in the region of the TARSAN AMIGOS, through-ice-shelf moorings that include sensors in the atmosphere, ice and ocean. The AMIGOS are multisensory stations that were deployed during the 2019/20 season to study the ocean circulation underneath the floating ice shelf and the weather patterns to study the environmental factors that influence the structural stability of the ice shelf.

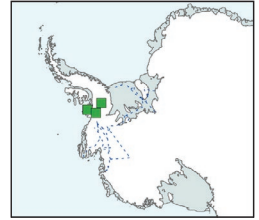
In addition, the Korean vessel *Araon* will be in the region at the same time, deploying the Australian AUV beneath Thwaites. We believe that it would be a world first to have three AUVs simultaneously surveying an ice-shelf cavity. Each AUV has different strengths, sensors and capabilities.



# Field Science (including Sledge Quebec)

## Ops Traverse

Calum Evans, Zac Gedny, Tyler Gilbertson, Chris Jacobs, Dave Jamieson, Logan Johnson, Dan Lewis, Marek Pazstor, Matt Rowbottom [and others], Rob Grant\*, Mark Scales\*, Catrin Thomas\*



**Location:** West Antarctica

**Timing:** November 2021 to March 2022

The BAS Tractor Traverse, consisting of a convoy of Piston Bulley 300s and various cargo and fuel sledges, will be conducting a logistics traverse in support of numerous science projects.

The traverse will be travelling from Sky-Blu throughout West Antarctica and beyond the Ellsworth Mountains covering much of Thwaites Glacier before linking up with RRS *Sir David Attenborough* (SDA) at the English Coast so as to facilitate the SDA's first ice-shelf relief. This effort will further provide critical support for the International Thwaites Glacier Collaboration (ITGC), supporting the GHOST, TIME, MELT and GHC projects, as well as positioning fuel and cargo depots for numerous aircraft movements and science projects throughout this and future seasons, before uplifting various cargo from previous seasons' science projects which are now complete.

To maximise efficiency, the traverse platform will split into two independent traverse platforms during the season, covering over 5,500km and deploying to the field for around 120 days. The offload alone with the SDA will see over 400m<sup>3</sup> fuel, 600 drums and 20 tonnes of cargo offloaded whilst we'll look to backload around 40+ tonnes of various science cargo and waste from the continent.



▲ PistonBulley pulling a load

## Field Science

### SOCHIC (*Southern Ocean Carbon and Heat Impact on Climate*)

(JEAN-BAPTISTE SALLÉE), ALEX BREARLEY, (ANDREW MEIJERS, Povl Abrahamsen), Mark Barham, Natasha Lucas

**Location:** Maud Rise and northern edge of Weddell Sea, onboard SA *Agulhas II*

**Timing:** December 2021 to January 2022

**More information:** <http://www.sochic-h2020.eu>

The Southern Ocean regulates the global climate by controlling heat and carbon exchanges between the atmosphere and the ocean. Rates of climate change on decadal time scales ultimately depend on oceanic processes taking place in the Southern Ocean, yet too little is known about the underlying processes. Limitations come both from the lack of observations in this extreme environment and its inherent sensitivity to intermittent small-scale processes that are not captured in current Earth system models.

To contribute to reducing uncertainties in climate change predictions, the overall objective of SO-CHIC is to understand and quantify variability of heat and carbon budgets in the Southern Ocean through an investigation of the key processes controlling exchanges between the atmosphere, ocean and sea ice using a combination of observational and modelling approaches.



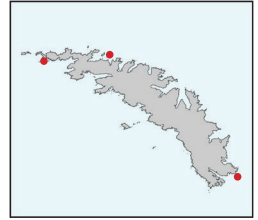
## Field Science

### *Spatial segregation and bycatch risk of seabirds at South Georgia*

VICTORIA WARWICK-EVANS, (Richard Philips)

**Location:** Paryadin Peninsula, Cooper Island and Prion Island (South Georgia)

**Timing:** 2001/02 season



Seabirds are amongst the most globally-threatened birds, often as a consequence of incidental mortality (bycatch) in fisheries. South Georgia holds globally-important populations of grey-headed, wandering, black-browed and white-chinned albatrosses (WCP), and GSGSSI are committed to the conservation of these iconic species. Rates of decline differ considerably between different colonies within South Georgia, almost certainly reflecting variability in at-sea distributions. Understanding where and when they are vulnerable is vital to conservation management.

Tracking from Bird Island (the only populations tracked to date) indicates that during the non-breeding season seabirds overlap with multiple fisheries. However, birds at breeding colonies elsewhere in South Georgia may encounter risks from different fisheries. We will be attaching tracking devices to seabirds, which will provide us with estimates of their location at regular intervals during the breeding and non-breeding season. By combining at-sea seabird distributions and fishing effort we will identify high-risk areas for each species and use this information to develop collaborative strategies for mitigating fisheries bycatch. We expect that individuals tracked across South Georgia will have different at-sea distributions, and it is likely that they will encounter threats from different fishing fleets to those birds tracked from Bird Island.



▲ A black-browed albatross feeding its chick

# Rothera Research Station

## Annual Rothera ramp re-survey

(ANDY SMITH), [BAS Engineer], [Met and Field Guide]

**Timing:** February to March 2022 (multi-seasonal)



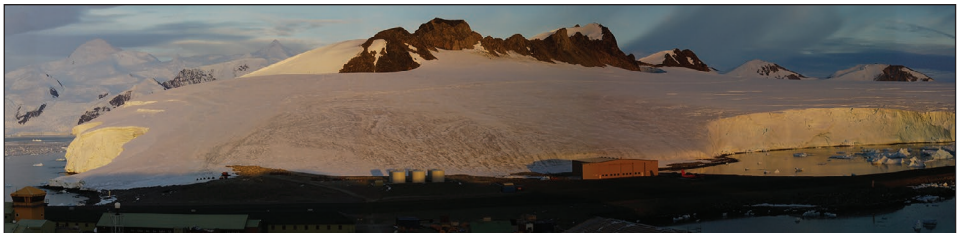
The ice ramp at Rothera is disappearing before our eyes! At the end of every summer the surface profile of the ramp is surveyed to see how much it is changing. Over the past 30 years the bottom has gone back well over 100m, and has lowered by almost 20m. The top hasn't changed much, which means that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

A comparison of photographs taken in 1992 and 2007 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 2007.

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 meteorological 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 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 ramp at Rothera Research Station in early 1992



▲ The ramp at Rothera Research Station in early 2007

# Rothera Research Station

## ARMS (Autonomous Reef Monitoring Structures)

MELODY CLARK, LLOYD PECK, [Rothera Dive Team]

**Timing:** January to March 2022

**More information:** <http://www.assembleplus.eu/research/genomic-observatories-jra/>

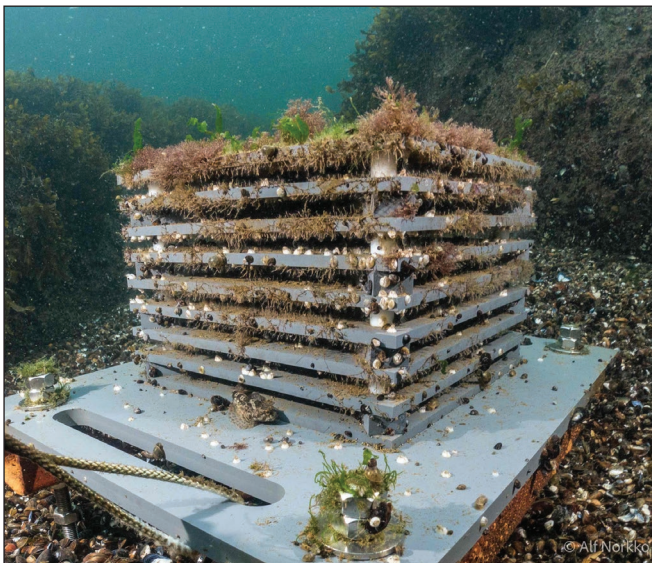
<https://www.oceanarms.org>

<https://ocean.si.edu/ocean-life/invertebrates/reef-monitoring-structure>



ARMS (Autonomous Reef Monitoring Structures) are a standardised method of collecting data on marine benthic encrusting biodiversity, developed by the Smithsonian Institute. Whilst some taxonomy will be used the main methodologies involve molecular analyses and metagenomics sequencing. ARMS are being deployed in a global network, including in Ryder Bay near Rothera Research Station.

Three sets of ARMS were deployed in Cheshire Cove and one each in North and South Coves. Originally the idea was to leave them in for one year to 18 months, but they have now been in place for almost three years, as we have been unable to retrieve them due to Covid-19. Hopefully we will make it this season! All data will be publicly available and the aim is to redeploy these ARMS after they have been collected, analysed and scraped clean, so that we can develop a time series and understand how biodiversity has changed over time using ARMS. This project is linked to a wider EU project (ASSEMBLE+) which is deploying ARMS around Europe and in the Polar Regions.



▲ A full set of ARMS (Autonomous Reef Monitoring Structures)

# Rothera Research Station

## BRUV (Baited Remote Underwater Video)

MELODY CLARK, (SIMON MORLEY), LLOYD PECK,  
[Rothera Dive Team]

**Timing:** January to March 2022

**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 Baited Remote Underwater Videos (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.

# Rothera Research Station

## Degradation dynamics of Antarctic macroalgae

(SIMON MORLEY), Nadia Frontier, (Ben Wigham), [Rothera Dive Team]

**Timing:** December 2020 to April 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. Carbon is transferred through an ecosystem in the form of detritus, where plant material is exported from shallow habitats into deeper sediments, carbon sinks, where it is sequestered. Studies across multiple ocean ecosystems have already shown that macroalgae species generally breakdown 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.

This project aims to quantify the breakdown of different Antarctic algae species. In situ sediment samples have been collected to test for the presence of macroalgae carbon transfer through the sediment-water interface. Furthermore, by experimentally simulating accumulations of detritus, this project seeks to explore the way in which this resource supports the food web. Sampling the invertebrate community associated with these algae accumulations, the detritivores, allow us to answer questions about how the detritus is being used as a food resource. By sampling the experimental detrital accumulations at different time points, we can track the succession of the invertebrate community and identify the range of species that either shelter in or eat this resource.



▲ Macroalgae play an important role in supporting food webs



▲ A diver collecting macroalgae samples



▲ Examples of animals living on Antarctic macroalgae

# Rothera Research Station

## IBIS (IceBerg Impact Study)

(DAVID BARNES), Hollie London, Ryan Mathews, [Rothera Dive Team]

**Timing:** Ongoing

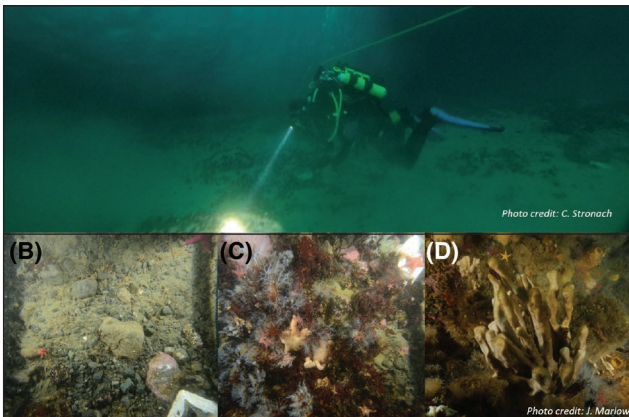


Since the austral summer of 2002/03 BAS has monitored the shallow seabed adjacent to Rothera Research Station. There are three grids of 25 concrete markers at each of 5, 10 and 25m on the seabed of South Cove, which are surveyed annually in December by the Rothera Marine Assistant. Each block that is 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 pummelled 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

## Modelling marine microbial interactions in the Southern Ocean

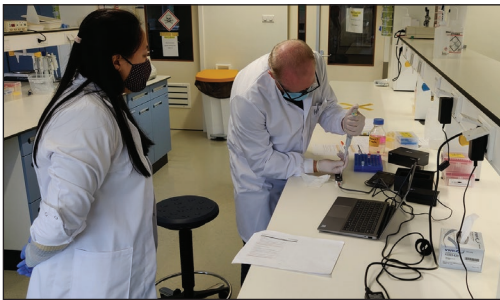
JULIA ENGELMANN, Swan Li San Sow

**Timing:** February to March 2022



Microorganisms in the Southern Ocean sustain the global marine food web. Here, phytoplankton use sunlight and  $\text{CO}_2$  to grow and produce oxygen, while bacteria, archaea, protists, and zooplankton then feed on phytoplankton or their remnants and are themselves consumed by larger organisms in the food web. How this intricate interplay of organisms will be affected by global environmental change is currently unknown. Besides temperature rise, inorganic  $\text{CO}_2$  levels in the ocean rise due to anthropogenic sources of  $\text{CO}_2$ , leading to a decline in seawater pH.

To predict how microbial communities will react to global change and ultimately, how this will affect the marine food web, we need to understand their interactions with each other and the environment. To gain this understanding, we will observe microbial communities at Rothera and the RaTS sampling site after the phytoplankton bloom period in late summer. During this period, the microbial food web metabolises organic material of phytoplankton at high rates, thereby sustaining ocean metabolism across most of the planet's oceans. We will use this observational microbial community data and computational approaches to generate hypotheses about potential interactions between microorganisms and how these are influenced by environmental parameters like temperature, salinity, and nutrient concentrations.



▲ Loading the DNA sequencer. Once we extracted DNA from marine microbial communities, we sequence marker genes or metagenomes in the lab using the MinION, a very small and portable sequencing device hooked up to a laptop



▲ Seawater filtration setup to collect microbial communities. On top of the thin filter membrane, microbes are retained. We fold the filter on the filtration platform, and transfer it to a plastic vial to store it in a  $-80\text{ }^\circ\text{C}$  freezer until we extract DNA

## Rothera Research Station

*Multi-omics analysis of the impacts of climate change and pollution on nitrogen-fixing microbial communities*

WAN LUTFI WAN JOHARI, (Mohd Yunus Shukor, Nur Adeela Yasid)



**Timing:** January to February 2022

Fuel spills in Antarctic soils can cause in extremely high soil carbon/nitrogen ratios, which may limit pollutant biodegradation. Thus, microbial nitrogen-fixing activity in such contaminated soils may be essential in providing adequate nutrient and increasing hydrocarbon bioremediation rate. The understanding of this process in this continent and the quantitative data are currently lacking, therefore there is a need to update the data and the knowledge on this subject.

In this research, we will integrate genomic, transcriptomic and proteomic data on community function and nitrogen-fixing activities. In the multi-omics analysis, the study will look at the diversity, composition and relative distribution of nitrogen-fixing microorganisms in the soil samples. Potential relationships between nitrogen-fixing bacteria, the broader microbial community and genes associated with degradation of pollutants will be analysed using multivariate statistical methods. The distribution of selected mRNAs will provide an immediate picture of the cells' responses to changing environmental conditions. Quantitative relationships between mRNAs and proteins relevant to nitrogen-fixing will also be studied.

We will expect to gain new data and a clearer picture of the nitrogen cycle in the Antarctic soil. Omics data will help discover possible new pathways or genes that may be essential in the biogeochemical cycle.

# Rothera Research Station

## Obtaining seasonal growth measures of key benthic species

(SIMON MORLEY, LLOYD PECK), Nadia Frontier, [Rothera Dive Team]



**Timing:** January 2021 to March 2023

This project aims to characterise the growth of benthic invertebrates across the seasons and to collect data about their feeding ecology. It is widely acknowledged that nearly all Antarctic species grow extremely slowly and not equally throughout the year. To contribute research towards answering the paradigm about slow growth in Antarctic species relative to species in other habitats, the study will gather growth rate data across the year. Most studies report annual growth rates but these metrics are not suitable for Antarctic species and omit crucial periods of growth which are often restricted to certain periods of the year.

Polar ecosystems are largely structured by strong seasonal forces that drive sea-ice dynamics and iceberg impact. The marine science research at Rothera Research Station builds upon long-term time series of oceanographic and biological data. These unique datasets will permit scientists to disentangle the influence of seasonal forces from inter-annual to multi-annual climatic variations. Understanding the fundamental ecology of Antarctic species is framed across the backdrop of assessing the ongoing impacts of climate change. Furthermore, without basic information about Antarctic species life history traits such as their growth rates, metabolism, reproduction etc. it is difficult to establish conservation measures for the species that live within these fragile Antarctic habitats.

Sampling Antarctic species all year round can only be conducted by the wintering dive team. We are the only research station in Antarctica that dives all year round and therefore the data we collect is even more unique.



▲ Sea cucumbers are filter feeders and a key species in the Antarctic benthos



▲ The limpet *Nacella concinna* is very abundant in the shallows around Rothera

# Rothera Research Station

## Post-construction benthic environmental monitoring of Rothera and KEP wharfs

(SIMON MORLEY, Kevin Hughes), Ben Robinson

**Location:** Rothera and KEP

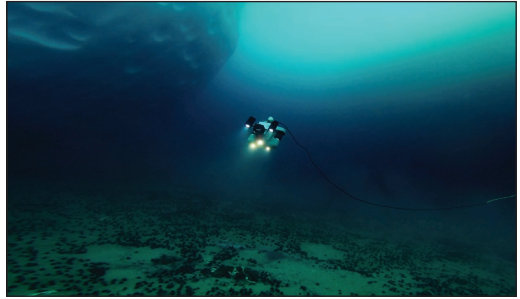
**Timing:** November/December 2021 or March/April 2022



As part of UK Environmental Impact Assessment obligations under the Protocol on Environmental Protection to the Antarctic Treaty and equivalent GSGSSI legislation, BAS needs to complete post-wharf-construction monitoring of the impacts of the work on benthic marine communities. The monitoring will be done using an underwater ROV and the data will be compared to pre-construction monitoring data. Dive surveys will also be undertaken at Rothera.



▲ Deploying the underwater ROV from a RIB at Rothera



▲ The underwater ROV will be used for monitoring

# Rothera Research Station

## Rothera biological long-term monitoring – reproduction

(DAVID BARNES), LLOYD PECK, Melody Clark, Hollie London, (Simon Morley), Ryan Mathews, [Rothera Dive Team]

**Timing:** Ongoing

**More information:** <https://www.bas.ac.uk/project/reproduction-in-a-changing-world/>



The marine team in the Bonner Laboratory have been collecting monthly samples of around 15 individuals from six common species in the nearshore environment around Rothera Point since 1998. They are the starfish *Odontaster validus*, the brittle star *Ophionotus victoriae*, the sea cucumber *Heterocucumis steineni*, the large predatory nemertean worm *Parborlasia corrugatus*, the limpet *Nacella concinna* and terrebellid polychaetes that form a species complex. More recently other species have been collected including the urchin *Sterechinus neumayeri* and the clam *Aequiyoldia eighsti*.

Samples collected are returned to UK where they are passed to collaborators in University of North Wales, Bangor, Newcastle University and Portsmouth University, where each months samples are analysed using histology for their gonad status and development of eggs and sperm. This data series has led the field in showing that development of gametes takes much longer in Antarctica than at lower latitudes (typically 18-24 months for eggs compared to three-to-six months in temperate latitudes). We have also demonstrated long-term patterns in reproductive output, with cycles of five-to-seven years evident in some species. This type of understanding of long-term cycles is not possible without multidecadal sampling and monitoring like this programme in Rothera, which is unique for seabed marine invertebrates in Antarctica and possibly worldwide.



▲ *Odontaster validus* in Backbay lagoon



▲ *Nacella concinna* in Backbay lagoon

# Rothera Research Station

## *Rothera Oceanographic and Biological Time Series (RaTS)*

DAVID BARNES, MICHAEL MEREDITH, HUGH VENABLES,  
Alex Brearley), Hollie London, Ryan Mathews



**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 four kilometres 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 near Rothera Research Station

## Rothera Research Station

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

(RICHARD PHILLIPS, Kevin Hughes), [Ruben Fijn](#), Aurelia Reichardt, Paul Whitelaw



**Timing:** December 2021 to April 2022

**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 next two (possibly three) seasons, plus training and radar equipment set up by an external consultant during the 2021/22 season. Other methods will include laser tracking, visual observation and deployment of GPS loggers on birds.



▲ A south polar skua on Rothera Point

## Rothera Research Station

*The Antarctic biota count (ABC): a functional trait-based approach to scale biodiversity from plot to region*

(HANS CORNELISSEN), Stef Bokhorst, Emma Ciric, (Pete Convey), Seringe Huisman, (Sander Veraverbeke)



**Location:** Rothera Station and local islands (Anchorage, Lagoon)

**Timing:** January to March 2022

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 (1-100m) across the length of the Antarctic Peninsula (>1,000km)?



# Halley VI Research Station

## All-sky camera – Optical

(TRACY MOFFAT-GRIFFIN), David Goodger, Hessel Gortler

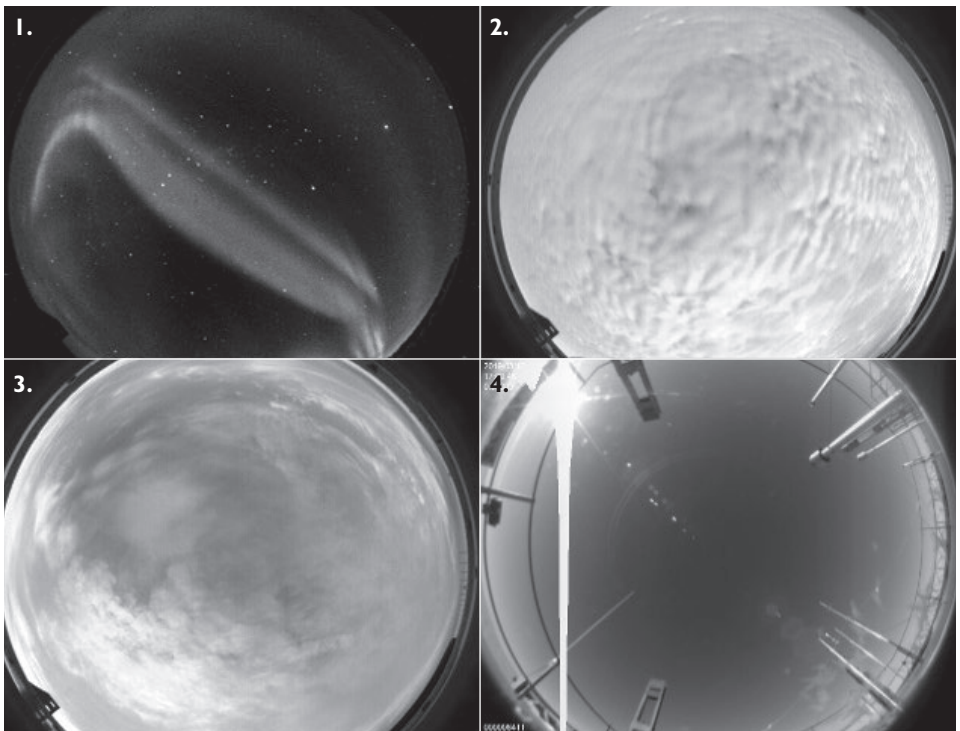
**Timing:** 2018-ongoing

**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 = 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. The instrument was first installed in the 2018/19 season and ran unmanned successfully for a month until an unfortunate computer failure. This year, the computer will be replaced and we are aiming to collect images throughout the entire Halley winter.



▲ 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 Halley Research Station that have run autonomously successfully for the first time over the winter of 2021. 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

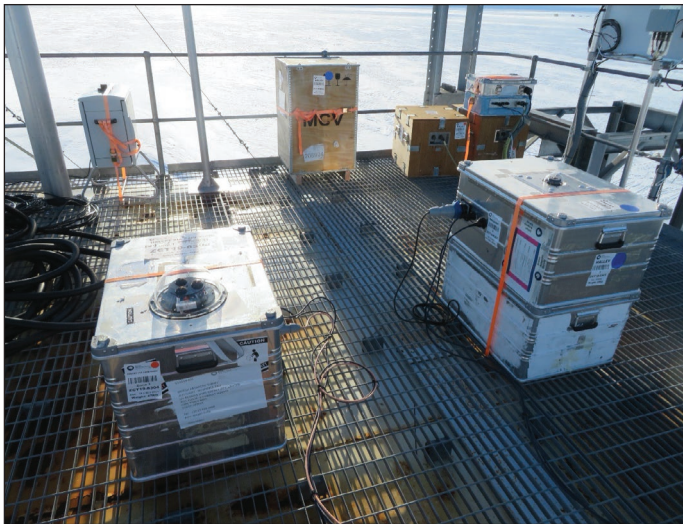
## *Auroral cameras continued*

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 the 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 of 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), Josh Eveson, [BAS Atmospheric Scientist]

**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.

This year, for the first time since the relocation of Halley, we are undertaking two dedicated field sampling campaigns. The first aims to quantify HONO emissions in order to trace reactive nitrogen formation and loss processes above the snow surface (see page 63). Measurements will be made by PhD student Millie Bond throughout the summer season. The second project aims to gather background methane ( $\text{CH}_4$ ) mole fractions, using both a continuous technique, and an automated flask sampler that will sample air throughout the winter period. The air samples will be analysed for the deuterium/hydrogen (D/H) isotope ratio of methane to constrain the source distribution of methane globally (see page 54).

### 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.



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



▲ The CASLab is located away from the main station

continued ▷

# Halley VI Research Station

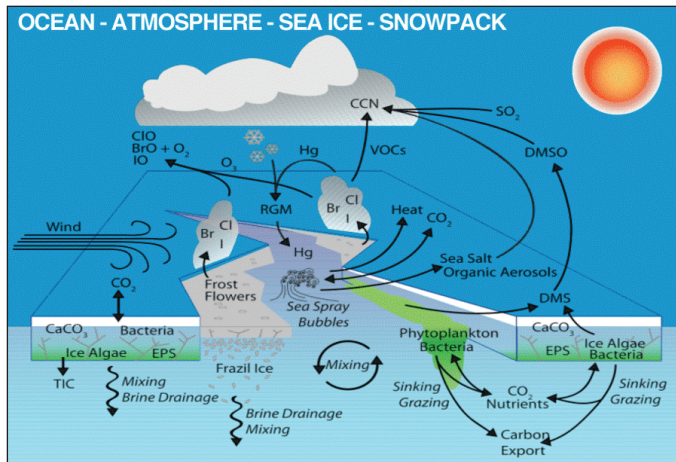
## Clean Air Sector Laboratory (CASLab) continued

### Aerosol loading

The Automated Condensation Particle Counter (CPC) instrument measures the concentration of particles ( $>0.01\mu\text{m}$ ) 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. Unfortunately, during the 2021 winter, the control PC for the instrument failed so we will look to replace this in the coming season.

### Greenhouse gas observations of $\text{CH}_4$ and $\text{CO}_2$

Finally, as part of the Halley Automation Project, we have developed two autonomous systems centred on the Picarro instrument, which measures the atmospheric methane ( $\text{CH}_4$ ) and carbon dioxide ( $\text{CO}_2$ ) mole fraction. We are currently running one of these systems with our international colleagues at the Alfred Wenger Institute's (AWI) Neumayer Station III. This year, we will install the second Picarro system in the CASLab at Halley. Measurements of  $\text{CH}_4$  and  $\text{CO}_2$  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, Euan Nisbet), Ross Sanders, (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  $^{13}\text{C}/^{12}\text{C}$  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  $^{13}\text{C}$ . 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  $2^\circ\text{C}$  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 newly-built automated flask sampler



▲ Samples are stored for analysis

# Halley VI Research Station

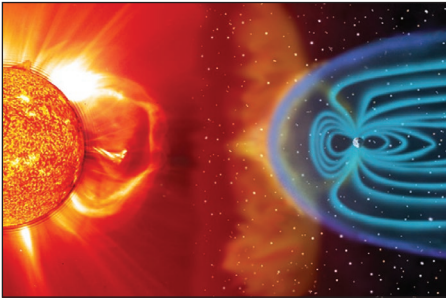
## Electro-Magnetic Quiet Area

(MARK CLILVERD, MERVYN FREEMAN, RICHARD HORNE)  
Sebastian Gleich, Hessel Gortler, Dominic Jaques

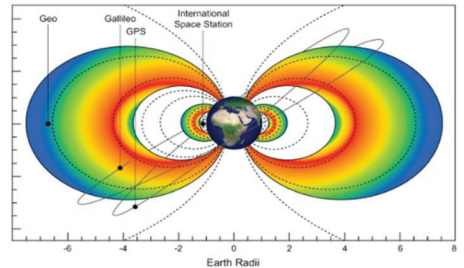
**Timing:** 2012-ongoing



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

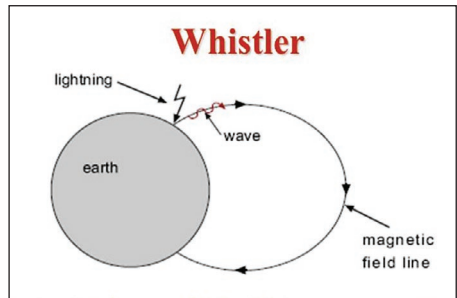
The Halley VLF receiver listens to very low frequency radio waves as part of several networks of receivers located all over the Polar Regions. The data gathered by these networks are used by more than 35 institutions around the world to:

- 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 1 x 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, DAVID VAUGHAN), James Byrne, Sebastian Gleich, Hessel Gortler

**Timing:** 2011-ongoing

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

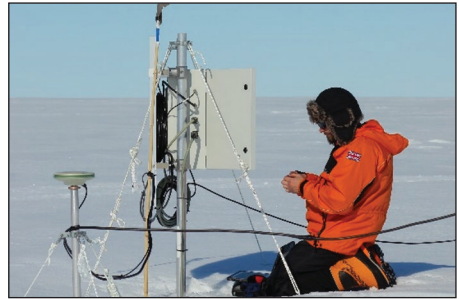


The project uses data from a variety of in situ instruments on the ice shelf, satellite data, and numerical modelling to understand the changing risk to our operations and infrastructure on the Brunt Ice Shelf. In 2012, satellite monitoring revealed the first signs of growth in a chasm (Chasm 1) that 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, but have not yet released the expected 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.



▲ The Halloween Crack in the Brunt Ice Shelf



▲ GPS measurements on the Brunt Ice Shelf

# Halley VI Research Station

## Halley Automation Project

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

**Timing:** 2017-2022

**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 have now completed their third winter of continuous operation. Each year we learn more about the operation of the system and make improvements where we can. This year, we will be upgrading our fuelling system to add in further redundancy, we'll be upgrading our ventilation system to improve our temperature control of the microturbine container and we'll be improving our fuel monitoring systems.

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. Each year we add in new experiments and this year we have four new systems to install, alongside maintaining the current suite. The automated Picarro instrument which will measure continuous CO<sub>2</sub> and CH<sub>4</sub>, the automated methane flask sampler, an infra-red all-sky camera and the SAOZ stratospheric ozone monitor, all of which you can read about in this document.



▲ The Automation Platform with four bulk fuel tanks that the containerised microturbine system autonomously fuels from throughout the unmanned winter. We did not raise any infrastructure at Halley in 2020/21 due to the small team and short time available to us, so we're expecting the infrastructure to be a little more buried than usual

# Halley VI Research Station

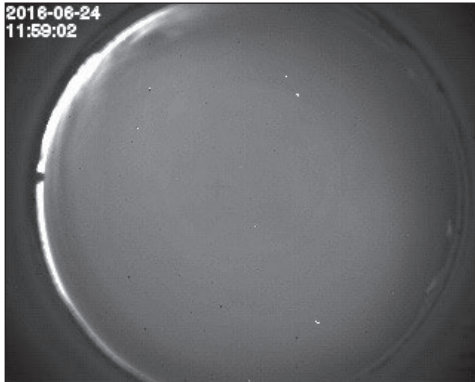
## Infrared Camera

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

**Timing:** 2021-ongoing



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). More information: <https://www.scar.org/science/angwin/angwin>. 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) Josh Eveson, Hessel Gorter, Dominic Jaques, Ross Sanders, [Halley Atmospheric Scientist]

**Timing:** 2012-ongoing



### Stratospheric Ozone measurements

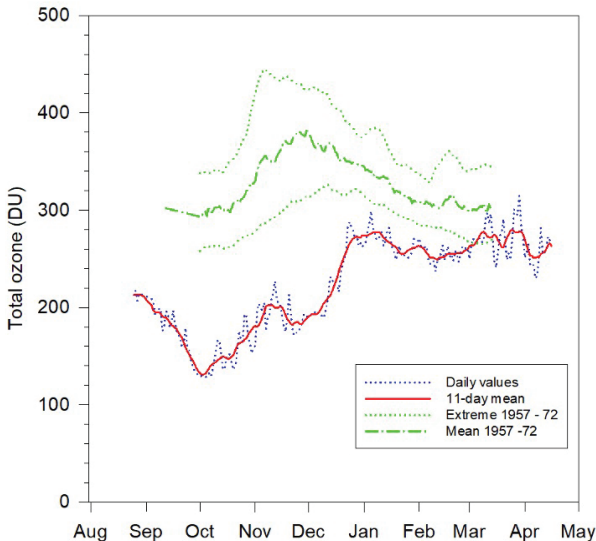
Stratospheric ozone shields the earth's surface from more than 90% of harmful solar ultraviolet radiation. The Ozone Hole was discovered in 1985 by BAS scientists using Halley's unique data set of Dobson spectrophotometer observations which now spans 60 years. Maintaining these observations, at Halley 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 three years now. This year, we will add in 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**

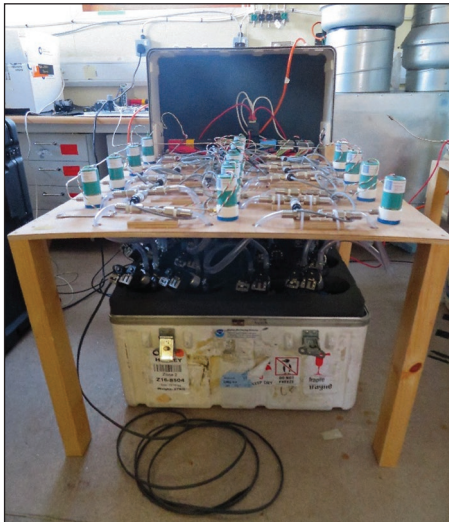
This year, we will resume our daily launch of radiosonde balloons as soon as personnel return to Halley in late November. These radiosondes measure temperature, humidity, wind speed and wind direction from the Earth's surface, through the troposphere (10km) and high up into the stratosphere (~25km). 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**

Last year we installed a new automated system for collecting air samples throughout the unmanned winter months. These air samples are collected on a monthly basis and sent to the U.S. 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. This summer will be the first time that we will ship out samples collected over the winter since 2017 and so represents a big leap forward in maintaining the long-term greenhouse gas record at Halley.

### **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

## Summertime observations of nitrous acid gas (HONO) concentrations and flux above snow in coastal Antarctica

(MILLIE BOND), Markus Frey, Freya Squires



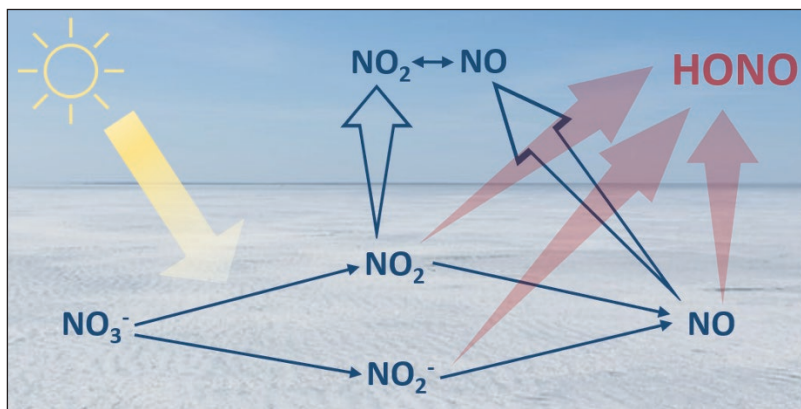
**Timing:** December 2021 to January 2022

**More information:** <https://www.bas.ac.uk/profile/amend37/>

<https://www.bas.ac.uk/science/research-topic/atmospheric-physics-chemistry/tropospheric-processes/>

Climate and environment in the Polar Regions are particularly sensitive to anthropogenic perturbation. Understanding the natural processes in the background atmosphere is essential to assess the human contribution to environmental change. It has been established that snowpack nitrate ( $\text{NO}_3^-$ ) is a photolytic source of the nitrogen oxides,  $\text{NO}$  and  $\text{NO}_2$ , which alter concentrations of ozone ( $\text{O}_3$ ), a pollutant and greenhouse gas, and the hydroxyl radical ( $\text{OH}$ ), which is responsible for the removal of many other atmospheric pollutants.

Nitrous acid gas (HONO) is a particularly reactive nitrogen species, related to  $\text{NO}$  and  $\text{NO}_2$ , which has been observed previously at surprisingly high levels in air above snow. This suggests a large snowpack source is present, but the reactions involved in HONO release are still largely unknown. The aim of this project is to quantify HONO emissions with an optical technique in order to trace reactive nitrogen formation and loss processes above snow in coastal Antarctica. Measurements of HONO concentration and flux, as well as snow and denuder sample collections will be carried out at the CASLab at Halley in the summer season during a six-to-eight week period. The proposed field project forms part of a NERC-funded PhD project aligned with the Clean Air Chemistry Programme at Halley and with the work package 'Tropospheric Chemistry' (Group Lead: M. Frey) in the BAS Atmosphere, Ice and Climate (AIC) science programme.



▲ A simplified diagram of reactions between nitrogen species occurring in the snowpack; red arrows represent unknown HONO formation processes

# Bird Island Research Station

## *Bird Island marine predators LTS*

(RICHARD PHILLIPS), James Crymble, (Mike Dunn), Jaume Forcada, Imogen Lloyd, Marine Quintin, Claire Stainfield, Erin Taylor, Mark Whiffin, (Andy Wood)



**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).



▲ A young wandering albatross on Bird Island, South Georgia



# Bird Island Research Station

## Cable installation for burrow-monitoring system at Bird Island

(RICHARD PHILLIPS), Mark Whiffin, [BI Tech Service]

**Timing:** First call

**More information:** <https://www.bas.ac.uk/project/white-chinned-petrel-tracking/#about>



With approximately one million pairs, the white-chinned petrel is by far the most abundant large seabird at South Georgia, and one of the two bird species that consume the most krill in the region. Its population trend at South Georgia (by far the largest population of any island group) drives IUCN Red List categorisation (as Vulnerable). It is the most common bird recorded as fisheries bycatch around SG and elsewhere in the Southern Ocean, and a difficult species to avoid catching because it can feed nocturnally and dive on hooks to 15m deep, hence it is still vulnerable to bycatch in fisheries adopting seabird bycatch mitigation methods.

The limited trend data provide some grounds for uplisting by IUCN to Endangered, and the species is also listed by the Agreement on the Conservation of Albatross and Petrels (ACAP). Determining population size from wide-scale surveys in a single season is time-consuming, and comparisons with previous years may be misleading given variability in breeding probability and recruitment rates. Automated annual monitoring of survival, breeding frequency, success, recruitment etc. of a marked population is a much more sensitive means of assessing current status and identifying key drivers of population dynamics. Analysis of attendance patterns and trip duration would also provide important data on seasonality of resource demand for ecosystem models.



▲ Cable installation for burrow-monitoring system



▲ White-chinned petrel on Bird Island

## Bird Island Research Station

*Using dynamic energy landscapes to understand drivers of movement, foraging and life history patterns in albatrosses*

(RICHARD PHILLIPS), LESLEY THORNE



**Timing:** November 2021 to February 2022

The aims of the project are to:

1. Quantify how oceanographic and atmospheric variability affect albatross foraging habitat and energetics
2. Assess how climate-driven changes to foraging habitat and energetics influence life history metrics
3. Develop mechanistic predictions about the impacts of future change on albatross populations. This requires targeted field studies to complement analyses of existing historical data. Together, these data will be used to parameterise models of the relationships between climate-driven oceanographic and atmospheric variability, foraging energetics, energy transfer to offspring, metrics of fitness (reproductive output) and, ultimately, population change in these sentinel species



▲ Weighing albatross chicks on Bird Island

# King Edward Point Research Station

## Cetacean monitoring in Cumberland Bay

(PHILLIP HOLLYMAN), Jamie Coleman, (Martin Collins, Jennifer Jackson), Matt Marsh

**Timing:** November 2021 to March 2022



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.

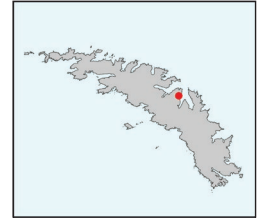


▲ A blue whale was spotted off the coast of South Georgia

## King Edward Point Research Station

Does rafting allow connectivity across the Antarctic Polar Front? A case study of the direct developing periwinkle *Laevitorina caliginosa*

SIMON MORLEY, Claudio Gonzalez-Wevar, [KEP staff]



**Timing:** Opportunistic throughout the season

There are five nominal species of *Laevitorina* described for South Georgia however, recent investigations of this 'species' across the southern seas have shown that these descriptions need revising. A combination of molecular and morphometric analyses will be used to investigate the different species, building a picture of how species have spread and evolved as the Southern Ocean formed and the polar front developed. Understanding how much of a barrier this has been to past connectivity between land masses will allow us to predict what might happen as a result of climate change.



▲ *Pelliitorina peltita*



▲ *Laevitorina* spp

# King Edward Point Research Station

## Higher predator monitoring at Cumberland Bay

(PHILLIP HOLLYMAN), Jamie Coleman, (Martin Collins),  
Meghan Goggins, Matt Marsh, Kate Owen

**Timing:** Ongoing



The 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 KEP 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 Maivken. 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 regular sampling of plankton (for larval fish) in Cumberland Bay and Bay of Isles (using the *Pharos* SG).

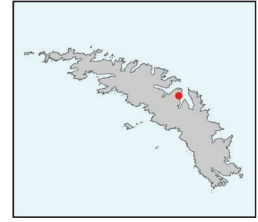


▲ An environmental monitoring programme is operated on the breeding success of the krill-dependent fur seals and gentoo penguins at Maivken

# King Edward Point Research Station

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

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



**Timing:** December 2021 to January 2022

The Southern Ocean, including around South Georgia, is experiencing significant environmental and climatic change, including increasing ocean temperatures, regional loss of sea-ice and wide-spread 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), Jamie Coleman, Meghan Goggins, Matt Marsh, Kate Owen



**Timing:** Ongoing since 2008/09

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-I plankton net using the Pharos SG to collect fish larvae and other plankton

## Signy Research Station

### *Signy Island marine predators long-term monitoring and survey programme*

(RICHARD PHILIPS, Mike Dunn), Derren Fox, (Andy Wood)

**Timing:** November 2021 to March 2022

**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



▲ Chinstrap penguins



# Signy Research Station

Summer-monthly collections of the intertidal bivalve *Lissarca miliaris* at Shallow Bay, Signy Island and T-logger maintenance

(KATRIN LINSE), Derren Fox, Fran Pothecary

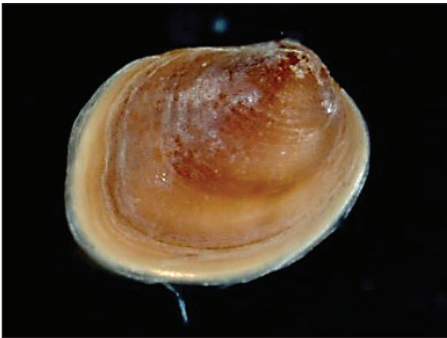


**Timing:** November 2021 to March 2022

*Lissarca miliaris* (Fig. 1) is a small, up to 5mm long, reddish-brown bivalves 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 (Fig. 2) 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 their batteries replaced.



▲ *Lissarca miliaris* on seaweed

# RRS Sir David Attenborough

## Rothera oceanographic mooring

ALEX BREARLEY, Mark Barham, Gareth Flint, Tom Gillum-Webb, (Clara Manno, Hugh Venables), [SDA Officers and Crew]



**Location:** Ryder Bay

**Timing:** February 2022

For over 20 years, the Rothera time series has acquired weekly measurements of physical and biological water-column properties to assess the changing temperature and ecosystem changes of the West Antarctic. While highly valuable in their own right, it has been increasingly realised that several important processes happen at shorter timescales than are easily sampled with the existing measurements alone.

Underwater glider deployments near Rothera have demonstrated that turbulence levels are significantly enhanced over the topographic sill that separates Ryder Bay from Laubeuf Fjord, yet the controlling processes on this interaction and its effect on water property transformations remain poorly known.

With this in mind, funding was acquired to deploy a mooring close to the existing Rothera time series site. The mooring includes Microcats (measuring temperature and salinity), ADCPs to measure the current profile and water column turbulence and a sediment trap capable of collecting 21 x 250ml of organic material.

The mooring was deployed from RRS *James Clark Ross* (JCR) in January 2020. Following JCR's retirement, subsequent maintenance visits will be conducted on RRS *Sir David Attenborough* – the first of which is scheduled for February 2022.



▲ A mooring is deployed from the back of the JCR



▲ RRS Sir David Attenborough

## Multiple locations

### *Southern Ocean clouds (Long-term measurements)*

TOM LACHLAN-COPE, (Anna Jones), Floortje Van Den Heuvel, Jonathan Witherstone

**Location:** Rothera, Bird Island, RRS *Sir David Attenborough*

**Timing:** February to mid-March 2022

Understanding the key processes driving the climate system and reducing the uncertainties in climate sensitivity is crucial if we want to improve climate projections. The Southern Ocean is an area where there are large biases in the representation of short and long wave fluxes and in the surface temperature – it is thought that poor representation of clouds, both at the micro- and at the macro-scale, is responsible for these errors. This proposal will use a novel multi-scale, multi-platform approach over a variety of temporal and spatial scales that will improve understanding of aerosol and cloud microphysics over regions with maximum climate model bias, namely both the Southern Ocean and coastal areas around Antarctica, leading to better representation of these processes in climate models.

Observations will be made at land stations in the Antarctic and sub-Antarctic as well measurements on the BAS ship that crosses Southern Ocean many times during a season and observations using BAS's instrumented aircraft. The aim of the observations is to identify the compositions and source of the aerosols that act as cloud forming nuclei. This information will be used to improve the representation of clouds in numerical models.



▲ *Nacreous clouds glowing in the winter sky above Rothera Research Station*

## Appendix

### List of non-BAS personnel and their associated institutes

#### Field-based

Name	Institute
Ronan Agnew	University of Leeds
Alison Barnwell	University of Colorado, USA
Mike Bentley	Durham University
Poul Christofferson	Cambridge University
Peter Clarke	Newcastle University
Michael Hartinger	Virginia Tech, USA
Karen Heywood	University of East Anglia
Matt King	University of Tasmania, Australia
Doug MacAyeal	University of Chicago, USA
Eleanor Maedhbh Honan	Durham University
Erin McClymont	Durham University
Javier Martin-Torres	University of Aberdeen
Kenny Matsuoka	Norwegian Polar Institute, Norway
Thamban Meloth	National Centre for Polar and Ocean Research (NCPOR), India
Anya Reading	University of Tasmania, Australia
Carleen Reijmer	University of Utrecht, Netherlands
Neil Ross	Newcastle University
Jean-Baptiste Sallée	Sorbonne University, Paris, France
Paul Smeets	University of Utrecht, Netherlands
Emma Smith	University of Leeds
Laura Stevens	University of Oxford
Michiel Van Den Broeke	University of Utrecht, Netherlands
Ewan Wakefield	Durham University
Pippa Whitehouse	Durham University
Ian Willis	Scott Polar Research Institute (SPRI), Cambridge
Terry Wilson	Ohio State University
Bert Wouters	University of Utrecht, Netherlands
TJ Young	Scott Polar Research Institute (SPRI)
Maria-Paz Zorzano	University of Aberdeen

continued ▷

## Appendix continued

### List of non-BAS personnel and their associated institutes

#### Rothera Research Station

Name	Institute
Stef Bokhorst	VU Amsterdam, Netherlands
Emma Ciric	VU Amsterdam, Netherlands
Hans Cornelissen	VU Amsterdam, Netherlands
Julia Engelmann	Royal Netherlands Institute for Sea Research (NIOZ), Netherlands
Ruben Fijn	Bureau Waardenburg, Netherlands (environmental consultancy)
Seringe Huisman	VU Amsterdam, Netherlands
Swan Li San Sow	Royal Netherlands Institute for Sea Research (NIOZ), Netherlands
Wan Lufti Wan Johari	Universiti Putra, Malaysia
Mohd Yunus Shukor	Universiti Putra, Malaysia
Sander Veraverbeke	VU Amsterdam, Netherlands
Ben Wigham	Newcastle University
Nur Adeela Yasid	Universiti Putra, Malaysia

#### Halley 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

#### Bird Island Research Station

Name	Institute
Lesley Thorne	Stony Brook University, USA

#### King Edward Point Research Station

Name	Institute
Claudio Gonzalez-Wevar	Universidad Austral de Chile, Chile

## **Feedback and further information**

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

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For further information about BAS, please visit:

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# BAS offices and research stations

NERC Ny Ålesund Research Station

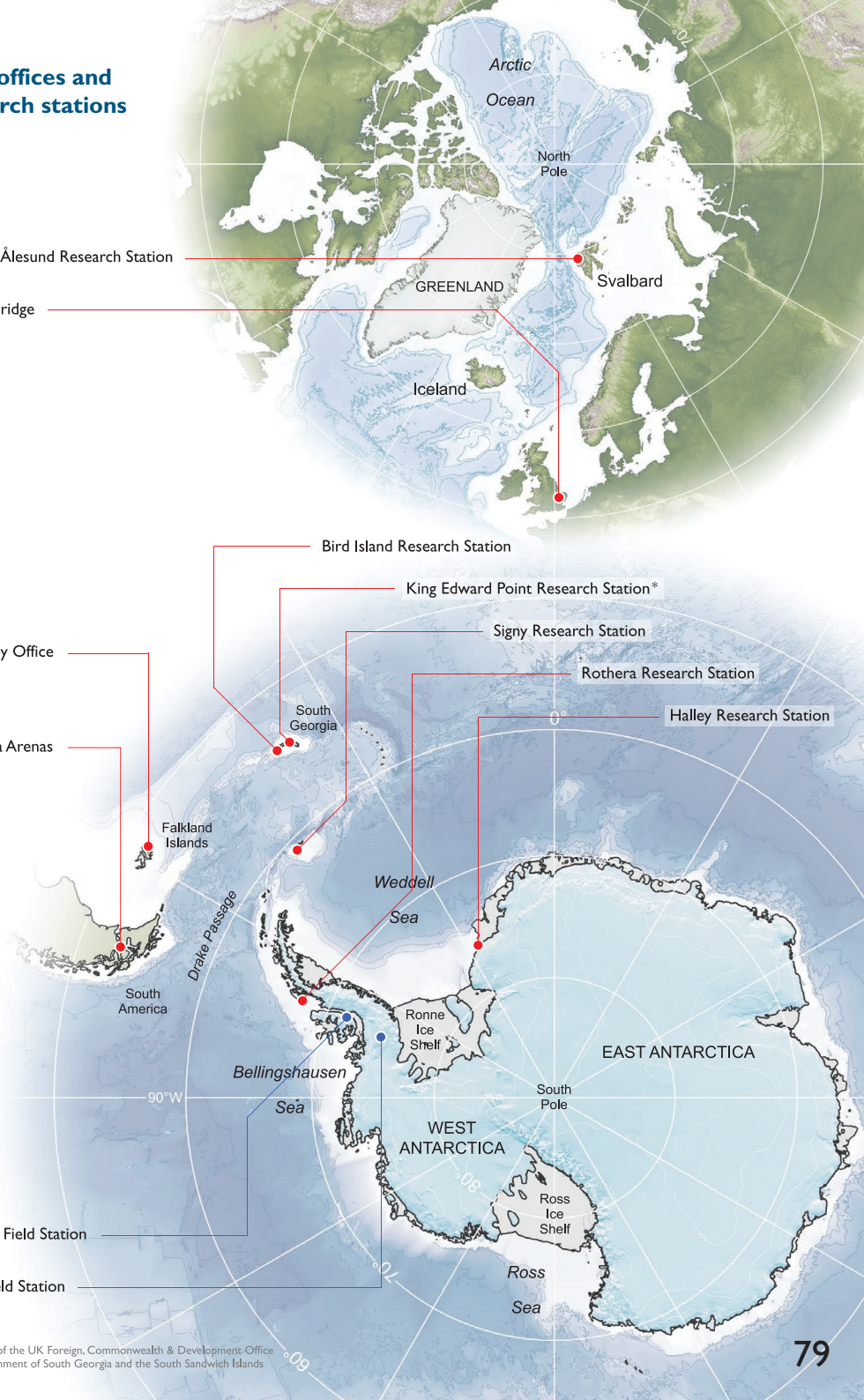
BAS Cambridge

BAS Stanley Office

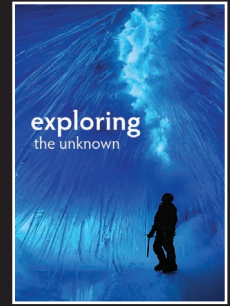
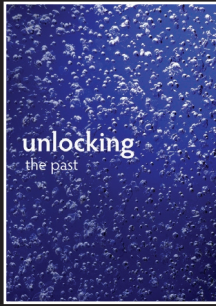
Punta Arenas

Fossil Bluff Field Station

Sky-Blu Field Station



\* 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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