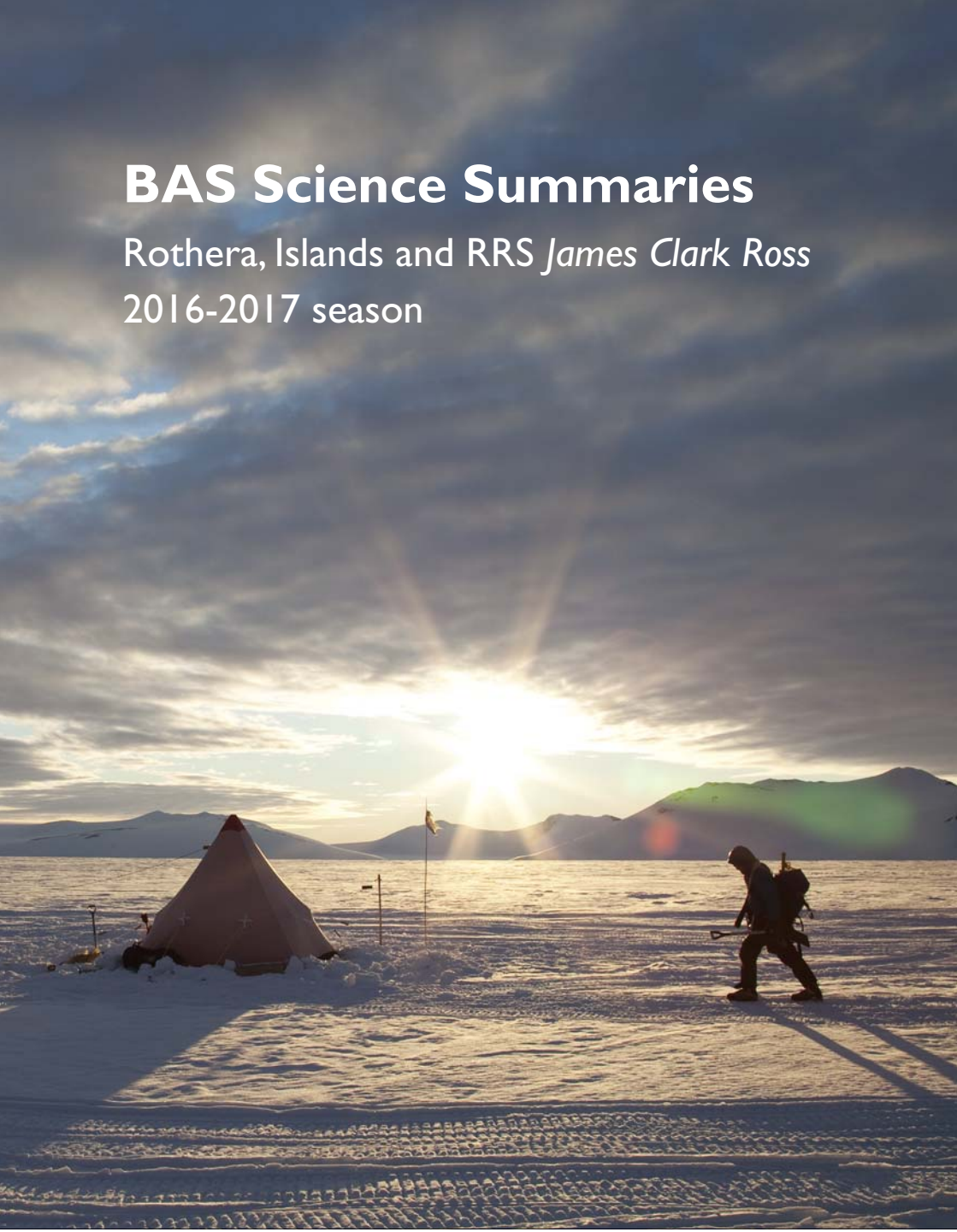
BAS Science Summaries

Rothera, Islands and RRS *James Clark Ross*

2016-2017 season



British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

POLAR SCIENCE
FOR PLANET EARTH

Contents

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NATURAL ENVIRONMENT RESEARCH COUNCIL

BAS Science Summaries

2016-2017

Introduction

This booklet contains project summaries of all field and station-based science taking place during the 2016-2017 Antarctic summer season from Rothera, Bird Island, King Edward Point and Signy Research Stations, and RRS *James Clark Ross*. It is intended as a brief overview of the science, for detailed information about individual projects please contact the Project Investigators (PIs) listed.

Please note that only the PIs and field personnel have been listed and full lists of project collaborators are not included in this summary. **PIs appear in capital letters, and in brackets if not present on site, and Field Assistants are indicated with an asterisk.** A list of non-BAS personnel and their affiliated organisations is shown in the Appendix.

Thanks to all the authors for their contributions and to Laura Gerrish for the field sites map.

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November 2016

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Field-based projects

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Rothera Research Station

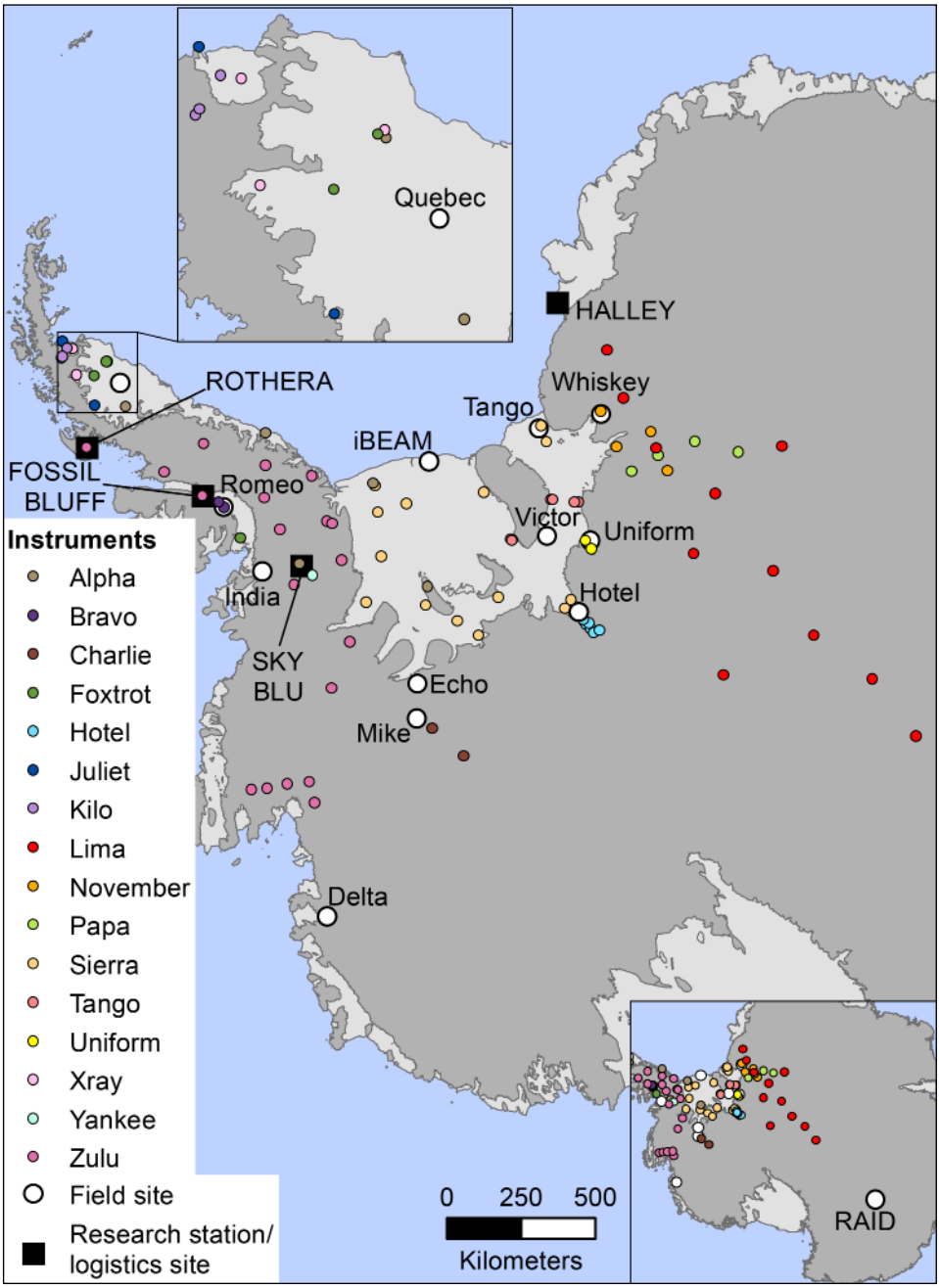
Islands

Detailed contents *continued*

RRS James Clark Ross

Map of field-based project locations

2016-2017



Sledge Alpha

Automatic weather station network servicing

(STEVEN COLLWELL), Rosey Grant, John Law, Mairi Simms

Location: Antarctic Peninsula

Timing: Opportunistic throughout the season

BAS runs a network of nine automatic weather stations (AWS) on the Antarctic Peninsula and in the Halley region. They are Larsen, Fossil Bluff, Butler Island, Sky-Blu, Site 8, Korf, Baldrick, Halley V and Windy Creek. The BAS AWS are just 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 that we have the best possible coverage of Antarctica in order to meet the needs of the scientific and forecasting communities. In addition to our own stations we also service stations for the Universities of Utrecht, Colorado 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 usually takes about six hours.

▲ *Butler Island automatic weather station (AWS)*

Sledge Bravo

Long-term micro-environmental monitoring for terrestrial biology

(PETE CONVEY, KEVIN NEWSHAM, LLOYD PECK), Ali Massey

Location: Antarctic Peninsula

Timing: Opportunistic throughout the season

BAS runs a network of four automatic weather stations (AWS) for long-term micro-environmental monitoring for terrestrial biology (at Signy, Anchorage Island, Coal Nunatak and Mars Oasis) which require annual checks and maintenance.

This is a long-term data-gathering activity, designed to provide robust descriptions of the 'micro-environment' experienced at biologically-relevant small physical scales in different but typical Antarctic terrestrial habitats. It is required because, whilst BAS and other Antarctic operators maintain very good large-scale meteorological and other climate observations from which well-known climate features and trends are described, most biology on land in Antarctica exists within a few milimetres or centimetres of the ground or rock surface, or within soils, and these environments experience temperatures and other features that are not well described by standard meteorological measurements.

These observing sites were established mostly in the early to mid-1990's, when it was realised that biological responses to climate variability and change were a fundamentally important research area, and yet that there was no way of linking large-scale climate descriptions with biologically relevant scales. Each site consists of a data logger, recording data from a range of probes measuring various temperatures (e.g. air, soil/rock surface, sub-surface), humidity, and irradiance. They operate year-round, giving a detailed picture of patterns of environmental variability over annual, seasonal, daily, and shorter timescales, and have made a central contribution to interpreting detailed biological studies of, for instance, microbiological, plant and invertebrate communities at the different locations. The AWS locations 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.

▲ *Coal Nunatak automatic weather station (AWS)*

▲ *Mars Oasis site*

Sledge Charlie

The contribution to sea-level rise of the Amundsen Sea sector of Antarctica (iSTAR D)

(MIKE BENTLEY, PETER CLARKE, MATT KING), Octavian Carp

Location: Union Glacier

Timing: December 2016

The overall aim is to determine the long-term (last 20,000 years) thinning history of the Amundsen Sea glacier catchments and their environs, and to use this information to provide better estimates of how much ice is being lost today. One of the main ways we measure ice mass loss from Antarctica is to use gravity satellites to determine the mass change over several years. However, the satellite data need to be corrected for an important effect called glacial-isostatic adjustment (GIA), where the solid Earth rebounds after deglaciation. Our work here is to produce a better model of GIA for this part of Antarctica so as to reduce the uncertainty in estimates of the ongoing sea-level contribution of this part of Antarctica.

Once we know how much ice was lost from the area and when, then we can input these data to models which simulate the crustal rebound of the Earth following deglaciation. We can determine if these models are any good by using our GPS measurements of uplift to test if they predict the correct uplift rates in this part of Antarctica, which currently is the single most important contributor to sea-level rise from the continent.

GPS receivers were installed at three sites in 2013/14 to measure crustal uplift over the next few years. An account of GPS installation and ice history work in season 2013/14 can be found here:

www.istar.ac.uk/2014/02/24/the-istar-d-team-describe-how-their-mission-went

The fieldwork this year will be for engineers to visit the sites using aircraft-supported day trips, download data, and to make any repairs or necessary upgrades.

▲ *Example of a GPS receiver installation at Mt Woollard*

Sledge Delta

Reconstructing millennial-scale ice sheet change in the western Amundsen Sea Embayment, Antarctica, using high-precision exposure dating (ANiSEED)

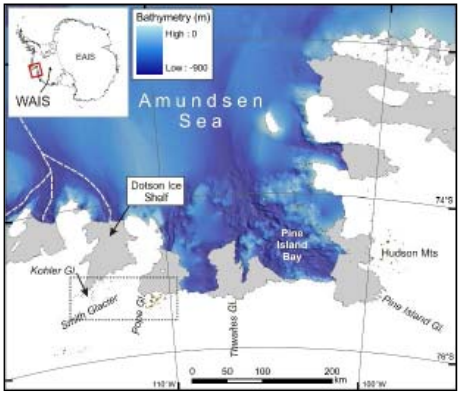
JOANNE JOHNSON, *Ali Rose

Location: Kohler Range, Marie Byrd Land

Timing: December 2016 to January 2017

The Amundsen Sea sector of the West Antarctic Ice Sheet is critical for obtaining reliable predictions of future sea-level rise because it could retreat very rapidly in future. If ice-sheet models cannot reliably reproduce the past size and shape of the ice sheet, they will have little chance of accurately predicting what will happen to it – and therefore to global sea level – over the next few centuries. We still urgently need information about ice-sheet history from geological studies for testing and improving those models.

Information on the shape and size of the West Antarctic Ice Sheet over the past 20,000 years – since the peak of the last glacial period – can be collected from rocks that were carried by glaciers and deposited on mountainsides as those glaciers thinned. We will collect rocks from the poorly-known western part of the Amundsen Sea Embayment, near the Pope, Smith and Kohler Glaciers (see map). Using the technique of surface exposure dating we aim to find out how rapidly the ice sheet thinned, and when the thinning started and stopped. Current modelling efforts are hindered by an almost complete lack of terrestrial data from this region.



▲ *The Amundsen Sea Embayment with our field area shown as dashed black box*

▲ *Rounded boulders like this have transported within glaciers and were deposited when ice retreated*

Sledge Echo

Basal conditions on Rutford Ice Stream: bed access, monitoring and ice-sheet history (BEAMISH)

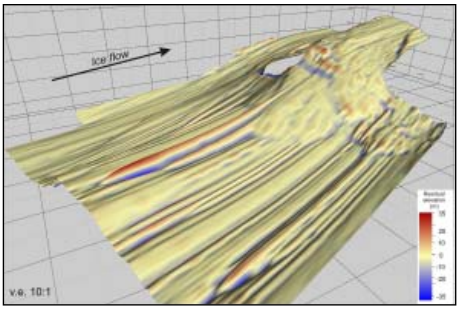
(ANDY SMITH), Alex Brisbourne, *Nick Gillet

Location: Rutford Ice Stream

Timing: November 2016 to February 2017

BEAMISH is all about being able to make better predictions of future ice-sheet change and its effects on sea level. At the moment, the biggest uncertainty in our ability to predict sea-level rise comes from the ice sheets. The BEAMISH project aims to improve understanding of two aspects of this uncertainty, the past behaviour of the West Antarctic Ice Sheet, and the flow of the glaciers that drain it. By choosing the right location, we can address both of these with a single project.

This season is the first of three and its main purpose is site survey, to confirm exactly where we will drill down to the base of the ice next year. Two people will spend this season on Rutford Ice Stream driving a grid of survey lines, towing a radar behind a skidoo. The BAS 'DELORES' radar is ideal for mapping the shape of the bed beneath the ice. We will also set up four instruments that will run continuously over the 2017 winter: two GPS stations to measure the ice movement and two seismic stations to record 'micro-earthquakes' – tiny shocks caused by the ice moving over the bed beneath it.



▲ *Subglacial topography around the BEAMISH site: the image shows the landscape underneath the ice, mapped with the DELORES radar*

▲ *BEAMISH site location on Rutford Ice Stream*

Sledge Foxtrot

Observing the turbulent oceanic boundary layer beneath ice shelves (SIBLEX)

(KEITH NICHOLLS), Octavian Carp, Ben Keitch

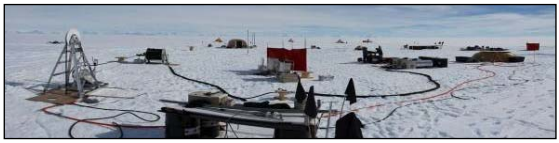
Location: Larsen C Ice Shelf, George VI Sound

Timing: Opportunistic throughout the season

Antarctic ice shelves act as a restraint on the flow of ice from the continental interior into the ocean, and as such act as a control on the Antarctic Ice Sheet's contribution to global sea level. Satellite data have shown the Amundsen Sea sector of the ice sheet to be reducing in size, indicating increased ice flow into the ocean. The continental shelf in that sector of Antarctica is flooded with relatively warm water, resulting in high melt rates at the base of the ice shelves. It is thought likely that changes in ocean conditions are causing increased melting, and, therefore, a reduction in the restraining effect of the ice shelves. We need to be able to predict the response of these ice shelves to the changing ocean conditions in order to predict how Antarctica's contribution to sea-level change will be affected by a changing climate.

These predictions will ultimately be made using numerical models of the ocean, including that part of the ocean occupying the cavities beneath the floating ice shelves. The key driver for the circulation of water in the Amundsen Sea sub-ice shelf cavities is the release of buoyant melt water at the base of the ice shelves. So the crucial process is the one by which the heat gets from the ocean up to the ice base through the ice-ocean boundary layer, that is, the layer of water, some tens of metres thick, that is affected by the presence of the ice base. The physics of the boundary layer beneath rapidly-melting ice shelves is particularly poorly understood, and as a result inadequately represented in numerical models. One of the problems is that the melting itself increases the buoyant flow up the inclined ice-shelf base, and the increased speed increases the turbulence and therefore the rate of transfer of heat towards the ice. At the same time, the increased buoyancy near the ice base makes it more difficult for the warmer, but denser, ocean water to be lifted through the boundary layer. The subtle interplay between competing effects results in a complicated, but fascinating, geophysical problem.

Five years ago, we used a hot-water drill to make access holes through both a rapidly melting ice shelf and a slowly melting ice shelf and made measurements in the boundary layers at their base to enable us to improve the way they are represented in models. Instruments were left suspended beneath the ice shelf so that they could monitor the speed of flow of the boundary layer, its temperature, and the rate of basal melting. The data will provide, for the first time, a comprehensive view of the boundary layer beneath a rapidly melting ice shelf, to be contrasted with the slowly melting counterpart, providing a step forward in our understanding of the physics of a unique environment. This year we will revisit the sites to replace and maintain data loggers and battery boxes.



▲ *Hot water drilling field site*

Sledge India

Ice dynamical changes over the Southern Antarctic Peninsula

(HILMAR GUDMUNSSON), HUGH CORR

Location: Southern Antarctic Peninsula

Timing: January 2017

Recent observations *(Wouters et al, 2015)* show that the Antarctic Peninsula has destabilised and glaciers are now losing mass at a rapid and accelerating rate. It has been suggested that this is due to a loss of ice-shelf buttressing but data is insufficient to directly support this idea. We are now conducting a numerical ice-flow study aimed at identifying the drivers behind this dramatic thinning that appear to have started around 2010. One of the key input parameters for such a study is the geometry of the glaciers. This is not currently known in sufficient detail and we propose a targeted airborne radar survey to eliminate gaps in ice-thickness maps.

The project involves one NSF-funded researcher (Brent Minchew) currently working at BAS. Brent will perform the numerical modelling part of the study. Helmut Rott, from the University of Innsbruck, will provide us with surface velocities of the area based on Sentinel 1 data. Jonathan Bamber, University of Bristol, will deliver the latest data sets on temporal ice-elevation changes.

Sledge Juliet

Earth's response to ice unloading: a unique GPS measurement from Antarctica

(MATT KING, ANYA READING, PAUL TREGONING, SIMON MCCLUSKY, EUGENE DOMACK, ERIN PETTIT) MICHAEL BENTLEY, PIPPA WHITEHOUSE, Chris Darvill, *[Field Assistant]

Location: Northern Antarctic Peninsula, near former Larsen B Ice Shelf region

Timing: November to December 2016

This proposal aims to deploy geophysical equipment within Antarctica to understand how Earth responds to changes in the amount of ice resting upon it. It exploits a globally unique natural experiment that commenced in 2002 with the break-up of the Larsen B Ice Shelf and which was followed by large-scale ice-mass unloading and instant and ongoing surface uplift. In particular, we hope to capture increased uplift that will occur as glaciers thin further, especially the thinning expected to commence when the last part of Larsen B (in SCAR Inlet) breaks up. To achieve this, we will install new GPS sites to measure deformation, broadband passive seismic measurements will be made to infer the Earth's interior properties and new geological measurements will be made to help understand changes in ice loading in recent centuries.

This year our objectives are to install GPS and seismometers at up to three new sites. We will collect geological samples to help determine past ice-sheet extents and retreat patterns.

Sledge Kilo

Larsen B Ice Shelf and glacier flow: instrument servicing

(HILMAR GUDMUNDSSON), Octavian Carp

Location: Larsen B Ice Shelf: Flask Glacier and Scar Inlet

Timing: November to December 2016

This fieldwork is part of a study on the interactions between ice shelves and glaciers. In 2002, most of the Larsen B Ice Shelf collapsed leaving a much smaller remnant ice shelf (Scar Inlet). Following this collapse, a number of glaciers feeding into the ice shelf have sped up and thinned and this thinning appears to be ongoing. Unfortunately, no *in situ* data on temporal variations in flow of the ice shelf and the glacier tributaries prior to and following the collapses could be collected. We therefore have limited means of testing numerical models.

During the 2012/13 season five GPS were deployed on Scar Inlet and its tributary glaciers (Flask and Starbuck) to measure the velocity of the ice shelf and the glaciers. It is anticipated that Scar Inlet Ice Shelf is likely to collapse in the near future so the aim is to measure how the glaciers are moving before, during and after the collapse. The two GPS sites on Starbuck glacier were removed during the 2014/15 season. This season the remaining sites will be visited for servicing and data collection. It is anticipated that the sites on the Flask glacier will also need to be moved upstream.

Sledge Lima

Low power magnetometer servicing

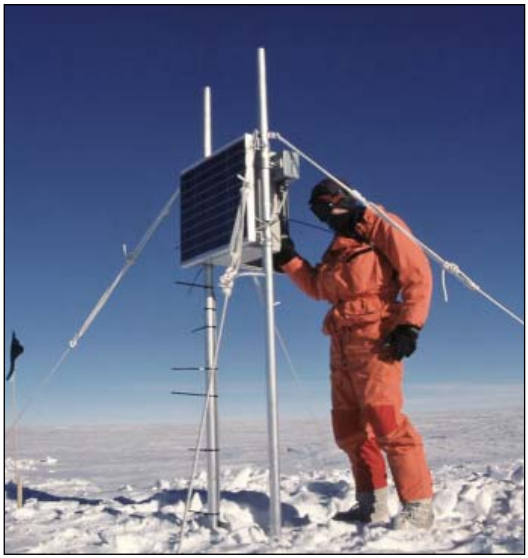
(MIKE ROSE), Octavian Carp, Gabor Gereb

Location: Polar plateau

Timing: Throughout the season

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

Information is recorded by the instrument and removed once a year during servicing.



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

Sledge Mike

Seismic investigation of Subglacial Lake CECs (SLC)

(ANDY SMITH), Alex Brisbourne, *Nick Gillet

Location: Subglacial Lake CECS

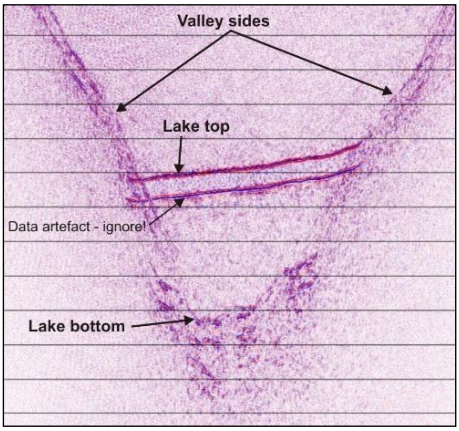
Timing: December 2016 to January 2017

Antarctic subglacial lakes contain unique records of ice sheet history and microbial life; they also act as large reservoirs of water that lubricates the ice-sheet bed and are potentially useful analogues when exploring for extra-terrestrial life. Hence, subglacial lakes are the subject of much scientific interest and a lot of effort has been put into investigating them.

To gain the maximum scientific benefit from subglacial lakes requires drilling into them so that lake water and bed sediments can be sampled. Prior to access, geophysical surveys can confirm that a lake actually exists and measure how deep the water is, and the only way to measure the water depth is with seismic methods. Seismic surveys involve detonating small explosive charges and recording the echoes that are reflected back off the top and bottom of the lake.

Colleagues from Centro Estudios Cientificos (CECs) in Chile have identified a subglacial lake West of the Ellsworth Mountains (Subglacial Lake CECS, or SLC). This season, BAS and CECs will collaborate there on an approximately two-week project to do a seismic survey of SLC to find out how deep its water is.

▲ *Detonating a small explosive charge during a seismic survey*



▲ *Example of a seismic record from nearby Subglacial Lake Ellsworth (SLE). The record is zoomed in on the lake itself, more than 3km of ice lies above this image*

Sledge November

Reducing the uncertainty in estimates of the sea-level contribution from the westernmost sector of the East Antarctic Ice Sheet since the Last Glacial Maximum

(MIKE BENTLEY, PETER CLARKE, KIRILL PALAMARTCHOUK), Gabor Gereb

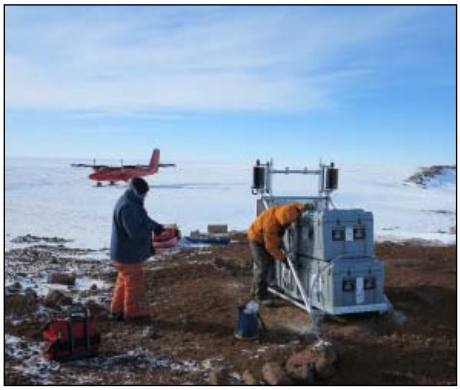
Location: Halley and Coats Land

Timing: December 2016 to February 2017

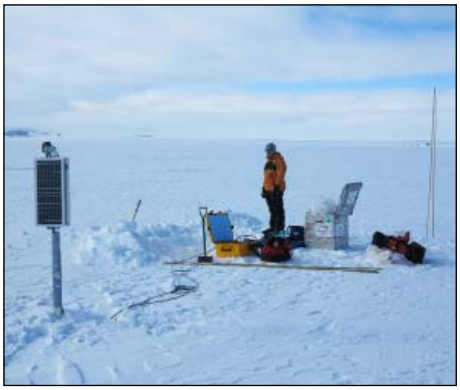
The project aim is to determine the long-term (20,000 years) Coats Land ice-thinning history, and to use it to better estimate current ice-loss rate. The main way we measure ice-mass changes is using gravity satellites, which need to be corrected for an important effect called glacial isostatic adjustment (GIA), where the solid Earth rebounds after deglaciation. We aim to produce a better GIA model to reduce the error in estimating the ongoing sea-level contribution of this part of Antarctica.

Last season, skidoo-based Sledge India was identifying geomorphological evidence of ice thinning in Coats Land, and collecting samples of rock and mumiyo (solidified petrel stomach oil), for radio-isotopic dating, which can tell us when ice was absent. Sledge November was using aircraft to install GPS at four sites to directly measure the uplift, and two seismometers to rectify the regional Earth interior models.

Once we know the ice loss history, we can input these data into models simulating the crustal postglacial rebound. We can evaluate these models by using our GPS measurements of uplift in this part of the continent, which currently has the highest uncertainty in its contribution to sea-level rise of any region of Antarctica.



▲ *GPS site*



▲ *Seismic site*

Sledge Quebec

Larsen C Ice Shelf bathymetry survey

(PAUL HOLLAND, ALEX BRISBOURNE), Tom Hudson, *Bradley Morrell

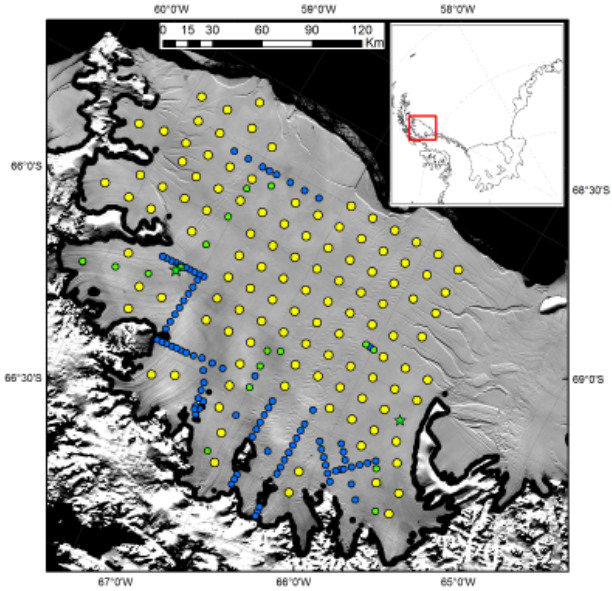
Location: Larsen C Ice Shelf

Timing: November 2016 to January 2017

Several ice shelves on the Antarctic Peninsula have collapsed catastrophically in recent decades. The largest remaining, Larsen C Ice Shelf (LCIS), is thinning. Despite the global importance of these collapses to sea-level rise and ocean freshening, their ultimate cause is still not known. Increased oceanic melting is the likely cause of ice loss from LCIS, but there is no direct evidence to support this theory.

Unfortunately, ongoing efforts to observe and model the ocean beneath LCIS are stymied by the unknown cavity geometry. The ice-shelf base is known accurately, but the sea-bed depth is very poorly sampled. The sparse existing data suggest large-scale sea-bed features that will guide ocean currents. It is impossible to understand ocean melting of LCIS without surveying these features.

In the 2016/17 season, a single field party will use hammer-and-plate seismic techniques to survey the sea-bed depth at a grid of locations (see Figure). It should be possible to gather over 100 point measurements focussing on 1) the south-east cavity, where a large ocean basin may govern the overall circulation beneath LCIS; 2) the north-east cavity, where the ice shelf grounds on Bawden Ice Rise; 3) deep embayments in the west, where rapid melting occurs.



▲ *115 proposed seismic sites (yellow) and previous sites from multiple surveys (blue and green)*

Sledge Romeo

Ultrasonic Planetary Core Drill

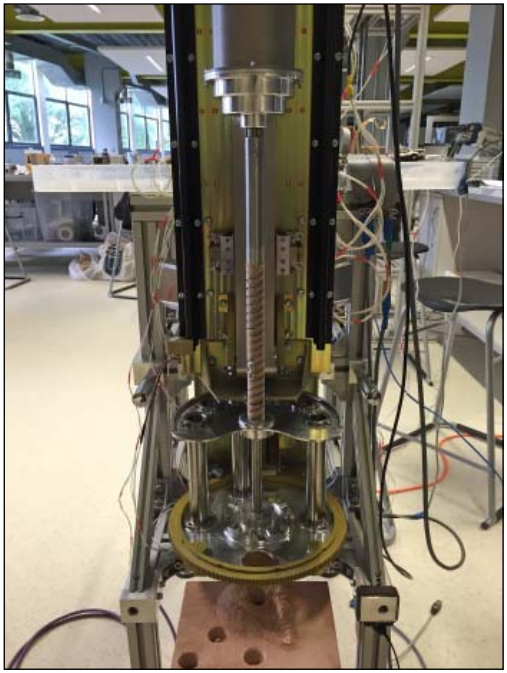
PATRICK HARKNESS, Ryan Timoney, Tatu Tolonen, Kevin Worrell, [*Field Assistant]

Location: Coal Nunatak

Timing: December 2016

The Ultrasonic Planetary Core Drill project is testing some technologies for obtaining rock samples from other planets, so that they can be returned to Earth for more detailed study. This is more difficult because we will not have as much gravity to produce weight on the drill bit, and as we will be trying to extract scientific samples we would prefer not to use a lubricating fluid down the hole. Commands from Earth will also take a long time to arrive, and so we need a highly autonomous system that can control its own descent in real time.

Therefore, we plan to vibrate the drill at a high frequency, using an ultrasonic transducer, to produce a hammering action while at the same time fluidising the spoil material so that it does not stick to the drill bit so much. The transducer will measure the effect of those hammering actions, which will be used by the drill software to determine if it is time to go deeper. Finally this will be built into a test system that can extract and store samples from underground, and which we will finally test somewhere as Mars-like as possible: the cold, dry, and rocky outcrops of Antarctica.



▲ *The UPCD drill after a test run in sandstone. The carousel used to offer new bits and cache old ones is visible at the front*

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

Sledge X-Ray

University of Utrecht IMAU AWS in the Antarctic Peninsula

(MICHIEL VAN DEN BROEKE, CARLEEN TIJM REIJMER, WIM BOOT), Rosey Grant, John Law, Mairi Simms

Location: Larsen B and Larsen C Ice Shelves

Timing: Opportunistic throughout the season

In close collaboration with BAS, UU/IMAU operates automatic weather stations, so called iWS, at three sites in the Antarctic Peninsula (AP). These are serviced each year by BAS personnel from Rothera.

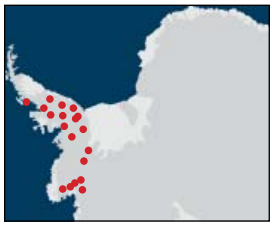
AWS14 is situated on Larsen C Ice Shelf, next to the BAS 'Larsen C' AWS. Last year, the mast was extended and the old AWS was removed. Coming season 2016/17 the iWS unit, memory card and thermocouple are exchanged (standard procedure). The radiation sensor will also be exchanged; the current sensor has a calibration error (data can be post-calibrated). BAS intends to remove their AWS.

AWS18 is also situated on Larsen C, in Cabinet Inlet. Originally planned for a single year of operation (MIDAS project Adrian Luckman), it was decided to keep this site operational instead of AWS17 (see below). In 2016/17 the iWS unit will be swapped (standard procedure) and a new mast installed with a larger base, limiting tilt in this high-melt environment.

AWS17 is situated in SCAR Inlet, on the remains of Larsen B Ice Shelf. In 2015/16, the previous 'classical' AWS was dismantled; the new iWS stopped transmitting in March 2016. In consultation with BAS logistics and scientists it was decided that this hard-to-reach site will be discontinued in 2016/17 and all remaining material returned to Utrecht.

▲ *An exciting new development is that iWS as of 2016/17 will be powered by six standard D cell alkaline batteries; this makes the use of Lithium batteries (considered dangerous cargo by BAS and commercial airlines) obsolete, much improving transport safety and flexibility*

Sledge Zulu



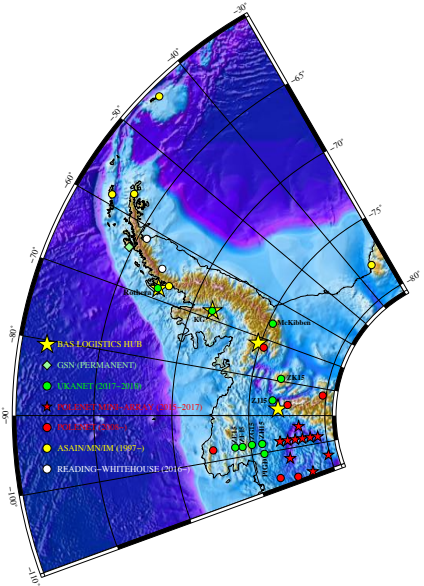
Lithospheric structure of West Antarctica to control Glacial Isostatic Adjustment (GIA) models (UKANET)

(GRAHAM STUART, ALEX BRISBOURNE), John Paul O'Donnell, Charlie Dunham, Octavian Carp, Ben Keitch, *Alistair Doherty

Location: The Southern Antarctic Peninsula and Ellsworth Land

Timing: December 2016 to January 2017

In order to predict future global sea-level change, it is vital to predict the evolution of the West Antarctic Ice Sheet. Fluctuations in the ice-sheet mass cause fluctuations in the Earth's gravity field, so gravity data can be used to track ice loss. However, the total gravity signal also reflects other Earth processes, the most problematic of which is Glacial Isostatic Adjustment (GIA). During GIA, the Earth's mantle slowly flows back toward equilibrium following the advance or retreat of a significant surface ice load. The extreme viscosity of the Earth's mantle means that this internal mass re-distribution can lag the actual ice-sheet change by thousands of years. Therefore, we can only isolate the gravity signal caused by present ice-mass change by removing the GIA signal caused by past ice-sheet behaviour. To do this, we must know the viscosity of the mantle. In 2014-15 we deployed a network of 10 seismic stations across eastern West Antarctica to record seismic energy from earthquakes occurring worldwide over a two-year period. This season we will service the stations (moving several) and retrieve the first year of data. We will ultimately recover the viscosity of the mantle from the recorded waveforms.



▲ *Seismic networks in eastern West Antarctica*

▲ *Installing a seismic station at McKibben nunatak on the Antarctic Peninsula*

Ice shelves in a warming world: Filcher Ice Shelf System, Antarctica (FISS)

Sledges Hotel, Papa, Sierra, Tango, Uniform, Victor, Whisky

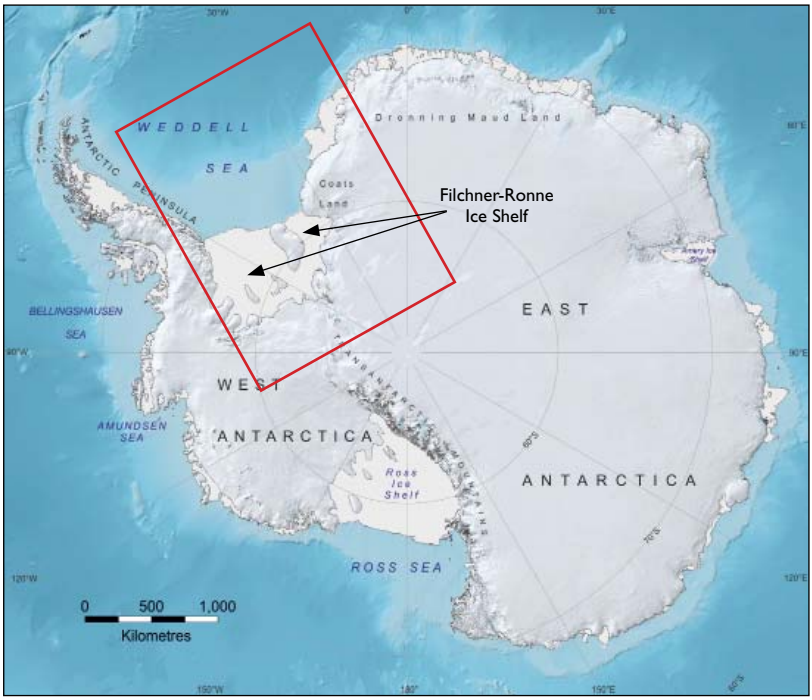
Location: Filchner Ice Shelf

Timing: October 2015 to February 2018

This section details the fieldwork to be undertaken in the 2016/17 season as part of the Large Grant 'Ice shelves in a warming world: Filchner Ice Shelf system, Antarctica' *(Grant reference: NE/L013770/1)*. The fieldwork will span three years and is one of the main deliverables of the project that has participants from two NERC centres (BAS and National Oceanography Centre (NOC)), the Met Office Hadley Centre (MO), University College London, the University of Exeter and Oxford University. The University of Bergen will participate in the oceanographic measurements beneath the ice shelf. Our European partner, Alfred Wegener Institute (AWI, Germany), bring scientific knowledge and expertise to the work. In addition AWI and BAS are partners in the fieldwork: both logistical and scientific.

Science Aims and Objectives

The primary aim of the project is to determine how a large sector of the Antarctic Ice Sheet will evolve in a warming world.



▲ *The red box shows the area of study*

Ice shelves in a warming world: Filcher Ice Shelf System, Antarctica (FISS) *continued*

The prospect is for atmospheric and oceanic forcing to reduce the thickness and extent of floating ice shelves as a result of increased melting at their base. A thinned ice shelf has a lowered ability to buttress the flow of its grounded tributary ice streams. Removal of an ice shelf therefore allows the restrained ice to flow faster, drawing down the vast interior reservoir and resulting in global sea-level rise. However, the rate, pattern and timing of the ice-shelf melt and the associated sea-level rise are uncertain. We propose a carefully targeted observational programme, in support of a comprehensive modelling activity. The sector to be studied is the Filchner Ronne Ice Shelf and its five tributary ice streams, which spans sections of both the East and West Antarctica Ice Sheet. Specifically, projections will be made out to the end of this century of the contribution to global sea-level rise from this sector.

The project aims are encompassed by the following deliverables:

Deliverable 1: New datasets from the Filchner region, and validated simulations of the present-day system and its variability.

Determine the geometry of the model domain (ice-bed elevation, ice thickness and sub-ice-shelf bathymetry) in several key areas that lack data coverage. Collect datasets designed to supply a physical understanding of Filchner Ice Shelf, its tributary ice streams and the sub-ice-shelf ocean, in the present atmospheric and oceanographic regime. Numerical simulation of the complete system will demonstrate the various interconnected physical processes and importantly, their sensitivities to a change in climatic forcing.

Deliverable 2: Reliable projections on how the Filchner region will contribute to sea-level rise over the 21st century.

Deliverable 3: An assessment of the uncertainties in the projections, and a broadening of the study to encompass all of Antarctica.

Key to the attainment of the project is the success of a carefully designed field campaign that will collect data both to improve the way the models work, and also to validate their results.

There is an urgent need to get and use the field observations. However, a substantial legacy of the project will be the observational datasets: long after the end of this five-year project the precious, hard-won data will be referred to time and time again.

Field campaign for 2016/17

There are seven primary activities planned, a description of each of these follows.

1. **Sledge Tango:** Oceanographic observations through hot-water-drilled access holes
2. **Sledge Victor:** Bathymetry beneath Filchner Ice Shelf
3. **Sledge Sierra:** Servicing of established ApRES sites
4. **Sledge Uniform:** Ground-radar measurements (pRES and snow-accumulation)
5. **Sledge Papa:** Static GPS on Recovery Ice Stream
6. **Sledge Hotel:** GPS measurements of tidal forcing
7. **Sledge Whiskey:** Airborne survey

Ice shelves in a warming world: Sledge Tango

Filchner Ice Shelf System: oceanographic observations through hot-water drilled access holes

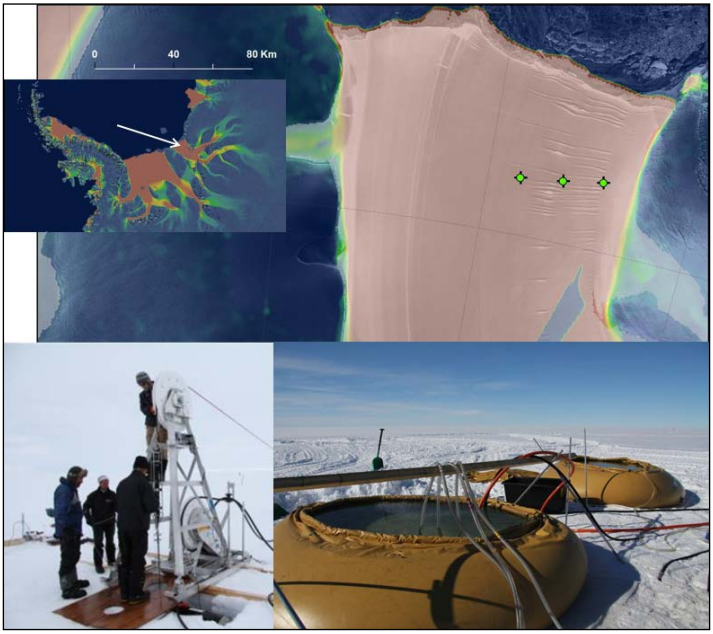
KEITH NICHOLLS, (ANGELIKA HUMBERT), SVEIN ØSTERHUS, Paul Anker, Jörg Brozek, Peter Davis, Tore Hattermann, JoHannes Lohse, Lewin Probst, *Scott Webster

Location: Northern Filchner Ice Shelf

Timing: November 2016 to January 2017

HotWaterOnIce

The cavity beneath an ice shelf is probably the least observed part of the World Ocean, as a result, models of the sub-ice-shelf circulation lack an observational basis for validation. A hot-water drill will make three access holes through the Northern Filcher Ice Shelf and obtain oceanographic (CTD) profiles from the underlying water column. Deployed instrumented moorings in the water column at each site will obtain long-term records of water properties, including currents, temperature and salinity. Currents will be measured at three depths, and temperature and salinity at seven depths. In addition, a thermistor cable will be frozen into the ice shelf at one of the sites to obtain time series of temperatures at 24 depths, with ~0.03˚C accuracy in temperature. To drill through approximately 650 metres of ice shelf and gain access to the ocean below, a hot water drill, pumping 90 litres of water per minute at around 90°C is used. The resultant 0.5MW of heating power makes a 30cm diameter access hole through the ice. Whilst the hole is open (unfrozen) water samples will be taken at discrete heights in the water column. Sediment cores from the ocean floor are planned to be recovered.



▲ *Approximate positions of the three boreholes on the northern Filchner Ice Shelf*

Ice shelves in a warming world: Sledge Victor

Filchner Ice Shelf System: bathymetry beneath Filchner Ice Shelf

HUGH CORR, (ANGELIKA HUMBERT), Coen Hofstede, Daniel Steinhage, *Daze Routledge

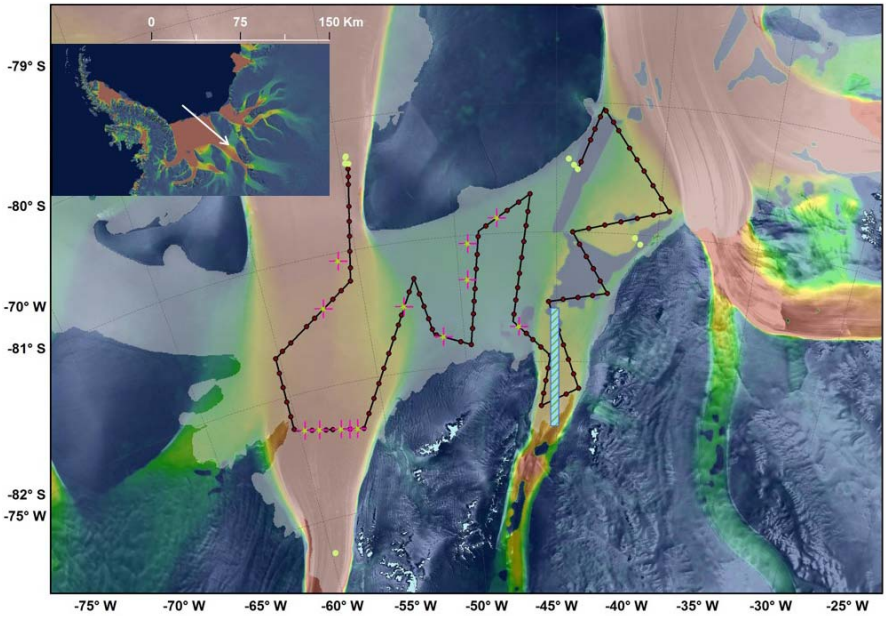
Location: Filchner Ice Shelf

Timing: November 2016 to January 2017

The fieldwork has three components:

1. Conventional spot depths for bathymetry at 104 locations
2. The revisit of 13 pRES sites established by in 2015/16
3. A focused, high resolution seismic-study of the geomorphology of the ocean bed forms

To define the model domain refinement, a two-person team will carry out seismic surveys to measure the bathymetry beneath Filchner Ice Shelf in regions where it is presently poorly known. A particular focus will be in the vicinity of ice-stream grounding lines where, along the centre line of the extension of the ice stream into the ice shelf, a spatial resolution on the order of one or two ice thicknesses will be sought. Using a power auger to install the explosive charge, with 24 Georods and a Geometrics Geode datalogger, we anticipate approximately 104 sites will be occupied during the season. An estimated traverse distance of 2,500km is anticipated. The spot measurements of water depths and bed elevation will provide a dramatic and vital improvement to the available bathymetric coverage. The repeated pRES measurements will provide an average melt-rate of the ice shelf.



▲ *The proposed route with the locations of the 104 point measurements of bathymetry. The hatched area marks the route for the high resolution seismic survey*

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

Ice shelves in a warming world: Sledge Sierra

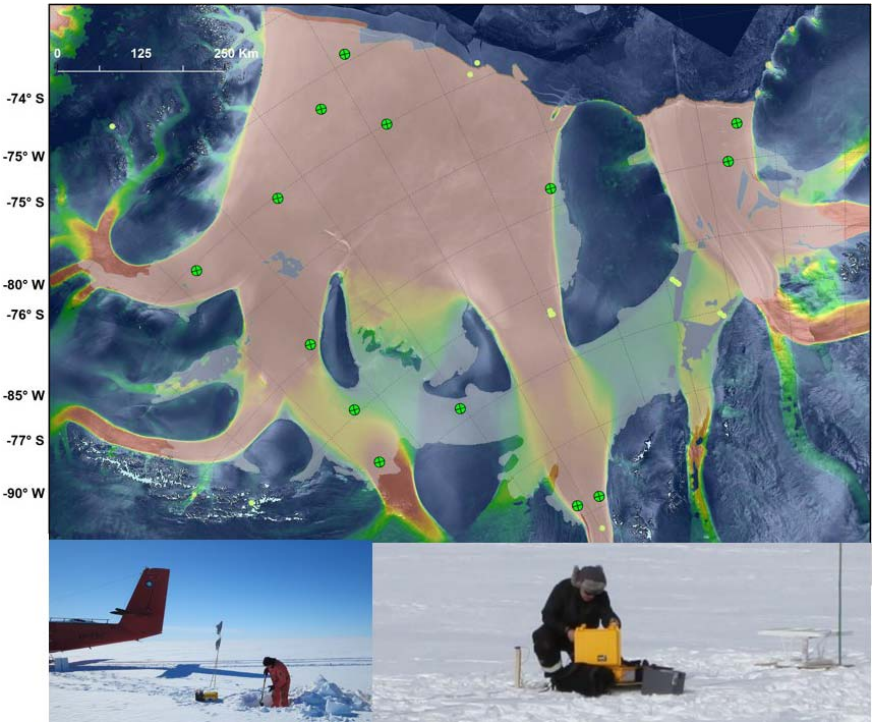
Filchner Ice Shelf System: servicing of established ApRES sites

KEITH NICHOLLS

Location: Filchner-Ronne Ice Shelf

Timing: November 2016 to January 2017

In the 2015/16 season, 14 phase-sensitive radars (ApRES) were established at carefully selected locations on both the Ronne and Filchner Ice Shelves. The ApRES instruments yield time series of ice-shelf thickness change at precisions of ~1mm, so that over a 10-day period, a precision in derived melt rate of a few centimetres per annum is determined. The aim is not to quantify the total melt rate of the ice shelf, but to use its variability to improve the performance of the ocean models by adjusting otherwise poorly-constrained model parameters to obtain the best match between modelled and observed variability. The system is a low-power, light-weight instrument developed in collaboration between BAS and UCL. It is a 200-400MHz FMCW radar, with a one-second chirp, run by controller; housed within its characteristic yellow box, the radar and a 100AH battery is buried in a shallow hole. The radar's transmit aerial and receive aerial are spaced five metres each side of the yellow box and are also buried. Each system will record for a nominal 12 months and has the ability to process and send melt-rate data via satellite link.



▲ *The location of the established 14 ApRES sites. The inserts are photographs for the installation last season*

Ice shelves in a warming world: Sledge Uniform

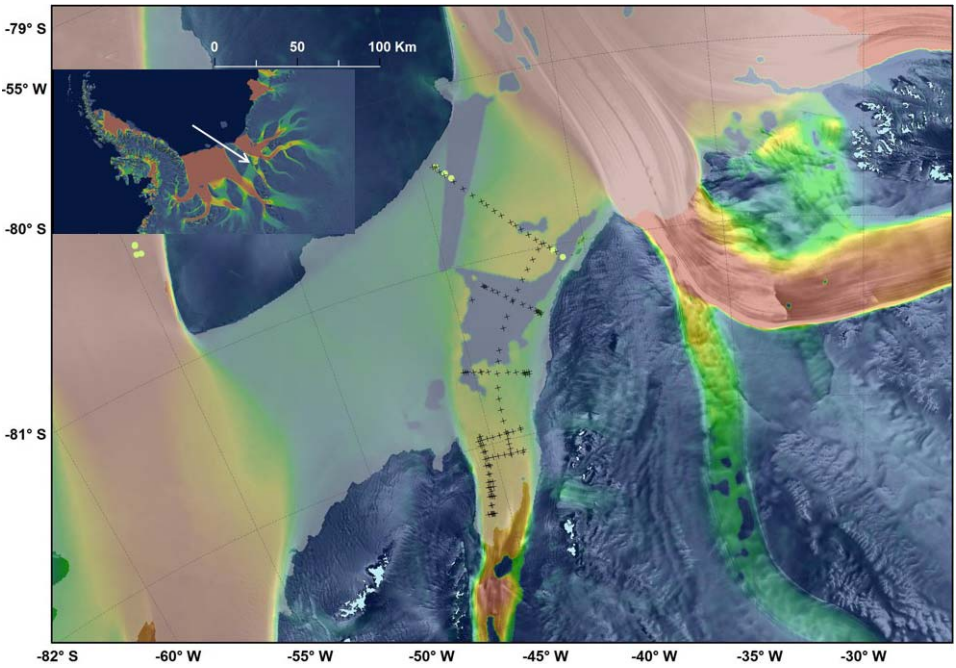
Filchner Ice Shelf System: ground radar measurements (pRES and snow accumulation)

DANIEL STEINHAGE, (ANGELIKA HUMBERT)

Location: Filchner Ice Shelf

Timing: November 2016 to January 2017

The two person party will work along an area of the Filchner Ice Shelf between the grounding line of Support Force Ice Stream and the southern drill sites, using a pRES instrument to provide an average melt rate for the area. During the previous season (2015/16) a total of 132 pRES sites were established. Each site is required to be reoccupied and the change in ice thickness recorded. Then by accounting for any spreading of the ice shelf the average melt rate can be determined. A high frequency radar will also be used in profile mode, this wideband system providing intricate detail of the spatial variation in accumulation and strain by tracking the internal reflection horizons. The distanced to be travelled is estimated to be 1,000km. In addition the team will service an automatic weather station (AWS) and in the latter part of the season join forces with Sledge Victor to support the high-resolution seismics.



▲ *The crosses mark the locations of the established 132 pRES measurement sites; the yellow dots mark the location of instrumented boreholes*

Ice shelves in a warming world: Sledge Papa

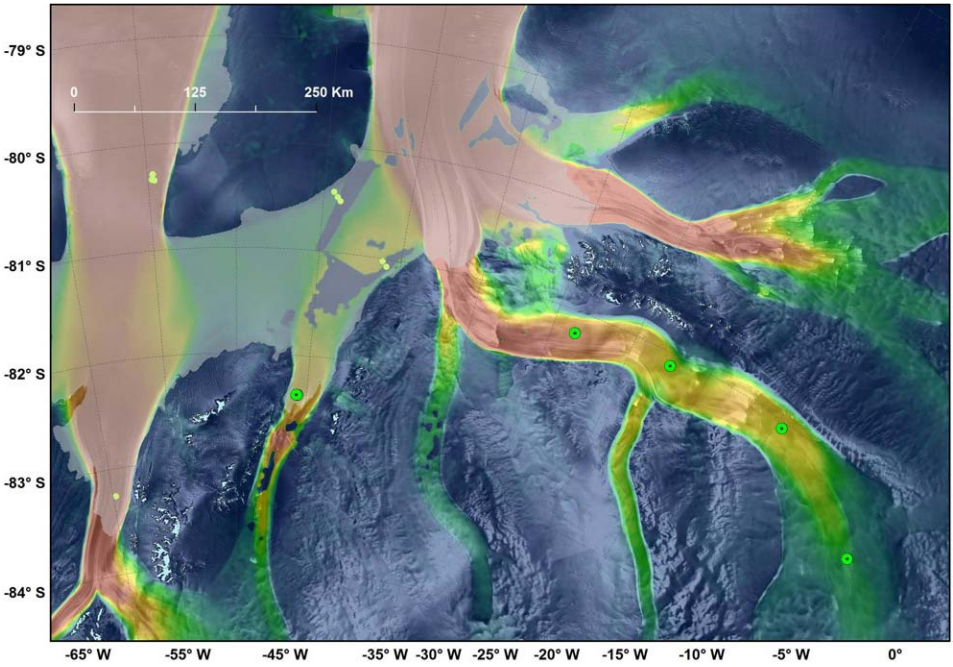
Filchner Ice Shelf System: static GPS on Recovery Ice Stream

DANIEL STEINHAGE, (ANGELIKA HUMBERT)

Location: Recovery Ice Stream

Timing: November 2016 to January 2017

In the 2015/16 season, four GPS stations were established along the length of the ice stream at various intervals spanning 500km of the ice-stream centre line. The remit is to measure the changes in ice-stream velocity caused by variations in the sub-glacial water flow. The water acts as lubricant by reducing the friction between the ice and the bedrock. Unlike the light-weight units to be deployed on the Foundation Ice Stream, these are to work year round and will therefore require more power, which is provisioned by wind turbines. The original intention was to remove all of these sites, however, because of a technical issue with the wind turbines, the two outer ones (Papa Alpha and Delta) will be serviced and the two closest to the grounding line, Bravo and Charlie, will be removed. The work will be done with Twin Otter aircraft support.



▲ *Location of the four GPS sites on Recovery Ice Stream and two seaward of the grounding line of Support Force Glacier*

Ice shelves in a warming world: Sledge Hotel

Filchner Ice Shelf System: GPS measurements of tidal forcing

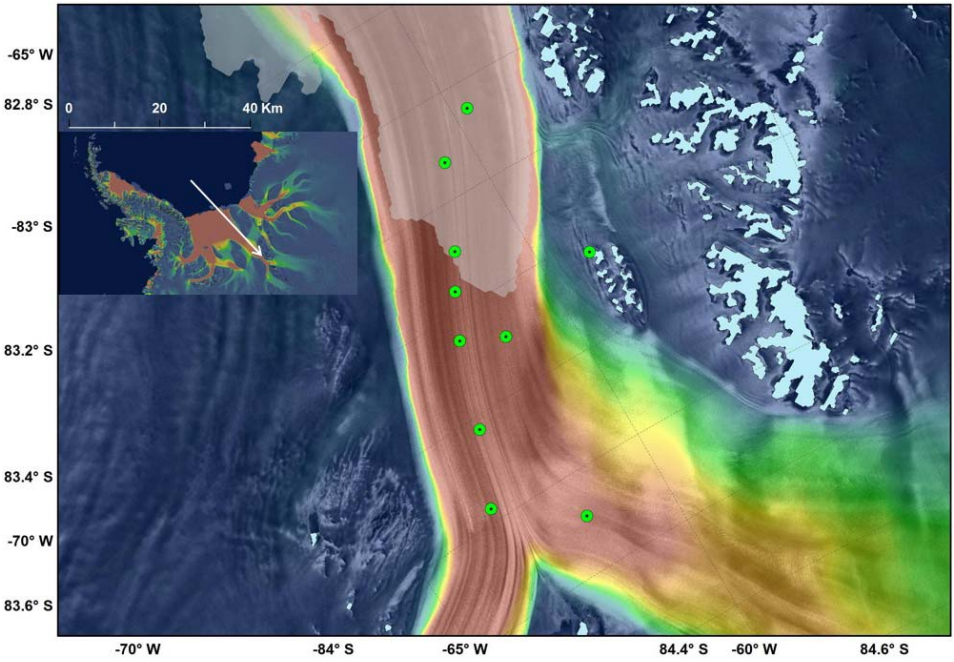
(HILMAR GUDMUNDSSON), Hugh Corr, Keith Nicholls

Location: Foundation and Möller Ice Streams

Timing: November 2016 to January 2017

Tidally-induced modulations in the flow of the ice stream serve as a natural forcing allowing us to constrain the form and the parameters of the basal sliding law used in our numerical ice-flow models. Modelled tidally-induced modulations in flow of the ice streams will then be compared with direct GPS measurements of ice-stream flow.

In the 2015/16 season, nine GPS stations were installed along the Foundation Ice Stream at approximately 10km intervals; a tenth, used as a fixed reference, was installed on a 'local' rock outcrop. Based on measurement on other ice streams flowing into Ronne Ice Shelf we expect to have recorded a large modulation in flow velocities at the Msf (approxiately two-weekly) frequency. We hope the units have survived the winter and have data for up to nine months. Five of the existing stations will be refurbished and the remaining four will be uplifted and deployed on the neighbouring Möller Ice Stream. Each of the stations consists of a GPS receiver, solar panel, two 100AH batteries and associated pipe-work to mount the solar panel and GPS aerial. The work will be done with Twin Otter aircraft Support.



▲ *The location of the ten GPS stations on Foundation Ice Stream*

Ice shelves in a warming world: Sledge Whiskey

Filchner Ice Shelf System: airborne survey

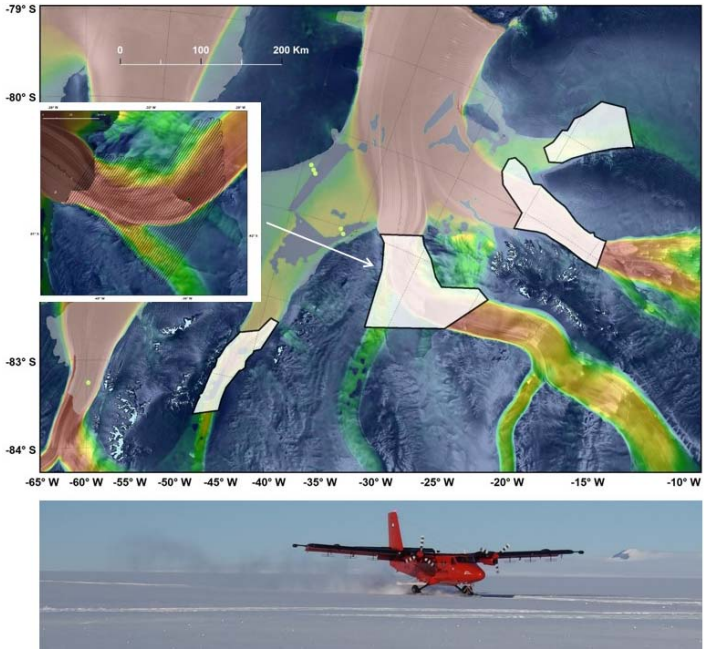
HUGH CORR, Carl Robinson, Ian Potten, *Catrin Thomas

Location: Eastern side of the Filchner Ice Shelf

Timing: November 2016 to January 2017

To describe the flow of an ice stream in a numerical model requires the mapping of the bed topography immediately upstream of the grounding line at a resolution high enough to depict its motion reliably. We will employ the proven capability of the NERC-BAS Twin Otter equipped as a geophysical measurement-platform to complete the close line-spaced survey of four major ice streams: Bailey, Slessor, Recovery and Support Force. Each of the ice streams will have a targeted 20 hour (20,000 line km) survey with a nominal line spacing of 2km and terrain clearance of 1,000 feet (300 metres). The standard instrument suite will include the proven ice-sounding radar PASIN, together with a scanning laser altimeter that will provide coincident survey topography and magnetometers that will help describe the underlying geological structure. Survey lines will be interleaved with the existing, very sparse, data, and will be complemented by data from an inland regional survey planned by Project Partner AWI. The radar is configured with multiple transmit and receive channels.

A studentship has been established at UCL with Paul Brennan to add value to the survey by exploiting the 3D potential of the data and produce a swath image of the ice bed.



▲ *The polygons mark the survey areas of the four major ice streams. The insert shows detail of the proposed flight plan for Recovery Ice Stream*

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

Sledge RAID

Beyond EPICA – Oldest Ice

ROBERT MULVANEY, Julius Rix

Location: Dome C, East Antarctic Plateau

Timing: November 2016 to January 2017

A decade ago, the European EPICA project completed the drilling of a deep ice core at Dome C, revealing the close link between climate and atmospheric greenhouse gases over the past 800,000 years. The record showed that the Earth's climate experienced a 100,000-year cycle of cold glacial periods (ice ages) interspersed with warmer interglacials. But marine sediment records show that earlier than one million years glacial periods occurred once every 41,000 years. We feel that the clue to the change in glacial frequency lies in the greenhouse gases in the atmosphere, so a team of European scientists intend to drill another ice core that we hope will reach back 1.5 million years.

Candidate sites for the 'Oldest Ice' drilling project have been chosen using ice-sheet modelling, but we need field observations to confirm and select the best site. We will deploy our Rapid-Access Isotope Drill (RAID) at candidate sites near to Dome C to recover ice back to the last glacial period to confirm age-depth models, and measure the borehole temperature to check for absence of melting at the bed. We will use two BAS radars (ApRES and DELORES) to provide supporting detail of the local ice sheet dynamics.

▲ *Setting up the ApRES radar antenna*

▲ *The RAID rapid-access drill*

Sledge UAV

Long-range fixed-wing UAV flight testing and integration into BAS Antarctic airspace

(CARL ROBINSON, MIKE ROSE), Scott Polfrey, William Clark, [UAVE Personnel]

Location: Antarctic Peninsula, Rothera

Timing: January to February 2017

BAS has a growing fleet of UAVs available to carry out science and operations tasks in Antarctica. One of the most recent additions to BAS capability is the purchase of two UAVE PRION3 airframes and ground system. During September 2016, BAS staff underwent training in Wales with the manufacturer and at the UK UAV test range at Aberporth, to learn how to operate and fly the PRION3 UAV.

This season will be the first time that a UAV has operated out of Rothera fully integrated with the normal BAS operations.

Aircraft operations	
Range	14 hours, 1,000+km
Airspeed	80km/hr data collection
Complement	One pilot and one ground controller
Altitudes	Up to 3,000m AGL plus

This year our objectives are to conduct flying from Rothera runway and ski-way to prove that the BAS PRION3 UAVs fly well in the Antarctic. Part of this test flying is to integrate long-range fixed-wing UAVs into the Antarctic airspace and to develop all the required protocols for the interfacing departments and sections.

▲ The BAS *UAVE PRION3*

Rothera Research Station

Impacts of marine vertebrates on Antarctic terrestrial foodwebs and nutrient cycling in an era of climate change

STEF BOKHORST, Emily Davey

Location: Rothera and local islands

Timing: January to February 2017

The Antarctic Peninsula is heavily impacted by climate change and warming has been extensive during the last decades. The first aim of this project is to quantify how plants and soil animals will respond to warmer temperatures. Eleven years ago we placed warming chambers on Anchorage Island to simulate climate warming scenarios and now we return to see the impacts on the plants and soil animals.

Penguin and seal populations are also affected by climate change along the Antarctic Peninsula and these populations may grow or decline in size depending on the local conditions. However, penguins and seals deposit huge amount of poo on land thereby fertilising nearby plants. The second aim of this project is to quantify the impact of additional nitrogen, from penguin poo, on plant growth and development of the foodweb. Finally, we aim to compare the impact of climate warming with the indirect impacts of fertilisation by penguins and seals for the development of Antarctic terrestrial communities.

During this summer we aim to quantify the effects of higher temperatures for the Antarctic vegetation and soil organisms, such as springtails and mites, in climate warming chambers on Anchorage Island. Further we will measure the impact of penguin and seal colonies for the vegetation and soil community by quantifying the community composition along transect away from penguin and elephant seal colonies. Here we expect that vegetation and soil communities will benefit from the additional nitrogen, from seal poo, and therefore grow more abundant than further away from the seal colonies.

▲ *Chinstrap penguin on nest*

▲ *Climate warming chambers, Anchorage Island*

Rothera Research Station

Using underwater gliders to understand the turbulent waters of the West Antarctic Peninsula

ALEX BREARLEY, HUGH VENABLES

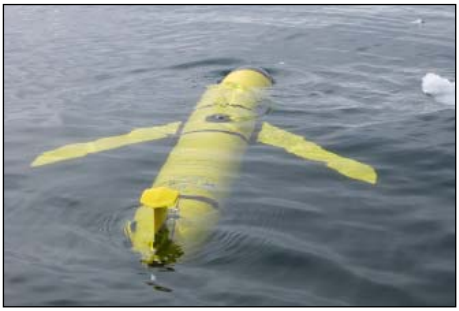
Location: Ryder Bay and beyond!

Timing: December 2016 to February 2017

Glaciers and ice sheets in West Antarctica are melting rapidly, contributing to global sea-level rise. The energy source driving this melt is not clear but, by elimination of other options and the pattern of glacial retreat, it is probably largely from the ocean. Warm water (>1°C, everything's relative...) is present at depths greater than 250m across the continental shelf to the west of Rothera, but there is still much to learn about how and where that warm water reaches the glaciers and ice sheets. Turbulence mixes warm waters from depth with cold waters near the surface but it is very patchy and requires specialised and very sensitive equipment to monitor. BAS are leading an ambitious programme to make the first direct measurements of mixing around the West Antarctic.

To address these challenges we are deploying two ocean gliders, including one with additional probes to measure turbulence directly. Both measure temperature and salinity and will be flown to areas where we suspect mixing processes are enhanced by the bathymetry. Ocean gliders fly by changing their buoyancy, with this vertical motion also converted to a saw-tooth pattern via passive wings, a tail fin and moving the front battery to tip the nose up or down. Once deployed they are piloted autonomously over an Iridium link. They are slow (100 miles per week) but very efficient (endurance about three months) and will hopefully provide exciting insights into these key processes.

▲ *Ocean glider SLOCUM on the snow before deployment*



▲ *Glider at the surface near Rothera Research Station*

Rothera Research Station

Monitoring of skua population on Rothera Point

(KEVIN HUGHES), RICHARD PHILLIPS, *Ali Massey

Location: Rothera Point and Anchorage Island

Timing: November 2016 to April 2017

Rothera Point has been the site of a BAS research station since 1975. Since the construction of the first hut, the station has grown in size and now is the largest British base in Antarctica with accommodation for up to 140 people.

Under the UK Antarctic Act, and the Environmental Protocol to the Antarctic Treaty, BAS are obliged to undertake environmental monitoring of its impacts on the natural environment. Antarctic Specially Protected Area No. 129 Rothera Point was specifically designated to act as a pristine control site on Rothera Point so that comparisons with impacted sites could be made.

Up to 25 pairs of skuas nest on Rothera Point including the ASPA, where the skuas have been studied to some extent since the late 1990s. In 2005, the study was redesigned to improve consistency in data collection methods to ensure the results are robust enough for a scientific publication as well as fulfilling our legal obligations.

The breeding parameters that are recorded include laying dates, clutch size, egg dimensions, hatching success, fledging success, chick condition and adult attendance (which provides an index of foraging effort). In addition, since the 2007/08 season, monitoring has included re-sighting 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.

▲ *South polar skuas on Rothera Point*

▲ *Weighing a skua chick*

Rothera Research Station

Phytoplankton primary production in the West Antarctic Peninsula (WAP-FRRf)

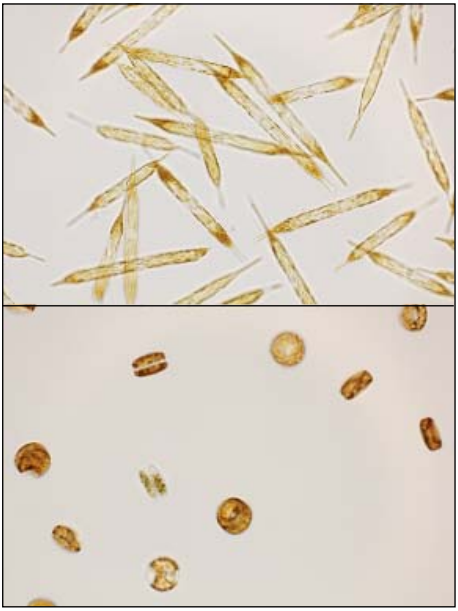
GEMMA KULK, (ANITA BUMA), Gerrit van der Goot, Emily Davey

Location: Ryder Bay, Rothera

Timing: November 2016 to April 2017

The Western Antarctic Peninsula is experiencing rapid warming with an increase of 3°C in the annual mean atmospheric temperature in the past century. The subsequent reduction in sea ice may stimulate and/or reduce marine primary production or may have no significant effect at all. To verify the effects of warming on marine phytoplankton in the Western Antarctic Peninsula, field-based primary production measurements are essential. Fast Repetition Rate fluorometry is an increasingly used method to estimate primary production of marine phytoplankton in the Antarctic.

However, research is needed to accurately convert fluorometry-derived electron-transport rates into carbon-fixation rates. This project therefore combines laboratory experiments and measurements of two field campaigns (summer 2015/16 and 2016/17) to estimate electron transport versus carbon-fixation relationships in key phytoplankton species and natural phytoplankton communities from the Western Antarctic Peninsula. Further implementation of the method will thereby strongly advance our understanding of factors that regulate primary production of marine phytoplankton in one of the most rapidly warming regions of the world.



▲ *The Antarctic diatom species Proboscia alata (top) and Thalassiosira Antarctica (bottom), collected from Ryder Bay*

▲ *Dr Gemma Kulk and Dr Libby Jones collecting water samples in Ryder Bay*

Rothera Research Station

The role of Antarctic snowpack in the global carbon cycle

AGA NOWAK, Andy Hodson, Pete Convey

Location: Rothera and local islands

Timing: November 2016 to February 2017

Predictions of climate change draw increasing scientific attention to the fertilisation potential of the Antarctic Peninsula for the Southern Ocean and consequently global ecosystems. Although the scientific community is becoming aware of a marked heterogeneity in the chemical signature of meltwaters and the snowpack across Antarctica, we are still estimating nutrient fluxes from the Antarctic continent based on point measurements and assumptions that nutrient production is uniform across the whole region.

Our understanding of the sources and processes influencing concentrations of nutrients is also far from complete. For example, it is widely accepted that ice-melt nutrients take part in microbially mediated reactions yet, nutrient dynamics in snow are usually thought to be associated with inorganic processes and the microbial contribution remains virtually unexplored. Such a knowledge gap is surprising, considering the efforts put into constraining Antarctica's contribution to the global carbon cycle, reconstructing past climates from ice-core records, or predicting changes in terrestrial and marine ecosystems as Antarctica responds to climate warming.

This project will therefore define for the first time the linkages between physical conditions, microbial activity, and the fertilisation potential of meltwaters from the Antarctic Peninsula snowpack. To fully appreciate heterogeneity of this vast environment, and to understand how physical conditions constrain nutrient turnover by resident microbial communities, the fieldwork will be performed at five locations on the Antarctic Peninsula (Rothera, Anchorage Island, Leonie Island, Fossil Bluff and Mars Oasis) throughout the whole 2016/17 Antarctic summer season. Over 200 snowpack, meltwater as well as snow-air samples will be collected throughout the campaign and then pre-processed at the Bonner Laboratory at Rothera Research Station. The samples will then be transported to the UK for further analyses at the Department of Geography, University of Sheffield.

The study aims to advance our knowledge of the Antarctic contribution to the global carbon cycle and provide crucial data for more accurate predictions of the effects of changing climate on the globally important Southern Ocean.

▲ *Example of an algal bloom on a coastal Antarctic snowpack*

▲ *Digging a snowsuit to collect a basal ice sample*

Rothera Research Station

Investigation of biodiversity, structure and physiology of Antarctic benthos down to 100m depth

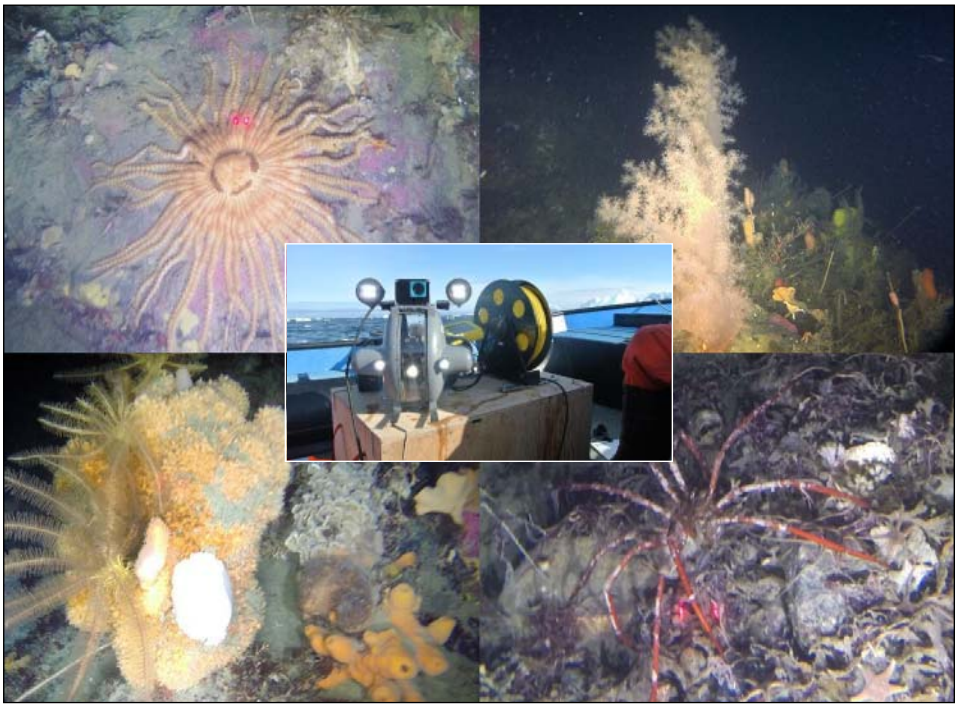
(LLOYD PECK), Ben Robinson

Location: Ryder Bay, Rothera

Timing: November 2015 to April 2018

The aim of the project is to investigate how the age and disturbance of the benthic community affects its composition, as well as how the benthic diversity and structure change between 10-100m depth. Continuing on from those projects will be an investigation of how the benthos colonised after the retreat of the Sheldon Glacier, a methodology comparison and the impact of mixing events on the benthos.

The ROV (Remotely Operated Vehicle), also known as DEBRA (Deep Environment Benthic Research Apparatus), is also being outfitted to collect multiple specimens at various depth, detect fluorescence and take sediment cores. Using DEBRA we are able to rapidly investigate sites normally too deep or hazardous for SCUBA divers and too shallow for large research ships (between 30-100m depth), discovering new marine communities and providing a greater understanding of the marine benthos.



▲ *DEBRA and Rothera marine life photographed by the ROV (inset)*

Rothera Research Station

1. Tracking and census of skuas at Rothera
2. Studies of snow petrels and Antarctic shags

RICHARD PHILLIPS, *Ali Massey

Location: Reptile/Stork Ridge, Lagoon Islands, Killingbeck Island, Anchorage Island, Rothera
Timing: January 2017

Tracking and census of skuas at Rothera

Monitoring of the south polar skuas at Rothera Point currently involves collection of data on timing of breeding, breeding performance, survival and breeding frequency of adults (identified from their uniquely-coded leg ring). However, nothing is known about feeding areas and diet, or about skua population trends on the islands in Marguerite Bay. This project will involve deployment of GPS and immersion loggers on breeding adults, and sampling of blood and feathers for stable isotope (SI) analyses. This provides information on the number and duration of feeding trips, foraging distances, flight times, travel speeds, number of landings (a proxy for foraging efficiency), location of breeding areas, importance of nocturnal foraging, and relative reliance on marine (fish, crustaceans) versus terrestrial food sources (predation or scavenging at bird colonies, seal carcasses etc.). By comparing SI ratios in plasma and cells, which have different turnover rates (days versus weeks), we can examine the degree of short and long-term dietary specialisation. By combining with the monitoring data, we can determine whether differences in foraging strategies or success among individuals affect breeding success. Nesting skuas will also be counted out on the islands in Marguerite Bay to estimate population size and trends.

Studies of snow petrels and Antarctic shags

Samples of blood, feathers, cloacal and oral swabs will be taken from adult snow petrels in crevices at Reptile/Stork Ridge for analyses of genetic structure and speciation (there are two subspecies) in collaboration with the Royal Belgian institute of Natural Sciences, for a comparison in breeding and non-breeding season diet of snow petrels between Rothera and Signy (comparing stable isotope ratios in blood and feathers), and for disease surveillance. Blood and feather samples will be taken from Antarctic shags for a global phylogenetic study.

▲ *Snow petrel*

▲ *South polar skua*

Rothera Research Station

Physiological responses of Antarctic amphipods to hypoxia – does increased temperature limit oxygen delivery?

JOHN SPICER, Simon Morley

Location: Ryder Bay, Rothera

Timing: January to February 2017

Low O_2 (hypoxia) is an increasing marine environmental concern, particularly coupled with rising temperatures which may further restrict O_2 delivery. While much is known of the physiological responses of animals adapted to environmental hypoxia, our knowledge of those that aren't is poor. Consequently I will investigate key physiological responses to hypoxia of animals that live in cold, O_2 rich waters, namely Antarctic amphipods.

Exposing individuals (active or resting) to acutely declining O_2 tensions, at a temperature within its natural range, and another just above, I will measure respiratory responses, and collect material for subsequent analysis of metabolic and molecular responses. This will enable me to characterise the hypoxic response of Antarctic amphipods and also allow me to test the OCLTT (oxygen and capacity limited thermal tolerance) hypothesis that increased temperature limits O_2 delivery.

▲ *Antarcic amphipod Paraceradocus*

Rothera Research Station

DMS dynamics at the Antarctic Peninsula

JACQUELINE STEFELS, MARIA VAN LEEUWE, Alison Webb, Emily Davey

Location: Ryder Bay, Rothera
Timing: November 2016 to April 2017

Climate on Earth is controlled by various gases of which many are produced in the ocean. DMS is a sulfate-containing climate gas that enhances cloud formation and thus contributes to a cooling of the earth's atmosphere as clouds reflect sunlight. DMS is produced by micro-organisms (unicellular algae) in sea ice and sea water. Very few data are available on DMS production in the Antarctic, and seasonal dynamics are hardly studied. The DMS team will measure how much DMS is produced in the water and sea ice around Rothera.

The team will take regular samples from sea ice and sea water in Ryder Bay. DMS will immediately be measured in the Gerritz Lab (container Hope), with highly specialised equipment. We will also collect samples to study which organisms are growing in Ryder Bay and within the sea ice itself, with a view to evaluating the significance of sea-ice DMS production to the global sulphur cycle. These samples will be analysed in the Netherlands.

To get a better understanding of DMS production (e.g. which are the organisms that produce more or less DMS), we will perform experiments in Hope and in an outdoor incubator. In these experiments the growth of algae will be monitored in parallel with DMS-production rates. With these experiments we want to address questions such as: Are these processes different in the surface of the ocean and in deeper waters? How do these processes change over the course of a season?

The data collected at Rothera will be used to improve climate models.

The work by the DMS team is carried out in close co-operation with the other marine scientists at the Bonner Lab. We highly appreciate the strong support from Rothera station. We have very much enjoyed working together with the RaTS-team and our other Dutch partners over the last four seasons, and we look forward to our final season at Rothera!

▲ *Dr Jacqueline Stefels and Dr Alison Webb collecting water samples from Ryder Bay*

▲ *Ryder Bay near Rothera Research Station in the Antarctic Peninsula*

Rothera Research Station

Analysis of the effects of global warming on the diversity and survival of micro-organisms in the Antarctic (using metagenomic and metatranscriptomic approaches)

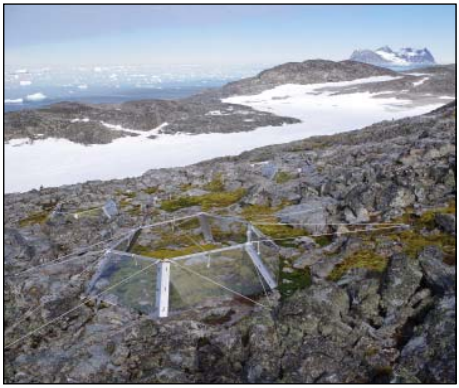
(GEOK YUAN ANNIE TAN), Shoba Thomas, Pete Convey, Stef Bokhorst

Location: Anchorage Island, Rothera

Timing: December 2016 to March 2017

Contemporary environmental changes affect many ecosystems globally, and some of these changes – particularly relating to rising temperatures – are seen most acutely in the polar regions. The changing conditions affect ecosystem processes, community structures and community processes. Microbial-mediated processes underlie all ecosystems globally, but in the polar regions (Antarctic and Arctic) this is particularly so, with microbes dominating all aspects of terrestrial ecosystem structure and function through their diversity, overall biomass, and their dominant contribution to trophic webs and major nutrient and energy flows.

This study intends to assess the impacts of both natural environmental variability and systematic or manipulated change on the microbial community as represented in well-studied terrestrial locations accessible from Rothera Station. To achieve this, small soil samples will be collected from open-top chambers (OTCs) and 'control' non-manipulated areas (and other representative local habitats) that have been set up as part of an existing manipulation project at Rothera under Dr Stef Bokhorst's project. Specific environmental bacteria will be isolated from the soil samples. In addition, DNA and RNA will be extracted and prepared to a stable state of preservation suitable for transport back to University of Malaya (Malaysia), for both the analyses of total microbial community and specific group functional studies. The samples collected this season will be compared to samples collected in summer 2015/16. As part of a larger project funded by the Malaysian Ministry of Science, Technology and Innovation, similar research is currently underway in the tropical climate of Malaysia.



▲ *Open-top chambers, Anchorage Island*

Rothera Research Station

Quantification and modelling of fluxes of persistent organic pollutants (POPs) to Antarctic marine benthic organisms (FluxPOPs)

(NICO VAN DEN BRINK), Artem Krasnobaev, David Amptmeijer, Emily Davey

Location: Rothera and Ryder Bay

Timing: 2015 to 2019

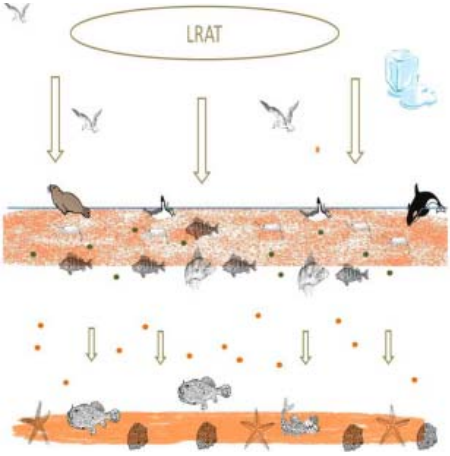
Persistent organic pollutants (POPs) are a major continuous global-scale environmental issue due to their long-range atmospheric transport (LRAT) from industrialised regions to remote areas like Antarctica. Monitoring contaminants on the Antarctic continent is not only essential for information on risks for local environment, but can also provide vital knowledge of worldwide trends in POPs emission.

Spatial differences in POPs concertation in Antarctica had been investigated well before, but recent studies showed their incompatible time trends in surface and deep water foodwebs of the Antarctic marine ecosystems. Concentrations in pelagic organisms (like seabirds) are declining, while concentrations of the same compounds were stable or even increasing in organisms living on the sea bottom.

To resolve this challenge we will take samples of snow, water and algae at different depths and time points around the coast near Rothera. Then the uptake of POPs in sea organisms will be quantified experimentally at BAS Cambridge and will result in development of computational models for evaluation of POPs behaviour in more detail and on longer time scales.

The results will help to interpret the effectiveness of current international measures for reduction of POPs emissions, and likewise facilitate design of a new monitoring system.

▲ *Water sampling in front of Sheldon Glacier, Ryder Bay*



▲ *Migration of POPs in an Antarctic coastal ecosystem induced by the Long-range Atmospheric Transport (LRAT) in summer*

Rothera Research Station

Long-term micro-environmental monitoring for terrestrial biology

HUGH VENABLES, Sarah Reed, Zoe Waring

Location: Ryder Bay, Rothera

Timing: 1997 onwards (ongoing long-term monitoring)

RaTS is the only year-round programme that collects physical and biological data throughout both the summer and winter months in Antarctica.

Oceanographic Monitoring

Twice a week in summer and roughly weekly in winter, profiles and water samples are collected from a RIB in Ryder Bay. The CTD is hand-winched to 500m (near bottom) and records salinity, temperature, depth, light and chlorophyll. Water samples are collected from 15m and the surface. In the lab, chlorophyll and phaeopigments are measured in four phytoplankton-size classes and ammonia concentrations analysed. Water is sent back to the UK for the analysis of salinity, macronutrients, oxygen isotopes and viral populations. Additional samples are taken for shorter-term projects (e.g. barium and carbon). The year-round monitoring has revealed that winter sea-ice variability leads to significant changes in phytoplankton and water temperatures the following summers.

Biological Monitoring

Eight different benthic species are collected every month, preserved and sent back to the UK for analysis of their reproductive state. Differences between years have been observed in the filter feeders which coincided with years of low summer blooms of chlorophyll which in turn was linked to the reduction in sea ice the previous winter. Various other projects are continued such as the IBIS grids (to monitor the impact of iceberg scouring on the sea floor) and settlement plates (to monitor the colonisation of artificial substrates).

The RaTS programme provides an important baseline and is a valuable resource for collaborators such as the Dutch team and colleagues from UK universities.

▲ *Diving through the sea ice in Hangar Cove*

▲ *Sarah Reed deploying the CTD through sea ice*

Bird Island Research Station

Nutritional stress in Antarctic fur seals

(JAUME FORCADA), Emily Humble

Location: Bird Island

Timing: November 2016 to February 2017

South Georgia, home to 95% of the world's Antarctic fur seals, is one of the most biologically productive areas of the planet. However, environmental change has led to increased sea-surface temperatures and reduced sea ice, leading to a reduction in the quantity and quality of Antarctic krill, the fur seal's main food supply. Consequently, pup birth weights of fur seals on Bird Island, South Georgia have reduced by 10% in the last 30 years and the population is experiencing a severe decline.

Indeed, the effect of nutritional stress on survival and reproduction is thought to be one of the largest indirect impacts of climate change on marine mammals. This season, we will measure the levels of nutritional stress in the colony of Antarctic fur seals on Bird Island, South Georgia, by evaluating the activity of genes that fluctuate in times of hunger: the nutrigenome. By combining this information with detailed data on foraging behaviour, pup weights and genetic diversity, we will be able to assess the impacts of a fluctuating food supply and to predict the capacity for Antarctic fur seals to respond to a changing environment.

▲ *Antarctic fur seal and pup*

Bird Island Research Station

Late Quaternary changes in the westerly winds over the Southern Ocean; the record in sub-Antarctic coastal peat lands

ANGELA GALLEGO-SALA, (DOMINIC HODGSON), Alex Whittle

Location: Antarctic Peninsula

Timing: February to March 2017

The aim is to determine whether the Southern Ocean acts as a net source or sink of atmospheric CO_2 by developing robust palaeoclimate records of Holocene westerly wind behaviour from peat deposits. Changes in the strength of the Southern Hemisphere Westerly Winds (SHW) influence Southern Ocean circulation and determine whether the Southern Ocean acts as a net source or sink of atmospheric CO_2. We aim to reconstruct past (decadal to millennial) changes in the SHW by generating records of wind-driven aerosols and other proxies in peat sediment records from bogs on the west coast of sub-Antarctic Bird Island, situated in the core belt of the SHW. The activities involved are:

1. Collection of small (10cm^3) soil surface samples on a salinity gradient (coastal to inland) to have a modern-day analogue for testate amoeba ecological distribution and other proxies at different salinity concentrations and build a statistical transfer function
2. Collection of peat cores and pond sediment cores to investigate the past record of wind-driven aerosols in the sediment
3. Deployment of atmospheric measuring instruments and chambers

▲ *Angela Gallo-Sala*

▲ *Alex Whittle*

Bird Island Research Station

Long-term science at Bird Island

(RICHARD PHILLIPS), Andy Wood, Lucy Quinn, James Robbins, Tim Morley, Tegan Newman, John Dickens, Carrie Gunn

Location: Bird Island

Timing: Year-round

The 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 (such as climate variability), whereas others are caused by humans (e.g. fishing). Monitoring breeding populations of seabirds and seals is therefore an important part of the BAS LTS programme, providing scientists and conservationists with indicators of wider changes 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.

BAS scientists have carried out targeted research projects on most of Bird Island's breeding species at some point over the last two-to-three 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 monitor 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.

▲ *Antarctic fur seals*

▲ *Grey-headed albatross*

King Edward Point Research Station

South Georgia and Shag Rocks groundfish survey

(MARK BELCHIER, SUE GREGORY), Vicki Foster, Keiran Love

Location: King Edward Point

Timing: January to February 2017

The main source of fishery independent data on commercially caught mackerel icefish *(Champsocephalus gunnari)* and Patagonian toothfish *(Dissostichus eleginoides)* are the South Georgia groundfish surveys, which have been undertaken on an approximately biennial basis since the late 1980s (with a period of annual surveys from 2006-2011). The surveys provide an estimate of the standing stock and length/age structure of the mackerel icefish population, which is used directly in their stock assessment. They also provide information on the abundance of pre-recruitment (juvenile) toothfish, the abundance of non-target species, and provide samples for a range of other projects including dietary and phylogenetic studies of fish.

▲ *Icefish trawler in Cumberland Bay*

▲ *Mackerel icefish*

King Edward Point Research Station

Long-term monitoring of higher predator populations at Maiviken, South Georgia

(MARK BELCHIER, SUE GREGORY), Vicky Foster, Kieran Love

Location: King Edward Point

Timing: Ongoing

The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) ecosystem approach to fisheries management ensures that the effects of commercial fishing on not only the harvested (target) species but also the animals that depend on the target species for food are closely monitored. Higher predators act as 'indicator species' by showing measurable responses to changes in the availability of the commercially caught fish/krill, for example changes in population size, breeding success, body mass and foraging behaviour. The long-term study programme at Maiviken, South Georgia, monitors Antarctic fur seals, gentoo penguins, and both northern and southern giant petrels. This information, in conjunction with comparable results collected at Bird Island, provides valuable data that are fed into stock assessments which are then used to set quotas that guarantee the responsible and sustainable management of the commercial fisheries in the region.

▲ *Gentoo penguin and chicks*

▲ *Antarctic fur seals*

King Edward Point Research Station

CASS-129

(ANDREW BRIERLEY), Stephen Votier, Norman Ratcliffe, Richard Sherley, Camille Le Guen

Location: King Edward Point

Timing: January to February 2017

In this project we will collect data on king penguin foraging behaviour to analyse in conjunction with data on acoustic deep scattering layers collected concurrently during the Antarctic Circumnavigation Expedition (ACE). King penguins are deep divers (several hundred meters), and we hypothesise that they hunt for prey in Deep Scattering Layers (DSLs). DSLs are vertically narrow (tens to hundreds of metres) but horizontally extensive (continuous for tens to thousands of kilometres), comprising communities of zooplankton and fish. During the ACE voyage we will map the depth and density of DSLs around the Southern Ocean with the objective, in part, of describing the prey field of deep-diving predators. We are collaborating with French and Australian colleagues to deploy tags on elephant seals – which we believe also forage on DSLs – and this CASS award will enable us to deploy tags on King penguins.

Richard Sherley and Camille Le Guen will spend approximately three weeks at Hound Bay. They will deploy GPS tags and time-depth recorders on king penguins, which at that time of year will be undertaking foraging trips of about six days duration. Analysis of the dive depth and location data will enable us to determine if indeed the penguins are foraging in the DSL, which will be mapperd off South Georgia as the ACE vessel passes *en route* from Punta Arenas to Cape Town.

Knowledge of king penguin foraging behaviour will contribute to basis studies of penguin and open-ocean ecology, and will inform efforts to manage the Southern Ocean in an ecosystem context.

▲ *King penguin with tag attached*

Signy Research Station

Diversity and biogeography of soil bacteria degrading phenol

AQLIMA AHMAD

Location: Signy

Timing: December 2016 to March 2017

Thinning of the Antarctic ice sheets and extent of annual sea ice has been observed as the result of climate change. Consequently, the level of organic pollutants has increased due to the remobilisation of long trapped pollutants in frozen ice as a result of ice melting. Due to its low temperatures, ecosystems in Antarctica are very sensitive to environmental changes even due to minor incidents. Phenol is one of the major pollutants in our environment that poses serious environmental concerns because of its toxicity to aquatic species and human health. Even at low concentrations, phenol can cause anti-bacterial actions in wastewater. Since the collaboration between Malaysian scientists and BAS in 1995, Signy Station has been a station for the study of microbial diversity and molecular biology in Antarctic. Therefore, soil sampling can be conducted in a range of natural and disturbed habitats on Signy Island to study on the biogeography and distribution of phenol-degrading bacteria. The soil samples will be collected at different sites nearby Signy Research Station and analysed by examining the salinity, pH and temperature of the soil.

▲ *Aqlima Ahmad.*

Signy Research Station

Stress physiology and ecological impacts of Eretmoptera murphyi

(SCOTT HAYWARD), Jesamine Bartlett

Location: Signy

Timing: December 2016 to March 2017

Since its accidental introduction to Signy from South Georgia in the 1960's, the flightless midge *Eretmoptera murphyi* has been thriving in its new habitat and is suspected of altering its local ecosystem by changing soil structure and chemistry. However, even now only fragments of its life cycle and ability to survive in this more extreme environment are understood. This project will fully detail the life history of *E. murphyi* and, in particular, establish the existence of any environmental controls on its development. Investigating its physiological capabilities to survive the cold and extreme conditions found on Signy will provide clues as to whether the midge could survive even further south. We will also assess the current distribution of the midge on the island and survey the effects it may be having on the ecosystem, namely through soil, invertebrate community and vegetation analysis. It is hoped that the findings of this field trip to Signy will help us show that even the smallest of insects are capable of some relatively large-scale changes in Antarctica, and add valuable information to knowledge of how animals can survive the cold.

▲ *Jeasamine Bartlett*

▲ *Flightless midge*

Signy Research Station

Long-term science at Signy: seabirds and seals

(RICHARD PHILLIPS), Mike Dunn, Stacey Adlard

Location: Signy

Timing: November to March 2017

The 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 (such as climate variability), whereas others are caused by humans (e.g. fishing). Monitoring breeding populations of seabirds and seals is therefore an important part of the BAS LTS programme, providing scientists and conservationists with indicators of wider changes 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.

Biologists at the BAS research station located on Signy Island monitor the breeding populations of Adélie, chinstrap and gentoo penguins, southern giant petrels, shags and the abundance of Antarctic fur seals and southern elephant seals, providing data to the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR).

▲ *Adélie penguin colony*

▲ *Southern giant petrel*

Signy Research Station

Signy meiofaunal diversity and function in terrestrial and freshwater ecosystems

MEGUMU TSUJIMOTO

Location: Signy

Timing: December 2016 to March 2017

This project aims to document meiofaunal diversity (particularly of tardigrades, nematodes and rotifers) and initiate genomic studies on function, in terrestrial and freshwater habitats on Signy Island, known to be one of the most diverse and a paradigmatic example of terrestrial ecosystems in the maritime Antarctic. These groups remain poorly known in terms of Antarctic biodiversity and biogeography studies, although have been an early focus of BAS terrestrial research in the 1970s and 1980s, long before the advent of current molecular and genomic technologies. Target micro-invertebrates are obtained by simple extraction from terrestrial and freshwater substrata in the laboratory. Samples of suitable substrata include different vegetation types, soils, obtained from hydric, mesic or xeric habitats, plus lake/stream vegetation and sediments.

▲ *Tardigrade (Acutuncus antarcticus)*

▲ *Nematode (Plectus murrayi)*

RRS *James Clark Ross*

Plastics in Antarctic Environment (PLANET) – International scientific project aims to assess both the presence and impact of micro and nanoplastics to Antarctic marine biota

(ILARIA CORSI), Elisa Bergami, Simone Cappello, Claire Waluda

Location: RRS *James Clark Ross*

Timing: December 2016 to January 2017

The presence of trillions of plastic pieces throughout the world oceans has been internationally recognised as one of the most important threats to marine ecosystems. Although Antarctica has been historically seen as a remote region physically isolated by the Antarctic Polar Front, large plastic debris (macroplastics, >1cm) have been reported in the Southern Ocean since the 1980s and, more recently, south of the Antarctic Convergence e.g. at South Georgia. Currently, there is a lack of information concerning smaller debris such as micro- (<5mm) and nanoplastics (<1µm) resulting from weathering and fragmentation of larger plastic debris. The PLANET project (PLastics in ANtarctic EnvironmenT) launched in 2015 by the Italian National Antarctic Research Programme (PNRA) is an international network of Antarctic research groups including the University of Siena and National Research Council (Italy), University of São Paulo (Brazil), University of Tasmania (Australia), Instituto Antartico Chileno (Chile) and the British Antarctic Survey. Our aim is to investigate the widespread nature of micro and nanoplastics in this remote environment. During JR16003, we will be examining the effects of nanoplastics on Antarctic krill, in order to investigate their impact on this key Antarctic species.

▲ *Plastic debris on a beach*

▲ *PLANET project*

RRS *James Clark Ross*

JR16003 – Western core box cruise

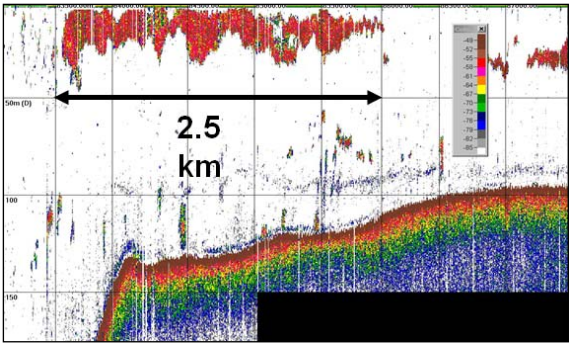
(SOPHIE FIELDING), Geraint Tarling, Clara Manno, Gabi Stowasser

Location: RRS *James Clark Ross*

Timing: December 2016 to January 2017

JR16003 is the Western Core Box cruise of the 2016/17 voyage of RRS *James Clark Ross* to the Antarctic. Since 1981, BAS have undertaken cruises to determine krill biomass as part of the ongoing assessment of the status of the marine ecosystem in the region of South Georgia. This unique time series, known as the Western Core Box, is part of the Ecosystems Programme contribution to BAS national capability. It comprises an acoustic grid survey of eight transects each of 80km in length, together with associated net and oceanographic sampling and the calibration of acoustic instrumentation.

In addition to the acoustic survey, which covers a wide area but has limited temporal coverage, there are three moorings (one on the shelf in the Western Core Box, and two in deep water to the south-west and north-west of South Georgia) to provide a temporal, year-round set of observations. The mooring instruments record parameters such as temperature, salinity and current velocities, as well as sediment traps that enable us to monitor the annual flux of carbon to deep waters. These moorings are recovered during the cruise, refurbished and data downloaded, and then redeployed later in the cruise. The shallow Western Core Box mooring has been in position more or less continuously since 2003.



▲ *Biological echosounder image*

RRS *James Clark Ross*

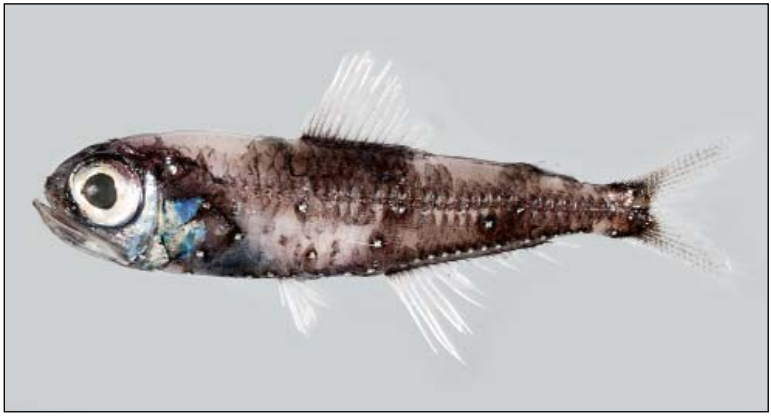
JR16003 – Abundance and distribution of mesopelagic fish in the Polar Front region

(SOPHIE FIELDING), Ryan Saunders, Tracey Dornan, José Xavier, José Seco

Location: RRS *James Clark Ross*

Timing: December 2016 to January 2017

The science conducted at these stations will provide data for a number of PhD and collaborative studies with scientists from various UK and international institutions. This year we hope (weather permitting) to venture from South Georgia to the Polar Front, sampling using large nets and acoustics. Tracey Dornan (ENVEAST DTP) will be investigating the abundance and distribution of mesopelagic fish, one of the least investigated components of the open-ocean ecosystem, and yet likely one of the most abundant vertebrates on earth. Conventional trawling estimates suggest that the biomass of mesopelagic fish is ~1,000 million tonnes. However a recent analysis of acoustic data and modelling show that the global estimate of these fish is at least an order of magnitude higher, and that they may respire ~10% of primary production in deep waters.



▲ *Mesopelagic fish*

RRS *James Clark Ross*

JR16003 – The impact of ocean acidification on calcifying organisms in the Scotia Sea

(SOPHIE FIELDING), Clara Manno

Location: RRS *James Clark Ross*

Timing: December 2016 to January 2017

Part of the work onboard will be focused on pteropod (zooplankton calcifiers) abundance and distribution within stations with different iron and carbonate saturation state levels. Pteropods have been identified to be a key part of the marine foodweb and biogeochemical cycle in the Southern Ocean. A critical tenet of the iron hypothesis is that enhanced iron supply would cause an increase in deep-ocean organic carbon flux, that in turn would increase deep-ocean sequestration of atmospheric CO_2. However, since the natural and artificial studies conducted to date seem to neglect the impact of iron fertilisation on the export of $CaCO_3$ the debate is still open. Recently, global models demonstrated that iron fertilisation can accelerate ocean acidification in the deep water.

The understanding of how calcifying organisms' life cycles can respond/adapt to natural iron supply in synergy with other environmental stressors around the South Georgia region is an important question. In this frame, the PhD student Miguel Mallo (Universitat Autonoma di Barcelona) will investigate calcifying phytoplankton (i.e. coccolithophores) in this region. Research suggests that ocean acidification may affect the calcification machinery of coccolithophores. However, the recent CO_2 increases have been accompanied by a sharp increase in the population of coccolithophores. Since the production of coccoliths require the uptake of both inorganic carbon and calcium, the response of this organism to the predicted CO_2 uptake increase is crucial to in turn understand the impact of anthropogenic stressors on biogeochemical cycles. To investigate the potential impact of ocean acidification on their carbonate shell living calcifying organisms will be compared with shells collected by deep sediment traps (1,500-2,000m), where carbonate saturation level is naturally lower.

▲ *Pteropod*

RRS *James Clark Ross*

Determining marine foodwebs from DNA Barcoding and eDNA

(SOPHIE FIELDING), Geraint Tarling

Location: RRS *James Clark Ross*
Timing: December 2016 to January 2017

To date, the use of DNA to identify species has been performed on organisms already captured. However, new techniques are being developed for marine habitats that will allow such information to be determined just from sampling the waters that these organisms have inhabited. This 'forensic' approach relies on obtaining just traces of DNA from skin, blood, faeces or mucous which can be used to identify which species have recently been present in the local environment. Given recent developments in DNA sequencing technology, this 'environmental DNA' (eDNA) promises to revolutionise the way we probe biodiversity in our environment, particularly in marine environments that can be very difficult to sample reliably.

Traditionally we have used nets to survey species larger than microbes in marine communities. However, sampling free eDNA in surrounding water is potentially faster, less expensive and less destructive than using such equipment. Use of trace eDNA also holds potential to identify species that are not reliably sampled in the environment, either because they are rare, small, or adept at avoiding nets. During this cruise we will collect water samples that will be filtered through low-cost laboratory grade filters and frozen for processing back in the UK. Molecular techniques are currently being developed to identify the range of planktonic organisms that have left traces within these samples in order to determine a species inventory and potentially, the structure of the foodweb. Traditional net samples will also be analysed in order to compare with the eDNA findings. The work is being carried out by Geraint Tarling and Sophie Fielding of BAS as part of the NERC funded SeaDNA project (NE/N00616X/1).

RRS *James Clark Ross*

Ascension Island's seamounts

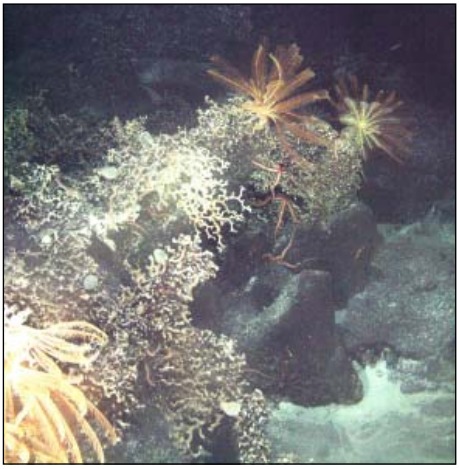
(ALAN FRIEDLANDER), David Barnes, Chester Sands, Simon Morley, Peter Enderlein, Ali Massey

Location: Ascension Island

Timing: May 2017

The sea around Ascension Island has been proposed to be one the world's largest Marine Protected Areas. National Geographic have chartered RRS *James Clark Ross* to investigate the deep cold coral reefs and seamounts to provide science to underpin that designation and also to film its amazing marine wildlife. BAS scientists have been invited to take part in a diverse range of work around the island on JCR's return from the summer Antarctic season. This work follows up a previous highly successful JCR visit by the same BAS team in 2015 as part of a Darwin Initiative project, supported by the Blue Marine Foundation charity. The BAS scientists are particularly interested in the role that marine biodiversity plays in capturing and storing carbon, the long-term record of environment characteristics in the organism skeletons and the sea-bed as a harbour of most of the island's endemics and rare species. BAS scientists will be work alongside those from the University of Hawaii, Zoological Society of London and Ascension Island Fisheries department amongst others.

▲ *Ascension crab*



▲ *The deep reef*

RRS *James Clark Ross*

Dynamics of the Orkney Passage Outflow (DynOPO)

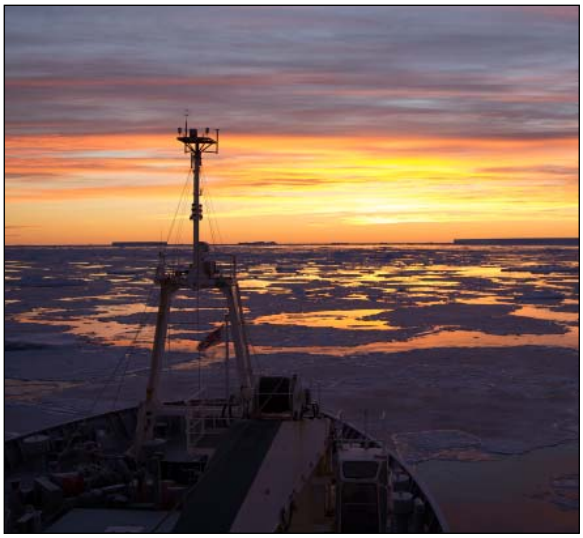
(ALBERTO NAVEIRA GARABATO), Povl Abrahamsen, Paul Anker, Eleanor Frajka-Williams, Keith Nicholls, [many more!]

Location: RRS *James Clark Ross*

Timing: March to May 2017

During the last three decades, the Antarctic Botttom Water (AABW) filling the bulk of the global ocean abyss has exhibited a striking warming and contraction in volume over much of the world ocean, particularly in the Atlantic basin. While the causes of these changes are unknown, available evidence suggests that in the Atlantic Ocean the warming and contraction of AABW may be caused by changes in winds over the northern Weddell Sea, where much of the AABW is produced. This hypothesis asserts that those winds regulate the volume and temperature of the AABW exported northward via the Orkney Passage (a major AABW exit route from the Weddell Sea) by altering the intensity of the turbulent mixing between AABW and overlying warmer waters.

BAS has been measuring the outflow through Orkney Passage since 2007 as part of LTMS and ORCHESTRA. This project is a detailed process study, which builds on and will help interpret our long-term measurements. For the last two years some of our oceanographic moorings have been enhanced for the project; these will be recovered on the cruise. In addition, we will be measuring turbulent mixing in and around Orkney Passage from the JCR using Vertical Microstructure Profilers (VMP), and deploying the Autosub Long Range autonomous underwater vehicle equipped with a microstructure probe.



▲ *Southern Ocean sunset*

▲ *AUV Autosub*

RRS *James Clark Ross*

Continuous monitoring of Antarctic Circumpolar Current bottom pressure and sea level

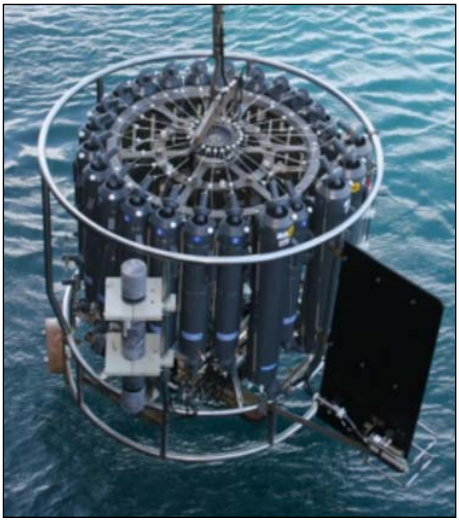
(ANGELA HIBBERT), Geoff Hargreaves, Emlyn Jones

Location: Rothera

Timing: November 2016

Like other large-scale ocean currents, the flow of the Antarctic Circumpolar Current (ACC) is proportional to the difference in pressure from one side of the current to the other. Instruments to measure bottom pressure have been placed at the southern and northern sides of Drake Passage in overlapping year-long deployments since 1988. The instruments, along with devices to measure bottom temperature and salinity, are mounted on sturdy lander frames (pictured), which are designed to be dropped over the side of the ship and sink to the bottom. The time series collected by these instruments have contributed to monitoring of the ACC as well as studies of the movements and properties of deep water in the area. On this cruise we will recover all five landers currently sampling in Drake Passage. During calls at Stanley, Rothera, and Vernadsky stations, technicians will also be able to service the tide gauges there in order to maintain high-quality long time series of sea level in the Falkland Islands and on the Antarctic Peninsula.

▲ *Deploying the lander frame*



▲ *CTD with water sampler rosette*

RRS *James Clark Ross*

Ocean Regulation of Climate by Heat and Carbon Sequestration and Transports (ORCHESTRA)

(MIKE MEREDITH), Yvonne Firing (JR16002), JB Sallée (JR16004), Povl Abrahamsen (JR16005), [many more!]

Location: RRS *James Clark Ross*

Timing: November to December 2016 (JR16002), January to February 2017 (JR16004), March to May 2017 (JR16005)

Climate change is one of the most urgent issues facing humanity and life on Earth. Whilst our everyday understanding of climate concerns the warmth of the atmosphere, the ocean is critical in controlling how our planet's climate changes. This is because the ocean absorbs vast quantities of heat and carbon dioxide which, if they had remained in the atmosphere, would have greatly accelerated the rate of climatic change there.

To address these issues, a new £8.4M programme funded by NERC has been created – 'Ocean Regulation of Climate by Heat and Carbon Sequestration and Transports (ORCHESTRA)'. ORCHESTRA will span five years and use a combination of data collection, analyses, and computer simulations to radically improve our ability to measure, understand and predict the circulation of the Southern Ocean and its role in the global climate.

Three different cruises on JCR this season will include elements of ORCHESTRA fieldwork: on JR16002 Yvonne Firing will be leading a repeat of the SR1b hydrographic section across Drake Passage. On JR16004 JB Sallée will be repeating the A23 section from the Weddell Sea to South Georgia. And on JR16005 Povl Abrahamsen will recover and redeploy oceanographic moorings monitoring the outflow of deep waters through Orkney Passage.

▲ *Deploying the CTD*

▲ *ORCHESTRA project*

RRS *James Clark Ross*

The Atlantic Meridional Transect (AMT)

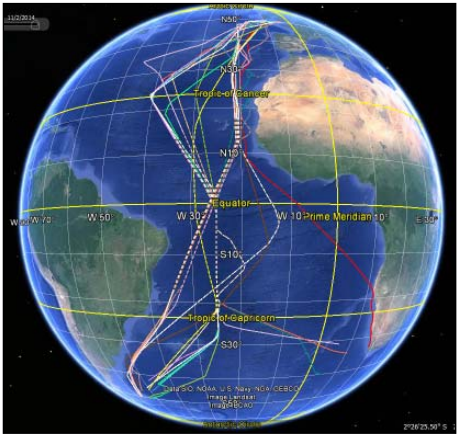
(ANDY REES), Glen Tarran, Carolyn Harris, Giorgio Dall'Olmo, Bob Brewin, Denise Cummings, Francesco Nencioli, Kerri Coombes, Madeline Steer, Katsia Pabortsava, Werenfrid Wimmer, James Ayliffe, Jason Hopkins, Emanuele Organelli, Rafael Rasse

Location: RRS *James Clark Ross*

Timing: 20th September to 4th November 2016

The AMT maximises opportunities offered by the regular transit of RRS *James Clark Ross* between the UK and the Falkland Islands. Now in its 21st year, AMT is a multidisciplinary programme which undertakes biological, chemical and physical oceanographic research during an annual voyage throughout the Atlantic Ocean. AMT objectives have evolved to enable the maintenance of a continuous set of observations, whilst addressing global issues that are raised throughout the most recent IPCC assessment and UK environmental strategy.

AMT objectives are to: (1) quantify the nature and causes of ecological and biogeochemical variability in planktonic ecosystems; (2) quantify the effects of this variability on nutrient cycling, on biogenic export and on air-sea exchange of climate active gases; (3) construct a multi-decadal, multidisciplinary ocean time-series which is integrated within a wider 'pole-to-pole' observatory concept; (4) provide essential sea-truth validation for current and next generation satellite missions; (5) provide essential data for global ecosystem model development and validation and; (6) provide a valuable, highly sought after training arena for the next generation of UK and International oceanographers. An exciting highlight of this AMT cruise is our ocean measurement validation of the European Space Agency Sentinel 3 satellite observations.



▲ *The previous AMT tracks*

▲ *Preparing the CTD with water sampler rosette*

RRS *James Clark Ross*

Understanding the tectonic and magmatic history of the Scotia Sea (Geology & Geophysics/CASS 123)

(TEAL RILEY), Phil Leat, Alex Burton-Johnson, Charlie Bristow

Location: RRS *James Clark Ross*

Timing: December 2016 to January 2017

As part of the British Antarctic Survey's long-term commitment to mapping the sea floor bathymetry of the Scotia Sea and understanding its tectonic and magmatic history, the Geology and Geophysics group have an allocation of eight days' ship time per season to carry out these aims.

During the 2016/17 Antarctic summer (December 2016 to January 2017) we will investigate two proposed target areas which can be carried out alongside our planned routine Swath bathymetry mapping of the Scotia Sea.

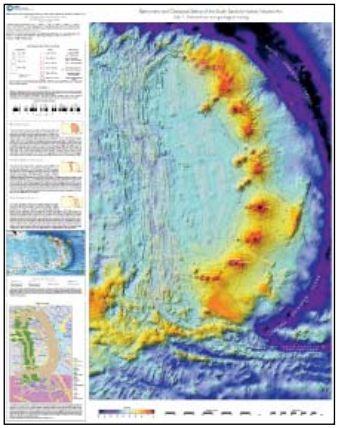
Area 1: Northern sector of the South Sandwich Islands

The South Sandwich Islands are entirely volcanic in origin with magma generation caused by the subduction of the South American plate beneath the arc. The rear arc seamounts of the South Sandwich Islands have never been sampled and provide an excellent opportunity to assess the primitive mantle of the arc system. During the proposed cruise, we will address these key questions with targeted dredging from known rear and back-arc seamounts in the north of the arc and collection of geophysical data.

Area 2: North Scotia Ridge (Shag Rocks)

The initial configuration of the blocks between South America and Antarctica prior to separation to form the Drake Passage remains uncertain. Resolving their positions and the timing of break out is key to establishing the extent of early pathways for ocean flows and thus realistic constraints for the ocean modelling.

▲ *Volcanic South Sandwich Island*



▲ *Bathymetric map of South Sandwich Islands*

RRS *James Clark Ross*

Water-mass transformation and pathways in the Weddell Sea (WAPITI)

(J B SALLÉE), [too many to list!]

Location: RRS *James Clark Ross*

Timing: January to March 2017

Deep water formed around the Antarctic continent drives the world ocean circulation. More than half of this deep water is formed within only about 10% of the Antarctic circumpolar band: the Weddell Sea. Subtle changes in the circulation of the Weddell Sea can lead to major changes in floating ice-shelves, with critical implications for global sea level, the production of deep water, and the global ocean overturning circulation. Despite these critical climate implications, the Antarctic shelf circulation remains poorly understood.

The five-year WAPITI project, funded by the European Research Council, will investigate a range of different aspects of the Weddell Sea circulation, using a combination of targeted observation, existing observation database, and high-resolution models, as well as the use of new, specifically-developed autonomous instruments. The ultimate goal of the project is to refine our understanding of the water-mass transformation and pathways in this key region of the world's ocean.

▲ *Preparing mooring on deck*

▲ *Deploying mooring*

Appendix

List of non-BAS personnel and their associated institutes

Field-based

Name	Institute
Mike Bentley	*Durham University*
Jorg Brozek	*Alfred Wegener Institute*
Peter Clarke	*Newcastle University*
Eugene Domack	*University of South Florida*
Charlie Dunham	*University of Leeds*
Patrick Harkness	*University of Glasgow*
Tore Hattermann	*Alfred Wegener Institute*
Coen Hofstede	*Alfred Wegener Institute*
Angelika Humbert	*Alfred Wegener Institute*
Matt King	*Australian Antarctic Division*
Johannes Lohse	*Alfred Wegener Institute*
Simon McClusky	*Australian National University*
John Paul O'Donnell	*University of Leeds*
Svein Osterhus	*University of Bergen*
Kiril Palamartchouk	*Newcastle University*
Erin Pettit	*University of Alaska*
Lewin Probst	*Alfred Wegener Institute*
Anya Reading	*University of Tasmania*
Daniel Steinhage	*Alfred Wegener Institute*
Graham Stuart	*University of Leeds*
Ryan Timoney	*University of Glasgow*
Tatu Tolonen	*Space Systems Finland*
Paul Tregoning	*Australian National University*
Michiel Van Den Broeke	*Utrecht University*
Pippa Whitehouse	*Durham University*
Kevin Worrell	*University of Glasgow*

Appendix *continued*

List of non-BAS personnel and their associated institutes

Rothera Research Station

Name	Institute
David Amptmeijer	*Wageningen University*
Stef Bokhorst	*VU University, Amsterdam*
Anita Buma	*University of Groningen*
Andy Hodson	*University of Sheffield*
Artem Krasnobaev	*Wageningen University*
Gemma Kulk	*University of Groningen*
Aga Nowak	*University of Sheffield*
John Spicer	*Plymouth University*
Jacqueline Stefels	*University of Groningen*
Geok Yuan Annie Tan	*University of Malaya*
Shoba Thomas	*University of Malaya*
Nico Van Den Brink	*Wageningen University*
Gerrit Van Der Goot	*University of Groningen*
Maria Van Leeuwe	*University of Groningen*
Alison Webb	*University of Groningen*

Islands

Name	Institute
Signy	
Aqlima Ahmad	*University Putra, Malaysia*
Jesamine Bartlett	*University of Birmingham*
Scott Hayward	*University of Birmingham*
Megumu Tsujimoto	*NIPR, Tokyo, Japan*
Bird Island	
Angela Gallego-Sala	*University of Exeter*
Emily Humble	*University of Bielefeld*
Alex Whittle	*University of Exeter*

Appendix *continued*

List of non-BAS personnel and their associated institutes

Islands continued

Name	Institute
King Edward Point	
Camille Le Guen	*University of St Andrews*
Richard Sherley	*University of Exeter*

RRS James Clark Ross

Name	Institute
James Ayliffe	*British Oceanographic Data Centre*
Elisa Bergami	*University of Siena*
Bob Brewin	*Plymouth Marine Laboratory*
Charlie Bristow	*University College London*
Simone Cappello	*Institute for Coastal Marine Environment, Italy*
Kerri Coombes	*Plymouth Marine Laboratory*
Denise Cummings	*Plymouth Marine Laboratory*
Giorgio Dall'Olmo	*Plymouth Marine Laboratory*
Eleanor Frajka-Williams	*University of Southampton*
Yvonne Firing	*National Oceanography Centre*
Geoff Hargreaves	*National Oceanography Centre*
Carolyn Harris	*Plymouth Marine Laboratory*
Jason Hopkins	*Bigelow Laboratory for Ocean Sciences*
Emlyn Jones	*National Oceanography Centre*
Phil Leat	*University of Leicester*
Francesco Nencioli	*Plymouth Marine Laboratory*
Emanuele Organelli	*Plymouth Marine Laboratory*
Katsia Pabortsava	*National Oceanography Centre*
Rafael Rasse	*Plymouth Marine Laboratory*
J B Sallée	*Laboratoire d'Océanographie et du Climat*
José Seco	*University of Aveiro*
Madeline Steer	*Plymouth Marine Laboratory*
Glen Tarran	*Plymouth Marine Laboratory*
Werenfrid Wimmer	*University of Southampton*

Appendix *continued*

List of non-BAS personnel and their associated institutes

RRS James Clark Ross continued

Name	Institute
[Additional collaborators]	*University of Bergen*
[Additional collaborators]	*Florida State University*
[Additional collaborators]	*Geophysical Fluid Dynamics Laboratory*
[Additional collaborators]	*National Oceanography Centre*
[Additional collaborators]	*Wood Hole Oceanographic Institute*

Feedback and further information

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

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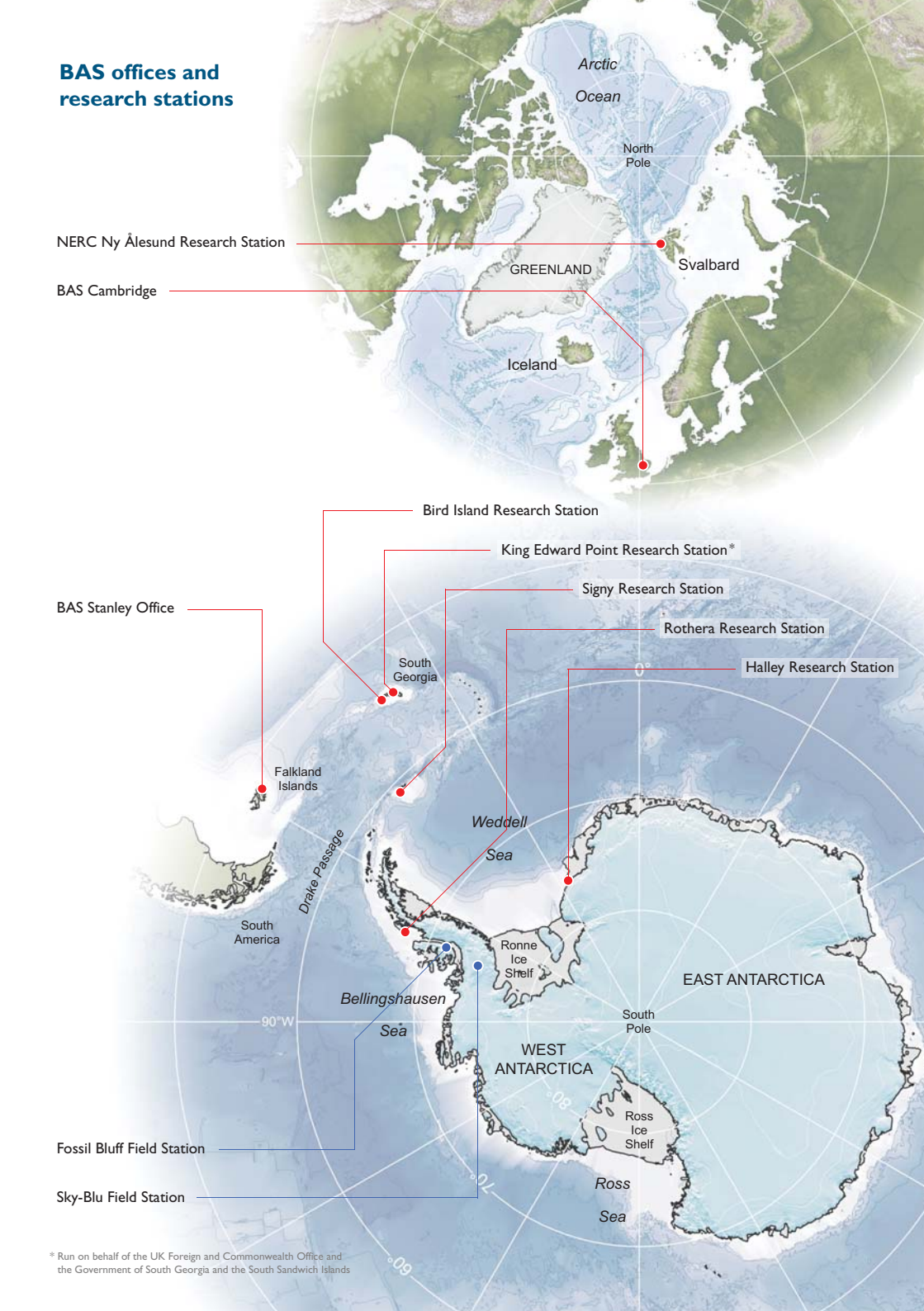
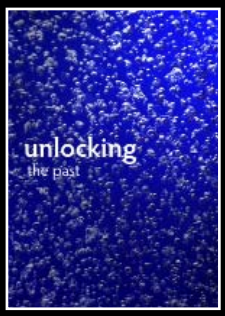
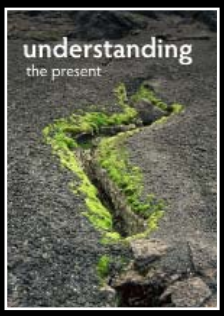
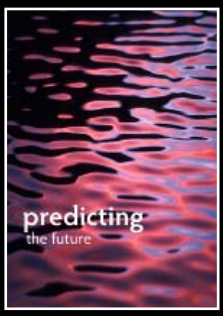
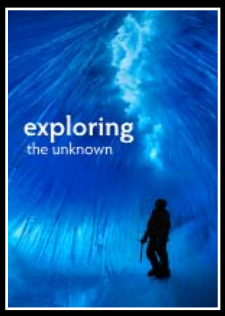


* Run on behalf of the UK Foreign and Commonwealth Office and the Government of South Georgia and the South Sandwich Islands









British Antarctic Survey (BAS), a component of the Natural Environment Research Council, delivers world-leading, interdisciplinary research in the Polar Regions. Its skilled science and support staff based in Cambridge, Antarctica and the Arctic, work together to deliver research that underpins a productive economy and contributes to a sustainable world. Its numerous national and international collaborations, leadership role in Antarctic affairs and excellent infrastructure help ensure that the UK maintains a world-leading position. BAS has over 450 staff and operates five research stations, two Royal Research Ships and five aircraft in and around Antarctica.

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