

AUSTRALIAN ANTARCTIC

MAGAZINE

ISSUE 28 2015



The Australian Antarctic Division, a Division of the Department of the Environment, leads Australia's Antarctic program and seeks to advance Australia's Antarctic interests in pursuit of its vision of having 'Antarctica valued, protected and understood'. It does this by managing Australian government activity in Antarctica, providing transport and logistic support to Australia's Antarctic research program, maintaining four permanent Australian research stations, and conducting scientific research programs both on land and in the Southern Ocean.

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- Derive any reasonable economic benefits from living and non-living resources of the Antarctic (excluding deriving such benefits from mining and oil drilling).

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The Editor
Australian Antarctic Magazine
Australian Antarctic Division
203 Channel Highway
Kingston, 7050
Tasmania, Australia.

Australian Antarctic Division
Telephone: (03) 6232 3209
(International 61 3 6232 3209)
email: magazine@aad.gov.au
Facsimile: (03) 6232 3288
(International 61 3 6232 3288)

Editor: Wendy Pyper
Production: Sally Chambers, Jessica Fitzpatrick.
Graphic Design: Paper Monkey
Issue 28: June 2015

ISSN 1445-1735 (print version)
Australian Antarctic Magazine is printed on Monza satin recycled paper; a 50% post consumer waste and 50% FSC certified fibre stock.

Australian Antarctic Magazine can be viewed online:
www.antarctica.gov.au/magazine



Australian Government
Department of the Environment
Australian Antarctic Division

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ABOUT THE COVER

Casey station mechanical supervisor, Gordon Tait, captured this image of the aurora australis (southern lights) in March this year. The photo is part of a panorama of three images stitched together to show the extent of the aurora over Casey and the amazing colours produced. Gordon used his Nikon D750 with a 20 mm lens, set to 20 seconds exposure, an aperture of f2.2 and ISO 1250. In balmy -12°C temperatures and no wind, Gordon said conditions were perfect for setting up his shots.

The good oil on krill

New research investigating the oils or 'lipids' in Antarctic krill will provide scientists and the krill fishing industry with improved tools for measuring the health of krill populations and their environment.

1

Antarctic krill (*Euphausia superba*) are a textbook example of the phrase 'you are what you eat'. As these shrimp-like creatures graze the tiny phytoplankton and zooplankton (marine plants and animals) with which they share the water column and sea ice environment, they assimilate the long-chain, omega-3 fatty acids (see 'Unravelling the fatty acid chain,' page 3), produced by these organisms, into their bodies.

These individual fatty acids are incorporated into lipids in the krills' bodies, where they are important for cell membrane structure and function and as an energy reserve for growth, reproduction and survival over the harsh winter months.

Among these fatty acids are those essential to human brain and heart health, including eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Fish oil and increasingly krill oil supplements supply a growing market for these essential fatty acids. But the quantity and quality of krill oil extracted from a catch — the amount of EPA and DHA and the ratio of the two — varies from season to season, most likely reflecting changes in krills' environment, and particularly diet.

Now, an innovative collaboration between Antarctic scientists and the krill fishing industry aims to better understand the reasons for this variable oil quantity and quality. Project Chief

Investigator and Australian expert on krill lipids, Dr Patti Virtue, from the Institute for Marine and Antarctic Studies, along with scientists from the Australian Antarctic Division, CSIRO, Griffith University and the University of Tasmania, have teamed up with Norwegian krill fishing company Aker Biomarine — a manufacturer of krill oil supplements and other krill products.

Using Aker Biomarine's considerable krill catching capacity, the team will be able to investigate research questions at a scale unprecedented in traditional scientific research. The work will enhance the quality control of commercial krill products and collect data essential to understanding krill and managing the fishery.

'Over the past 20 years scientists on research vessels have only been able to collect small krill samples in a limited time, and while we've done some good research, we really only have a snapshot of what's going on in the wild and very little information about what happens in winter,' Dr Virtue said.

'This means that key questions of the basic biology and ecology of krill remain unanswered — in particular, what is the relationship between seasonal dietary changes and krill growth, condition, maturity, reproduction and the recruitment of young krill into the adult population?

'This information is critical for estimating krill production to assist the Commission for the Conservation of Antarctic Marine Living Resource (CCAMLR) to set sustainable catch limits and to understand how environmental change may affect krill populations.'

Over three years, Aker Biomarine will collect daily krill samples from the South West Atlantic fishing grounds, which encompasses waters near the Antarctic Peninsula, South Orkney Islands and South Georgia.

Scientific advisor to Aker Biomarine and a former krill researcher at the Australian Antarctic Division, Dr Steve Nicol, said the Marine Stewardship Council-certified company uses a specially designed pumping system that excludes bycatch and delivers krill to the ship alive and in pristine condition. Scientific samples will be snap frozen in a -80°C freezer onboard the ship.

1. Krill incorporate long-chain, omega 3 fatty acids from the food that they eat into structural and functional lipids in their body. These fatty acids include the essential fatty acids human's need for brain and heart health, which are concentrated in krill oil supplements manufactured by Aker Biomarine and others. The digestive gland in the krill in this photo is coloured green from the animal's diet of phytoplankton.



'This will allow us to look at lipid changes on a daily, weekly and seasonal basis,' Dr Nicol said. Aker Biomarine will also collect oceanographic data (sea surface temperature, currents) and bathymetric data (seafloor structure). The ship's acoustic data will be used to analyse the density and vertical distribution of krill, patterns of daily migration (day/night) and swarm aggregation behaviour. Scientists will also collect phytoplankton samples from onboard the fishing vessel, and satellite information on phytoplankton production and abundance.

'We'll be able to match all this information with the results of our lipid studies, to relate the physical condition of krill at different times of year with what's happening in their environment,' Dr Virtue said.

'This will allow us to identify the factors governing the lipid content and composition in krill.'

This knowledge could help commercial fishers to better plan their fishing strategy. Most of the 300 000 tonnes of krill caught in the fishery (from a total allowable catch of 620 000 tonnes for the South West Atlantic – about 0.3% of the total estimated biomass of krill), is used for aquaculture. About 10% of this catch is processed for oil.

'If krill are predicted to have a favourable lipid profile at a particular time of year, for example, fishers could target krill specifically for their oil, based on that knowledge, and ensure a standardised product,' Dr Nicol said.

Lipid fingerprint

To understand how and why lipid content and composition changes, Dr Virtue, CSIRO's Dr Peter Nichols, and Aker BioMarine's Dr Nils Hoem, will study 'signature' lipids. Like a human fingerprint, these lipids are characteristic of the organisms that produced them – the krills' food source.

'Krill primarily feed on larger phytoplankton – the diatoms and dinoflagellates – which are both microalgae,' Dr Virtue said.

'Diatoms tend to be dominated by EPA and dinoflagellates by DHA. However, krill are also omnivores, depending on the season and the food source available, and we have seen lipid signatures for bacteria, detritus and copepods.'

Dr Nichols said there would be a staged approach to lipid analysis.

'The first thing we'll do is look at the lipid content of the whole animal or individual tissues, such as the ovaries. This will give an indication of the condition of animals in different seasons,' he said.

'Then we'll look at the lipid classes – so whether they're structural or storage lipids. This will tell us whether they're starving or not. Then we'll identify the individual fatty acids that make up the lipids and compare these to our database of algal lipids to see what they've been eating.'

The work will also provide insights into the role of lipids in krill during periods of limited food supply (particularly over winter) and whether krill exploit alternate winter food sources for growth and survival.

'This will allow us to develop a seasonal nutritional model to predict variability in spawning and recruitment,' Dr Nichols said.



Oil change

Alongside the signature lipid research, Australian Antarctic Division krill scientist Dr So Kawaguchi, will conduct experiments on live krill in the Antarctic Division's krill aquarium, to look at the effect of dietary changes on lipid content and composition, as well as the effects of climate change.

'We'll be able to look at environmental changes, such as temperature and carbon dioxide levels, on growth, reproductive potential and other metabolic processes that affect lipid accumulation and profiles,' Dr Kawaguchi said.

Previous research at the Australian Antarctic Division by Dr Andrew Davidson (see page 20) also suggests that warmer ocean waters and ocean acidification (due to increasing amounts of carbon dioxide dissolving in seawater) could favour smaller phytoplankton species over larger diatoms (*Australian Antarctic Magazine* 24: 22–23, 2013).

'Many of these smaller phytoplankton are less nutritious for krill than the larger diatoms, and changes in their abundance or composition could alter the types and amount of fatty acids available for krill growth, reproduction and recruitment into the fishery,' Dr Kawaguchi said. 'These changes will have implications for krill fishery management into the future.'

POP populations

The research team will also analyse field-caught krill for persistent organic pollutants (POPs), to provide clues to krill population distribution and movement.



POPs are chemicals found in common household items which persist in the environment (see page 15) and accumulate in the lipids of plants and animals. Therefore, populations of krill found in the vicinity of local contamination sources will carry distinctive POP 'signatures', which will be reflected in their tissues.

By examining these signatures, scientists hope to determine whether krill populations intermingle or remain separate.

'Recent research suggests that Antarctic krill do not move passively on ocean currents but may be capable of maintaining distinct population distributions,' Dr Virtue said.

'The question as to whether krill are one or many populations has implications for management, so we will use POPs to determine whether fishing operations are targeting one or many krill populations.'

Ultimately, the research aims to provide win-win outcomes for scientists, the krill fishery, the krill population and the predators that feed on them.

'Our current view of krill is all built on the capacity of scientific research vessels,' Dr Kawaguchi said.

'Now we have a chance to use a completely different way of sampling to understand what's happening in the wild.'

WENDY PYPER

Australian Antarctic Division

Unravelling the fatty acid chain

Krill assimilate 'long chain' omega-3 fatty acids into their bodies from their food. These fatty acids have 20 or more carbon atoms in their structure (hence the term 'long chain'), in contrast to other shorter chain (18 carbon) omega-3 fatty acids such as those found in chia or flax seeds. Krill are a good source of health-beneficial eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). EPA has 20 carbon atoms and five double bonds in the chain (20:5 ω 3), with the first double bond beginning at the 'tail' or omega end of the chain (ω 3). DHA has 22 carbon atoms and six double bonds (22:6 ω 3).

A sustainable krill fishery

Despite reports of unsustainable and even illegal krill harvesting, illegal harvesting does not occur and would not be cost-effective in the current market. Krill is one of the few marine resources with the potential for a large but sustainable increase in catches, if an appropriate management scheme is in place. CCAMLR sets and regularly reviews and revises precautionary catch limits based on the best available science. The krill fishery is currently operating only in the South Atlantic sector with an annual catch of up to about 300 thousand tonnes. The sum of the precautionary catch limit established for the Antarctic krill fishery is presently 5.6 million tonnes in the South Atlantic Ocean and 3 million tonnes for the South Indian Ocean.

2. Aker Biomarine's fleet of krill fishing boats in Antarctica
3. Krill lipid expert, Dr Patti Virtue, is leading the study on changes in the quantity and quality of krill oil. Here she collects larval krill from under the ice using a zoo-net, during a winter/early spring research voyage to the Southern Ocean in 2012.
4. Krill oil (orange colour) and a marine oil extracted from phytoplankton (central green flask). The colour of krill oil is due to a carotenoid pigment called astaxanthin.
5. Dr So Kawaguchi monitors phytoplankton cultures in the Australian Antarctic Division's krill aquarium facility. Dr Kawaguchi will investigate the effects of changes in diet and environment on lipid accumulation and profiles.
6. Dr So Kawaguchi (right) and Mr Rob King in the Australian Antarctic Division's krill aquarium.

Acoustic technology provides insights into blue whale behaviour

DAVE ALLEN, NIWA

Australian and New Zealand scientists encountered an aggregation of an estimated 80 rare Antarctic blue whales during a six week ecosystems research voyage to the Balleny Islands and Ross Sea in February this year.

The encounter was made possible largely through the use of underwater listening devices, known as sonobuoys, which the Australian team, led by the Australian Antarctic Division's Dr Mike Double, has trialled and refined on previous blue whale voyages (see related story on page 6).

'For quite a few days we didn't hear any whales and we wondered whether there were any around. Then suddenly they "switched on",' Dr Double said.

'We were able to triangulate their position with the sonobuoys and when we got to the location a few days later we were staggered to witness many large groups of whales in a relatively small area of about 100 square kilometres.'

For the duration of the the voyage, on board New Zealand's research vessel *Tangaroa*, the sonobuoys allowed the team to pick up more than 40 000 whale calls, some more than 1000 km away, and make 520 hours of song recordings. The team was also able to photo-identify 58 individuals through the mottled patterns on their skin, and collect one skin biopsy for DNA analysis. The photos and biopsy will contribute to a global repository of circumpolar data, for longer-term analysis.

The work is part of the Australian Government's ongoing commitment to the International Whaling Commission's Southern Ocean Research Partnership. The partnership aims to develop, test and implement non-lethal

scientific methods to estimate the abundance and distribution of whales and describe their role in the Antarctic ecosystem.

Like many whales, Antarctic blue whales were hunted to the brink of extinction during industrial whaling, and sightings have been extremely rare in the past 50 years. Between 1978 and 2010 blue whale surveys recorded only 216 visual encounters.

'With such a patchy distribution it is only possible to study this endangered species efficiently using acoustic technology,' Dr Double said.

Australian Antarctic Division acoustician, Dr Brian Miller, said the acoustic technology and methodology used by the team has developed sufficiently to allow them to gain insights into the behaviour of blue whales.

'We can hear and track these animals over ranges much bigger than you can see them, so to try and study them without listening to them only gives you a part of the picture,' Dr Miller said.

'By looking and listening at the same time, we're beginning to reconcile what we hear with what we see.'

For example, at the start of the voyage the team saw and heard two blue whales at the Balleny Islands. However, they also heard a few calls to the east of the islands and decided to follow their acoustic bearings. Within days their decision proved correct (Figure 1).

'We started getting frequent, loud calls from the direction we were headed. And then we were inside the aggregation and the noise drowned out everything else,' Dr Miller said.

'We re-sighted the two whales we'd seen at the Balleny Islands, so they must have taken a similar path to us to join the aggregation.'

'These observations support the idea that blue whales communicate with each other over vast distances. It could be that they're calling to assemble in groups for feeding or breeding.'

Dr Miller said the whales made two types of calls within the aggregation – frequency modulated (FM) calls and tonal 'Z' calls (Figure 2). The first component of the Z call, a 26 Hz tone, was heard at large distances from the aggregation.

'We discovered a variety of forms of FM calls, which seem to be associated with animals in groups and may be shorter range, social or foraging sounds. The tonal calls seem to be produced more by individuals and could be for longer range communication.'

The team also recorded vocalisations while filming individual whales. Using a video coupled with a GPS and gyro compass, the team recorded dive times, surfacing locations and blows (Figure 3).

'One of the whales we filmed would dive for about five minutes and then surface to blow a few times. It did this for about an hour and then its movements completely changed and it turned in circles and surfaced every minute, which is likely to be indicative of feeding,' Dr Miller said.

1. Members of the 2015 'close approach' blue whale team (L-R): David Donnelly, Natalie Schmitt, Blake Hornblow, Paula Olson, and Australian blue whale project leader Mike Double.

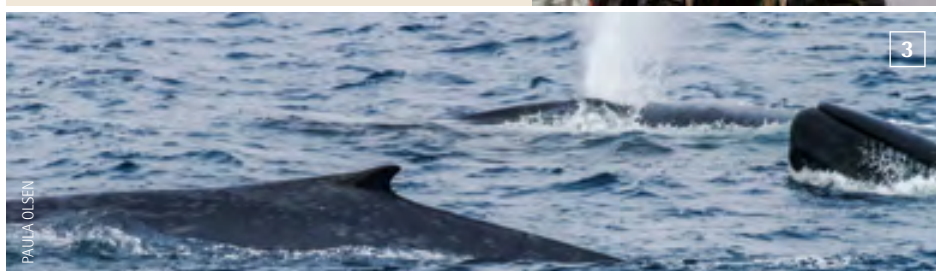
2. The New Zealand research vessel *Tangaroa* searching for whales in the Southern Ocean in 2015.

3. Researchers found themselves surrounded by an estimated 80 rare and endangered blue whales during an ecosystems voyage to the Southern Ocean in February this year. Scientists photo-identified 58 blue whales during the voyage using the mottled patterns on their skin.



GLENN WALKER, NIWA

2



PAULA OLSEN

3

'By matching sounds with movements such as this, we may be able to identify sounds associated with feeding or breeding.'

While observers were enjoying the blue whales' antics from the ship's deck, a hardy group of data miners were analysing echosounding data in the bowels of the vessel for evidence of the whales' food source — krill.

Echosounders send pings of sound into the water and then record the returning echo, which changes when it bounces off fish, krill and other reflective objects in the water column. The resulting images provide information about the location, distribution and density of the objects.

Australian Antarctic Division krill survey designer, Dr Martin Cox, said the krill aggregated in a distinctive way, quite different to anything he had encountered before.

'Typically you'll get dense patches of krill, but you'll also get a sparse background level that sit in layers, 20 to 30 metres deep, which can stretch for tens to hundreds of kilometres,' he said.

'We didn't see that at all. Instead we found huge balls of tightly packed krill and nothing else — no background. We estimated that one of the balls contained 100 tonnes of krill.'

The whale team hypothesize that blue whale aggregations could be driven by foraging and that these dense krill swarms suit the whales, allowing them to feed quickly and efficiently. However, more blue whale and krill surveys are need to confirm this.

'We always found krill when we saw whales, so it could be that blue whales somehow know that krill form these dense aggregations in certain areas,' Dr Cox said.

As well as the blue whale research, the team spent time tracking humpback whales near the Balleny Islands, again acquiring photo-identifications and 10 biopsy samples and collecting samples of water, krill and fish to understand food availability.

With the whale studies completed, the expedition moved to Terra Nova Bay in the Ross Sea to explore any ecosystem effects of commercial toothfish fishing.

National Institute of Water and Atmospheric Research (NIWA) fisheries scientist, and Voyage Leader, Dr Richard O'Driscoll, said the team conducted 18 trawl surveys to examine the abundance and distribution of species that make up the bycatch of the toothfish longline fishery, including grenadiers and icefish.

'We caught over 100 species or species groups from the trawls and collected 370 sample lots for taxonomic identification,' Dr O'Driscoll said.

'The data collected will help validate models and inform management decisions by the Commission for the Conservation of Antarctic Marine Living Resources.'

The team also deployed an echo sounder, moored in 550 m of water in Terra Nova Bay, to monitor the spawning of Antarctic silverfish; one of the main Antarctic prey species.

'The instrument will detect and record the abundance of silverfish over winter to see whether there is a mass migration of the fish to the Ross Sea over winter, or whether their eggs drift in from somewhere else,' Dr O'Driscoll said.

After their 15 000 km journey, the team is confident the data and samples collected will add significantly to scientists' understanding of the Southern Ocean ecosystem.

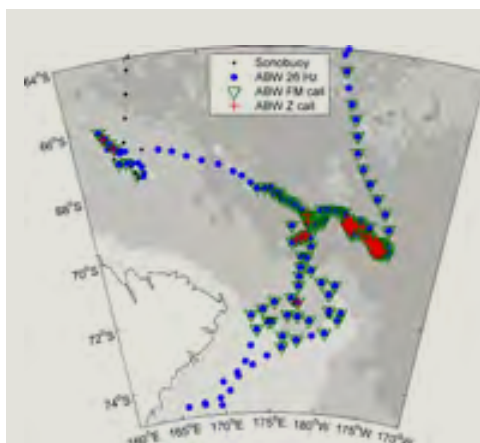


Figure 1: This map shows the location of detected blue whale calls by sonobuoys (black dots) during the six week voyage. The ship travelled to the Balleny Islands, east to the whale aggregation, south to the Ross Sea for fishing studies and then northwards, back to New Zealand, via the aggregation. FM and Z calls were predominantly heard inside the whale aggregation, while longer-range 26 Hz calls were detected over vast distances. (Brian Miller)

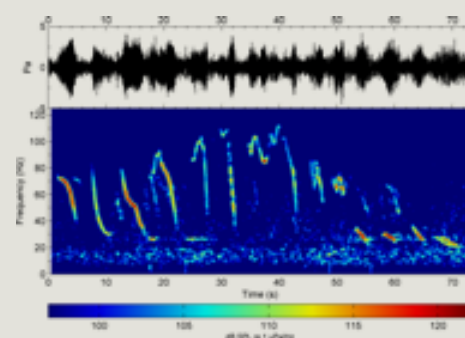


Figure 2: The sonobuoys detected a variety of forms in FM (frequency modulated) calls of Antarctic blue whales within the aggregation. The most common call types are to the left of the spectrogram. (Brian Miller)

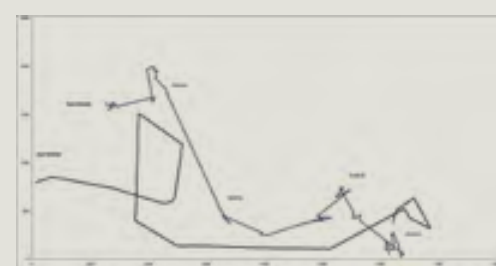


Figure 3: An example of an Antarctic blue whale (blue line) tracked using photogrammetry (video) on 10 February. Blue crosses indicate surfacing locations of the whale. The black line shows the track of the *Tangaroa*. At the end of the track the whale can be seen turning and blowing frequently — indicative of feeding behaviour. (Russell Leaper and Susannah Calderan)

Read more about the voyage at www.niwa.co.nz/antarctic-ecosystems-voyage

WENDY PYPER

Australian Antarctic Division

1

1. A blue whale research voyage in 2013 identified seven blue whale hotspots using acoustic technology.
2. Susie Calderan deploys a sonobuoy. The acoustic listening devices allowed scientists to pick up more than 40 000 whale calls and make over 520 hours of individual song recordings during the 2015 voyage.

Sound science finds Antarctic blue whale hotspots

PAULA OLSEN

Australian Antarctic researchers have used underwater acoustic technology to find 'hotspots' of endangered Antarctic blue whales in the vast Southern Ocean.



DAVE ALLEN, NIWA

2

The research, led by the Australian Antarctic Division and published in January in *Endangered Species Research*, was conducted during a seven week voyage to the Southern Ocean in 2013 (*Australian Antarctic Magazine* 24: 16–17, 2013).

The Antarctic Blue Whale Project team used directional sonobuoys to listen for the whales' distinctive songs and calls across a 9300 km survey area.

They identified seven areas of high acoustic activity where they were able to visually sight 84 Antarctic blue whales, take 50 photo identifications, collect 23 biopsy samples for genetic analysis and deploy two satellite tags.

Project leader, Dr Mike Double, said that the whales were clustered together into distinct regions, generating an intense source of low-frequency calls.

'We encountered seven distinct hotspots for blue whales in our survey area and some of these were detectable from 600 nautical miles (1100 kilometres) away,' he said.

'There was a steady increase in the intensity of song and other vocalisations as we approached these regions, which suggests that these acoustic hotspots may persist for several days, even if individual whales within them may change.

'This means that targeting acoustic hotspots, even from long distances, is a reliable method for encountering Antarctic blue whales.'

Australian Antarctic Division acoustician, Dr Brian Miller, was part of the 18-strong team of observers, cetacean biologists and acousticians.

'Antarctic blue whales have very loud, low frequency songs that are distinctive from other populations of blue whales,' Dr Miller said.

'Initially we deployed single sonobuoys to establish the direction of the sound, and then as we got closer and the intensity of the sound increased, we deployed multiple sonobuoys to triangulate the whales' position.

'This method allowed us to locate whales to within a few kilometres — close enough for our observers to visually sight them.'

The researchers are optimistic their work has demonstrated a new blueprint for future studies of Antarctic blue whales. Their expectations were validated during the most recent blue whale voyage in February this year, when they successfully used the technology to locate large aggregations of blue whales (see page 4).

'Acoustic tracking allows for a fundamentally different kind of survey than those of the past,' Dr Miller said.

'It provides a way to stay with a group of whales for as long as they continue vocalising, allowing sampling of as many individuals within a group as possible, and providing time to study their behaviour and ecological linkages.'

WENDY PYPER

Australian Antarctic Division

Measuring clouds from every angle

An array of atmospheric instruments will be deployed on Macquarie Island next year to measure clouds from every possible angle.

For most people clouds are ephemeral shapes in the sky or harbingers of rain, but for climate modellers they are a conundrum, especially in the Southern Ocean.

Australian Antarctic Division atmospheric scientist, Dr Simon Alexander, says Southern Hemisphere climate models are afflicted by a lack of data on clouds that prevents them from accurately representing atmospheric energy balance — heat coming into the atmosphere versus heat going out. This in turn prevents accurate representations and forecasts of atmospheric temperatures, the movement of weather systems, sea ice formation and ocean currents.

'Most research on high latitude clouds has focussed on the Arctic, but the southern high latitudes are a different environment, so the results from the Arctic can't be directly applied', Dr Alexander said.

'One of the key unknowns in the Southern Ocean region is the occurrence of super-cooled water clouds, which remain as liquid water despite being at sub-zero temperatures.

'To address this and other knowledge gaps, we have established an international collaborative project to characterise clouds present above the Southern Ocean, so that we can validate satellite measurements and improve climate models.'

Dr Alexander's project will involve deploying numerous atmospheric observing instruments on Macquarie Island in March 2016, for a full year, to determine cloud thickness, height and composition, as well as the surface energy budget (the balance between incoming and outgoing solar radiation). The experiments will be repeated a few years later on the Antarctic continent at Davis, with related experiments to be conducted at other East Antarctic stations.

Members of the scientific team will contribute a range of instruments that use electromagnetic radiation (such as light, radio waves and microwaves) to measure cloud properties.

These instruments will include a cloud 'lidar' (light detection and ranging), a cloud radar and a microwave radiometer. Other instruments will observe incoming and outgoing solar radiation.

'The cloud lidar uses laser pulses to measure light scattered off cloud water droplets or ice particles, which gives us information about the thickness, composition and height of the clouds,' Dr Alexander explained.

'The cloud radar will provide us with the liquid and ice water content of clouds, amongst other properties, which will complement measurements of the total amount of liquid water and water vapour obtained by the microwave radiometer.

'Together these instruments will give us details about the phase of clouds; that is, whether they're composed of ice or water or a mixture of the two. We'll also determine the altitude at which these different cloud phases occur, how frequently they occur and how they're related to weather systems and the surface energy budget.'

The team will use their Macquarie Island-based instruments to measure clouds from about 100 m to 10 km in altitude. Satellite-based instruments will measure the clouds from above, including high cirrus clouds that the ground-based instruments can't reach if there is thick lower-level cloud.

By combining all the data the team will be able to validate satellite measurements of clouds over the Southern Ocean and improve the representation of Southern Ocean cloud processes in models.

'One of the first things we'll do is look at the seasonal and altitudinal distribution of clouds relative to the centres of low pressure systems and cold and warm fronts,' Dr Alexander said.

'We will compare how models represent these distributions with our observations to understand the discrepancies.'

Dr Alexander said positioning instruments on Macquarie Island was the best way to capture information representative of the Southern Ocean.

'Macquarie Island is in the path of all the weather systems that circulate around the Antarctic continent,' he said.

Similarly, when the experiment moves to the Antarctic continent in a few years' time, instruments at Davis and Dumont d'Urville will capture cloud processes that are representative of coastal East Antarctica, while instruments at the French/Italian station of Concordia (at Dome C, about 3000 m above sea level), will capture cloud processes representative of the high Antarctic plateau.

WENDY PYPER

Australian Antarctic Division



1. One of the key unknowns in the Southern Ocean region is the occurrence of super-cooled water clouds, which remain as liquid water despite being at sub-zero temperatures.



Future ocean success

The first Antarctic ocean acidification experiment using four specially designed underwater chambers, was successfully conducted under the sea ice at Casey for eight weeks this summer, according to Project Chief Investigator Dr Jonny Stark.

Two of the four semi-enclosed chambers were used to mimic future ocean conditions under a 'business as usual' carbon dioxide emissions scenario, to examine the impact of ocean acidification on marine and sediment communities. The other two chambers acted as 'controls' for comparison.

'The aim of the Antarctic Free Ocean Carbon Enrichment (AntFOCE) experiment was to create ocean conditions that we might expect to see by the end of this century if we continue to emit carbon dioxide into the atmosphere at the current rate,' Dr Stark said.

'This carbon dioxide dissolves in the ocean and causes chemical changes that make seawater more acidic, with profound implications for marine life. So we wanted to look at how these chemical changes might affect the community of plants and animals living on the Antarctic sea floor.'

For the past two years the AntFOCE team has been developing and testing the design of the underwater chambers for Antarctic conditions (*Australian Antarctic Magazine* 27: 4–5, 2014). The chambers were adapted from a prototype developed by the Monterey Bay Aquarium Research Institute in California that has been used in temperate, tropical and sub-tropical waters.

'The scientists and science technical support team at the Australian Antarctic Division did a lot of work to modify the system for the rigours of Antarctica, such as the sea ice and cold water and air temperatures,' Dr Stark said.

'We also had to identify a suitable site close to the shore, so we could set up shore-based infrastructure to power and monitor the experiment. The site also needed to retain sea ice over the summer to provide a platform for us to work on.'

In November 2014 the team finally got the chance to put all their hard work, planning and design to the test. Project Manager, Dr Glenn Johnstone, was amongst the first of the 15-strong team to arrive at Casey and begin the process of deploying the chambers in O'Brien Bay.

The team — which included scientific and commercial divers, dive supervisors, engineers and technicians — began by drilling holes in the sea ice to deploy their chambers and four 40 m-long ducts or 'slinkies' that would carry the carbon dioxide-enriched and untreated seawater to the experimental and control chambers.

'On the shore we had our "silver chalet" containing all the sensing equipment to monitor the experiment, such as oxygen and pH sensors, as well as computer equipment to relay this information back to the station,' Dr Johnstone explained.

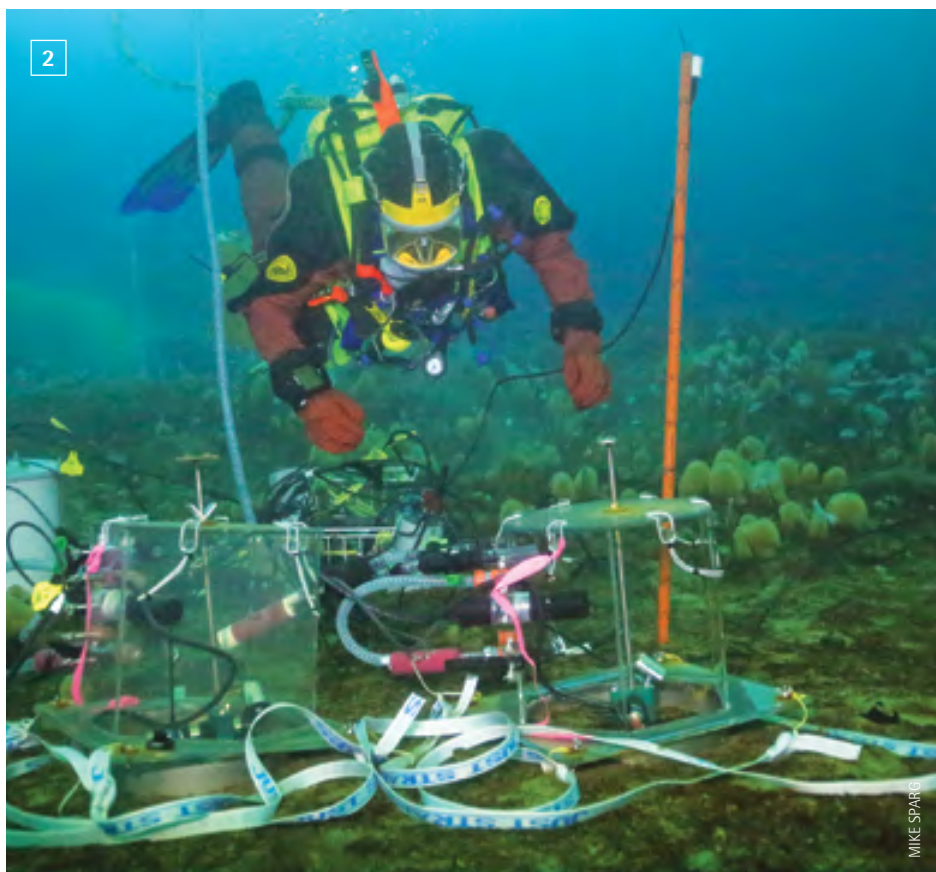
'We also had a generator van for power, cage pallets of gas cylinders full of carbon dioxide, and pumps for pumping water up and down.

'All this was connected across the intertidal zone and tide cracks by a big umbilical cable and a float, which took power, data and water between the surface and under the ice.'

To deploy the chambers on the sea floor the team used lift bags and ropes to gently lower them and avoid disturbing the fine layer of sea floor silt. Similarly, a complicated rope and pulley system was rigged to carefully deploy and connect the ducts to the chambers.

'Equipment like this has never been deployed in Antarctica,' Dr Johnstone said.

'However, our team had a lot of different expertise and experience, and we were able to combine mountaineering and climbing experience with commercial diving experience to rig up a system that would suspend the ducts and allow us to control their descent and connection.'



Once the chambers and ducts were in place and teething problems ironed out, the experiments required very little maintenance.

'We didn't disturb the chambers during the experiment. They ran for eight weeks and we sampled them at the end,' Dr Stark said.

'We ran a constant flow of carbon dioxide-enriched seawater through the two experimental chambers, keeping the pH at 0.4 pH units below the naturally fluctuating pH of the seawater. To put this in perspective, in the past 25 million years the pH of seawater hasn't changed by more than 0.1 or 0.2 pH units, but by 2100, under a business as usual carbon emissions scenario, we're expecting a 0.4 unit change. On an evolutionary time scale, that doesn't give animals much time to adapt.'

Over the coming months the team will examine their samples for, among other things, changes in the biodiversity and composition of the seafloor invertebrate community and the bacteria and diatom (single-celled marine plants) communities, changes in sediment nutrient cycling, and changes in the growth of diatoms and other tiny marine plants.

During the main experiment the team also deployed two mini-chambers, which were designed to investigate specific questions over 24 to 48 hours. Here the team looked at the respiration rates in sea urchins under controlled and acidic conditions, and changes in photosynthesis in marine microalgae growing on the sea floor.

'It appears that acidification induced a response from these microalgae communities, possibly making them migrate deeper into the sediment than in the control treatments, but more work is needed to confirm this preliminary result,' Dr Stark said.

'However, it is an encouraging sign for the rest of the experiment in terms of detecting the potential effects of acidification.'

Unfortunately, issues with weather meant the team couldn't run the experiments for as long as they'd hoped. Any future experiments would ideally run for three to 12 months.

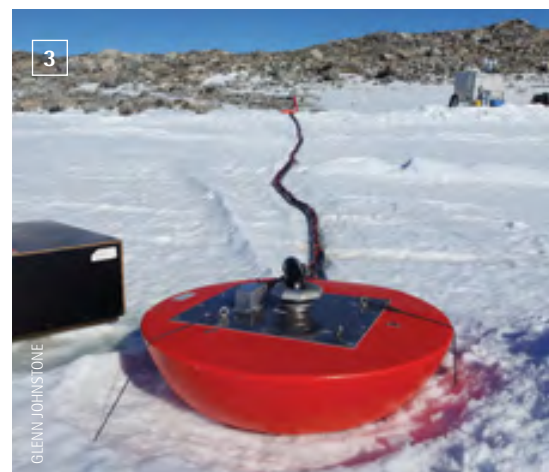
'Despite the challenges the project was an outstanding success, and we now have many months of sample processing ahead,' Dr Stark said.

'Every aspect of the project was new to us, but our team was able to modify and invent ways to do the work, and it all came together over many frozen sandwiches and blocks of chocolate.'

WENDY PYPER

Australian Antarctic Division

This research was funded by the Australian Antarctic Division, the Antarctic Climate and Ecosystems Cooperative Research Centre and the Australian Research Council's Special Research Initiative for Antarctic Gateway Partnership.



1. One of the experimental chambers in place on the sea floor of O'Brien Bay, attached to its duct ('slinky'), which delivers carbon dioxide-enriched seawater from the surface.
2. A mini-chamber used to conduct short-term ocean acidification experiments over 24–48 hours.
3. Electronic cables and water pipes ran between the surface and underside of the sea ice via a modified sea ice buoy, nicknamed the 'smartie'.
4. The 'silver chalet' van containing all the sensor and computer equipment and the power generation van behind. The vans are on sleds for easy deployment to the site.
5. One of the ducts, or 'slinkies', being recovered to the surface through the dive hole. Divers guided the four 40 m long slinkies to the hole using lift bags.



Totten Glacier melt-down

Warm ocean water is likely melting the largest glacier in East Antarctica from below.

For the past 15 years satellites have shown that the Totten Glacier in East Antarctica has been thinning faster than other glaciers in the region. While theories existed as to why, no one had been able to breach the thick sea ice around the region to find out.

Then in January this year a team of scientists on board Australia's icebreaking ship, *Aurora Australis*, managed to reach the face of the glacier and deploy a suite of high-tech instruments that could help solve the puzzle.

'We wanted to test the theory that warm ocean water is reaching the glacier and is capable of driving melt,' Voyage Chief Scientist Dr Steve Rintoul, from the Antarctic Climate and Ecosystems Cooperative Research Centre (ACE CRC), said.

'Initially I didn't think we'd be able to reach the glacier, but we got just the right weather and wind conditions to take advantage of a crack that opened up in the sea ice and extended all the way to the glacier front.

'And we found evidence that warm water does indeed reach the Totten Glacier.'

The Totten Glacier is the largest glacier in East Antarctica and drains 538 000 square kilometres. Seventy billion tonnes of ice flow out of it every year. Like a giant tongue, the glacier sweeps down the continental land mass and then juts out another 120 kilometres into the ocean.

'The front of the glacier where we made our measurements is about 200 metres thick, and it gets thicker as it goes back towards the continent and the grounding line — where the glacier leaves the bedrock and starts to float. This grounding line is two kilometres below sea level,' Dr Rintoul explained.

The floating ice shelves around the edge of Antarctica act like a buttress, allowing thick layers of ice to accumulate on the continent. When the ice shelves thin or collapse, this allows more ice to flow from the continent to the sea, raising sea level. Glaciers that are grounded on rock well below sea level are particularly vulnerable to warming of the ocean or changes in ocean currents. Indeed, model simulations suggest the Totten Glacier could be melting at a rate of more than 50 metres per year in

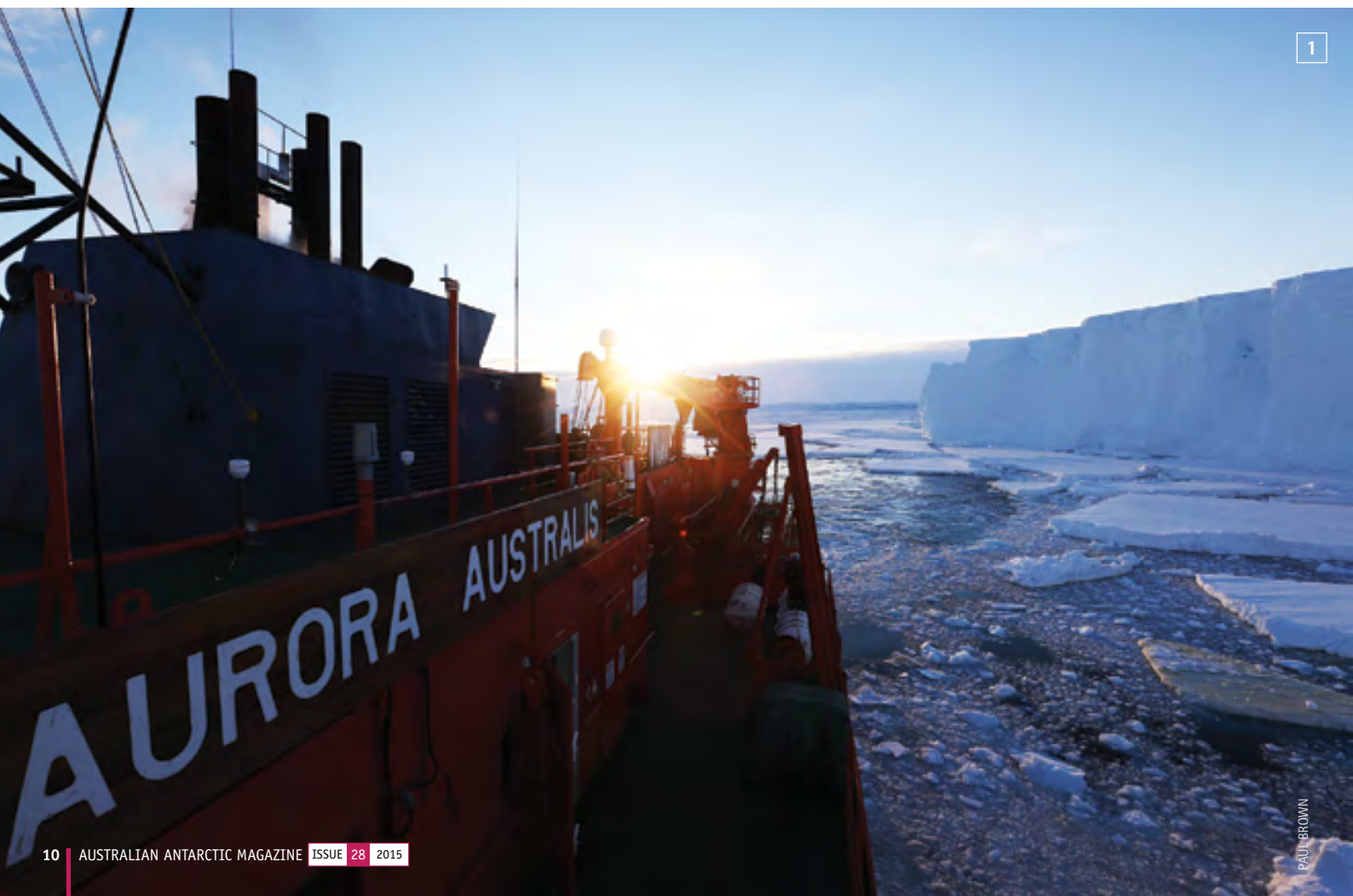
the deepest part of the ice shelf (*Australian Antarctic Magazine* 21: 14–15, 2011). The deep basin drained by the Totten Glacier, known as the Aurora Basin, could contribute some 3.5 metres of ocean warming-driven melt to global sea level rise.

'This study will help us address one of the biggest questions concerning future sea level rise — how will changes in ocean temperature or currents affect the Antarctic ice sheet?' Dr Rintoul said.

To find out, the research team deployed a range of floats, gliders and traditional ocean profiler instruments to measure temperature at the glacier front and to obtain chemical evidence of glacial meltwater in seawater samples.

'We can detect the melting of glacial ice in a few different ways,' Dr Rintoul said.

'One way is through temperature. If our water samples are less than minus two degrees Celsius we know they must contain melt water from below the ice shelf, where the high pressure depresses the freezing point. Another way is through chemistry. As glacial ice melts, it leaves



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a signature in the water that we can detect using different chemical elements and isotopes of helium and oxygen.'

The team found that water temperature at the front of the Totten Glacier is about three degrees warmer than the melting point at the grounding line. This provides a measure of how much heat is available to melt the ice.

Worryingly, geophysical research published two months after the voyage, revealed a seafloor 'gateway' that could allow this warm ocean water to reach the base of the glacier, with consequences for ice melt and sea level rise (see story page 12).

During the voyage the team also visited the front of the Mertz Glacier, which calved in spectacular fashion in 2010. As a result of this calving the functioning of the region – which previously acted as a 'sea ice factory' – changed dramatically. Australian and French researchers deployed a number of moorings in the region immediately after the calving to collect temperature and chemistry data and these moorings were collected by Dr Rintoul's team.

'The Mertz Glacier region is a place where cold, dense, Antarctic Bottom Water is formed, which contributes to a global pattern of ocean currents that regulates climate,' Dr Rintoul said.

'These moorings will provide an unprecedented view of what's happened since the tongue calved. We'll also be able to compare the results with those from the Totten Glacier.'

'We know the Mertz Glacier is not thinning as rapidly as the Totten Glacier, so these analyses will give us insights into why that's so and this in turn will tell us more about how Antarctica will change in the future.'

WENDY PYPER

Australian Antarctic Division

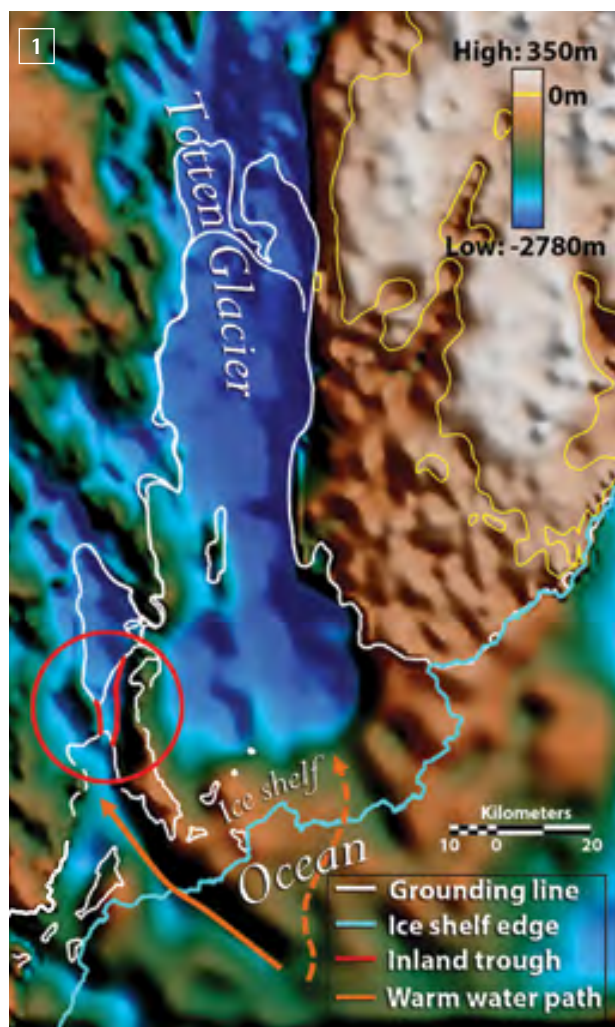
The seven week marine science voyage was funded through the Australian Research Council's Special Research Initiative for Antarctic Gateway Partnership, the Australian Antarctic Division, the ACE CRC, CSIRO and the Integrated Marine Observing System.

1. The *Aurora Australis* alongside the Totten Glacier. The ship took advantage of a crack that opened up in the sea ice that led all the way to the glacier front.
2. A mooring retrieved from the Mertz Glacier region. Data from the mooring will help scientists unravel how the functioning of the region has changed since a large iceberg calved off the glacier in 2010.
3. A Conductivity Temperature and Depth (CTD) instrument lowered over the side of the ship collected continuous vertical profiles of temperature, salinity, and oxygen at each sampling point. Water samples will be analysed for oxygen, salinity, phytoplankton pigments and microbial DNA. Oxygen and helium isotopes will be measured as tracers of glacial ice melt.
4. This map shows the extent of the catchment area for the Totten Glacier.



Hidden oceanic gateway beneath Totten Glacier

Ice-penetrating radar imagery has revealed a five kilometre-wide seafloor valley beneath the Totten Glacier that could allow warm water to infiltrate its base, causing potentially destabilising melting.



1. This graphic shows the ocean floor and bedrock in the Totten Glacier ice shelf region. The front of the ice shelf is indicated by the blue line, and the grounding line (where the ice begins to float) is delineated by the white line. Warm and deeper ocean waters require deep channels to access the grounding line. This study has identified a deep trough or gateway (red line) through which warm water (orange solid line) can access the deep parts of the grounding line and drive retreat. A secondary path (dashed orange line) is identified, but is shallower and less significant.

The discovery, published in the journal *Nature Geoscience* in March, is the first to identify a mechanism that could explain why the Totten is the fastest thinning glacier in East Antarctica.

It follows findings from a marine science voyage to the glacier earlier this year, which measured ocean temperatures at the front of the glacier capable of causing melt at the glacier's grounding line (see story page 10). However, oceanographers were unable to establish if or how this warm ocean water was getting under the glacier.

Australian Antarctic Division glaciologist and a contributor to the geophysical project, Dr Jason Roberts, said that the infiltration of warm water beneath the glacier, via the seafloor valley or 'gateway', had the long-term potential to cause 3.5 metres of sea level rise.

'The glacier catchment reaches as deep as 1.7 kilometres below sea level and is covered by up to four kilometres of ice,' Dr Roberts said.

'There is enough ice in the Totten Glacier alone to raise global sea level by at least 3.5 meters, roughly equivalent to the projected contribution of the entire West Antarctic Ice Sheet if it were to completely collapse.

'While it may take several centuries to melt, once it passes a certain point our analysis reveals it would likely be irreversible.'

Lead author of the research paper, Mr Jamin Greenbaum, a PhD student from the University of Texas at Austin, said technology played a key role in identification of the seafloor gateway.

'Satellite analyses conducted by other teams had indicated that the ice above the seafloor was resting on solid ground,' he said.

'However, special analysis of ice-penetrating radar data shows the bottom of the ice over the valley is smoother and brighter than elsewhere in the area, which is a tell-tale sign that the ice is floating and being eroded by the ocean.

'Knowing this will improve predictions of ice melt and the timing of future glacier retreat.'

The discovery comes after five field seasons of aerial surveys over more than 156 000 km of the Australian Antarctic Territory. The surveys were conducted from Australia's Casey station between 2008 and 2013 (*Australian Antarctic Magazine* 19: 7, 2010).

The Basler BT-67 aircraft used in the surveys was fitted out with radar, laser, gravity meter and geomagnetic sensors for determining ice thickness, bedrock topography, seafloor bathymetry, and bedrock properties.

'The findings from this study present a strong case for using airborne geophysical surveys to look at ice-ocean interactions in other parts of Antarctica, including the virtually unknown Antarctic inner continental shelf,' Mr Greenbaum said.

The research was conducted through the ICECAP (International Collaboration for Exploration of the Cryosphere through Aerogeophysical Profiling) project (see story on page 13), which involved the Australian Antarctic Division, Antarctic Climate and Ecosystems Cooperative Research Centre, the University of Texas Institute for Geophysics, the US National Science Foundation, the UK's Natural Environment Research Council, as well as NASA's Operation IceBridge and the G. Unger Vetlesen Foundation.

WENDY PYPER and NISHA HARRIS
Australian Antarctic Division

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PAUL HELEMAN



What lies beneath

Australian Antarctic Division Senior Principal Research Scientist Dr Tas van Ommen describes new insights into the bedrock structure beneath the East Antarctic ice sheet that could influence future increases in sea level.

In 2007 my colleague Donald Blankenship, from the University of Texas, got in touch with a no-brainer proposal to map one of the last great unsurveyed tracts of Antarctica. He and UK glaciologist Martin Siegert had put together two-thirds of a great plan to fly radar, laser, geomagnetic and gravity instruments over an area the size of New South Wales, inland of Australia's Casey station. They needed Australian support and participation for the project to fly.

At that time there were huge gaps in our maps of the bedrock under the ice. But we knew that in places the ice was over four kilometres thick, making it some of the deepest ice on the continent. We also held a view that East Antarctica was probably not a dynamic place. While we needed data, we expected to find a stable ice sheet that was unlikely to be affected by changes in a warming planet. This view would soon change when the ICECAP (International Collaboration for Exploration of the Cryosphere through Aerogeophysical Profiling) project began.

In 2011 I participated in several ICECAP survey flights from Casey. Each flight lasted about seven and a half hours and covered some 2000 km at a time. To date the project has surveyed over 150 000 km in East Antarctica.

It did not take long for the value of the data to be appreciated. Even as the project progressed, satellite monitoring was drawing the attention of global researchers to a hot-spot right beside our Casey hub; the Totten Glacier. This glacier is the largest in East Antarctica. It drains most of the area of our survey; every year discharging over 70 cubic kilometres of water into the ocean. As it does so it carves a deep trench over two kilometres below sea level, through which the ice emerges and begins to float. During ICECAP, satellite measurements showed that just around the point where the ice begins floating, the Totten is thinning and the surface height is lowering by about two metres per year. ICECAP set about measuring the Totten Glacier outlet so that we could understand what is happening.

What ICECAP has revealed is really a connecting story in two parts: how our view of East Antarctica has changed dramatically; and what this means for changes in the Totten Glacier itself. Previously we thought that, aside from a poorly mapped valley far inland of Casey known as Aurora Basin, most of the ice was resting on bedrock hills and mountains above sea level. It turns out that Aurora Basin is very deep and much larger than we thought. More seriously, the basin is connected to the coast by terrain that is extensively below sea level. This makes it much more like



JAMIN GREENBAUM

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West Antarctica, where there is concern that gradual, but irreversible ice loss is underway. The prospect that such a pattern could also impact East Antarctica is a new one, and suggests that changes to the Totten Glacier might be the first stages of such accelerating loss in East Antarctica.

Outlet glaciers like the Totten meet the ocean in floating ice shelves where they calve icebergs and also melt in the relatively warmer ocean. These ice shelves are buttressed against the coast on the sides, and in some cases, like the Totten, are very congested at the calving front. This provides an impediment to the ice flow that can be likened to a cork in a bottle. Any loss of the ice shelf and retreat of the calving front reduces this impediment and is typically followed by acceleration of the feeding glacier, which leads to rising sea level.

A second issue arises when the glacier rests below sea level on a bed that deepens towards the interior. If the ice retreats, a process of accelerating flow and further retreat is unstoppable until the ice reaches a point where the bed begins to rise. In the case of the Totten Glacier, such a retreat all the way into the deep Aurora Basin would lead to a the sea level contribution of at least 3.5 metres. Such a change would take several centuries and is equal to, or a little larger than, the potential contribution from all of West Antarctica.

Interestingly, this potential sea level rise from East Antarctica could be the answer to a mystery from the last global warm period, some 120 000 years ago. At this time the Earth was around two degrees warmer than present (portentously, around where current projections are headed) and evidence suggests sea levels were six to nine metres higher than present. Earth scientists have struggled to explain the source of this rise using only Greenland and West Antarctic melt, but the presence of a significant source of melt from East Antarctica could solve the puzzle.

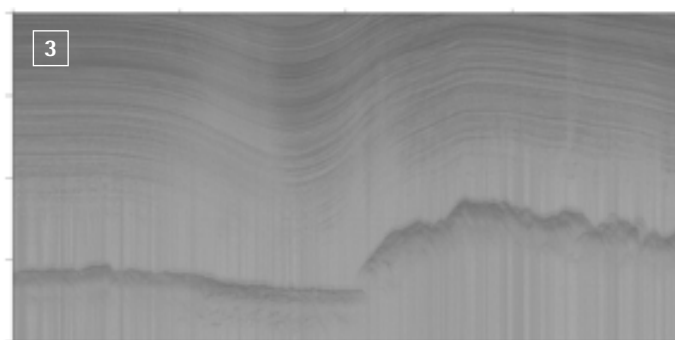
So where is this work leading? An oceanographic voyage to the front of the Totten in early 2015 (see page 10) has discovered that relatively warm deep ocean water is present on the continental shelf in front of the Totten Glacier. This is warmer than the colder water typical of the coastal continental shelf zone and it has potential to produce accelerated ice melt. Secondly, the ICECAP flights have been able

to identify at least two deep channels reaching back under the glacier front (see page 12).

These channels may provide a way for warm water to reach deep under the glacier and could explain the observed thinning and lowering. The airborne measurements have provided key evidence. Airborne radar measures the ice thickness, but cannot penetrate the ocean, while gravity measurements reveal contrasts between rock and water that can be used to map the shape of the ocean cavity itself. Other clues, like the brightness of radar reflection from the ice-water surface can tell us about the strength of melting that is taking place.

Ideally, what is needed are direct ocean measurements to augment the airborne evidence, and plans are being considered for the use of remotely controlled underwater vehicles and robot floats dropped from the air.

Also key to predicting the future is matching observations with computer model simulations of the ice-ocean system. This effort is technically demanding and relies heavily on observations from ICECAP to provide accurate bedrock and ocean cavity measurements. Oceanographic observations are needed to feed information



ROLAND WARNER
AND JASON ROBERTS

about currents and heat flow, and this ice-ocean model must be coupled with climate models to project the changes in the system as a whole.

For now, ICECAP has a considerable task ahead to refine the basic mapping beneath the ice to monitor the changes. Plans are well advanced to increase the efficiency and reach of the airborne survey work with light, long-range drone aircraft, in coming seasons. These will allow for targeted studies using a reduced suite of instruments to match payload limits. For much of the work, however, our retrofitted DC3 workhorse will continue surveying East Antarctica for many years to come.

TAS VAN OMMEN

Program Leader, Antarctica and the Global System, Australian Antarctic Division

An edited version of this article first appeared in The Conversation on 30 April 2015 theconversation.com/melting-moments-a-look-under-east-antarcticas-biggest-glacier-40960



ESMEE VAN WIJK

1. The 72 year old Basler BT-67 aircraft (a turboprop make-over of a DC3 operated by Kenn Borek Air) with its wing-mounted, ice penetrating radar antennae.
2. Dr Tas van Ommen in the Basler BT-67 (a retrofitted DC3) on an ICECAP flight.
3. This 60 km section of radar signals over the Aurora Basin shows the lower half of the East Antarctic ice sheet. The strong bedrock reflection is seen through about four kilometres of ice, and internal layers in the ice can be seen sweeping over an 800 m change in bedrock height.
4. The Totten Glacier is the largest glacier in East Antarctica. The glacier tongue stretches 120 km from the grounding line and the front of the glacier is 200 metres thick.

Household pollutants detected around Antarctic stations

Australian Antarctic stations are leading chemical management efforts in Antarctica after the discovery that common household pollutants are dispersing from Casey station into the local environment.



WICKY LOEBERMAN

Research published in *Environmental Science and Technology* and led by Dr Susan Bengtson Nash from Griffith University's Southern Ocean Persistent Pollutants Program, records the first evidence of the dispersal of these pollutants from local sources — such as furnishings and electronic equipment — in the Australian Antarctic Territory.

Australian Antarctic Division ecotoxicologist and a co-author on the paper, Dr Catherine King, said Persistent Organic Pollutants or POPs are known to reach the poles from other parts of the world through the atmosphere.

'What this study shows is that human activity in polar regions has increased the potential for the direct introduction of these long-lived, bioaccumulative and toxic chemicals into the environment,' she said.

'The chemical signatures in the samples tested at Casey station were consistent with those previously reported in homes and offices from Australia, reflecting the consumer products and materials of the host nation.'

While existing POPs can't be removed due to their long half-lives and persistence in the environment, the study provides information that will help Australia and other countries identify local sources of POPs that can be reduced or eliminated.

'We've already started the process of eliminating or carefully selecting building materials and consumer products, such as personal care products, food packaging, clothing, carpets and electrical appliances, to minimise the potential introduction of toxic substances into the Antarctic environment,' Dr King said.

'This study provides a baseline by which future improvements in our operational practices, use of building materials and consumer products on station can be measured.'

'It has also alerted the international community to the fact that POP pollution comes from both distant hemispheric sources and local activities.'

POP records

The international research team collected and analysed a range of samples from around Casey station — indoor dust from four buildings, mosses and lichens in the immediate station vicinity, local soil, effluent discharged from the station's wastewater treatment plant, and samples of sediment, phytoplankton, amphipods and fish from the marine environment.

Their analysis provided the first evidence of the presence of perfluoroalkylated substances (PFASs) in the Antarctic environment. These chemicals are commonly found in non-stick coatings and on waterproof clothing worn by expeditioners.

Polybrominated diphenyl ethers (PBDEs), found in electronic equipment, textiles and fire-fighting foam, were also prevalent in indoor dust, and the terrestrial and marine environments near the station.

Both these chemical families are common in Australian homes and offices and are listed under the Stockholm Convention as chemicals that should be 'restricted', in the case of PFASs, and 'eliminated' in the case of PBDEs.

'As a signatory to the Stockholm Convention, Australia is legally obliged to reduce and ultimately eliminate these compounds from the environment,' Dr King said.

'Chemical monitoring is also a requirement under the Protocol on Environmental Protection to the Antarctic Treaty and the Protocol prohibits the importation of specific POPs of known risk.'

Lead author of the paper, Griffith University PhD student Mr Seanan Wild, said the highest concentrations of PBDEs in the study were found in the communications and science buildings, which contain a higher density of electronic equipment.

The highest concentrations of PBDEs in lichen and moss were found in samples close to the station, and they decreased sharply with distance. In marine sediments, PBDEs with chemical profiles similar to the station's treated wastewater were highest in areas adjacent to the wastewater outfall.

PFASs were detected in the station's wastewater, warehouse and living quarters — again at levels comparable to houses and offices around the world.

'The study clearly demonstrates the emission of both PBDEs and PFASs from the station via treated sewage, and their presence in the local environment, with decreasing levels as distance from the station increases,' Mr Wild said.

WENDY PYPER

Australian Antarctic Division



TIM SPEEDING

1. The 'Red Shed' and other buildings at Casey station contain equipment, furniture and other common household items that act as a local source of persistent organic pollutants (POPs).
2. Polybrominated diphenyl ethers (PBDEs) have been detected in samples around the wharf and in the marine environment at Casey station.

Refining gravity waves in climate models

New research aims to improve the way gravity waves are represented in climate models.



Weather maps, with their high and low pressure systems, tell us about where the wind is going to blow and help us plan our weekend. In the southern hemisphere the wind blows clockwise around a low pressure system and anticlockwise around a high. To predict our future climate, however, we need to include other influences on atmospheric circulation, such as the waves that are ever present in the air above us.

Gravity waves are made when our atmosphere is disturbed by fronts, storms or air blowing over hills and mountains. As gravity tries to restore the atmosphere to its undisturbed state, it forces the common 'overshoot' that generates a wave. Gravity waves vary enormously in the rate at which the air oscillates (frequency) and their horizontal and vertical repetition scale (wavelength). They have a significant influence on the workings of our weather and climate because they can force air movements in the atmosphere. This influence provides the motivation behind our research to improve the way gravity waves are represented in climate models.

Model waves

A key characteristic of gravity waves is that their typical horizontal wavelength, which ranges between tens to thousands of kilometres, is too small for them to appear naturally in most climate and weather prediction models. Models divide the atmosphere up into a grid of points over the globe and gravity waves rarely span the distance between two adjacent grid points. So while high and low pressure systems are easily represented in models, gravity waves need to be incorporated using representations known as 'parameterizations'.

Parameterizations typically distil the process they represent into the parts that are physically important and that can be derived from information already in a model. An ideal parameterization of gravity waves would use low level winds and temperatures to calculate which waves were being produced when, how much momentum they would carry, and how that momentum would be deposited back into the airflow as the waves propagate up from their sources. In reality, many parameterization schemes are overly simple, due to our poor knowledge of wave generation processes and the momentum carried by the various scales of gravity waves.

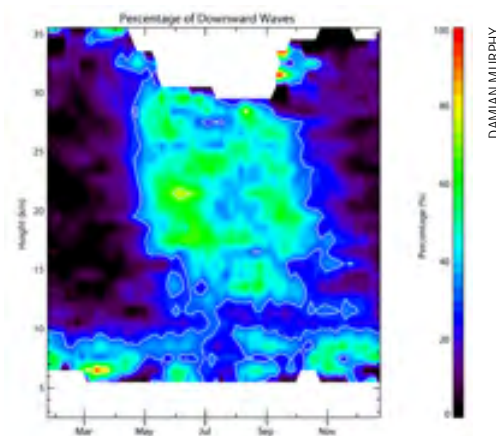


Figure 1: Percentages of downward moving gravity waves measured using meteorological balloons. Scientists are investigating whether these waves could be generated by disturbances in the stratospheric polar vortex in Antarctica.

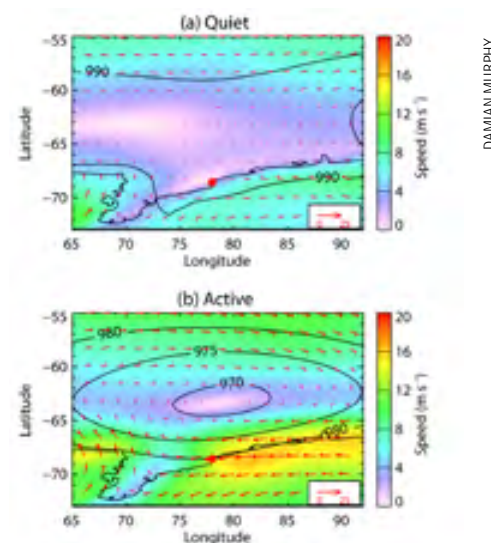


Figure 2: Large scale pressure distributions in the Davis area for quiet and active gravity wave activity. The presence of large scale low pressure systems (lower image) in the atmosphere enhance winds upstream from Davis, represented by the red arrows, and generate more gravity waves. Less wave production occurred when synoptic patterns did not reinforce this flow (top image).

1. The wave structure in these clouds over Mawson is caused by gravity waves in the Antarctic atmosphere.
2. The VHF radar at Davis can be used to measure winds in the lower part of the atmosphere, providing a window on the high frequency part of the gravity wave spectrum.

Models can generate very useful data with a simple gravity wave parameterization. However, the stratosphere above Antarctica where the ozone hole occurs (typically between 15 and 50 km up) nearly always comes out too cold. This means that the model cannot accurately represent ozone chemistry, which is strongly dependent on temperature. The presence of the ozone hole has changed the north-south movement of the surface westerly wind belt that circles Antarctica in the Southern Ocean. This in turn affects weather and rainfall patterns in southern Australia in late spring and summer. Accurate representations of gravity waves and, as a result, ozone chemistry, is therefore critical for southern hemisphere climate predictions.

Wave observations

Our research aims to improve gravity wave parameterizations by combining our existing observational expertise with new knowledge of parameterization schemes, to design physically realistic and computationally simple improvements. Our work has progressed through the analysis of 12 years of meteorological balloon releases, which has taught us about the nature of gravity waves in the atmosphere above Davis. Improvements to our atmospheric radar at Davis have also allowed us to study wave sources.

The daily release of meteorological balloons provide excellent data for studies of parts of the gravity wave spectrum. Vertical profiles of wind and temperature can be mined for wave-like features and these can provide many gravity wave characteristics. One interesting wave attribute is whether the wave is going upward or downward. Scientists generally assumed that gravity waves always go up. However, we have recently shown that downward propagating waves exist over a broad height range through the winter stratosphere. In fact, through much of the middle of the year, around half of the waves seen by the meteorological balloons were going downward (see Figure 1). One possible reason for this is that disturbances in the strong winds that flow around the southern pole (the stratospheric polar vortex) generate gravity waves. The influence of these downward

waves on wind patterns below is still being considered, as is implications for including a new stratospheric gravity wave source in models.

The VHF radar at Davis can be used for measuring winds (see side bar) in the lower part of the atmosphere much more regularly than meteorological balloon releases, as new wind observations are made every six minutes from around 2–12 km in altitude. These provide an excellent window on the high frequency part of the gravity wave spectrum.

Recently, we found that when large scale low pressure systems produced north-easterly wind flow that enhanced the katabatic winds over Davis, gravity wave production was at its most active (see Figure 2). The principle source of the waves was airflow over an ice ridge line northeast of Davis. Less wave production occurred when synoptic-scale meteorological patterns did not reinforce this flow. This and future studies have the potential to provide the links between the synoptic patterns that are easily seen in models and the sub-grid scale gravity waves they produce. Recent improvements to the VHF radar system at Davis have increased the height range over which observations are available.

Linking observations and models

The 'Gravity wave drag parameterization' project team includes international collaborators in Japan and the USA who are actively developing the representation of gravity waves in their models. In particular, we are working with researchers at the US National Center for Atmospheric Research to improve the stratospheric ozone chemistry performance in the Whole Atmosphere Community Climate Model (WACCM), through changes to its wave parameterization. Our collaboration with them is enhancing our knowledge of model design and providing observational input into their developments. These developments will be of particular value when work begins on similar improvements to the Australian Community Climate and Earth System Simulator (ACCESS) model in the near future.

DAMIAN MURPHY, SIMON ALEXANDER,
ANDREW KLEKOCIUK and PETER LOVE
Australian Antarctic Division



Linking atmospheric research and meteorological operations

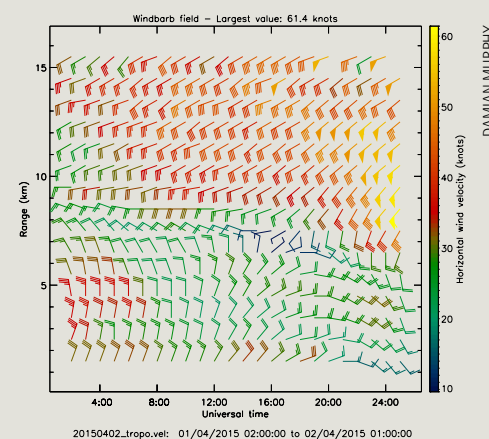
Radar wind profilers similar to the one used for our research at Davis (see main story) are used operationally around Australia by the Bureau of Meteorology to complement their balloon observations and improve the quality of their weather forecasts. Although the wind profilers do not provide temperature and humidity, the high frequency of the wind measurements makes them a valuable addition to the Bureau's observing network.

Daily plots of winds between 2 and 15 km from our research radar have been available to the summer forecasters at Davis for some years (see image). Recently, technological advances have enabled us to convert this data into a format that can be incorporated into meteorological forecasting models, and regular transfers to the Bureau are now being made.

DAMIAN MURPHY¹ and SCOTT CARPENTIER²

¹ *Australian Antarctic Division*

² *Bureau of Meteorology*



A graphical display of hourly winds in the atmosphere above Davis. The colours (and the number of barbs) indicate the wind speed in knots. The orientation of the 'flags' show the wind direction (with vertical being northerly) at a range of heights and times.



DANA BERGSTROM

Iconic Macquarie Island cushion plant dying out

Old growth cushion plants and mosses on subantarctic Macquarie Island are being decimated by recent climate change.

New research, published in the *Journal of Applied Ecology* in April, reveals the cushion plants, *Azorella macquariensis*, estimated to be hundreds of years old, are dying due to windier and drier conditions.

Lead author and ecologist with the Australian Antarctic Division, Dr Dana Bergstrom, said the dieback of the cushion plants and mosses is rapid, progressive and widespread across the island.

'This is a plant that has survived for thousands of years, but it's now struggling to cope with the rapid changes occurring on the island,' Dr Bergstrom said.

'Over the past four decades the environment has altered dramatically from wet and misty to one subject to periods of drying.'

The study, undertaken by 18 scientists from 10 institutions, looked at 115 sites across the Macquarie Island alpine tundra.

Between 2008 and 2013 the researchers found that in 88% of the study areas almost all the plants died, often leaving a desert-like landscape. The extent of the death of this keystone endemic cushion plant is so severe that it has been declared critically endangered. The primary cause of the species' collapse is suspected to be the failure of cushion plants and mosses to withstand changes in summer water availability.

'We found that for 17 years in a row there was not enough water available to the plants,' Dr Bergstrom said.

'Additionally, between 1967 and 2011, there has been uniform increases in sunshine hours, wind speed and water loss from the leaves of the plants and soil despite overall increases in precipitation from storm events.'

Australian Antarctic Division spatial ecologist, Dr Aleks Terauds, said the cushion plants and mosses are an important habitat for many other species on Macquarie Island.

'The cushions act as a refuge for a whole range of spiders, mites and other plants, in what can be a very inhospitable environment,' Dr Terauds said.

'The dieback is essentially taking away that critical habitat and with annual growth of the plant rarely exceeding 5 mm, it will be difficult for the species to recover.'

An insurance population of 54 irrigated plants has been set up on the island as a growth trial.

'These plants are growing successfully in what is considered the best way to conserve the species until large quantities of seed can be harvested,' Dr Bergstrom said.

'This rapid ecosystem collapse on Macquarie Island is giving us a window into the potential impact of climate-induced environmental change on vulnerable ecosystems elsewhere.'

NISHA HARRIS

Australian Antarctic Division



DANA BERGSTROM

1. Cushion plants are one of the dominant plant species on Macquarie Island and provide important habitat for many invertebrates.
2. Dieback has set in on this once healthy cushion plant, possibly as a result of changes in summer water availability.

1

Rare sub-glacial eruption at Casey

Australian scientists are hoping a rare sub-glacial water eruption near Australia's Casey station, will reveal why meltwater is present, and the extent of a river and dam system flowing deep under the Law Dome ice cap.

AL DEAN

In only the second reported incident of its type in Antarctica, a Jökulhlaup, or sudden outburst of basal melt water from beneath the ice cap, erupted near Robinsons Ridge, 15 kilometres south of Casey.

Associate Professor Ian Goodwin from Macquarie University observed the first recorded Antarctic Jökulhlaup, also near Casey station, in 1985–86, and located a large sub-glacial lake near the ice margin. The new eruption was first noticed by Casey expeditioners over the 2014 winter.

'The expeditioners saw the melt water rising to the surface and dispersing over the surrounding ice sheet, before refreezing,' Professor Goodwin said.

'The refrozen Jökulhlaup water is very prominent because of its striking olive-green colour, which contrasts sharply with the surrounding blue glacial ice and white snow.'

Samples of the frozen Jökulhlaup water were collected by Dr David Etheridge from the CSIRO and Dr Andrew Smith from the Australian Nuclear Science and Technology Organisation in February this year.

The ice is now being analysed at Macquarie University, Curtin University and the Antarctic Climate and Ecosystems Cooperative Research Centre, to find out more about the conditions under Law Dome.

'There have been advances in technology and techniques since the last known eruption 30 years ago, which will allow us to measure the hydro-chemistry of these samples in much more detail,' Professor Goodwin said.



'We will measure the major ionic chemistry and isotopes to find out how the bottom of the ice sheet is melted, how far the water has travelled, and to get an insight into the stability of the ice sheet. We will also attempt to estimate the age of the water, which is potentially tens of thousands of years old.'

Previously, scientists thought the Law Dome ice cap was frozen to the bedrock. However, the 1985 Jökulhlaup showed water is produced underneath some parts of the ice cap, at least episodically.

'Our observations of the Jökulhlaup confirmed Law Dome had high geo-thermal heat emanating from the Earth's crust, which was melting the bottom of the ice cap,' Professor Goodwin said.

'This water then flowed in river systems under the ice sheet out into the ocean, or in this case, where the rivers are dammed by frozen ice, the water flows up to the surface through weaknesses in the ice sheet.'

Program leader with the Australian Antarctic Division, Dr Tas van Ommen, said recent aerial radar work through the ICECAP project (*Australian Antarctic Magazine* 19: 7, 2010) will help the researchers pinpoint the origin of the water.

'The ICECAP project used ice-penetrating radar to map the conditions at the base of the ice sheet in East Antarctica, and this can help identify which areas are more likely to produce basal melting and water,' Dr van Ommen said.

'Putting the whole picture together, with data from ICECAP, deep ice core temperature measurements from Law Dome, and samples from the Jökulhlaup, will help us understand the past and present behaviour of the ice cap, and how it might evolve in the future,' he said.

Analysis of the Jökulhlaup samples is expected to take several months.

NISHA HARRIS

Australian Antarctic Division

1. The refrozen Jökulhlaup water, dispersed across the ice, is very prominent because of its striking olive-green colour.
2. Dr David Etheridge (left) and Dr Andrew Smith take samples of the rare sub-glacial water eruption for analysis.



Sweating the small stuff

After 17 trips to Antarctica over 31 years, marine microbial ecologist Dr Andrew Davidson is hanging up his ice axe for the last time to focus on publishing a backlog of data from his research. As a senior research scientist at the Australian Antarctic Division, Dr Davidson leads a small team studying plankton in the Southern Ocean, to better understand the sensitivity of Antarctic life to human-induced environmental change. Here he reflects on three decades of life and research in the Antarctic.

In 1983 I was considering doing an Honours degree and was looking around to see what was available at a range of institutions. At the Antarctic Division I met Harvey Marchant, whose encyclopaedic knowledge and infectious enthusiasm for the single celled organisms that inhabit the Southern Ocean captured my imagination. He opened my eyes to the importance of these tiny creatures and exposed me to a world of unimagined beauty and complexity.

These organisms thrive in what I'd presumed to be an extreme and harsh environment. This immediately begged the question 'how do they excel in an environment that is apparently so forbidding?' The rest of my career has involved trying to identify and understand pieces of that puzzle. I still marvel at these organisms' plasticity and the adaptations that allow them to proliferate, despite the environmental challenges they encounter.

I fondly recall the mixture of trepidation and the thrill of adventure as I set off on my first trip to Antarctica as part of my Honours research. Not long before the vessel was to leave the wharf, Harvey asked if I'd included a length of garden hose amongst my equipment. I couldn't imagine why I might need it. He rushed off to retrieve one from his home and cast it across the ever-widening gap between the wharf and the vessel as she pulled away. He was right, it proved very handy for getting seawater to the lab.

When I began my research, fundamental questions were still being asked about what protists (single celled plants and animals) occupied Antarctic waters. This was significantly due to the introduction of techniques and technologies (such as fluorescent and electron microscopy) that allowed small cryptic organisms to be resolved and identified. The recognition that these organisms play a vital role in mediating global climate has meant

that we still need to know what's there and how much is there, but we also need to understand their roles in mediating food webs and global climate, and the effect of climate change on these processes.

Antarctica is a special place to work, but it is challenging and experience in the environment is invaluable. My first attempt at operating an incubation facility consisted of constant repairs and maintenance of frozen plumbing, broken pumps and fractured pipes. I also had 'aspirational' expectations of what I could achieve, unwittingly designing experiments that required up to 76 hours without sleep. However, the most productive and publishable experiments were often those conceived using simple techniques.

One of my most interesting discoveries involved an alga, *Phaeocystis antarctica*, which is abundant in Antarctic waters and which forms balloon-like colonies that can fill the water column with little translucent spheres. Each of these spheres may contain thousands of cells.

I found that this remarkable alga filled its colonies with a sunscreen that was much more effective at absorbing ultraviolet radiation than the commercial sunscreen at the time. My studies showed that under high ultraviolet light, the sunscreen allowed *Phaeocystis* to out-compete other algae. We were approached by a French company that was interested in using these compounds in commercial sunscreens, but I don't know whether they ever included them in their products.

One of my most memorable trips was a 1985 voyage aboard the *Nella Dan*, which set an unassailable record of 57 days besetment in Amundsen Bay. I was one of the lucky ones as there are always marine microbes to be studied, but some people were utterly unoccupied. Highlights included massive snow fights, soccer matches on the ice and some expeditioners developing a life-long antipathy for Danish pastries, pork or 'Spong' (a strange gelatinous pudding that came in a range of colours). However, the voyage led me to some interesting insights into the successional sequence of sea ice microbes and challenged some of the assumptions about Antarctic protists at the time. This season just past (2014–15) was my last season in Antarctica as I have a backlog of research that needs to be published. It's one thing to study a system, but you can only change the attitudes of people and the outcome for the region if you convince society and policy-makers that there are ways that we can nurture this planet to a better future.

It was great to finish my Antarctic service on a high note. The excellence of the research team and the application of new techniques and instruments meant that we could employ the most up-to-date and stringent methods, and the unfolding results of our experiments look fascinating.

Our early results reinforce that carbon dioxide (CO₂) concentrations at or above those predicted by the end of this century negatively affects phytoplankton, reducing their productivity, growth and changing their composition. As the base of the Antarctic foodweb, changes at the microbial level are likely to impact on all other life in Antarctic waters. Together with the results from the Free Ocean Carbon Enrichment experiment (see page 8), we are beginning to formulate a picture of the vulnerability of a range of Antarctic ecosystems to increased CO₂.

The Southern Ocean absorbs around 40% of the CO₂ humans are adding to the atmosphere and marine microbes play a critical role in facilitating and mediating this rate of CO₂ uptake. Our results suggest that ocean acidification may reduce the capacity of the Southern Ocean to absorb CO₂. This would accelerate the rate that CO₂ accumulates in the atmosphere, worsening climate change. Yet ocean



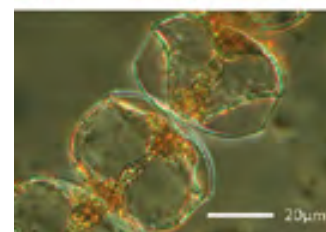
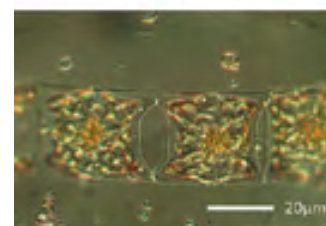
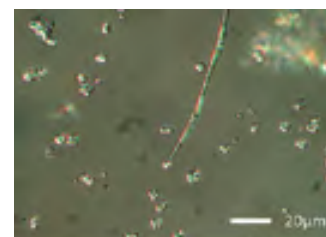
EXPEDITIONER PHOTO



KAREN WESTWOOD



ROWAN BUTLER



ANDREW DAVIDSON

1. Dr Andrew Davidson at Davis station during the 2008–09 summer of marine microbial experiments.
2. One of Dr Davidson's experiments to expose phytoplankton to different levels of ultraviolet light.
3. 'Minicosms' housed in a shipping container on the Davis shoreline. These incubation tanks are filled with local seawater and filtered to remove organisms larger than 0.2 mm — mostly predatory grazers. The resulting marine microbial communities are subjected to different concentrations of carbon dioxide to determine the impact of ocean acidification on the communities.
4. One of Dr Davidson's more memorable trips was aboard the *Nella Dan* when she was beset by ice 13 feet thick for 57 days, in 1985. She was released by the Japanese icebreaker *Shirase*.
5. Some of the marine microbes Dr Andrew Davidson studies, including the small diatom *Fragilariopsis cylindrus* (top), and larger diatoms *Eucampia antarctica* (middle) and *Stellarima microtrias*. Ocean acidification due to increasing concentrations of carbon dioxide dissolving in seawater is expected to alter the abundance of these organisms (see *Australian Antarctic Magazine* 24: 22–23, 2013).

acidification is only one of the stressors we are imposing on these organisms and the net effect of coincident changes in other environmental factors (e.g. temperature, salinity, light and nutrients) may be profound.

Our experiments, along with a vast and compelling array of evidence from around the world, sound an alarm. As arbiters of the

future global environment, we have an obligation to minimise the severity of climate change on all the living things with which we share the Earth. Our time to act is running out.

ANDREW DAVIDSON
Australian Antarctic Division

Changing Antarctica

I've experienced many changes during my 31 years visiting Antarctica, but living conditions are the aspect of Antarctic service that has changed the most.



I first summured at Davis in 1990–91 when the old Donga Line (the original station) was still inhabited. It was a close-knit environment in which your living space was separated from the main corridor by a curtain. The corridor had roof hatches to allow access when the doors were obstructed by snow or the occasional slumbering elephant seal. Though rudimentary, it had a lovely Heath Robinson air of rustic charm and bred an intimacy and conviviality.

The ablution facilities and toilets were interesting. I had long hair in the early years and walking from the summer ablutions block to the shipping container after a shower, my hair would freeze into a chandelier. There were also gas-fired toilets that incinerated solid human waste. However, any liquid on the spark plug would cause the gas to build up without igniting, leading to panic stricken and inadequately clad expeditioners staggering from the toilets before the inevitable explosion.

The social isolation of working in Antarctica has greatly diminished. Gone are the days of the weekly WYZZA telex message. These messages contained coded strings of letters that the recipient looked up in a book to decipher their meaning. They included codes such as 'I've grown a beard and everyone thinks it

looks good', to the socially inept 'I miss you and love you very much' (which lost all emotional credence as WYZZA code). Now mobile phones, email and the internet keep expeditioners in constant touch with the world and people are regularly warned that someone has left their head lights on in the Antarctic Division's headquarters car park in Tasmania.

One thing that hasn't changed is the Christmas tradition. I've spent possibly 14 Christmases in Antarctica or onboard a ship. The chefs always do a spectacular job, with tables groaning under the strain of sumptuous food, all stunningly presented and tempting you into glutinous excess. The company is invigorating, the wine and conversation flows, the climate is reminiscent of the European tradition, and everyone is dressed to kill in their glad rags. Yet I shan't miss them. To me, Christmas is an intimate time spent with a close circle of friends and family. Try as I might I can't shed the niggling feeling that Christmas in Antarctica is like frequenting a soup kitchen for vagrant gentry.

I made 17 trips to Antarctica during my career. Some of these have been marine science trips but most have been to Davis. I've also been lucky enough to visit Heard Island, Macquarie

1. Dr Davidson at Garnet Knob in the Larsemann Hills, February 1991.

2. Dr Davidson deploys equipment used to incubate phytoplankton at different depths from the MV *Southern Comfort*.

Island and some of the further-flung areas around Prydz Bay, including the Rauer Islands, Larsemann Hills, and the Amery and Cape Darnley region east of Mawson.

Overall, Heard Island is my favourite location in the Antarctic. The rugged beauty, volcanic grandeur, wildlife and knowledge that it is unspoiled by feral introduction, make it a very special place. But it's also special because it's located at the boundary between the polar and sub-polar waters; a boundary that is on the move due to climate change. This makes it one of the locations where the effects of climate change are most severely felt, and to me it signifies both the stunning beauty and vulnerability of Antarctica.

ANDREW DAVIDSON
Australian Antarctic Division

1

DAVE AND FIONA HARVEY

Fulbright scholar to advance whale ageing technique

A DNA-based test for estimating the age of humpback whales has earned its co-developer, Australian Antarctic Division molecular biologist Dr Simon Jarman, a prestigious Fulbright Scholarship to study in the United States.

1. A new DNA-based test will help scientists understand the age structure of Australian humpback whale populations.
2. Australian Antarctic Division molecular biologist Dr Simon Jarman will travel to the United States on a Fulbright Scholarship to pursue whale ageing research.



GLENN JACOBSON

2

Dr Jarman and his colleague Andrea Polanowski, in collaboration with the US Centre for Coastal Studies and the Australian Genome Research Facility, developed the first DNA-based test for

estimating the age of humpback whales, based on recent advances in human medicine.

The non-lethal test looks at age-related changes in the DNA of skin samples that can be collected from live whales using biopsy darts.

The test relies on changes in the 'DNA methylation' of genes involved in the ageing process. DNA methylation is a biochemical process where a methyl group (CH₃) is added to specific DNA building-blocks. This process alters the expression of genes.

'We've long known that DNA methylation is involved in processes like sex determination and the development of many cancers, but it has only recently been shown to be involved in the ageing process,' Dr Jarman said.

'We used information on age-associated DNA methylation in human and mouse genes, to identify similar gene regions in

humpback whales. We then developed an assay using three of the most informative methylated genes, which estimates age with a high level of precision.'

Dr Jarman's scholarship will enable him to spend three months working with scientists from the Centre for Coastal Studies in Massachusetts, to study humpback whales in the Gulf of Maine, refine the DNA ageing method, and improve understanding of whale ecology.

'The population of humpback whales in the Gulf of Maine has not been hunted since the early 1900s and it contains a large number of whales of known age, as they were visually observed when they were less than one year old and re-sighted in later years,' Dr Jarman explained.

'In contrast, Australian humpbacks were hunted until 1962, which is within the 95 year life span of individuals in the current population; so we expect the population to be biased towards younger animals.

'We'll compare skin biopsy samples from the known-age whales to our Australian population to calibrate the DNA age estimation method and get a more accurate picture of the age structure of the Australian humpbacks.'

Dr Jarman said the scholarship would also allow him to investigate other population parameters.

'Estimating age is important for monitoring the recovery of whale populations following

commercial whaling. When combined with genetic information about the relatedness of individuals in a population (parents, siblings, offspring), age data improves methods for estimating the size of whale populations and their reproductive potential. It is also critical to understanding how biological characteristics of whales change with age.'

Dr Jarman's work could also be extended to age estimation in other animal species.

'We intend to develop similar genetic age estimation methods for other long-lived wild animals such as albatross and penguins and to use the age information for population status monitoring,' he said.

Dr Jarman's previous research has included the study of Antarctic animals' diets, including penguins, Antarctic krill, seals and whales, using the DNA found in their stomach contents and scats.

The Fulbright Program is the largest and one of the most prestigious educational scholarship programs in the world, operating in the United States and over 155 countries worldwide.

Dr Jarman will travel to the United States to take up his scholarship in August.

WENDY PYPER

Australian Antarctic Division

Antarcticans and the war

As Australia commemorates the centenary of its involvement in World War I and the Battle of Gallipoli (25 April 1915 – 9 January 1916), it is timely to reflect on the contribution many Antarctic explorers made to the war effort.



Following a sense of adventure or patriotism, or simply the call of friendship, many people who had experience in Antarctic exploration volunteered to serve in the armies of World War I.

Traces of many of these men, the records they leave in maps, diaries, photographs, printed materials and ephemera are preserved in the State Library of New South Wales. They are a reminder of the contribution they made to our understanding of the world. In the worst case, they are a reminder of their sacrifice and of an untimely end to a life of potential and contribution.

Companions in the south, the paths of these men sometimes crossed in the trenches of the European war. Here, Australian photographer Frank Hurley met sledging companions Leslie Russell Blake and Eric Webb. A few years before, during their expedition towards the South Magnetic Pole, these friends nearly died in the harsh and dangerous conditions on the Antarctic plateau. Later, while on leave in London, Hurley met both Douglas Mawson and Ernest Shackleton.

The living conditions on the front often reminded men like Hurley of his experiences in the south. Only a short time after his extraordinary time lost on the bitter Antarctic Elephant Island and living for 4 1/2 months with 21 others under upturned lifeboats, Hurley wrote in his war diaries about the warmth of companionship. In his diary, he commented on his response to the carnage while walking through battlefields strewn with dismembered corpses:

The Menin road is like passing through the Valley of Death, for one never knows when a shell will lob in front of him. It is the most gruesome shambles I have ever seen, with the exception of the South Georgia whaling stations, but here it is terrible as the dead things are men and horses (17 September 1917).

On 30 December 1917, Hurley was with members of the Australian Light Horse in Palestine. That evening the men made camp, settling and feeding the horses. As the dark grew around them, the soldiers gathered around a fire and asked Hurley to tell them about Antarctica. In this extraordinary moment the connections between the experiences of the explorers of the then almost completely unknown southern



continent and the experiences of people in World War 1 became apparent. He wrote about the episode:

After dinner the boys invited me to their campfire, and asked me to give them a few words about my Antarctic experiences. The novelty of the surroundings impressed me greatly, and I felt, in the interest expressed on the faces around me a reward for the tribulations of the South... How all these, my fellow countrymen appreciated my story. How they sympathized with the hardships and how they joined in hilarity when I related... the primitive routine of daily life. I enjoyed it as much as they.



He completed his entry with a reflection that the companionship of these men reminded him of that of the Antarctic teams, sleeping in cramped and dangerous circumstances: 'tightly packed, but warm and contented'.

Sir Ernest Shackleton, famous for his expeditions to Ross Island and the Trans Antarctic Expedition, came to Sydney in 1917 and assisted the Australian recruitment drive by writing the pamphlet *A Call to Australia*:

Here in Australia the call to service sounds loud and clear. I speak to you men as one who has carried the King's flag in the white warfare of the Antarctic and who is going now to serve in the red warfare of Europe. I say to you that his call means more than duty, more than sacrifice, more than glory. It is the supreme opportunity offered to every man of our race to justify himself before his own soul. Love of ease, love of money, love of woman, love of life — all these are small things in the scale against your own manhood. The blood that has been shed on the burning hills of Gallipoli and the sodden fields of Flanders calls to you. Politics, prejudices, petty personal interests are nothing. Fight because you have the hearts of men, and because if you fail you will know yourselves in your own inner consciousness to be for ever shamed. And to the women of Australia, I would say just this: be as the women of Rome, who said to husbands, brothers, and fathers, 'Come back victorious, or on your shields'.

Some of these men died while in the war. Bob Bage, a fellow expeditioner of Webb and Hurley, was killed at Gallipoli. Twelve days after the landing, he was shot by Turkish machine gun fire as he laid out trench lines near Lone Pine. His scientific field books are preserved in the Mitchell Library. In these,

his careful measurements of the progress towards the south magnetic pole are recorded in a tight, precise hand.

Leslie Russell Blake, another of the men of the Australasian Antarctic Expedition, died on 3 October, 1918 just weeks before the Armistice. He was awarded the Military Cross. Blake's beautiful and carefully drafted map of Macquarie Island is one of the most accurate representations of that remarkable island.

Others served in different ways. Morton Moyes, meteorologist with Douglas Mawson's Australasian Antarctic Expedition, was a naval instructor during the War. Despite attempts to leave this post and go on active service in the Navy, he was considered too valuable as a trainer to go to war. In 1917, he sailed south with the *Aurora* on the relief expedition for the Ross Sea party with Shackleton as his cabin mate. The official log of this voyage and an oral history by Ross Bowden with Moyes are both in the Mitchell Library collection.

After the war Hurley wrote in the *Australasian Photo-Review* (14 February, 1919):

What a contrast to the ice fields of Antarctica! It would be impossible to find in the vast domain of photography two branches of work more divergent. In the latter — everything beautiful, reposeful, and of infinite charm; the former, filled with horror — it was all action and suffering.

Like Hurley and members of the Light Horse around the campfire in the Judean Hills, Apsley Cherry-Garrard, assistant zoologist with Sir Robert Falcon Scott's ill-fated British National Antarctic Expedition (1910–1912), valued the friendships forged in the south. Garrard attempted to serve in the war but, afflicted with nervous damage, returned

to London. However his comments about friendship and reliance in Antarctica ring true for both fields of endeavour. In his book about his Antarctic experiences, *The Worst Journey in the World*, Cherry-Garrard wrote about the companionship of the men on a harsh sledging journey as 'gold, pure unalloyed gold'.

STEPHEN MARTIN

Stephen is a former senior librarian and researcher for the Mitchell Library, Sydney, and has been visiting Antarctica as a history lecturer, field guide, sailor and tourist for the last two decades. He is the author of A History of Antarctica (Rosenberg Publishing, 1996; revised 2013).

1. Leslie Russell Blake was a geologist and cartographer for the Macquarie Island Party during Mawson's Australasian Antarctic Expedition. His main task was to map the island and describe its geology — tasks which later contributed to the island's nomination as a World Heritage Area. In 1916 he was awarded the Military Cross for conspicuous and continual gallantry in the field during the Battle of the Somme.
2. Morton Moyes was a meteorologist with Douglas Mawson's Australasian Antarctic Expedition and a naval instructor during the War.
3. James Francis (Frank) Hurley was the official photographer on Mawson's 1911–14 Australasian Antarctic Expedition and Shackleton's ill-fated 1914–17 Imperial Transantarctic Expedition. He served in Europe as an official photographer with the AIF from 1917–18, producing the only colour-plate photographs of the war.
4. Edward Frederick Robert Bage trained as an engineer and was responsible for astronomical and tidal observations and maintaining chronometers during Mawson's Australasian Antarctic Expedition. He was also leader of the Southern Sledging Party, charged with locating the shifting South Magnetic Pole. Captain Bage was killed in 1915 by Turkish machine gun fire while marking out a trench line near Lone Pine.
5. Frank Hurley was struck by the connections between the experiences of Antarctic explorers and those of the people in World War 1 and he reflected on the companionship he felt in both situations in his diary. Here he trims John Hunter's beard in the tight confines of the Main Hut at Cape Denison, Antarctica.



Antarctica 1 – Volkswagens in Antarctica

The Editor at the Volkswagen Club in Sydney, Phil Matthews, recently completed a history of the Volkswagen 'Beetles' that served at Mawson station between 1963 and 1970. The following is an edited extract from *The Antarctic VWs*, an expanded version of a story that originally appeared in his book *Knowing Australian Volkswagens* (Bookworks 1993). The full story of the Ruby-Red Beetle, Antarctica 1, and two orange vehicles – Antarctica 2 and 3 – can be read at www.clubvw.org.au/antarctic-vws.

In 1962, the Australian National Antarctic Research Expeditions (ANARE) was looking for cheap motorised transportation to complement the heavy tracked vehicles at Mawson. Transport at Mawson was normally provided by tracked vehicles, dog sleighs and motorbikes. But all these had their limits. The motorbikes could only transport small loads. The tractors could run at a maximum speed of 5 km/h and used too much fuel. The dog teams needed to have been in harness for a long time, required continual care and could only be managed by someone experienced in their handling.

The incoming 1963 expedition leader was a young engineering draughtsman named Ray McMahon. While he was making preparations at ANARE Head Office in Melbourne, he read that there were a couple of water-cooled vehicles at Mawson; a Ferguson tractor and a flat topped Bedford truck. He reckoned if they were being used successfully around the station, then why wouldn't an air cooled VW be suitable for some 'around the station' functions? Using his initiative, he picked up the phone and rang the marketing office of Volkswagen Australasia at Clayton. Ray spoke with a cadet marketing person by the name of Graham Massingham. Ray asked him if VWA would be cooperative and loan ANARE a VW to take to Mawson for the year.

It just so happened that the Volkswagenwerk Head Office in Germany had recently been encouraging their subsidiaries around the world to concentrate their marketing efforts on publicising VW service in Arctic conditions. Young Graham scored the promotional coup of his life, and the opportunity to send a VW to Mawson was enthusiastically welcomed by his superiors.

Ray was invited to Clayton, and an Australian-made Ruby-Red 1962½ model Beetle was selected at random from a batch made in December 1962. The Ruby-Red colour was chosen so the car would stand out from the snowscape.

The Clayton Service Workshop then gave the Beetle a thorough 'winterising', a northern European process unknown in hot Australia. The engine was rebuilt with special European 'winter' quality crankshaft bearings for extreme service low-temperature conditions, such as those in Norway and Finland. The exhaust manifolds were wrapped in asbestos insulation to assist initial warm-up. The front wheel bearings and torsion bars were lubricated with winter-spec lithium grease. The VW was fitted with a pair of heavy-duty six-volt batteries in series, so that starting could be achieved at 12 volts through the 6-volt starter motor, but the rest of the electrical system remained 6-volt. A rear tow bar and sump guard was fitted, and a factory storage rack was bolted to the roof.

Official VW preparation was very thorough.

The car was delivered with a box of general spare parts and spare wheels, as well as a quality Bolex cine camera with a generous stock of movie film. Large ANARE labels were painted on the doors, and special aluminium 'ANTARCTICA 1' number plates were made and mounted front and rear. Volkswagen Australasia covered the costs of the vehicle and all spares and modifications.

After collection and inspection by Ray McMahon, the VW was loaded aboard the supply ship *Nella Dan* at Port Melbourne, and shipped 6100 km south to Mawson. It was unloaded with the normal year's supplies in January 1963. The engineers filled the petrol tank with BP winter-grade petrol, which proved perfectly suitable for the local conditions.

The VW underwent some initial trial runs, including a 35-km round-trip to the inland Rumdoodle airstrip up on the ice plateau. The VW made the run in 65 minutes, a near record. There is a very steep snow slope behind Mawson, which must be climbed to reach the plateau. Many doubters – including even the Captain of the *Nella Dan* – bet Ray McMahon that the Volkswagen wouldn't make it under its own power. It did.

ANARE official photographer Geoff Merrill took a number of photos of the VW at Mawson, at the airstrip at Rumdoodle, and in several stunning nearby locations that showed the beauty of the



Antarctic area. He also shot the first 500 feet of movie film, which returned to Hobart aboard the *Nella Dan*. These first photos caused a sensation, and were used in a string of VW ads and promotions.

The VW spent a whole year at Mawson, competing with dog teams, Polaris medium over snow vehicles and larger tracked vehicles such as the Weasels, Caterpillars and Porsche 356-engined Snowtracs. Subjected to smothering snows, bitter cold down to -50°C and knifing 200 km/h winds, it turned out to be excellent for running around the station and short traverses of the ice-bound country. It even went up snow-covered hills which were difficult to climb on foot because of the sinking snow. Being air-cooled it never froze, and being tightly sealed it was immune from drifting powder snow, which at Mawson was so fine that it could blow through pin holes.

Scientists soon fell in love with the VW and christened it their 'Red Terror', but it was officially known as Antarctica 1. VW Australia proudly called it 'the first production car to visit Antarctica'. It was used for a multitude of purposes and within its limitations proved extremely useful, according to ANARE people who used it. With snow chains on all four wheels, it could be used for everything from transporting supplies out to field teams, to towing skiers around the base, to taxiing VIPs to and from the airfield at Rumdoodle, to driving glaciologists three or four kilometres out onto the sea ice to test its thickness.

While Antarctica 1 performed admirably, the brutal treatment it received over its year in the ice did reveal one major weakness — the chassis frame head, where the two transverse front suspension tubes mounted to the frame. Although it's not an unknown weakness in VW Beetle construction, it almost



never showed up in a lifetime of normal use for most cars. In Antarctica the cracking could be induced in only a few hundred miles, thanks to the punishing conditions and extremely low temperatures. Antarctica 1 suffered frame head cracking only a month or two after it arrived, thanks to assorted heavy hands and leaden feet. Then again, on washboard-like corrugated ice thousands of years old, and driving over ice cracks ten or twenty centimetres across and bottoming the suspension constantly under full loads of men and equipment in temperatures dozens of degrees below zero, what wouldn't fail in such conditions? The Mawson mechanical workshops soon learnt to diagnose the problem and were always on hand for a welding repair job.

When the 1964 expedition team arrived they brought with them Antarctica 1's replacement — another Volkswagen called Antarctica 2. The new car was also an Australian-made Beetle; a 1963 model painted International Orange. It was fitted out in the same winterised manner, complete with ANARE labels on the doors and special 'Antarctica 2' number plates. It also had the benefit of additional bracing of the front axle to reduce the frame head problem. The orange car was unloaded at Mawson to begin its term of

service, and briefly the two Antarctic VWs stood side by side at the docks for the first and only time, before Antarctica 1 was loaded onto the *Nella Dan* for the journey home.

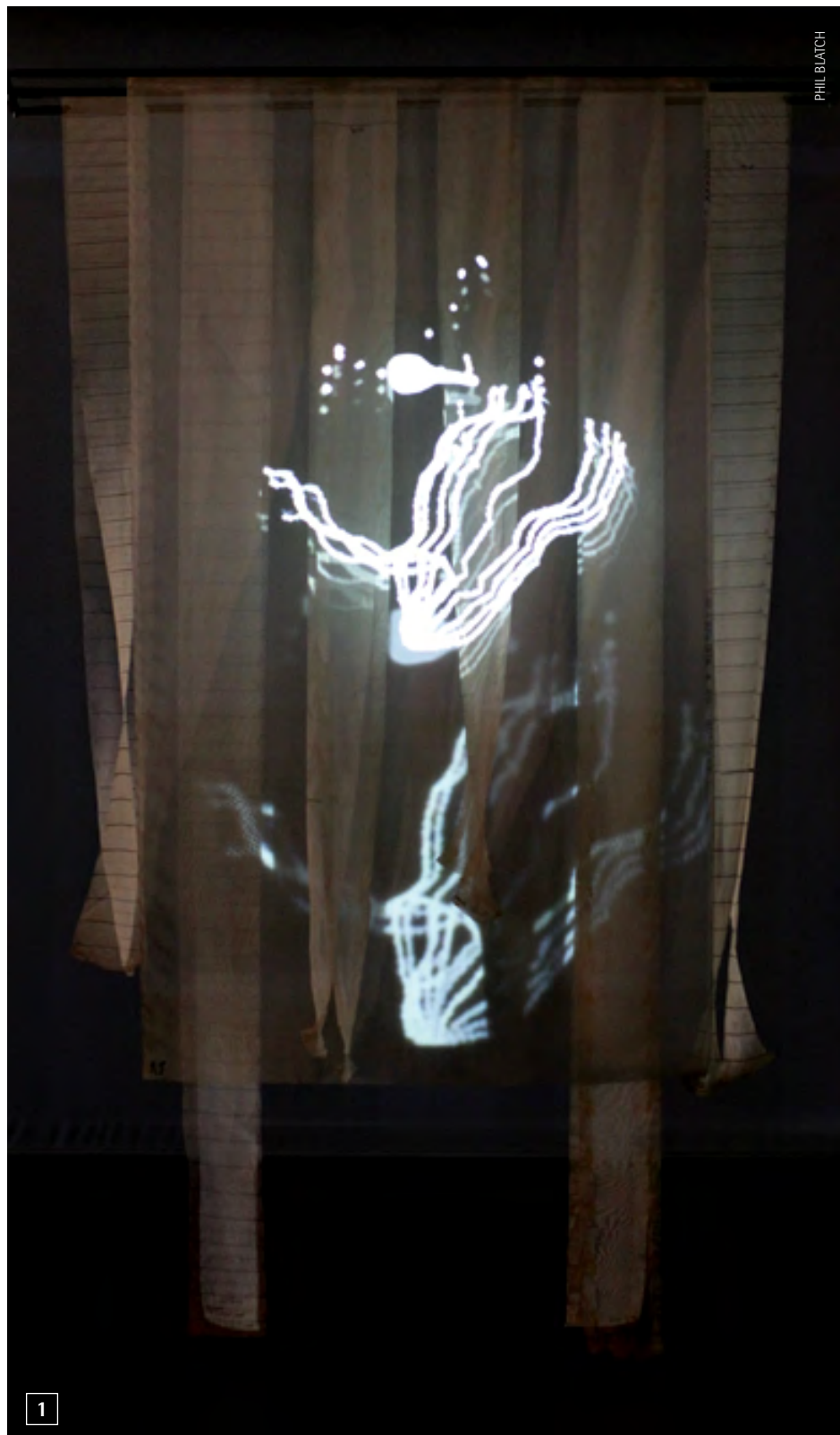
The cine camera was used to make a fascinating short general interest 16mm film called *Antarctica 1* (now on YouTube). There is an original 16 mm copy in the National Library of Australia's collection. A shorter edited version called *Taxi to Rumdoodle* was also released and is currently available on DVD from the Club Veedub Sydney library.

PHIL MATTHEWS
Volkswagen Club, Sydney

1. The Ruby-Red Antarctica 1 proved very useful for 'around station' jobs including transporting supplies out to field teams.
2. A Volkswagen publicity poster for Antarctica 1 that appeared in the *Australian Women's Weekly* on July 10, 1963.
3. Antarctica 2 is unloaded from the *Nella Dan* while Antarctica 1 (foreground) waits to be loaded for its journey back to Australia.
4. The Volkswagen held its own alongside larger tracked vehicles such as Weasels and Caterpillars.

Living data: how art helps us all understand climate change

We hear so much about the integrity of scientific process and the role of data in driving action on climate change — but what role is there for artists in bringing about changes in understandings?



PHIL BLANCH

Science and the arts are often polarised as incompatible ways of understanding the world. That's not necessarily true — and what brings them together is creativity and curiosity.

Creativity is at the heart of art and science and passion drives both as ways of satisfying curiosity and expressing new findings. Science builds a world-view based on currently known facts. Art expresses personal understanding and experience. When a scientific view aligns with lived experience, iconography and story may lead us usefully towards a sustainable future.

The need to understand climate change is urgent. For some people, the facts about climate change don't matter — so we need experiences that stir strong feelings of connection. Artists are leading the way to reconnect methods of analysis and expression in this way. The Living Data program that I lead is one of several initiatives to bring together scientists and artists.

The creative challenge we face is to accurately express the changes happening to natural systems in ways that resonate with feelings of connection. It is not enough to know the science. People process information in different ways, from the mechanistic to the sensory, from Skeptical Science to Green Porn. For that reason, we need to make icons which have a dual resonance, that speak to the mechanistic and the sensory.

This kind of practice is evolving on a global scale through a network of artist-led programs. Conversations between climate change scientists and artists are led through Lynchpin (Hobart), Sur Polar (Buenos Aires), Cape Farewell (London) — as well as the Living Data program.

The programs are led by people with knowledge and concern about how the natural world is changing and the desire to respond most usefully.

How Living Data works

We link up to share data, iconography and stories to expand our reach beyond our labs and studios. We present online, in conferences, exhibitions, public spaces, and academic, mainstream and social media. As scientist Kirralee Baker notes, 'it's not about the story teller but the story to be told'.



2

My role in driving action on climate change is as an artist. My inspiration comes from dance, from my experience of Antarctica — and from 12 years of working with scientists and other artists whose concern is climate change.

A methodology that uses drawing and dance as tools of enquiry is a radical idea for those accustomed to the conventions of the scientific method. But when choreographic analysis is embedded within scientific research, pattern recognition can contribute to some startling discoveries.

Previously unseen behaviour in Antarctic krill is revealed through the patterns in mating dances. As are rhythmic cycles of Antarctic sea ice and the relationship between water temperature and the abundance of marine algae.

My practice is animation and my approach is collaborative. In the Living Data program scientists and artists share data, iconography and methodology, to develop new ways of understanding and expressing changes in natural systems. Dance and drawing are tools that help me generate animations that combine the primal forms of circling, spiralling and crossing that I recognise in scientific data and subjective responses.

Iconography developed through art of many forms can embody sensory connection to scientific data. Scientists and artists involved in Living Data conversations develop new material for presentation and publication.

Physical and online presentations, peer reviews and comments make sure shared material is used ethically and lets everyone see how collaborations evolve and have impacts.

Working together

This practice exemplifies the shift towards collective knowledge production that is essential to advance understanding of climate change.

My work is guided by biological and Indigenous methodologies that acknowledge how the natural world works and is maintained. The story I present does not belong to me or even to the association of research participants. Guided by Indigenous Canadian scholar Shawn Wilson I recognise the story as part of the relationships that exist between us and the natural world.

I recognise iconography we use in art, science and systems of belief as primal forms of connection that are available to everyone.

In Australia I've observed that we — as scientists and artists — tend to express climate change knowledge more quietly in recent years, than do our international colleagues. In our current political climate it is vital that we continue to create and present a global conversation through strong works of pathos, beauty, mystery, wit, pragmatism, human interference, techno wizardry, timeless rhythms and grand symphonic form.

The mix of expressions is vital to inspire and energise new generations of artists and scientists — and to better understand our changing planet.

LISA ROBERTS

University of Technology, Sydney

*This article first appeared in THE CONVERSATION on 5 February 2015:
theconversation.com/living-data-how-art-helps-us-all-understand-climate-change-36890*



3

Artist brings data to life

Visual artist and interactive author, Dr Lisa Roberts, travelled to Antarctica on an Australian Antarctic Arts Fellowship in 2002. Her fellowship inspired her to embark on a PhD to find out how animation could be used to combine scientific data and subjective responses to the changing environment. In 2011 Lisa initiated the Living Data program at the University of Technology, Sydney (UTS), to highlight the understandings shared between scientists and other artists.

In 2014 Lisa received the inaugural C3 Creative Fellowship at the UTS, to further develop animations and installations from conversations with UTS and Australian Antarctic Division scientists. These creative works aim to visualise new understandings of krill, whales, phytoplankton, and other interacting systems and the main drivers of change. In the ten years since Lisa voyaged south, much has changed in understanding Antarctica.

Lisa's work has previously featured in the *Australian Antarctic Magazine*, including her work on animating the krill life cycle. She is a Visiting Scientist at the Australian Antarctic Division. Read more about her work at www.lisaroberts.com.au.

1. An animated installation by Lisa Roberts of Oceanic Living Data that evolves, like a scientific model, to reflect current knowledge of the global ecosystem.
2. Living Data: Evolving Conversations; an exhibition and forum at the University of Technology Sydney in 2014, curated by Lisa Roberts and Anita Marosszeky.
3. Dr Lisa Roberts in her studio in Sydney.

A busy season on the 'bacon index'

This Antarctic season saw 557 people travel in support of the Australian Antarctic program.

The *Aurora Australis* was engaged for 183 days and there were nine direct flights to Wilkins in the A319.

With Wilkins runway operating from November to March, it was our longest flying season yet. But it's the 'bacon index' that perhaps provides the best indication of season activity, with some 1244 kg consumed!

Highlights of the season include the return of the six-week whale research voyage on *Tangaroa* in mid-March. Whales were located acoustically more than 1000 km away from the ship, and scientists completed numerous sampling trawls, visual whale sightings, biopsy collections and more (see page 4).

An early season voyage of *Aurora Australis* to the Totten and Mertz glaciers successfully collected some tricky moorings and many chemical and physical seawater profiles (see page 10).

At Mawson, early fears about sea ice extent did not materialise and the ship made it into Horseshoe Harbour to fully refuel the station. With extra time on their hands after the resupply and refuelling, a team at Kingston Headquarters and on the ship put together a fantastic marine science program for the remainder of the voyage. Some high value science was achieved, including trawling for sample collection, live krill collection and mooring recovery.

Mawson also saw the continuation of the Béchervaise Island penguin monitoring program, while fuel depots were also established along a 600 nautical mile round trip flight from Richardson Lake to Enderby Land, in support of one of our high priority projects to install mass balance GPS equipment.

The folks at Macquarie Island had a busy time restoring their water supply after the biggest rainfall event recorded on the 'sponge' (105.6 mm in 36 hours) filled up Gadgets Gully dam with mud and rock. A lot of work was needed to clear out the dam and fix broken lines to get water flowing again. Despite this, field work continued on the island, including albatross population monitoring, fuel spill bioremediation work and Parks and Wildlife projects, while scientific field huts were restocked and many of the huts flown in for the pest eradication project were removed.

At Casey, scientists running the Free Ocean Carbon Enrichment (FOCE) experiment (see page 8) successfully installed and operated ocean acidification chambers under the sea ice in O'Brien Bay. A hydrographic survey crew were also out on the water around Casey and a swag of French expeditioners moved through Casey (via the A319) and up to Dome C by air.



GORDON TAIT

The Casey team managed a successful resupply early in the season, while hosting a Channel 7 media crew and our Minister, Secretary and Deputy Secretary on a multi-day VIP trip.

Ocean acidification work continued at Davis, using 'minicosms' installed in shipping containers on the shoreline (see page 20). Davis also supported a Chinese geology team with trips to Mount Brown and the Beaver Lake area. Science work at the Amanda Bay penguin colony was also completed from Davis. The concrete slab for the new waste management facility was poured and installation of the first tank completed. The Davis team also put in an amazing effort to assist the medical evacuation of a sick team member back to Hobart on the ship.

In February the United States terminated a high altitude balloon flight for NASA's ANITA III astrophysics experiment, just 100 nautical miles from Davis. Two of our helicopters collected the science payload, which was jettisoned from 125 000 feet by parachute.

In April we undertook a proof of concept flight for the United States program, taking 14 US expeditioners direct from Hobart to McMurdo. The A319 collected the expeditioners from a commercial flight in Melbourne and flew

them to Hobart, where they were kitted with pre-positioned US clothing. Currently, the US flies all their Antarctic expeditioners stationed at McMurdo via Christchurch in New Zealand. It is hoped the flight will prove that flying to McMurdo via Hobart is a viable cost-effective option that might complement the existing route through Christchurch.

Operations down south continue now with 68 winter expeditioners across the four stations engaged in maintenance, science, infrastructure projects, and programs for the Tasmanian Parks and Wildlife Service and Bureau of Meteorology.

Thanks go to everyone involved in making this season so successful, safe and efficient.

ROBB CLIFTON

Operations Manager, Australian Antarctic Division

1. The A319 made nine direct flights from Hobart to Wilkins Runway in the longest flying season yet. It also conducted a test flight, delivering United States Antarctic Program personnel to McMurdo.

Addressing sea ice impacts on Antarctic operations

The impact of changing sea ice conditions on Antarctic operators was the focus of an international workshop in Hobart in May.

The two day Antarctic Sea Ice Challenges Workshop, was convened by the Council of Managers of National Antarctic Programmes (COMNAP) and jointly hosted by the Australian Antarctic Division and the Antarctic Climate and Ecosystems Cooperative Research Centre (ACE CRC).

The workshop brought together 58 of the world's Antarctic program managers and scientists, for the first time, to examine the latest scientific advice on the causes and likely future trends in sea ice cover, and to identify potential solutions.

COMNAP Executive Secretary Michelle Rogan-Finnemore said challenging sea ice conditions in some parts of Antarctica, including thicker and more extensive sea ice coverage, were affecting the delivery of Antarctic scientists, support personnel and supplies to Antarctic research facilities.

'Innovative and pragmatic approaches are needed to solve these evolving challenges,' she said.

Professor Tony Worby, CEO of the ACE CRC, said changes in sea ice conditions were largely driven by strengthening westerly winds around Antarctica, as a result of changes in atmospheric chemistry and interactions with other climate variability drivers. Local effects resulting from sea ice build-up around grounded icebergs were also part of the problem.

He said each of the past three years had broken the record for sea ice extent, creating a challenge for ships and in some cases causing a complete rethink of how Antarctic stations are resupplied.

Australian Antarctic Division General Manager of Operations, Dr Rob Wooding, said that in the 2013–14 summer, for example, the Division had to refuel Mawson station by helicopter when thick sea ice prevented access to the station by ship. Similar problems are being encountered by French and Japanese expeditions.

'The main purpose of this workshop was for national Antarctic programs and other operators in the Southern Ocean to speak with leading sea ice researchers and analysts about the challenges of changing patterns of sea ice distribution and how operators and experts could work together to respond to these challenges,' Dr Wooding said.

'These discussions focussed on improved sea ice charting and forecasting services to assist navigation.'

Professor Worby said sea ice thickness remains one of the hardest climate parameters to measure and monitor, although improving satellite technology is providing imagery that can be sent directly to ships, helping them choose the best possible route through the sea ice.

'The use of autonomous underwater vehicles, equipped with upward-looking sonar and video is also providing new insights into the complex under-ice world of the Antarctic sea ice zone,' he said.

The outcomes from the workshop will be published by COMNAP later this year (www.comnap.aq).

CORPORATE COMMUNICATIONS



DR JAN LIESER AND
AERIAL IMAGING GROUP

Challenging sea ice conditions in East Antarctica have brought polar operators and scientists together to solve operational challenges.

Director retires

The Director of the Australian Antarctic Division, Dr Tony Fleming, has announced he will leave the Division in August.

Dr Fleming became the Director of the Australian Antarctic Division in 2011 (*Australian Antarctic Magazine* 21: 1–3, 2011) following a long career in the federal and state public services and the not-for-profit sector.

He said it has been a privilege to be at the helm of such a strategically important government organisation for four years.

'I am proud to have been a part of such a dynamic organisation and to have played a role in steering the future direction of Australia's Antarctic program, ensuring we continue to work collaboratively with our international partners to improve global understanding of this magnificent region,' he said.

During his time with the Division, Dr Fleming has been the Australian Commissioner of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), playing a key role in developing a proposal for Marine Protected Areas off East Antarctica. In 2012 he led a commemorative voyage to Mawson's Hut at Commonwealth Bay, as part of the centenary of the Australasian Antarctic Expedition 1911–1914.

He championed the importance of promoting understanding and awareness of the value of Antarctica and the Australian Antarctic program by encouraging visits by high level officials, including hosting the first visit by an Australian Governor-General, Ms Quentin Bryce AD CVO, in 2013.

Dr Fleming has also driven the modernisation of the Australian Antarctic program, including the procurement process for a new Australian icebreaker to replace the ageing *Aurora Australis*.

NISHA HARRIS

International Year of Light

The United Nations' International Year of Light was launched in Paris – the City of Lights – in January, kicking off a year celebrating light science and its applications.



A spectacular green aurora is intersected by the LIDAR (light detection and ranging) laser beam at Davis station.

The goal of the International Year of Light is to raise global awareness of how light and light-based technologies – such as lasers, UV and X-ray sources, and photonic electronics – promote sustainable development and provide solutions to global challenges in energy, education, agriculture, communications and health.

Scientists and expeditioners in Antarctica are reliant on light and light-based technologies. Just some examples include:

- The dramatic seasonal changes in day length that affect daily life on station;
- The use of solar power to run VHF radio repeaters, remote radio installations and automatic weather stations;
- Remote sensing technologies such as LIDAR (light detection and ranging) instruments to measure sea ice thickness, snow cover and atmospheric properties;
- Communication systems such as the internet, video conferencing and telemedicine, which connect Antarctic stations to the rest of the world.

In Australia, a range of activities will promote improved public and political understanding of the central role of light in the modern world, while also celebrating noteworthy anniversaries – from the first studies of optics 1000 years ago to discoveries in optical communications that power the Internet today. For more information visit light2015.org.au.

WENDY PYPER

Adding value to research data

The Australian Antarctic Data Centre (AADC), which is responsible for long-term management of Australia's Antarctic data, is now a 'recommended repository' for the *Nature* journal *Scientific Data*.

This journal aims to make research data more widely available and reusable, by publishing detailed descriptions of how data is produced and what quality-control experiments were performed.

AADC Manager Dr Ben Raymond said the new affiliation means that anyone lodging data with the AADC can also consider publishing a data paper.

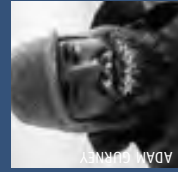
'This paper is, in essence, an extended description of the data, giving extra exposure to their work and highlighting its value to the broader scientific community,' he said.

Further information about *Scientific Data* and data repositories is available at www.nature.com/news/announcement-launch-of-an-online-data-journal-1.13906

JILL BROWN



Dr Tony Fleming at Mawson's Huts during the commemorative centenary voyage in 2012.



FREEZE FRAME

Expedition mechanic, Corey Brazendale, has completed two winters at Davis and one summer at Mawson. As well as servicing and fixing heavy vehicles and equipment, Corey volunteered on the stations' emergency response teams and provided 'lay surgical' assistance to the stations' doctors. His work as a volunteer firefighter with the Tasmanian Fire Service has taught him not to over-react in stressful situations.



This photo was taken during the 2014–15 resupply voyage of Mawson station on a relatively calm night. It was the last opportunity I had to wander around the base after a busy summer season, before departing for Davis. I had been walking at West Arm, saying my farewells to the lazing Weddell seals, moulting Adélie penguins and the station off in the distance. On my return I had to pause to admire the Aurora Australis safely moored under the heavy skies in Horseshoe Harbour. Luckily I had my tripod handy and the long exposure shot really captured the mood of the night. (Nikon D800E, Sigma 35mm, f1.4).

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