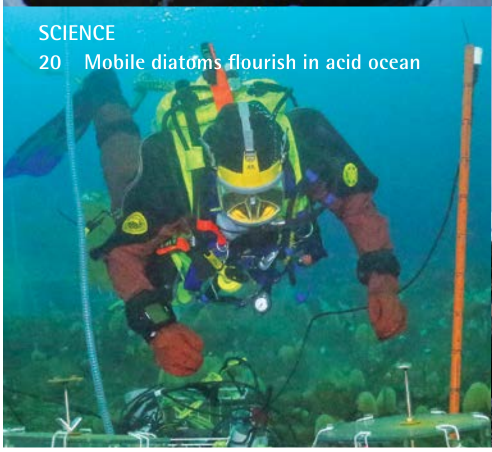
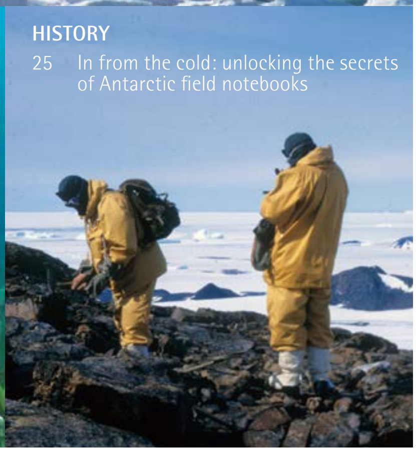
AUSTRALIAN

ANTARCTIC

MAGAZINE

ISSUE 31 | 2016





CONTENTS

ABOUT THE COVER

This photograph of an Adélie penguin sizing up the bow of the *Aurora Australis* was taken by Dean Lewins, a senior staff photographer for Australian Associated Press (AAP) for the past 18 years (and a photojournalist for 30 years). Dean has covered major sporting events, including six Olympic Games, and the conflict and unrest in East Timor, Solomon Islands and Iraq. Travelling to Antarctica with the Australian Antarctic Division for the Mawson Centenary in 2012 was a once in a lifetime assignment.

The Australian Antarctic Division, a Division of the Department of the Environment and Energy, 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.

Australia's Antarctic national interests are to:

- Preserve our sovereignty over the Australian Antarctic Territory, including our sovereign rights over the adjacent offshore areas.
- Take advantage of the special opportunities Antarctica offers for scientific research.
- Protect the Antarctic environment, having regard to its special qualities and effects on our region.
- Maintain Antarctica's freedom from strategic and/or political confrontation.
- Be informed about and able to influence developments in a region geographically proximate to Australia.
- Derive any reasonable economic benefits from living and non-living resources of the Antarctic (excluding deriving such benefits from mining and oil drilling).

Australian Antarctic Magazine is produced twice a year (June and December). *Australian Antarctic Magazine* seeks to inform the Australian and international Antarctic community about the activities of the Australian Antarctic program. The views and opinions expressed in this publication are those of the authors and do not necessarily reflect those of the Australian Government or the Minister for the Environment and Energy.

Editorial enquiries, including requests to reproduce material, or contributions, should be addressed to:

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 31: December 2016

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

From the Director

This year we are celebrating two important milestones — the 30th anniversary of the moratorium on commercial whaling and the 25th anniversary of the signing of the Protocol on Environmental Protection to the Antarctic Treaty (Madrid Protocol).

As this magazine went to press I attended the annual International Whaling Commission meeting in my new role as Australia's Commissioner to the IWC. Australia was instrumental in establishing the moratorium on commercial whaling in 1986, and as Commissioner I will continue to advocate for a permanent end to all forms of commercial whaling and so-called scientific whaling. Australian researchers, many coordinated by the Australian Marine Mammal Centre at the Australian Antarctic Division, have demonstrated that all information necessary for the management and conservation of whales can be obtained through non-lethal methods.

Australia, alongside France, also played a key role in the development and signing of the Madrid Protocol, which bans mining in Antarctica indefinitely and designates Antarctica as a natural reserve, devoted to peace and science. The Protocol has been a highly successful agreement, providing a framework for advancing environmental protection and accommodating emerging environmental challenges. At this year's Antarctic Treaty Consultative Meeting, Antarctic nations issued the 'Santiago Declaration', reaffirming their commitment to the objectives and purpose of the Antarctic Treaty and Madrid Protocol (page 29).

Among the rules for Antarctica's protection are requirements that environmental impact assessments are completed for planned activities. This issue of the magazine includes one such example at Davis research station, aimed at identifying the level of wastewater treatment needed to ensure that Australia meets its environmental responsibilities under national legislation and the Madrid Protocol (page 14).

Wastewater management is recognised by all national Antarctic programs to be a complex issue, and a wide range of technologies are in use across Antarctic stations. In the last issue of this magazine we showcased the truly cutting-edge advanced wastewater treatment plant developed by the Australian Antarctic Division and a range of academic and industry partners, as a result of our scientists' environmental impact assessment advice. This technology has now been nominated for an engineering excellence award.

Another exciting engineering project is of course the design and build of our new Antarctic icebreaker (page 2). The icebreaker is the centrepiece of our *Australian Antarctic Strategy and 20 Year Action Plan*, launched by the Australian Government in April this year. In this issue we look at what it takes to build a multi-purpose ship that meets the challenges of science and resupply today and 30 years into the future.

In this first year of the *Action Plan* we are also developing options for future aviation capabilities that provide year-round access to Antarctica. This is not a commitment to build a year-round runway; at this stage we are only scoping environmental and operational costs of establishing such a capability.

Similarly, we have begun scoping development of a deep-field overland science traverse capability and mobile research station infrastructure — both essential for Australia's involvement in major Antarctic research projects, including the quest for a million year-old ice core.

Our traverse investment, combined with work towards an expanded aviation capability, will significantly improve Australia's leadership in science and operations and offer Australia's Antarctic Program unprecedented access to and across East Antarctica.

If science is the 'currency' of Antarctica then the Australian Antarctic Science Program has proven its worth this year with a range of important research papers published. This season we have a number of exciting projects on the go that will continue to add to this knowledge bank in years to come. (See the science pages of this magazine for an overview).

Our sub-Antarctic station on Macquarie Island has also been an important focus of research effort for the past 70 years and the Australian Government has recently committed $50 million to replace the ageing station with state-of-the-art infrastructure that supports globally important science and a permanent, year-round presence.

Planning to decommission and remove ageing infrastructure on the island is now underway, with a focus on lightening the environmental footprint on this important World Heritage site. The new research station is expected to be operational in 2021–22.

Dr NICK GALES
Director, Australian Antarctic Division

Future-proofing icebreaker science

How do you build an Antarctic science and resupply ship that retains its leading-edge status into the future? It's a question the Australian Antarctic Division's Modernisation Taskforce has been grappling with during the design of Australia's new Antarctic icebreaker, which has an expected life span of 30 years.

The new multipurpose ship, which will replace the *Aurora Australis* in the 2020–21 season, will have an icebreaking capability of 1.65 metres at three knots, a 1200 tonne solid cargo capacity, and the ability to meet changing scientific requirements.

It is this last capability that is particularly sensitive to future-proofing, and the demands for ongoing scientific capability have a big impact on the whole structure.

Silent ship

As the Icebreaker Project Manager, Nick Browne, explained, an important part of the ship's scientific capability will be its acoustic instruments. These will be used to conduct seafloor and habitat mapping, visualize and measure the biomass of marine organisms in the water column, and measure ocean currents. To do this the instruments, mounted in the ship's hull, send pings of sound out into the environment and listen to the returning echo to create images of their surroundings. But to work effectively they need a degree of hush.

"A major design challenge for the ship is the requirement for low acoustic noise, so as not to interfere with the quality and detection range of these scientific instruments," Mr Browne said.

"Noise radiated away from the ship can also affect the behaviour of fish and other marine organisms.

"So the ship will be built to a 'Silent R' rating at speeds up to eight knots, ensuring very quiet operations during scientific surveys."

To achieve this rating a significant amount of work has gone into the design of the ship's hull and propulsion system, to reduce noise associated with the engines, gear boxes and propellers, and bubble formation and movement, while still maintaining the required icebreaking capacity and efficiencies in ocean transit. Big diesel engines directly drive the propellers when icebreaking, while quiet electric motors, powered by diesel generators on flexible mounting systems, power the ship for silent research operations.

To get the hull and propeller system right, hydrodynamic consultants used numerical modelling (computational fluid dynamics) to optimise the design. They then built a six-metre model to conduct a range of physical tests — icebreaking, propeller cavitation (generation of air bubbles in areas of low pressure) and sea-keeping (response to waves).

As an added level of precaution the ship also has two drop keels, packed with acoustic sensors, which drop below the bubble layer formed by ocean waves. These duplicate some of the multibeam and bioacoustic capabilities installed in the hull, but include other instruments and an "expansion space" for future equipment.

Flexible science platform

With the fundamental performance requirements bedded down, the ship design is now focused on delivering a flexible scientific platform that can react to changing scientific needs.

Scientific Research Systems Lead, Mr Jono Reeve, is responsible for channelling the needs, wants and dreams of scientists into the final design. The process has involved many months of workshops with scientists, the development of position papers by experts in oceanography, atmospheric science, marine geoscience, glaciology and biological science, and ongoing consultation with key parties as plans for work spaces and equipment interfaces are drawn up.

The process has also drawn heavily on the work done for CSIRO's Marine National Facility, RV *Investigator*; the new icebreaker will match *Investigator's* scientific capabilities in blue water, but will extend them into the ice.

"We looked at best practice around the world and asked what the future directions were for science and what capabilities would be important," Mr Reeve said of the process.

"Scientific research voyages often require a unique combination of activities and sometimes activities not previously undertaken. So you need a platform that's flexible enough to support the new activities that come up.

"The fundamentals of that platform are low noise, good deck handling equipment such as winches and cranes built into the ship, and an open deck that gives you the space and flexibility to do new things." (See boxed text).

Time-saving design

Many of the scientific design considerations aim to improve efficiencies in operation and reduce the amount of time the ship has to stop for science. The moon pool inside the ship, for example, is a 13 m vertical shaft, four meters square, which runs from the science deck through the hull to the ocean. When its hatches are open, the moon pool allows instruments that were previously deployed only in open water, to be deployed in bad weather and sea ice.

"Once the ship is surrounded by sea ice we can use the moon pool to drop nets and deploy remotely operated vehicles and CTDs (conductivity, temperature and depth rosettes)," Mr Reeve said.

"The moon pool will also allow us to deploy equipment at the same time as we're running nets or other equipment off the stern, so that we can make the most of the ship's time."

One possible addition to the ship's scientific capability is a "wet well sampling space", centred in the hull, below the water line (see story page 7). Large volumes of water would gravity feed into the wet well via observation tanks and filter tables designed to catch krill and more fragile life forms such as jellyfish and salps.

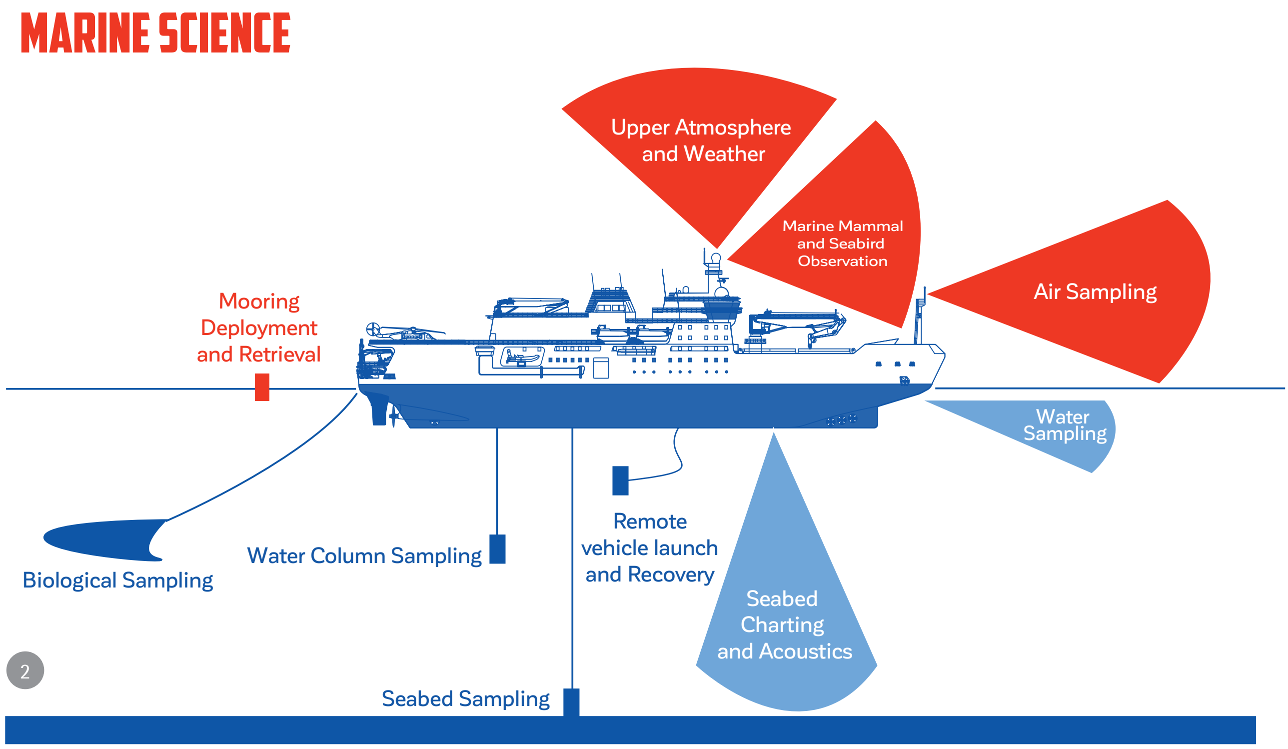
The brainchild of krill researcher Rob King, the wet well idea solves a major conflict between scientific and resupply needs, by allowing some science activities to be undertaken independently of other ship priorities.

To meet changing scientific needs the new icebreaker will have:

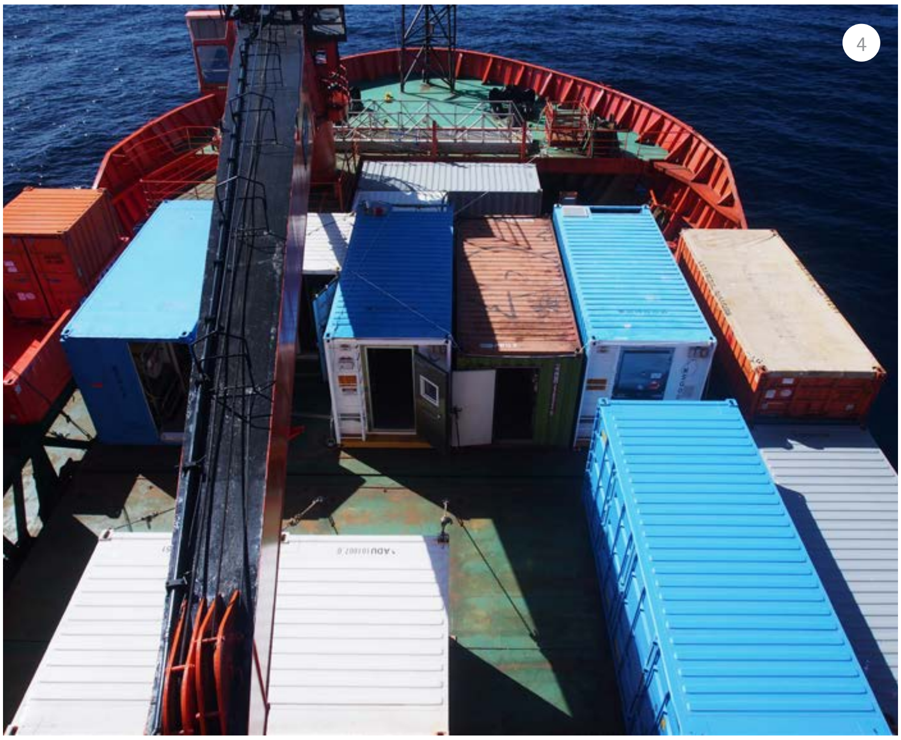
- state-of-the-art scientific equipment, including a moon pool;
- space for up to 30 science containers on the aft deck, above the heli-hanger and at the front of the heli-deck;
- a range of power and water supplies for containerised laboratories;
- overhead cranes, specialist winches and a 30 tonne A-frame to lift and position containers and equipment, sediment coring systems and rock drills;
- a range of towing points to deploy nets and other equipment;
- fibre optic cables with bandwith suitable for real-time video for underwater sensors;
- three small boats ('tenders') and a science tender for nearshore surveys, to take samples or retrieve equipment, and to deploy personnel from ship to shore.

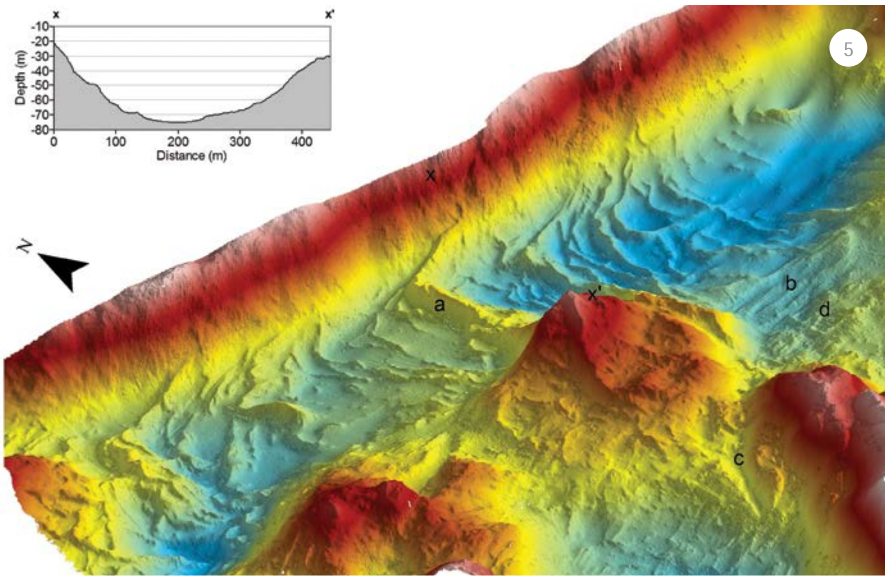
1. *An Autonomous Underwater Vehicle is deployed from the trawl deck of the* Aurora Australis. *On the new ship, instruments that previously had to be deployed from the trawl deck or CTD door, can be deployed through the moon pool during bad weather or while the ship is in the ice. (David Lubbers)*

2. *The new icebreaker has many scientific capabilities. (Rob Bryson)*



2





"To catch krill we usually deploy a trawl net, which involves slowing and stopping the ship for a few hours. If you haven't got time to stop, or there's ice in the way, bad luck," Mr King said.

"The wet well will allow us to capture live krill and other planktonic organisms, in the open ocean and the ice, without stopping the ship or interfering with other activities."

Winning synergy

For the Modernisation Taskforce, the design development process (conducted in consultation with Serco [or DMS Maritime] and vessel designer Damen) has largely been about finding synergies between the three non-negotiable ship functions – icebreaking, science and station resupply. There's a long way to go yet before the blueprints for internal spaces, fixtures and fittings are finalised, but the team is confident they're on a winner.

"This ship will open up new opportunities for Australian scientists and international collaborators," Mr Reeve said.

"Science will continue developing new questions, and this ship will be flexible enough to support answering them. In fact, I can't think of any ship that will be able to combine icebreaking, science and logistics better than this."

WENDY PYPER
Australian Antarctic Division

3. *Jellyfish-like salps (pictured) are important prey species for larger marine organisms. Bioacoustic transducers can be used to identify such organisms in the water column and measure their biomass. On the new ship, salps and other fragile organisms could be collected in observation tanks in the 'wet well sampling space.' (Wendy Pyper)*

4. *Containerised laboratories on the fore deck of the* Aurora Australis. *The new ship will have the capacity to house fourteen 20-foot and six 10-foot science containers on the aft deck, four containers above the heli-hanger, and 10 in the sea ice staging area within the hold. These science containers will be serviced by a variety of water, power and communication services. (Wendy Pyper)*

5. *A map of the seafloor of Newcomb Bay (near Casey research station) created using a mulitbeam echosounder. A U-shaped valley typical of a glacially eroded channel is visible (blue), with a glacial moraine at 'a', which is about 25 m high. (Royal Australian Navy/Geoscience Australia)*

Heavy lifting

As well as providing a platform for science, the new icebreaker must resupply Australia's three Antarctic stations and Macquarie Island. To do this the ship can carry 1200 tonnes below decks, in up to 96 20-foot shipping containers. Further containers and very large items can be carried on the cargo hold hatches. The ship also has storage for some 30 more containers on the science deck and elsewhere around the ship.

The two below-deck holds, however, are the workhorses of station resupply. Each hold can carry 48 containers. The forward hold is designed for dangerous cargo (such as drums of aviation fuel), while the rear hold can accommodate another 48 shipping containers or a mix of containers and oddly-shaped cargo, such as heavy vehicles.

"This cargo capacity is a major increase on the 19 containers that can be carried in the holds of *Aurora Australis*, and potentially enables the resupply of two stations in one voyage, rather than one at a time," Shipping Interfaces Manager, Mr Vic Doust, said.

To move all these containers and heavy equipment around, the ship has two 55 tonne 'knuckle-boom' cranes next to the main holds, a 15 tonne crane on the helideck and a 15 tonne side-loading crane that can move containers from the wharf to the science aft deck.

Once at station there are a range of options for transferring cargo from ship to shore.

Two barges will be able to carry over 45 tonnes each, enabling then to carry a truck loaded with a 20 foot container to and from the ship. In a loop between the ship and station the trucks will deliver cargo to the station and 'return to Australia' cargo to the ship.

Three smaller watercraft ('tenders') are available to move passengers from ship to shore, while a fourth science tender is available for inshore studies and to survey unchartered areas.

The new ship also has space for four AS350 B3 helicopters or two medium-sized helicopters similar to Sikorsky S92s. This capacity will enable the ship to be utilised by a range of other agencies outside the Antarctic season, including for humanitarian missions.

The B3s can sling load up to 1200 kg at a time from ship to shore. Four helicopters will be able to operate at a time, with one potentially landing on the aft helideck, another sling loading cargo from the front, and two others in-transit or off-loading ashore.

1. *Barges play a critical role in station resupply — seen here delivering a refrigerated container to Casey research station. The new icebreaker will have two much larger barges capable of carrying over 45 tonnes each. (Wendy Pyper)*
2. *A side-by-side comparison of the new icebreaker and the* Aurora Australis. *(AAD)*

One of the exciting new possibilities enabled by the size of the ship is concurrent operations. For example, both main cargo cranes could be loading barges, while helicopters load cargo from the heli-deck. Similarly, science operations can occur at the stern, side of the ship, and forward sea ice boom, at the same time. This will significantly reduce the time needed for resupply and science operations.

When it comes to refuelling, the ship can carry up to 1.9 million litres of fuel — enough for two stations. To facilitate over-water and over-ice refuelling operations the ship has a 'dynamic positioning system', which allows it to hold its position in high winds, tides and sea states within ±20 metres. This means the ship can get closer to the station than the *Aurora Australis*, so that during refuelling over water and ice there is less hose pipe interacting with sea ice, and improved pumping efficiency — reducing the time required to refuel and the hazards involved.

The size and scale of the new ship offers a new paradigm for science and resupply operations — it is now up to the Australian Antarctic Division to make the most of it.

WENDY PYPER
Australian Antarctic Division

Icebreaker at a glance

The new icebreaker will provide a state-of-the-art platform to conduct multidisciplinary science in sea ice and open water. It will also deliver personnel, cargo and equipment to and from Australia's Antarctic stations and Macquarie Island.

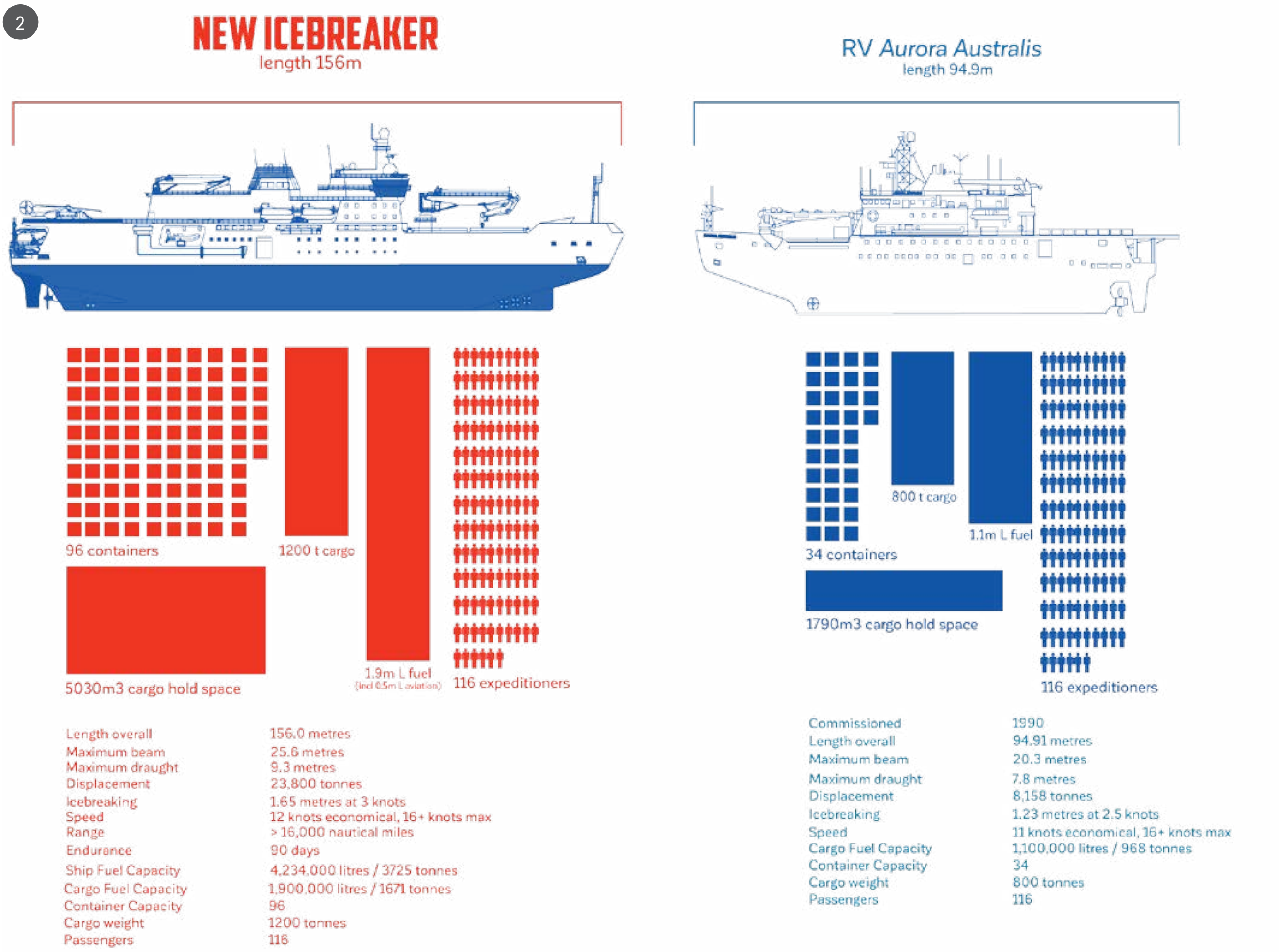
The icebreaker will be able to handle:

- waves up to sea state 9 (over 14 metres significant wave height);
- wind speed up to Beaufort 12 (hurricane);
- air temperature ranging from –30°C to 45°C; and
- water temperatures ranging from –2°C to 32°C.

As well as its modern scientific capabilities (see story page 2) the ship will be able to:

- travel at an efficient cruising speed of 12 knots, with a maximum sustained speed of 16 knots in open water;
- break 1.65 metre-thick ice at a continuous speed of 3 knots;
- transfer personnel and cargo from ship to shore, over water, ice and by air;
- support the use of four light helicopters or two medium helicopters;
- handle, stow and transport up to
  - 1200 tonnes of solid cargo consisting primarily of containers and break bulk cargo, including large items of plant and equipment, and
  - 1 900 000 litres of bulk liquid cargo (Special Antarctic Blend diesel used for station operations);
- support voyages for up to 90 days, which includes the ability to remain within the Antarctic area for up to 80 days;
- accommodate 116 personnel; and
- ensure minimal environmental impact.

2



New ways to catch krill

Krill researcher Rob King has spent many frustrating hours on the deck of the *Aurora Australis* observing overturned ice floes peppered with krill, as the ship ploughed relentlessly south.

"I've spent a lot of time looking at the ice and wishing I had access to the water column as we were bashing our way to station, knowing there were krill under there," he said.

"But you can't stop and dig a hole to get them out. It's intensely frustrating."

As one of the collectors for the Australian Antarctic Division's krill aquarium, Rob needs to catch enough wild krill each year (about 25 000) to sustain important experiments on the animals' life cycle, behaviour and response to climate change.

To do this he deploys a special 'rectangular midwater trawl' net into the open ocean, when a krill swarm is detected with the ship's acoustic echosounders. His ability to do this, however, often depends on how it interferes with other scientific activities or station resupply timeframes and priorities. And krill are often found close to the ice edge, or within the sea ice zone, where deploying a net may be difficult.

So Rob came up with a solution that he hopes can be incorporated into the design of the new icebreaker (see page 2); to build a watertight room, or "wet well", deep in the heart of the ship that can process large volumes of seawater.

"The wet well would be located below the water line and connected to the outside by inlets, at two and five metres below the surface and in the keel," Rob explained.

"Water would gravity feed to large viewing tanks and filter tables and adult and larval krill would end up at the end of the filter tables, where we could collect and transfer them to a temporary aquarium in the wet well space.

"The idea of the viewing tanks is that if we see a very fragile organism, such as a jellyfish, we can shut down the water flow and remove the animal from the viewing tank before it reaches the filter table and disintegrates."

Locating the water inlets at different depths would allow scientists to see how the krill and plankton community changes over time — as many marine organisms are known to rise to the surface at night to feed, and descend during the day — while the ability to catch fragile organisms would open up new research opportunities.

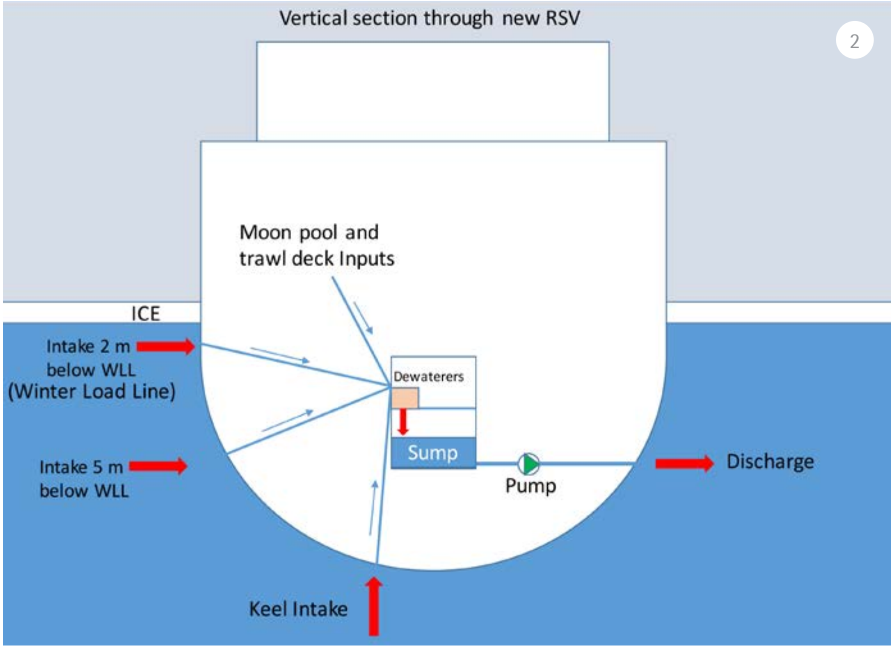
"There are many fragile species that we know little about because only divers have been able to collect them in perfect condition," Rob said.

"Some of these species could become more prominent ecosystem players if krill are negatively affected by climate change in the future. So we'll hopefully be able to collect them live and in perfect condition, and study their growth rates, physiology, reproduction and behaviour."

While the idea is novel, Rob has a high degree of confidence in its success, based on previous work that catalysed his vision. This included work on *Aurora Australis* and on the German icebreaker *Polarstern* in 2013, where Rob set up a filter table in the moon pool area of the ship.

"We were able to pump about 900 litres per minute on to the filter table and we caught krill larvae in really good condition; so we proved the idea works," Rob said.

"We expect this new design would work well when the ship is stationary or moving slowly through ice, rather than at cruising speed.



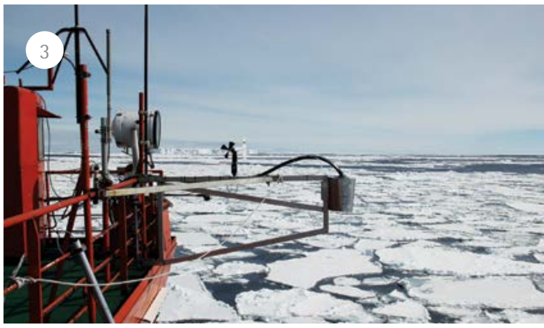
While the wet well may not catch krill as quickly as a big trawl, it could provide access to previously inaccessible water (due to sea ice cover or rough conditions), and at times when krill are in very high abundance. Critically, it could enable scientists to capture the animals in perfect condition, without losing ship time to do it.

WENDY PYPER
Australian Antarctic Division

1. *Previous efforts to catch krill in the sea ice zone have involved fishing with hand nets – a cold and inefficient process. (Rob King)*
2. *The new wet well could allow scientists to filter large volumes of seawater. The room is expected to have multiple inlets, three filter tables ('dewaterers') and small aquariums to temporarily house captured animals. (Rob King)*

This Picture
Rob King with a filter table, connected to a fish pump, set up on the Aurora Australis. *While this set up did catch some krill, water had to be pumped through a long tube passed out of the side of the ship into a hole in the sea ice, resulting in a flow of only 300 litres/minute. (Wendy Pyper)*

Sea-ice bacteria involved in mercury transformation



Scientists have found evidence that certain bacteria can convert mercury into the neurotoxin methylmercury in Antarctic sea ice.

The discovery, published in *Nature Microbiology* by an international team led by PhD student Caitlin Gionfriddo and Dr John Moreau of the University of Melbourne, is the first to show that sea ice bacteria are capable of converting mercury into a more toxic form.

"Mercury is a heavy metal pollutant that is released into the atmosphere through volcanic eruptions, bushfires and human activities such as gold smelting and burning fossil fuels," Ms Gionfriddo said.

"Our study shows that atmospheric mercury deposited onto sea ice and seawater can be methylated by microbes."

While this process could contribute to the 'bioaccumulation' of the neurotoxin in the Antarctic marine food web (where predatory organisms accumulate mercury [mostly methylmercury] contained in their prey), other studies have shown that both Antarctic krill and toothfish contain low levels of mercury, considered safe for human consumption.

Ms Gionfriddo collected sea ice, snow, brine and seawater samples for the study* during the Australian Antarctic Division's Sea Ice Physics and Ecosytem eXperiment-II voyage in 2012 (*Australian Antarctic Magazine* 23: 4, 2012). The samples were analysed for different forms of mercury at the United States Geological Survey in Wisconsin, while DNA and proteins from sea ice microorganisms were studied at the University of Melbourne and the Lawrence Livermore National Laboratory in California.

The team found slightly enriched concentrations of mercury and methylmercury in sea ice compared to seawater, consistent with atmospheric deposition of mercury and subsequent methylation within the sea ice.

The team also confirmed the presence of a marine bacterium, *Nitrospina*, carrying genes that allow it to convert mercury into methylmercury.

No-one really understands why some bacteria produce methylmercury. However, Dr Moreau said their presence in sea ice suggests they could play a role in forming the methylmercury observed in the oceans worldwide.

The study highlights the importance of reducing mercury contamination in the environment.

"Some people think that because the Southern Ocean is so far removed from industrial contamination in the northern hemisphere that it's less of a problem," Dr Moreau said.

"But geographic isolation seemingly provides no protection from human-made and natural toxins."

WENDY PYPER
Australian Antarctic Division

*Australian Antarctic Science project 4032

More information

Gionfriddo C.M., Tate, M.T., Wick, R.R. et al (2016). Microbial mercury methylation in Antarctic sea ice. Nature Microbiology. DOI 10.1038/NMICROBIOL.2016.127 http://www.nature.com/articles/nmicrobiol2016127

1. *University of Melbourne PhD student Caitlin Gionfriddo collected sea ice, snow, brine and seawater samples to study their methylmercury content, during the Sea Ice Physics and Ecosystem eXperiment voyage in 2012. (Caitlin Gionfriddo)*
2. *PhD student Caitlin Gionfriddo during the sea ice voyage in 2012. (Expeditioner photo)*
3. *Caitlin Gionfriddo collected air samples to analyse atmospheric mercury concentrations, onboard the* Aurora Australis *in 2012.*

Exposing a sulphur-mediated microbial liaison

Novel bacteria traps, heavy molecular labels and UV chambers will be deployed by marine scientists at Davis this summer, to understand the sulphur-mediated attraction between Antarctic phytoplankton and bacteria.

The distinctive 'smell of the sea' is the result of an important sulphur-cycling relationship between phytoplankton and bacteria. But the intimate details of this liaison are not well known.

To find out more, marine biologist Dr Katherina Petrou and her colleagues from the University of Technology Sydney, are conducting a project* at Davis research station this summer to identify the bacteria involved and the effects of climate-related stressors on the sulphur cycle.

"We know that many species of phytoplankton, including Antarctic diatoms and haptophytes, transform sulphur in seawater into dimethylsulphoniopropionate (DMSP), which is very attractive to some bacterial species as a carbon and sulphur source," Dr Petrou said.

"But we don't know which bacteria are involved or how changes in DMSP production as a result of environmental stressors might influence the structure of the microbial community and subsequent chemical processes."

This is important because when bacteria consume DMSP, released when phytoplankton die, they can either use it for their own growth needs, or metabolise it into dimethylsulphide (DMS). This volatile compound ventilates into the atmosphere, creating the sea smell reminiscent of boiled cabbage and forming aerosols that can promote cloud formation and subsequently influence regional climate.

One of the key questions Dr Petrou's team wants to investigate is how increased ultraviolet light exposure affects phytoplankton production of DMSP and its subsequent fate. Phytoplankton generally exist in the sunlit layers of the ocean, from the surface down to about 100 m depth. But as the ocean warms in response to climate change it can become more stratified, with warmer waters on top, trapping the phytoplankton in the uppermost, more exposed surface layer.

"One of the effects of ocean warming is that the surface mixed layer where phytoplankton reside becomes shallower, exposing the cells to more light and UV in a daily cycle," Dr Petrou said.

"Studies elsewhere suggest that DMSP production increases under UV stress and we want to see whether this holds true in Antarctica and whether this shift affects the bacterial community and ultimately the fate of sulphur in the ocean.

"Will more DMS be released into the atmosphere or will the DMSP be utilised in the marine food web?"

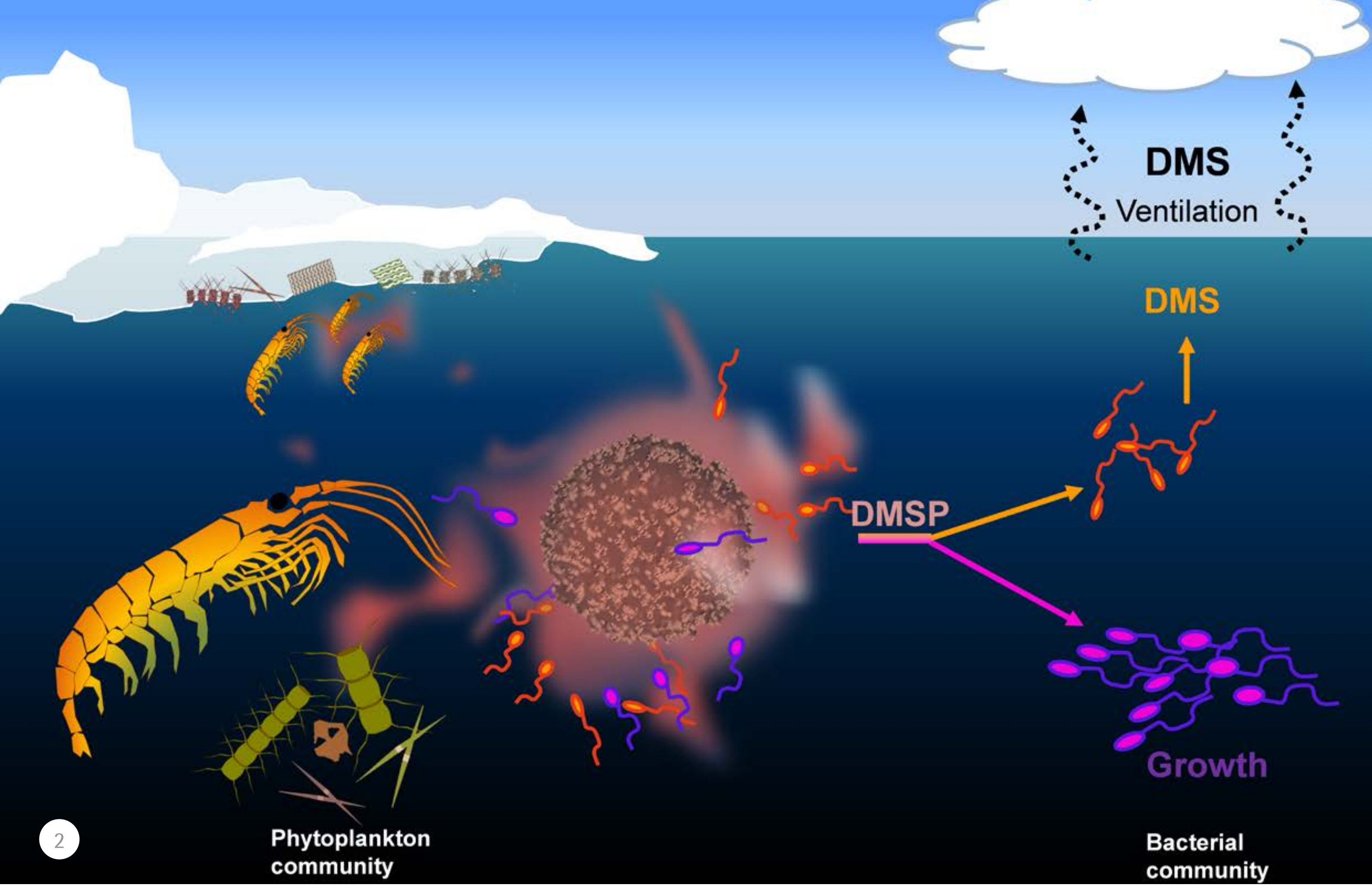
To find out, Dr Petrou and her team will collect surface water samples (5-20 m depth) at different locations and times during the five-week visit to Davis, to ensure they have a representative sample of the summer phytoplankton and bacterial community.

Some of these water samples will then be incubated in three-litre UV-transparent acrylic chambers, and exposed to different durations of UV light for up to three days. At the end of the experiment the amount of DMSP, and the numbers of phytoplankton and bacteria (including who is there), will be measured.

To identify the bacteria involved in the sulphur cycle, some of the water samples will be inoculated with DMSP tagged with a stable, heavy carbon label (^{13}C). When the bacteria consume this labelled DMSP some of the ^{13}C will be incorporated into their DNA, making it heavier.

"We'll be able to separate the heavier bacteria that have taken up the labelled DMSP from the lighter bacteria and then identify them through DNA sequencing," Dr Petrou said.

The team will also use a novel micro-trap to capture DMSP-consuming bacteria in the water column. The trap relies on the principle of 'chemotaxis', where an organism moves in response to a chemical cue — in this case the attraction of bacteria to a food source.



"It's a bit like a microbial mouse trap," Dr Petrou said.

"We have some very tiny chambers containing DMSP, which we'll deploy at different depths in the water column for about one hour. This will allow the DMSP to leak out into the surrounding water and form a chemical gradient that will be sensed by nearby bacteria. If they like what they sense they will swim down the gradient and into our chambers."

The team will use DNA sequencing to identify the bacterial species captured, and they'll be able to compare the identity of these captured bacteria with those from the ^{13}C experiment, to see if they match.

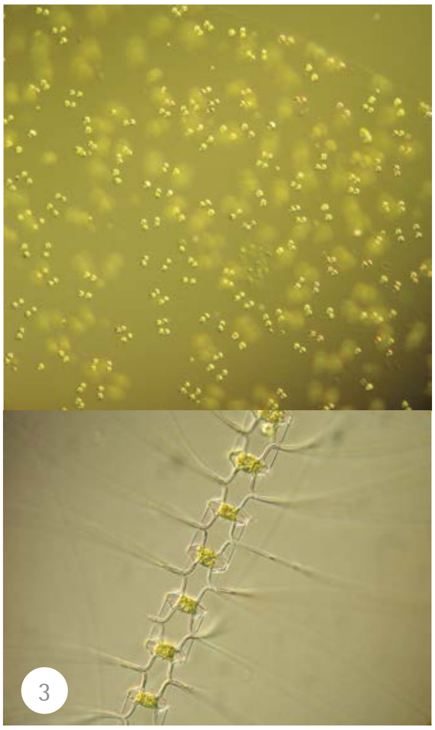
"Marine microbes perform invaluable ecosystem services," Dr Petrou said.

"Any changes in chemical cycling and the microbes responsible for that cycling will have ripple effects for the marine food web, affecting ocean productivity – including fisheries yields – and our climate.

"This project will provide the first insight into which direction the sulphur cycle might move in the future."

WENDY PYPER
Australian Antarctic Division

*Australian Antarctic Science project 4315



1. *Dr Katherina Petrou will investigate the sulphur-mediated attraction between Antarctic phytoplankton and bacteria at Davis this summer. (Cristin Sheehan)*
2. *In Antarctica many species of phytoplankton produce dimethylsulphoniopropionate (DMSP) which is attractive to bacteria as a carbon and sulphur source. When bacteria consume DMSP they can use it for growth, or metabolise it into dimethylsulphide (DMS). This volatile compound ventilates into the atmosphere, creating the distinctive smell of the sea and forming aerosols that can promote cloud formation and subsequently influence regional climate. As a major source of organic sulphur, DMSP is readily transferred through the food web. It is also a chemical attractant for zooplankton (such as krill), and a foraging cue for fish and other marine organisms, making it an important compound in marine chemical ecology. (Katherina Petrou)*
3. *Many species of Antarctic phytoplankton, such as the chain-forming diatom,* Chaetoceros *(bottom) and colonial Phaeocystis (top) transform sulphur in seawater to dimethylsulphoniopropionate (DMSP), which is released into the environment when the cells die. (Rob Johnson, Harvey Marchant)*

Melting ice shelves reduce critical deep water formation

Elephant seals have helped show that fresh water from melting Antarctic ice shelves can interfere with the formation of deep ocean currents that drive global ocean circulation and affect climate.

The research, published in *Nature Communications* and led by Dr Guy Williams from the Institute of Marine and Antarctic Studies and Antarctic Climate and Ecosystems Cooperative Research Centre, shows that the formation of cold, salty 'Antarctic bottom water' in Prydz Bay (near Davis research station), is reduced by the inflow of fresh meltwater from the nearby Amery Ice Shelf and West Ice Shelf.

The discovery comes after the analysis of temperature and salinity data collected by small oceanographic instruments attached to elephant seals.

"Antarctic bottom water production is vital to the Earth's climate system and biogeochemical cycles because it results in powerful currents of cold water that drive global ocean mixing and regulate atmospheric temperatures," Dr Williams said.

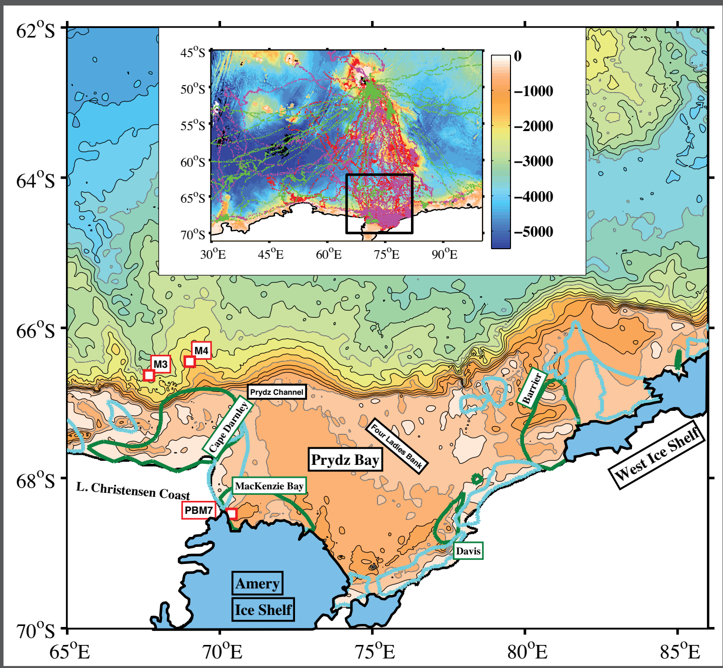
"If the production of Antarctic bottom water weakens, through processes such as those identified in this study, it would lead to changes in global ocean circulation patterns that could, in turn, change the global climate."

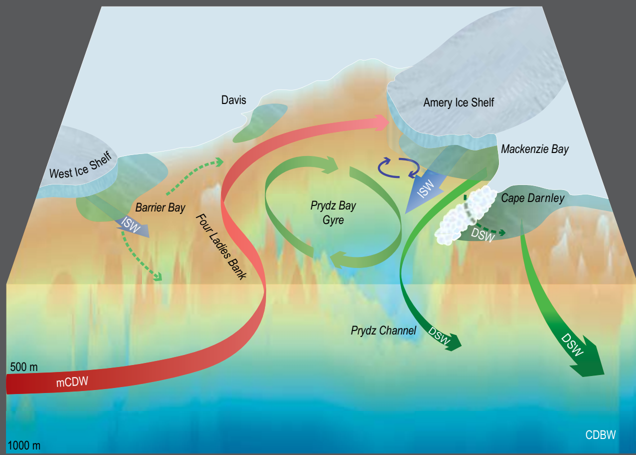
Antarctic bottom water is created when sea ice forms in winter, close to the continental shelf. As it forms, the sea ice rejects salt, making the water below saltier and denser (known as 'dense shelf water'). While sea ice grows everywhere around Antarctica in winter, there are only a handful of regions — known as 'polynyas' (or ice factories) — where enough sea ice forms to produce the dense shelf water necessary for Antarctic bottom water.

Scientists have known about three sources of Antarctic bottom water, in the Weddell Sea, Ross Sea and Adélie Coast, since the 1970s. In 2013 Dr Williams and other Australian and Japanese scientists confirmed a fourth source of bottom water at Cape Darnley — thanks in part to elephant seals tagged with oceanographic instruments for an unrelated seal behaviour project* (*Australian Antarctic Magazine* 24, 6–7, 2013).

These instruments included a small satellite relay that transmitted temperature, salinity and location data up to four times a day, during the five to 10 minute intervals when the seals surfaced.

"Several of the seals travelled into the Cape Darnley polynya in the middle of winter, providing information on the source of this Antarctic bottom water, in an area that had proven impossible to access by ship," Dr Williams said.





This map shows the greater Prydz Bay region visited by seals carrying small oceanographic instruments. The tracks of the elephant seals are shown in the inset, with red and magenta lines showing the movement of seals from Davis station, while the green lines show seals travelling from Kerguelen Island. The black box in the inset shows the study area. Dark green contours in the study area on the main map delineate coastal polynyas at Cape Darnley, MacKenzie Bay, Davis and Barrier Bay. Despite strong sea ice production from these polynyas, the study showed that fresh meltwater from the Amery and West ice shelves limits the overall formation of dense shelf water in Prydz Bay. This reduces the formation of Antarctic bottom water, which affects ocean circulation and ultimately, global climate. (Guy Williams/*Nat. Commun.* 10.1038/ncomms12577)

This graphic shows how the formation of dense shelf water (which becomes Antarctic bottom water when it sinks to abyssal depths) is suppressed by fresh meltwater from the West Ice Shelf and Amery Ice Shelf. Dense shelf water (DSW) from the MacKenzie Bay polynya joins the DSW from the Cape Darnley polynya to produce Antarctic bottom water. However, meltwater (Ice shelf water- ISW) from the ice shelves recirculates within the Prydz Bay Gyre, limiting the overall contribution of the Barrier Bay and Davis polynyas to Antarctic Bottom water. (Modified Circumpolar Deep Water, mCDW, is a relatively warm water mass that comes from the Antarctic Circumpolar Current and strongly influences the melting of ice shelves along the Antarctic margin). (Guy Williams/*Nat. Commun.* 10.1038/ncomms12577)

Following on from this success Dr Williams' team analysed a further two years of salinity and temperature observations from 20 instrumented seals, to expand the spatial and seasonal coverage of Antarctic bottom water formation at Cape Darnley and the nearby Prydz Bay region. The seals foraged to depths of 1800 metres up to 60 times a day while they were in the region (see map).

"Our 2013 study suggested that Prydz Bay, which is adjacent to the Amery Ice Shelf, contributed to Cape Darnley's bottom water," Dr Williams said.

"This extra two years of data has confirmed that Prydz Bay does contribute bottom water to the Cape Darnley source, but it is fresher, due to meltwater from the Amery and West ice shelves."

Despite strong sea ice production from three polynyas in the region, Dr Williams said freshening from the ocean/ice-shelf interactions limits the overall formation of dense shelf water in Prydz Bay.

"This study highlights the susceptibility of Antarctic bottom water to increased freshwater input from the enhanced melting of ice shelves, and ultimately the potential collapse of Antarctic bottom water formation in a warming climate," he said

"We can easily imagine that the production of global ocean currents will slow as the rate of ice shelf melting all around Antarctica continues to increase."

WENDY PYPER
Australian Antarctic Division

The elephant seal data is accessible from the Integrated Marine Observing System (IMOS) data portal. The oceanographic data collected by the seals is also used for ecological research into their behaviour, and aids in conservation. Animal ethics approval for the research was received from Macquarie University, University of Tasmania and the Australian Antarctic Program.

*Australian Antarctic Science project 4329

More information

Williams G.D. et al (2016). The suppression of Antarctic bottom water formation by melting ice shelves in Prydz Bay. *Nat. Commun.* 7: 12577 doi: 10.1038/ncomms12577

1. *Southern elephant seals carrying small oceanographic instruments, provided scientists with temperature, salinity and location data in the Prydz Bay region near Davis research station. Animal ethics approval was received to conduct the research and the instruments fell off after a year. (Iain Field)*

Treating sewage seriously

An environmental impact assessment of the effect of sewage discharged from Davis research station on the marine environment, has resulted in an ambitious engineering project to upgrade wastewater treatment plants at Australia's Antarctic stations.

The detailed environmental impact assessment, undertaken by the Australian Antarctic Division in 2009–10 (*Australian Antarctic Magazine* 19: 8–9, 2010), aimed to identify the level of sewage treatment needed to ensure that Australia meets its environmental responsibilities under national legislation and the Environmental Protocol to the Antarctic Treaty. These responsibilities require Australian stations to dispose of effluent "in a manner that does not adversely affect the local environment" and at a location that allows for "initial dilution and rapid dispersal".

Between 2005 and 2015, after Davis station's sewage treatment plant failed, effluent was macerated and discharged to the sea from a pipe near the station's wharf — a practice permitted under the Environmental Protocol.

The environmental impact assessment showed that the effluent was poorly dispersed during the three-month period of the study, resulting in the accumulation of some contaminants in the environment and a range of adverse impacts. These impacts included accumulation of faecal contaminants, heavy metals and persistent organic pollutants in the sediments near the outfall, the transfer of antibiotic resistance genes from faecal bacteria to the local microbial population, differences in benthic communities around the outfall compared to reference sites, and the exposure of seals and penguins to high levels of faecal bacteria within 50 m (and at times 500 m) of the outfall pipe. These levels of exposure are considered unsafe for humans under Australian and New Zealand Environment and Conservation Council guidelines.

Quality and quantity

To deliver this assessment, the scientific team had to first determine the properties of the wastewater in the different septic tanks that contributed to the final outflow, and how the effluent was dispersing and diluting in the environment.

Project Leader, Dr Jonny Stark, said the effluent came from eight different buildings and varied depending on the building's use and the number of occupants.

Contaminants in the tanks included metals such as copper, zinc, lead and mercury, surfactants (from soaps and shampoos), oils and other hydrocarbons, and polybrominated diphenyl ether (PDBE) compounds, which are used as flame retardants in clothes, plastics and building materials.

"By understanding what goes into the sewage outfall line, we can identify which treatments we need to deal with the contaminants," Dr Stark said.

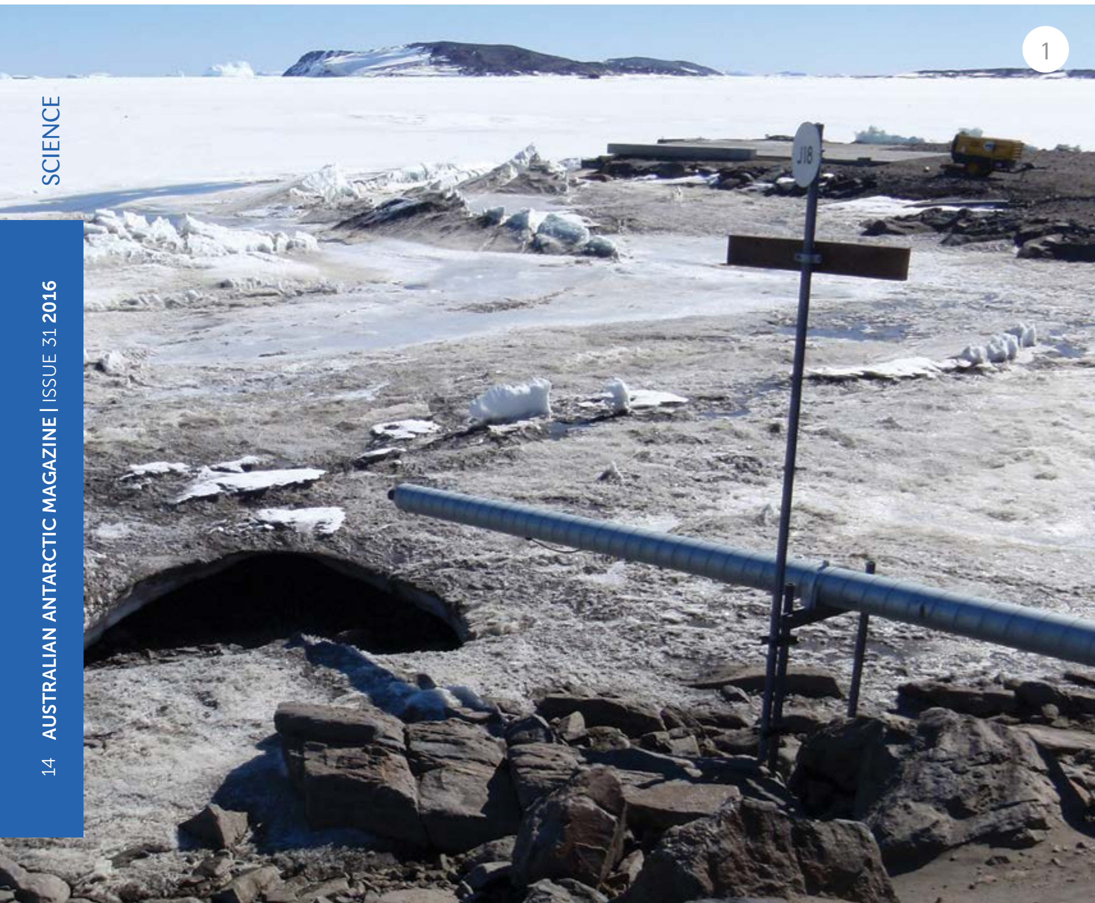
"For example, to remove nitrogen, phosphorous and bacteria we need enhanced secondary treatment, but to remove heavy metals and PBDEs, we need advanced treatment."

Dispersal and dilution

To determine how the effluent was dispersing once it left the outfall pipe the team placed non-toxic tracer dye at the outfall site under both rising and falling tides. They also looked at the concentration of faecal microbes and other contaminants in the water column at various sites.

These experiments showed that most of the effluent moved south along the coast, in a poorly diluted stream, and then out towards an area of open water where it could be further dispersed and diluted. Some of the effluent was retained around the outfall site and some dispersed north along the main Davis beach, particularly on the outgoing tide.

With this dispersal pattern in mind the scientific diving team identified 30 experimental and control sites from which to sample sediment, water and marine organisms (including heart urchins, clams, macroalgae and fish). Faecal samples were also collected from southern elephant seals, Adélie penguins and Weddell seals.



1

2

Sample analysis showed low levels of metal accumulation in marine sediments close to the outfall and levels of PDBEs at concentrations significantly above background levels. Low levels of human-derived faecal contaminants were detected in sediments up to two kilometres in the direction of the main current flow. Sewage markers were also detected in two predatory sea floor animals — a snail and fish — suggesting that some contaminants were entering the marine food chain.

Sediments were tested for a range of other organic contaminants, including petroleum hydrocarbons (from fuel), polychlorinated biphenyls (PCBs), phthalates (from plastics), detergents and nutrients, and there was some evidence of contamination from some of these.

"Our experiments indicate that the dispersal and dilution of effluent from the outfall wasn't rapid enough to prevent the accumulation of contaminants," Dr Stark said.

"The situation is likely to be worse when sea ice is present as it further reduces dispersal and dilution. We estimate that this is likely to be a common problem around most Antarctic stations, particularly those with sea ice for much of the year."

Flow-on effects

The team also found evidence that antibiotic resistance genes from faecal bacteria were 'jumping' into local bacteria via mobile genetic elements known as integrons (see next story, page 16). These mobile pieces of DNA can capture and lose genes and move between related and different bacterial species.

"Four different genes encoding resistance to the antibiotics streptomycin, spectinomycin and trimetheprim were detected in the effluent," Dr Stark said.

"Bacteria isolated from the water column and sediments near the outfall site were carrying antibiotic resistance genes similar to those found in bacteria in the septic tanks. We also found antibiotic resistance genes in bacteria isolated from a burrowing bivalve, indicating that these bacteria had entered the Antarctic foodweb."

A small sample of the Antarctic coastal fish (*Trematomus bernachii*) collected adjacent to the sewage outfall also showed signs of disease in their liver and gills, unlike fish caught in the control sites.

Pollution solutions

The research identified a number of potential problems associated with untreated effluent and limited dilution and dispersal, in particular the spread of non-native bacteria and antibiotic resistance, and cumulative pollution of the environment with metals and persistent organic pollutants.

As a result of the study the Australian Antarctic Division committed to replacing and upgrading its stations' secondary treatment plants and installing a state-of-the-art advanced treatment system at Davis — to convert water from the secondary treatment plant into some of the cleanest water in the world (*Australian Antarctic Magazine* 30: 2–3, 2016).

The secondary treatment plant was commissioned at Davis in December 2015 and the advanced system is due to be installed this summer (2016–17). A new secondary treatment plant is also onsite at Casey research station, while at Mawson, the necessary infrastructure improvements are being planned to house its newly acquired treatment plant.

Dr Stark said the comprehensive steps taken by Australia to understand and address the environmental impacts of wastewater discharge at Australia's research stations represent Antarctic and world best practice and reinforces Australia's international leadership in the fields of Antarctic science, operations and environmental management.

Wastewater management is recognised by all national Antarctic programs to be a complex issue, and a wide range of technologies are in use across Antarctic stations. The treatment and disposal of wastewater is an issue currently being considered by the Committee for Environmental Protection to the Antarctic Treaty.

WENDY PYPER
Australian Antarctic Division

More information

Stark J.S, Corbett P.A., Dunshea G. et al. (2016). The environmental impact of sewage and wastewater outfalls in Antarctica: An example from Davis station, East Antarctica. *Water Research* 105: 602–614. http://dx.doi.org/10.1016/j.watres.2016.09.026

1. *For most of the year the sea surrounding the old Davis sewage outfall was frozen. The heated effluent melted a hole in the sea ice, but the sea ice limited its dilution and dispersal. (Glenn Johnstone)*
2. *A diver enters the water from the workboat* Pagodroma *to collect specimens for the Davis environmental impact study. (Helena Baird)*
3. *The secondary treatment plant newly installed at Davis research station in December 2015 after advice from the environmental impact assessment. (Michael Packer)*
4. *A slick of effluent from the old Davis sewage outfall is visible on the surface of the water. This may be due to the presence of surfactants (detergents) and oils from the kitchen. (Jonny Stark)*

Antarctic fauna at risk from human pathogenic bacteria

This Picture
A Macquarie University researcher goes in search of penguin poo. (Michelle Power)

1. The Macquarie University team collected faecal samples from seals, although some excellent samples were unobtainable (pictured). Sample analysis found E. coli strains that cause disease in humans and birds. (Michelle Power)

Human sewage disposal into the Antarctic marine environment poses a risk of introducing non-native organisms, and 'gene pollution' from pathogenic human bacteria, according to research published in *Environmental Pollution* in May.

The research*, led by Macquarie University, was part of a larger environmental impact assessment of sewage discharge at Davis research station, conducted by the Australian Antarctic Division in 2009–10 (see story page 14).

Macquarie University biologist Dr Michelle Power, and her colleagues, showed that the presence of human bacteria in the marine environment, specifically *Escherichia coli*, could affect the diversity and evolution of native Antarctic microbial communities and the health of associated Antarctic fauna.

The team used DNA technology to identify genes commonly associated with *E. coli* in humans, and track what happened to these bacteria after they were released into the Antarctic environment in sewage.

Testing of *E. coli* isolated from Antarctic marine invertebrates, and faecal samples from seals and penguins, showed that human *E. coli* had established in Antarctic animals. The bacteria also contained antibiotic resistance genes within mobile genetic elements, known as integrons, which can move within and between microbial species.

"Our study confirms that the sewage disposal practice occurring at the time of this study facilitated the introduction of non-indigenous microorganisms into the Antarctic ecosystem, specifically human *E. coli* strains with pathogenic characteristics," Dr Power said.

"Some of the *E. coli* strains that we detected in seal faeces are known to cause disease in humans and birds.

Antibiotic resistance genes were also discovered in many of the *E. coli* strains tested. They were not detected in penguins or seals, but were found in a filter-feeding shellfish species that is part of Antarctic food-web.

"The integrons and associated genes these *E. coli* are carrying are polluting the Antarctic environment and their presence may affect the evolution of endemic microbes through the transfer of novel genetic material," Dr Power said.

In accordance with Antarctic Treaty requirements, the release of untreated sewage into the sea is allowed under certain conditions and is common practice at many coastal research stations. With most stations located on the Antarctic coastline, the research provides scientific evidence to support development of improved regulations for human waste disposal.

"With more than 30 nations operating in Antarctica, and around 4000 people living at Antarctic research stations during the summer months, the potential impact of their presence on the surrounding ecosystem cannot be underestimated," Dr Power said.

She said further research is needed to identify a baseline for the natural distributions and genetic and physical characteristics of microbes associated with Antarctic marine life.

"Simple and rapid genetic tools can and should be used to determine the extent of gene pollution across Antarctica," she said.

"Such approaches provide a means for measuring impacts of microbial pollution in Antarctica."

WENDY PYPER[1] and
ANNA GARCIA-LOYOLA[2]
[1]Australian Antarctic Division,
[2]Macquarie University

*Australian Antarctic Science project 2936

More information

Power M., Samuel A., Smith J., Stark J., Gillings M., Gordon D. (2016). *Escherichia coli* out in the cold: Dissemination of human-derived bacteria into the Antarctic microbiome. *Environmental Pollution* 215: 58–65. doi 10.1016/j.envpol.2016.04.013

This Picture
Associate Professor Nerilie Abram and Australian Antarctic Division ice core scientist Dr Mark Curran (who was a co-author on the Nature *paper) used ice core climate records and other natural climate archives to pinpoint the beginning of the Earth's global warming trend to the 1830s. (Oliver Berlin)*

Scientists pinpoint beginning of current global warming trend

New research using climate data from ice cores, corals, sediment layers and tree rings has found human-induced global warming began about 180 years ago; much earlier than previously thought.

The study published in the journal Nature in August, charts warming from its earliest stages, beginning in tropical oceans and the Northern Hemisphere, and in the Southern Hemisphere several decades later.

The research was led by Associate Professor Nerilie Abram from the Australian National University and involved a team of 25 scientists from the Past Global Changes 2k Consortium (including scientists from Australia, United States, Europe and Asia).

Australian Antarctic Division climate program leader, Dr Tas van Ommen, said significant human-induced warming was previously thought to have been a 20th century phenomenon.

"The new climate data analysed in this research stretches back 500 years and allows us to see warming in its earliest stages, progressing across the globe," he said.

"It shows the Earth's climate is sensitive to even small changes in greenhouse gas levels, providing a valuable context for modelling future climate."

As well as examining natural climate archives (such as ice cores), the research team analysed thousands of years of climate model simulations — including those used to inform the Intergovernmental Panel on Climate Change.

They found that warming did not develop at the same time across the planet.

"The tropical oceans and the Arctic were the first regions to begin warming, in the 1830s, while Europe, North America and Asia followed some two decades later," A/Prof Abram said.

"Warming in parts of the Southern Hemisphere was delayed up to 50 years, and the Antarctic continent is yet to show significant overall warming."

However, the study did find significant regional warming in West Antarctica and the Antarctic Peninsula since the mid-20th century, with warming in these areas among the most rapid seen anywhere on the globe.

The research team said Antarctica has generally been buffered from major continent-wide changes due to its thermal isolation, with the Southern Ocean muting warming.

"The Southern Ocean currents that flow around Antarctica tend to move warmer surface waters away from the continent, to be replaced with cold deeper water that hasn't yet been affected by surface greenhouse warming," A/Prof Abram said.

"The westerly winds that circle Antarctica also reduce warm air reaching the continent. Ozone depletion and rising greenhouse gases have acted to make this wind barrier stronger."

A/Prof Abram said that by pinpointing the date when human-induced climate change started, scientists can begin to work out when the warming trend broke through the boundaries of the climate's natural fluctuations, because it takes some decades for the global warming signal to "emerge" above the natural climate variability.

"According to our evidence, in all regions except for Antarctica, we are now well and truly operating in a greenhouse-influenced world," she said.

"We know this because the only climate models that can reproduce the results seen in our records of past climate, are those that factor in the effect of carbon dioxide released into the atmosphere by humans."

The early onset of warming also means that the Earth is closer to the 1.5–2°C warming limit agreed at last year's Paris climate summit.

"Instrumental records indicate that 2016 is on track to be 1.3°C warmer than when those records began in the late 19th century, but a couple of tenths of one degree needs to be added to that figure to fully account for how much humans have changed the climate since industrialisation," A/Prof Abram said.

However, given how quickly the climate responded to the small increases in greenhouse gases in the early 19th century, there is potential for it to respond quickly to small decreases.

"If we can do anything to slow down greenhouse gas emissions, or even start to draw them back, there may be at least some areas of the climate system where we get a rapid payback," A/Prof Abram said.

CORPORATE COMMUNICATIONS
Australian Antarctic Division

More information

Abram N.J., McGregor, H.V., Tierney J.E. et al (2016). Early onset of industrial-era warming across the oceans and continents. Nature 536: 411–418. doi:10.1038/nature19082 http://www.nature.com/nature/journal/v536/n7617/full/nature19082.html

1. This map shows the location of the ice shelves and glaciers under investigation.

2. A diagram showing the location of boreholes drilled on the Amery Ice Shelf. Boreholes AM05 and AM06 are the focus of recent instrument deployments to understand the interaction between the ice sheet and the ocean cavity beneath, which leads to basal melting and refreezing. 'LT' indicates the location of the rift forming the 'Loose Tooth.' (Adam Treverrow)

This Picture

A team deploy an ApRES instrument (inside the black box) on the Sørsdal Glacier near Davis in the 2015–16 summer. The radar instrument is buried in a shallow pit under the ice. It sends a radio pulse down through the ice to measure its thickness with millimetre accuracy. (Sue Cook)

Understanding ice shelf processes

SCIENCE

Ice shelves around Antarctica are thinning in response to climate change, with some, such as the Ross and Larson, calving huge icebergs, while others, such as the Amery, developing large rifts.

To understand the fundamental processes driving ice shelf thinning, Antarctic scientists will tackle the issue from above and below this season, deploying instruments on the surface of, and in the ocean beneath, the Amery and McMurdo ice shelves and on the Totten and Sørsdal glaciers.

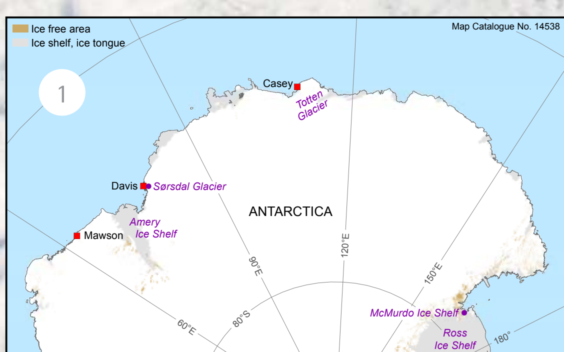
By combining surface glaciological measurements with sub-ice oceanography, they hope to understand the ice shelves' stability (ice gain versus loss) and their response to changes in environmental conditions, such as air and ocean temperatures and ocean currents.

Australian Antarctic Division ice-ocean modeller, Dr Ben Galton-Fenzi, said that in the past decade scientists have found that a significant cause of ice shelf thinning is through the interaction of the base of the ice shelf with the ocean (basal melting). However, he hopes the deployment of more modern technology will refine understanding of the fundamental processes involved, and inform the next generation of models.

"We have a crude idea of the drivers of basal melting and refreezing, which is reflected in our current models, but there are many details that we need to understand to get a more accurate picture of how the ocean interacts with the base of an ice shelf and drives grounding line retreat."

Since 2010 the Amery Ice Shelf Ocean Research team has been monitoring a range of instruments deployed into two of six boreholes drilled on the Amery Ice Shelf (AM05 and AM06) and on the surface of the ice shelf in 2015 (see ice shelf graphic). This season they plan to retrieve the data and redeploy some of the surface instruments for a second year.

Instruments deployed into the boreholes include fibre optic distributed temperature sensors (DTS) that measure ice and ocean temperature at the base of the ice shelf, and acoustic doppler current profilers (ADCP), which measure the speed of water flowing beneath the ice shelf and ice shelf thinning due to basal melting. On the surface of the ice shelf are GPS to measure ice flow speeds and surface elevation changes, and two autonomous phase sensitive radio echo sounders (ApRES), which measure the thickness of the ice shelf with millimetre accuracy.



The ApRES instruments are part of a broader international project known by its acronym NECKLACE, which aims to deploy the instruments on all the major ice shelves around Antarctica (like a necklace). This will allow scientists to detect seasonal variability in basal melt rates and over time provide longer-term melt trends around the continent.

Contributing to this effort, Dr Galton-Fenzi plans to deploy up to six ApRES and six GPS instruments on the Totten Glacier (near Casey research station) this season. The Totten Glacier drains a sub-glacial basin containing enough ice to raise sea levels by 3.5 metres, and is a focus of Australian and international research through the ICECAP project (International Collaboration for Exploration of the Cryosphere through Aerogeophysical Profiling – *Australian Antarctic Magazine* 28: 12–15, 2015).

Recent research shows the Totten Glacier is susceptible to substantial amounts of interannual variability in basal melting and flow, and ICECAP research has found deep channels that could allow warm water to infiltrate the base of the glacier through to its grounding line, causing potentially destabilising melting and increasing this vast drainage basin's contribution to sea level rise.

The ApRES and GPS instruments will be deployed on the Totten Glacier for six weeks over the 2016 summer, with a couple of sites left to overwinter, sending back information via satellite. The deployment sites will be along two glacier flow lines, from the point where the ice begins to float and further downstream, to measure flow speeds, thinning and melt-rates.

"This work will help us understand how the flow regime of the Totten varies with time, its basal melt rates, and how the ocean is driving melting," Dr Galton-Fenzi said.

"Ultimately, it will allow us to provide a risk assessment of the likelihood of the collapse of the Totten over the next few hundred years."

Similar instrument deployments occurred on the Sørsdal Glacier near Davis research station last summer by Dr Sue Cook of the Antarctic Climate and Ecosystems Cooperative Research Centre, as part of a project led by Dr Christian Schoof of the University of British Columbia, Canada. Dr Cook plans to redeploy ApRES and GPS instruments on the glacier again this season, as well as some pressure transducers to monitor lake formation on the surface of the glacier.

"In Greenland, lakes forming on the surface of the ice sheet are known to drain down to its base, changing how the ice sheet slides over the bedrock below," Dr Cook said.

"So we want to test a similar theory in Antarctica – that surface meltwater ponding is occurring more frequently on outlet glaciers, and potentially reaching the bedrock and driving increased lubrication and acceleration of the glaciers.

"The pressure transducers will tell us how much water forms."

Dr Cook will also conduct some seismic work on the glacier using a hammer and plate system.

"The radar of the ApRES can't penetrate salt water, so we just get measurements of the ice thickness. But the seismic system can penetrate through the water column below, so you can map out the size of the ocean cavity," she said.

"A common problem for many ice shelves is that we don't know where the grounding line is or the bathymetry of the seafloor below it.

"The seismic work will allow us to identify this grounding line, as well as stratification [layers] in the water and the bathymetry of the seafloor, which both influence how the ocean interacts with the base of the ice shelf."

To complete the East Antarctic ice shelf research this season, Institute for Marine and Antarctic Studies PhD student Ms Madelaine Rosevear will work with New Zealand scientist Dr Craig Stevens, to deploy oceanographic instruments through a borehole on McMurdo Ice Shelf. The data she collects will feed into a high resolution numerical model looking at the role of ocean mixing on the basal melting of ice shelves.

"Altogether, our study of ice sheets this season will provide good data on the fundamental processes that drive basal melting, as well as information about the bathymetry beneath ice shelves, ocean temperatures and the general state of the region," Dr Galton-Fenzi said.

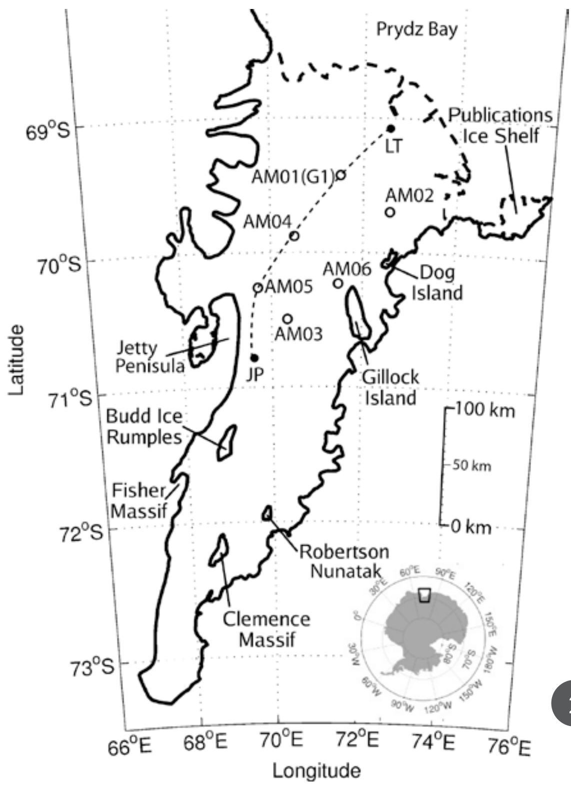
"We'll put all that information into numerical models and look at regions potentially susceptible to rapid deglaciation, such as the Totten.

"From this we'll be able to come up with better bounds on the problem and estimates of the uncertainty."

WENDY PYPER

Australian Antarctic Division

This research includes Australian Antarctic Science projects 4096, 4342 and 4287.



2

Mobile diatoms flourish in acid ocean

Thick mats of single celled microalgae, 'pulsing' in the seafloor sediments under the Antarctic sea ice, could flourish as ocean acidification intensifies.

The microalgae mats are a mix of more than 60 species of single-celled diatoms, which migrate up and down through sediment in response to daylight. They are expected to be amongst a small number of 'winners' as the Southern Ocean continues to absorb carbon dioxide from the atmosphere.

Institute for Marine and Antarctic Studies PhD student, James Black, has been studying the migratory behaviour and photosynthesis of these diatom mats, which can grow about 0.5 mm thick, as part of the Antarctic Free Ocean CO_2 Enrichment (antFOCE) experiment*, conducted over two months at Casey research station in 2014 (*Australian Antarctic Magazine* 27: 4-5, 2014).

"The antFOCE experiment focused on longer term ecological changes in the benthic [seafloor] community under ocean acidification conditions, but I was interested in how the short-term physiological changes could influence the longer term changes — what happens to benthic organisms over hours and days," Mr Black said.

"I was particularly interested in diatoms because they are responsible for between 60 and 90 per cent of the primary production [plant growth] at the study site."

To assess short-term physiological changes in the diatom-covered sediment, Mr Black deployed two 'mini-chambers' alongside larger FOCE chambers under the sea ice in the bay near Casey (see photo). Each mini-chamber contained seawater enriched with carbon dioxide to pH 7.8 (0.4 pH units below natural ocean pH). Every six hours this water was refreshed and the cycle repeated for up to 144 hours.

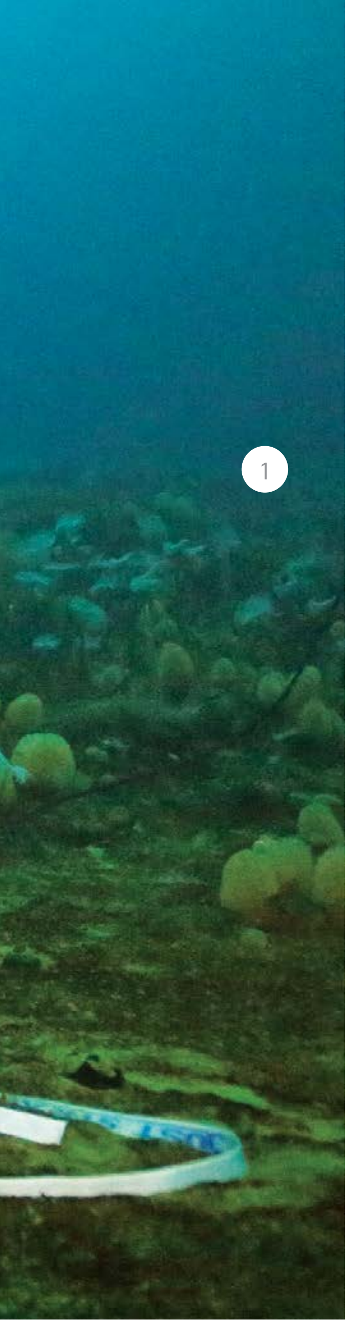
To monitor the health of the diatoms during the experiment, an instrument sent a pulse of light over the microalgae mats every 30 minutes and recorded how much light they absorbed — a measure of their 'photosynthetic yield'.

Preliminary analysis of the results suggests there is an interaction between the intensity of the light cycle and ocean acidification that affects diatom behaviour and photosynthetic yield, and that the diatoms require a regular day/night cycle to coordinate their sediment migration.

"When the diatoms experienced regular light/dark cycles under ocean acidification conditions, they coordinated their migration 5–10 mm up and down through the sediment over the course of the day. This appeared to regulate their exposure to ocean acidification and resulted in a positive photosynthetic response under most circumstances," Mr Black said.

"They also migrated more rapidly upward through the sediment under acidic conditions. This may be related to the increased availability of carbon dioxide in the water, which the diatoms use for photosynthesis and growth."

While the field experiments showed some strong positive trends in microalgae behaviour and response to light under ocean acidification conditions, the natural range of light conditions and experimental replication were limited. To tease out the findings further, Mr Black set up replicate experiments in the laboratory with the help of the Australian Antarctic Division's Science Technical Support team.



"Performing long-term laboratory experiments on Antarctic organisms is no easy task, and requires a team of people skilled in transport and logistics, software and electrical engineering, and science, to ensure success," Mr Black said.

The sediment faunal communities and diatoms were collected from Antarctica and placed into 20 chambers set up in a smaller but similar fashion to the original mini-chambers. These natural assemblages of marine organisms were then exposed to 10 weeks of ocean acidification or control conditions.

"The laboratory experiments replicated both the regular and longer day/night light cycle conditions seen in the field and we observed similar results to our field experiments," Mr Black said.

As diatoms can modify the pH of their immediate environment through photosynthesis, Mr Black will now look at how much the diatoms alter the pH of the sediment and 'boundary layer' (water just above the sediment) under high light conditions.

While the experimental results will take some time to fully process, Mr Black is excited at the prospect of having found a photosynthetic species to better understand the effect of ocean acidification on usually sedentary photosynthetic marine organisms.

"You can't look at the behaviour of seaweeds because they don't move," he said.

"So these diatoms are not just important in an ecosystem context, they're important as a model species to study the effects of ocean acidification on photosynthetic organisms.

"To be able to see the migration of diatoms and link it to 'choices' they're making, provides a greater insight into how ocean acidification affects photosynthesis and microalgae growth."

WENDY PYPER
Australian Antarctic Division

*Australian Antarctic Science project 4127

1. *James originally installed minichambers under the sea ice at Casey as part of the broader Antarctic Free Ocean CO2 Enrichment (antFOCE) experiment in 2014. (Mike Sparg)*
2. *Australian Antarctic Division Science Technical Support technician, Mark Milnes, was instrumental in setting up the antFOCE equipment in Antarctica and adapting it for James' experiment in the laboratory – modifying field equipment for a laboratory setting and ensuring many of the measurements were automated. (Nick Roden)*
3. *PhD student James Black with his minicosm experiment set up in the laboratory at the Australian Antarctic Division. Twenty chambers containing sediment and diatoms from the original study site at Casey are subjected to different CO_2 concentrations under a natural summer light regime, to examine the impact of ocean acidification on the diatoms, and the effect of the diatoms on seawater pH. (Wendy Pyper)*

Ice core study shows plants absorb less carbon in a warming world

The Earth's land biosphere takes up less carbon in a warming climate according to research published in *Nature Geoscience* in July.

The research, led by Dr Mauro Rubino of CSIRO and the Seconda Universita di Napoli, used bubbles trapped in Antarctic ice cores during the Little Ice Age (1500 to 1750 AD), to measure the sensitivity of the Earth's land biosphere to changes in temperature.

The study focused on the Little Ice Age era (a period of severe winters and expanded glaciation, particularly in Europe and North America), as it occurred before the growth of industry and agriculture affected carbon dioxide concentrations.

Previous studies have shown that carbon dioxide levels in the atmosphere went down slightly during the Little Ice Age. But it was not known whether this was due to the response of the terrestrial biosphere (plants and soils) to temperature change (cooling), or to vegetation re-growth due to land-use changes.

Australian Antarctic Division ice core scientist and study co-author, Dr Mark Curran, said the research team used ice cores to look at changes in the carbon-13 isotope ratio — a signature from land plants. This confirmed that the carbon dioxide changes during the Little Ice Age originated from the land biosphere.

"Ice cores preserve atmospheric gases in the bubbles trapped in the ice, and many of the samples used in this study were collected from the Australian Antarctic Program's Law Dome site," Dr Curran said.

"The very high detail preserved in the Law Dome ice cores was key to unlocking this information."

The team then looked at another ice-bound natural gas, carbonyl sulfide. Like carbon dioxide, carbonyl sulfide is taken up by plants during photosynthesis, but unlike carbon dioxide, it is not released back into the atmosphere when the plants respire at night.

Measurements of carbonyl sulfide ruled out vegetation regrowth as a contributor to the decline in carbon dioxide and confirmed that the decline was related to cooling of the land surface.

This result implies that a warmer climate in the future will lead to a reduction in carbon dioxide uptake, providing a positive feedback to greenhouse warming as more emissions remain in the atmosphere.

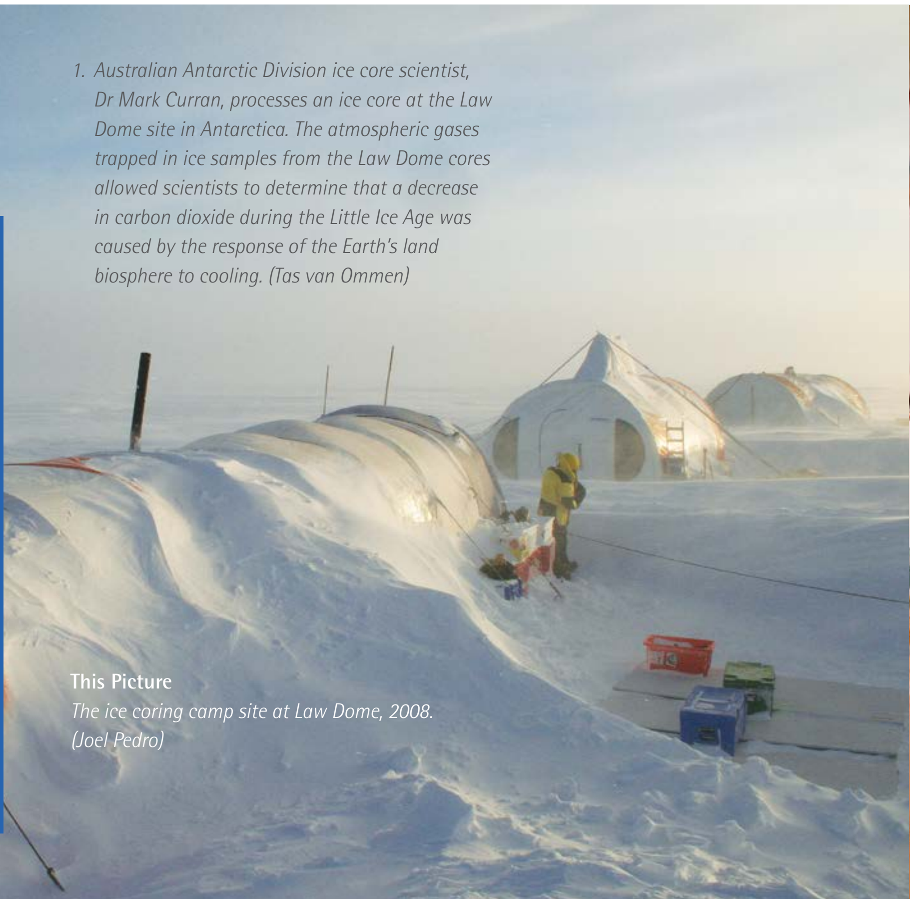
Study co-author and CSIRO scientist, Dr David Etheridge, said the research showed that for every degree Celsius of global temperature rise, 20 parts per million less carbon dioxide is absorbed by the land biosphere.

"It has long been assumed that as the Earth's surface warms, the ability of land-based plants to store carbon is reduced. This study puts definitive numbers around this positive feedback," Dr Etheridge said.

About half the carbon dioxide emitted by human activities since 1850 has been taken out of the atmosphere by the land biosphere and the ocean. Uncertainties in how this uptake might change in the future has been a significant source of uncertainty in climate projections.

These new results will reduce the uncertainties of climate models such as the Australian Community Climate and Earth System Simulator (ACCESS), which is used to project future climates scenarios from human greenhouse gas emissions.

WENDY PYPER and ELIZA GREY
Australian Antarctic Division



This Picture
The ice coring camp site at Law Dome, 2008. (Joel Pedro)

1. *Australian Antarctic Division ice core scientist, Dr Mark Curran, processes an ice core at the Law Dome site in Antarctica. The atmospheric gases trapped in ice samples from the Law Dome cores allowed scientists to determine that a decrease in carbon dioxide during the Little Ice Age was caused by the response of the Earth's land biosphere to cooling. (Tas van Ommen)*

Magnetic field and radioactivity monitoring at Mawson

The Australian Antarctic Program relies on the technical expertise of multi-talented expeditioners, wintering on Antarctic research stations, to conduct a range of year-round scientific observations and measurements. Among these activities are weekly magnetic observations for Geoscience Australia and daily seismic and radionuclide monitoring for the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA)* – as Mawson Station Leader, Jenny Wressell, describes.

Magnetic measurements

One of the many jobs our communication technician, Tony Harris, is responsible for is taking weekly magnetic observations.

The magnetic absolute building is a little hut that was transported here from Heard Island in 1955. It sits in isolation from the rest of the station, towards the glacier edge. The reason for the isolation is to try and reduce any interference from metal objects on the magnetic field measurements.

Tony uses a declination-inclination magnetometer and a total field intensity magnetometer to measure both the direction and strength of the magnetic field. It takes about an hour to take the measurements, using the little window in the door to line up with a stake outside. Other measures use little marks all over the inside of the hut that people have created over the years.

It is a pretty unremarkable process, but what happens to the results is very interesting. Geoscience Australia maintains a national network of geomagnetic observatories which forms part of a global observatory network.

Geoscience Australia uses the data measured in our little hut to show how the Earth's magnetic field changes in the Australian region due to processes taking place beneath the Earth's surface, in the upper atmosphere and in the earth-sun space environment.

This data is then used in mathematical models of the geomagnetic field, to monitor space weather, and for scientific research. The resulting information can be used for compass-based navigation, magnetic direction finding, and to help protect communities by mitigating the potential hazards generated by magnetic storms.

Radionuclide monitoring

The Australian Radiation Protection and Nuclear Safety Agency, more generally known as ARPANSA, is the national agency that helps to support Australia's involvement in the comprehensive nuclear test ban treaty.

The comprehensive nuclear test ban treaty was signed on the 24th September 1996 and ratified on the 9th of July 1998. Another 182 countries are also signatories of the treaty, which involved the creation of an international monitoring system that ensures compliance with the treaty.

At Mawson we have a seismic and radionuclide monitoring system that the station communication technician and station leader monitor on a daily basis.

Seismic monitors detect vibrations in the Earth's crust. The principal use of the seismic data in the verification system is to locate seismic events and to distinguish between an underground nuclear explosion and the numerous earthquakes that occur around the globe.

The radionuclide system can detect radioactive debris from atmospheric explosions or vented by underground or underwater nuclear explosions. The presence of specific radionuclides provides unambiguous evidence of a nuclear explosion. To detect radioactive debris we go through a daily routine in the ARPANSA lab on station.

The first step is to place a piece of special filter paper into a frame and expose it via a high volume air sampler for about 24 hours. The filter paper is then crushed into a small disk and left to 'decay' for another 24 hours; the decay process allows naturally occurring radionuclides to be removed. Finally the disk is placed in the gamma detector to be analysed. The data is automatically transmitted to the international data centre in Vienna for collation and review.

It is an interesting process to be a part of and has been a great opportunity to learn more about Australia's involvement with an international monitoring system.

JENNY WRESSELL
Station Leader, Mawson

*Australian Antarctic Science project 4092

1. *The 'magnetic absolute hut' at Mawson. (Jenny Wressell)*
2. *The high flow air sampler, where filter paper collects particulates for 24 hours as part of Mawson station's radionuclide system. The system can detect radioactive debris from atmospheric explosions or vented by underground or underwater nuclear explosions. (AAD)*
3. *Mawson Communications Technician Tony Harris takes a measurement with the declination-inclination magnetometer mounted in the middle of the room. (Jenny Wressell)*

VALE Bob Dingle: 1920–2016

Pathfinder at war and in the Antarctic

Bob Dingle, who was deeply involved with the establishment of Australia's continental Antarctic stations in the 1950s and spent seven winters on Australian and American Antarctic stations, died in a Tasmanian nursing home on 5 September, aged 95. He was born William Robert John Dingle at Stithians, Cornwall, England, on 5 November 1920, the only surviving child of William Dingle, petty officer, Royal Navy and Miriam Jane Dingle née Reed. He was educated at the nearby Helston School, which he left in 1936 to join the General Post Office as a clerk and telephonist.

With the advent of World War II, he enlisted in the Royal Air Force Volunteer Reserve and trained as a wireless operator/air gunner, serving operationally with Nos. 78 and 35 Squadrons. By mid-December 1943, he had been awarded a Distinguished Flying Medal as a member of an elite pathfinder crew, which had successfully flown 38 missions including six to Berlin, four to Hamburg and two to Turin. On his next mission to Frankfurt, the starboard inner engine of his Halifax inexplicably caught fire. All attempts to extinguish it were unsuccessful, and the pilot gave the order to bale out. The navigator's parachute failed to open and the pilot and rear gunner stayed with the plane — three fatalities, all New Zealanders, all with the Distinguished Flying Cross.

Dingle landed alone in a ploughed field and walked through the night, spending the next day hidden in a haystack. At dusk he began walking again but about half an hour later he spoke to a farmer who put him in touch with the Belgian underground. On January 6, 1944, he was caught, in a random search by the Gestapo, boarding a train to Brussels, and spent the rest of the war as a POW.

Demobbed in 1947, he migrated to Australia in 1949 and the following year joined the Commonwealth Bureau of Meteorology (BOM) as a trainee weather observer. Often seconded to the Australian National Antarctic Research Expeditions (ANARE), he served at all five Australian Antarctic stations — Heard Island in 1951, Mawson in 1954, Macquarie Island in 1956, Davis Station in 1957 and at Wilkes in 1959 when it was transferred from the United States Antarctic Research Program (USARP) to ANARE. He was awarded the Queen's Polar Medal with a dated clasp (Antarctic 1954–55) as the sole weather observer in the party of 10 that established Mawson Station and an additional clasp (Antarctic 1957) as officer-in-charge of the five-man party that established Davis Station.

In between his Antarctic postings, Dingle served at numerous isolated meteorological stations including Port Hedland, Norfolk Island, Willis Island, the Giles Weather Station in Central Australia and many RAAF stations. Later he was granted special leave from the BOM and spent two winters with USARP — at Byrd Station in 1962 and Plateau Station in 1967.

In August 1968, Dingle was the senior Australian weather observer on the US Navy ship *Eltanin* and over the next three-and-a-half years he served on 18 consecutive marine cruises. After 25 years with the BOM, he retired in 1975 and moved to Swansea on the east coast of Tasmania.

After an extremely varied and adventurous working life, he spent 40 years as a generous and active member of the community in this small town. He was a quiet, introspective and extremely private man, who loved his small house, and his flower and vegetable garden. Mister Dingle, as he was universally known, shared his vegetable produce and many daffodils with neighbours and friends. He visited the sick to see how he could help and for many years audited the local Anglican Church accounts. Periodically though he would take off alone on bushwalking trips around Tasmania. At home he enjoyed listening to his extensive collection of classical symphony and choral music on tape. An accomplished photographer, he held slideshows for local volunteer groups. A book of his Antarctic photographs was published in 2011 (*Antarctica: Photographs by Bob Dingle.* Text by Susan Gordon-Brown, published by Blurb.com, Melbourne).

HERBERT J.G. DARTNALL

This is an edited version of an article that appeared in the *Sydney Morning Herald*, 12 October, 2016.

Herbert Dartnall is an Antarctic freshwater biologist who has served on British, Australian and South African research expeditions, including four months on Macquarie Island (1989–90) and one year at Davis research station (1991). He is a polar historian and long-term friend of Bob Dingle.

1. *Weather observer, Bob Dingle, using a theodolite near Mawson Station in February 1955. (AAD)*
2. *The 1957 Davis Station team (L–R): Nils Lied, Bruce Stinear, Bob Dingle, Alan Hawker and William Lucas. (AAD)*

In from the cold: unlocking the secrets of Antarctic field notebooks

From the early 1960s through to the 1990s Geoscience Australia's predecessors conducted numerous remote field programs, mapping the geology of the Australian Antarctic Territory. Scientific observations, measurements, sample numbers, locations, and other anecdotal information, such as weather conditions and day-to-day life in the field during those early Australian National Antarctic Research Expeditions, were faithfully and sometime painstakingly, recorded in that quintessential accessory, 'the field notebook', by field geologists. These handwritten field notebooks now reside in the Geoscience Australia library, and are publicly available for all to enjoy.

Currently, the interested geologist or historian must physically visit Geoscience Australia to gain access to these irreplaceable and invaluable sources of scientific and other information. The Geoscience Australia library regularly receives requests from researchers to view field notebooks, as the raw data contained is of continued relevance and value to contemporary scientific research.

In addition to the scientific observations, the notebooks record the realities of what everyday life in Antarctica was like. Among the scientific data are lists of food supplies, field logistics and planning, equipment requirements, comments on the dog sledge teams, and WYSSA (private telegram) messages home to loved ones. Increasingly, we are finding that family historians are keen to access their relative's field notebooks for inclusion in their own publications and family histories.

In order to make these valuable records more accessible to the world and in line with Geoscience Australia's policy of ensuring that our geoscience data, information, and collections are discoverable, accessible and searchable as a public resource, a digitisation project has been undertaken. Under the guidance and assistance of the Australian Museum's DigiVol program (https://volunteer.ala.org.au/), and with a loyal cadre of hardworking volunteers, we are digitising and transcribing all the Antarctic field notebooks for web delivery.

Thanks to the hard work of our dedicated volunteers, our collection of almost 90 Antarctic field notebooks is well on its way to being released.

Although the Geoscience Australia library has a comprehensive collection of Antarctic field notebooks, we do have some gaps which we are keen to fill. We'd like to hear from anyone who has any Bureau of Mineral Resources, Australian Geological Survey Organisation, or Geoscience Australia Antarctic field notebooks that we could include in our project, to make the important information contained in them accessible to researchers from around the world.

If you're interested in finding out more, you can meet one of our notebook authors, Dave Trail, via this video https://www.youtube.com/watch?v=Q6QRor7wwhY&feature=youtu.be .

For more information about the project please contact Jane Black, Librarian at Geoscience Australia library on jane.black@ga.gov.au or (02) 6249 5895 or Chris Carson on chris.carson@ga.gov.au

JANE BLACK and CHRIS CARSON
Geoscience Australia

1. *Ian McLeod, Dave Trail and Graham Wallis working on the Taylor Glacier, January 1965. (Geoscience Australia)*
2. *Ian McLeod taking geological notes at Wilkes in January/February 1960. (Geoscience Australia)*

HISTORY

Creative solutions to Antarctic challenges

"Another day, a whole 'nother set of fresh possibilities".

It's a quote from *McGyver*, the 1985 American action-adventure television series about a resourceful secret agent "possessed of an encyclopaedic knowledge of the physical sciences", who solves complex problems by making things out of ordinary objects and his Swiss Army knife.

It's also a concept that reflects the work (and thinking) of electronics engineer Kym Newbery, who, as a member of the Australian Antarctic Division's Science Technical Support (STS) team, has to build and troubleshoot a vast array of electronic equipment for Antarctic science projects, in a challenging environment that demands creative problem solving.

So successful has Kym been in his 17 years in the role, that in June he received the Australian Antarctic Medal for his "outstanding technical contribution to the success of Australia's scientific and logistical activities in Antarctica and the Southern Ocean".

Among his many contributions are remote nest cameras, now installed near more than 50 penguin and flying seabird nesting sites around Antarctica. The cameras are programed to take photographs of the colonies at specific times throughout the breeding season and over winter. Depending on the species, photos are taken from 10 times per day in summer, to two per day in the winter, providing important information to seabird biologists on the changes in adult and chick numbers and movements. In many cases the photographs are the only way this information can be collected, given the remoteness of the locations and the challenge and expense of getting people on the ground.

The camera system has been so successful that the concept is likely to be adopted as a new standard method by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) for future ecosystem monitoring in Antarctica. It is also used on the continent by several other countries, and has provided photos for a citizen science 'Penguin Watch' program.

Kym is also responsible for the Automated Penguin Monitoring System (APMS), which is used to monitor the health of Adélie penguins (via changes in their weight) on Béchervaise Island, near Mawson, for the long-running CCAMLR Ecosystem Monitoring program. Kym designed a major update to the APMS, originally developed by scientists in the late 1990s.

"We went through a number of iterations with the APMS design but the final system involves passively directing penguins, using narrow gates, over a weighbridge," he says.

"Many of the birds can be individually identified by microchips implanted under the skin, and these tags are detected via two antennas on each side of the weighing platform. The antennas use Radio Frequency Identification (RFID) technology to read the tag numbers and identify the direction the birds travel, into or out of the colony.

"The new automated system improves on the tag read rate and the ability to remotely download, maintain and operate the system."

It's not all about penguins, however. Kym and the STS team have also developed a "flying toolbox" to assist sea ice scientists to measure the thickness and temperature of sea ice and snow cover (see side bar). In 2014 they helped scientists design and build an underwater chamber system and associated electronics for ocean acidification experiments (*Australian Antarctic Magazine* 27: 4–5, 2014). More recently, Kym has been developing a fibre optic tow system to allow high definition video streams from the end of a tow cable attached to trawl nets on the *Aurora Australis*.

Prior to joining the STS team in 2001, Kym spent a winter at Mawson station as the support engineer for the Antarctic Division's Atmospheric Space Physics Program. Since then he has spent part of almost every year in Antarctica, or on marine science voyages, working alongside other STS team members to support scientists working within the Australian Antarctic Program. No two days are the same.

"When I'm on the ship I usually support and look after the marine science instrumentation, or specific pieces of kit like towed electronic systems, remotely operated vehicles and whale recorders. In Antarctica I spend a lot of time maintaining, building and repairing different infrastructure," he says.

When he's not in Antarctica, Kym works on multiple projects from the Division's Head Office in Kingston, Tasmania, designing new equipment, maintaining or upgrading existing projects, processing data and responding to science proposals.

Working outside in the cold on delicate and complicated electronics is always difficult so Kym designs a lot of systems — including the remotely operated cameras and penguin weighbridge controllers — to fit inside portable Pelican cases, which can be carried inside a warmer building, rather than remaining bolted to a rock.

"It's not just for my comfort — soldering electronics in the cold is unreliable and prone to error, so working inside greatly increases the reliability of electronic systems," Kym says.

The equipment Kym uses is either straight off the shelf, modified or built completely from scratch using mechanical and electronic computer aided design (CAD) software. Computer controlled temperature chambers are used to make sure that problems with the cold are discovered sooner rather than later. But even with the best preparations problems still arise, leaving Kym scrambling for his "McGyver hat" to work it out.

"So far the only problem I haven't been able to crack is how to keep platelet ice from forming on under-ice instrumentation, without using excessive amounts of electrical power," he says.

Fortunately, Kym has a range of McGyver quotes up his sleeve for inspiration.

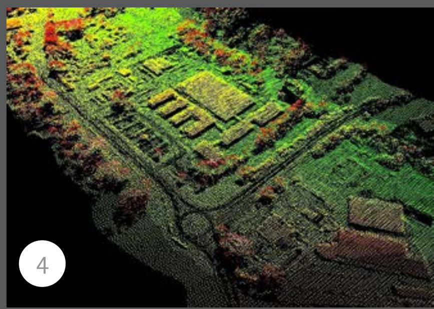
"Desperation tends to make one sort of flexible," he offers.

WENDY PYPER
Australian Antarctic Division

1. *Kym (right) demonstrates a remotely operated penguin nest camera. The camera is mounted on a tripod, weighed down with rocks, and sheltered from the worst of the weather inside Pelican cases (black box under Kym's hand). (AAD)*
2. *The Automated Penguin Monitoring System on Béchevaise Island uses RFID technology to identify tagged penguins, and collects data on their weight and direction of travel as they cross a weighbridge. (Kym Newbery)*
3. *Kym setting up the RAPPLS system in a modified Squirrel helicopter. (Jan Lieser)*
4. *An example of a point cloud produced from LASER pulse data and aircraft positon information. (AAD)*

Flying toolbox

Kym and the Science Technical Support team have developed a helicopter-borne 'RADAR Aerial Photography Pyrometer Laser Scanner' (RAPPLS) to assist sea ice scientists to measure the thickness and temperature of sea ice and snow cover. The system was used successfully during the Sea Ice Physics and Ecosystem eXperiment in 2007 and 2012 (*Australian Antarctic Magazine* 23: 5, 2012) and two voyages to Davis research station in 2008–09 and 2009–10.



In the nose of the helicopter is the LIDAR (Laser Scanner), GPS and Inertial Navigation System (INS) and the Pyrometer (which measures temperature of the sea ice via Infra-Red radiation). Below the operator is a 50 megapixel medium format digital camera, which takes synchronised photos looking straight down. The camera is mounted in a "bucket" (silver box in photo) in the floor of the helicopter to make sure it has an un-obscured view.

"The INS system records the precise location of the helicopter and camera/LIDAR so that LIDAR data can be matched to the aerial photographs," Kym says.

"The LIDAR has a rapidly rotating four-facet polygon mirror and fires 10 000 laser pulses per second at the mirror. It then measures the time travelled for each pulse to return from the ground below. The resulting LASER pulse data, along with the aircraft position information, results in a 'point cloud' representing the sea ice or object below."

The high resolution camera is used to measure ice floe sizes, ice types and distribution. It has also been used in aerial survey work to estimate the population of nesting Adélie penguins in the Vestfold Hills.

"The development of the RAPPLS system required modifications and additions to the helicopter, which had challenges with aircraft modification and certification, as well as managing vibration from the main rotor blades," Kym says.

Antarctic Medal

1. Antarctic Medal recipient, plumber Bob Rowland. (Geoff Overmyer)
2. Antarctic Medal recipient Dr John Cadden. (John Cadden)
3. Professor Pat Quilty AM is the 2016 recipient of the Phillip Law Medal. (Glenn Jacobson)

Long-time Antarctic expeditioners from three diverse careers were honoured with the Australian Antarctic Medal in June — Dr John Cadden, plumber Robert (Bob) Rowland, and electronics engineer Kym Newbery.

Dr Cadden has provided medical services to expeditioners over two Antarctic winters, resupply and marine science voyages, and summer expeditions, between 1999 and 2016. His outstanding skills in psychiatry and psychology, as well as surgery and remote medicine, has earned him the respect, confidence and gratitude of many expeditioners.

Mr Rowland has been a plumber at Australia's Antarctic stations from 1983 through to 2015. He has been instrumental in station maintenance and building programs, with an extensive knowledge of station waste management, water reticulation, heating and ventilation systems. He has also played a key role in fostering a supportive community environment on station and mentoring less experienced expeditioners.

Mr Newbery has been an expeditioner and head office employee at the Australian Antarctic Division for 17 years (see story page 26).

The Australian Antarctic Medal was established in 1987 and is an award in the Meritorious Service Awards category of the Australian Honours System. It replaced the (British) Imperial Polar Medal and its variations which date back to 1857 for service in the Arctic and Antarctic regions.

NISHA HARRIS
Australian Antarctic Division

Phillip Law Medal

The Australian Antarctic Division's former Chief Scientist, Professor Patrick (Pat) Quilty AM, was awarded the prestigious Phillip Law Medal during midwinter celebrations in Hobart in June.

The award, administered by the Australian National Antarctic Research Expeditions (ANARE) Club, recognises an individual who has made an outstanding contribution to Antarctic affairs and the Antarctic community.

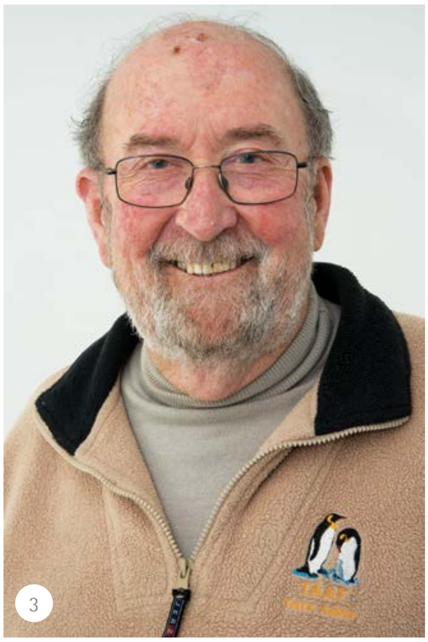
Professor Quilty led the Antarctic Division's science program for 19 years from 1980–1999. He first visited Antarctica in 1965 as a field palaeontologist for the University of Wisconsin, and spent many summer seasons working on the continent and on marine science voyages. He has published over 200 scientific papers, including co-editorship of the 2014 Geological Evolution of Tasmania. He has five fossil species named after him — a fish, a bivalve and three planktonic species — and two geographic locations — the Quilty Nunataks on the southern Antarctic Peninsula and Quilty Bay in the Larsemann Hills.

In 1997 he was awarded Membership of the Order of Australia (AM) and was made Inaugural Distinguished Alumnus from the University of Tasmania. He has received the Royal Society of Tasmania Medal (1996) and the US Antarctic Services Medal (1974).

For four years Professor Quilty was vice-president of the Scientific Committee on Antarctic Research. He is currently an Honorary Research Professor at the University of Tasmania, School of Earth Sciences and Institute of Antarctic and Marine Sciences.

Dr Phillip Law was the founding Director of the Australian Antarctic Division, a position in which he served from 1949 until 1966. He had a major influence in Antarctic affairs as a leader, explorer and administrator.

CORPORATE COMMUNICATIONS
Australian Antarctic Division



Twenty five years of the Protocol on Antarctic environmental protection

This year (2016) marks the 25th anniversary of one of the key agreements that governs Antarctica – the Protocol on Environmental Protection to the Antarctic Treaty. The Antarctic Treaty Consultative Meeting in Santiago, Chile, in May, provided the opportunity for the international Antarctic community to reflect on the importance of the Protocol, its enduring importance for Antarctic environmental protection, and future work to ensure Antarctica's environment is protected.

The Protocol is a legally binding international agreement that establishes Antarctica as a natural reserve devoted to peace and science, and enshrines Antarctic environmental protection as a core objective for all nations active in or interested in the region.

The Protocol was signed in 1991, and entered into force in 1998. There are now 38 Parties to the Protocol, including all of the nations that are active in Antarctica.

25th Anniversary symposium and declaration

This year's Antarctic Treaty Consultative Meeting included a special symposium to mark the 25th Anniversary of the Protocol. The symposium was opened with a video message on the development and ratification of the Protocol from the Hon. Bob Hawke AC, Australia's Prime Minister at the time of the Protocol's adoption.

The symposium provided an opportunity for the Antarctic Treaty Parties, and observer and expert organisations represented at the meeting, to reflect on the past successes and future challenges in Antarctic environmental protection.

The symposium noted the effectiveness of the Protocol since its entry into force, the importance of the Protocol's ban on mineral resource activities, and the flexibility afforded by the Protocol's annexes to adapt to future challenges. The symposium participants reinforced the importance of the best available scientific evidence for future management decisions, and the facilitation of scientific efforts through collaboration and capacity building.

The symposium stressed that effective international arrangements through the Antarctic Treaty Consultative Meeting and its Committee for Environmental Protection, and continued cooperation between the Treaty Parties and all Antarctic stakeholders, are essential to delivering the objective of the Protocol – the comprehensive protection of the Antarctic environment – in the face of future challenges. The key outcomes of the discussions, and the commitment of the Parties to the Protocol and to meeting future challenges, were reflected in the adoption of the "Santiago Declaration", the full text of which can be found at http://atcm39chile.gov.cl/2016/05/espanol-declaracion-de-santiago-en-ocasion-del-25o-aniversario-de-la-firma-del-protocolo-al-tratado-antartico-sobre-proteccion-del-medio-ambiente/.

Reaffirming the commitment to the ban on mining

During the meeting, Australia co-sponsored, with other Parties, a Resolution titled *Confirming ongoing commitment to the prohibition on Antarctic Mineral Resource Activities, other than for scientific research: support for the Antarctic mining ban*. The meeting noted that there was a widespread misconception and misunderstanding that there was an 'expiry date', in 2048, for the Protocol's mining ban.

The Resolution notes that the Protocol does not expire in 2048, and reinforces the commitment of all nations active in Antarctic management and governance to the Protocol's ban on mining. Through the Resolution, the Parties:

- acknowledge the benefits to the Antarctic environment resulting from the prohibition on activities relating to mineral resources, other than scientific research, under Article 7 of the Protocol;
- reaffirm their commitment to Article 7 of the Protocol; and
- declare their firm commitment to retain and continue to implement this provision, as a matter of highest priority, to achieve the comprehensive protection of the Antarctic environment and dependent and associated ecosystems.

PHIL TRACEY
Senior Policy Officer,
Australian Antarctic Division

Misconceptions on the mining ban

The Protocol includes an indefinite ban on mining and mineral resource activities. This ban is unambiguous: "Any activity relating to mineral resources, other than scientific research, shall be prohibited" (Article 7).

The ban represented a rapid change in thinking on Antarctica and its future. In 1988, an agreement permitting (but carefully regulating) mineral resource activities in Antarctica had been finalised. Australia, joined by France, played a pivotal role in deciding not to bring this agreement into force, and instead pushed for the Protocol and its comprehensive environmental protection regime.

The status of the Protocol's ban on mining is often misunderstood. Some people assume that the ban on mining 'expires' in 2048, or that there will automatically be a review of the Protocol at that time – this is not the case.

Like most international agreements, the Protocol includes provision for review. Up until 2048, unanimous agreement of Antarctic Treaty Consultative Parties would be required to change the Protocol to remove the mining ban. Fifty years after the 1988 entry into force of the Protocol (2048), a Consultative Party can request a review conference to consider part or all of the Protocol. However, even then the Protocol contains strict conditions which would have to be met before the mining ban could be changed, including that a change could not enter into force without being implemented by all 26 countries that were Consultative Parties at the time of adoption of the Protocol – including Australia.

What does the Protocol do?

- Establishes Antarctica as a natural reserve devoted to peace and science.
- Provides comprehensive environmental protection to the area south of 60°South latitude.
- Prohibits mining and mineral resource activities indefinitely.
- Requires all activities to be planned and conducted to minimise impacts.
- Requires environmental impact assessments for all activities.
- Regulates waste management – wastes are to be removed, old waste and waste sites to be cleaned up.
- Provides for designation and management of specially protected areas to provide additional protection to key values, and specially managed areas to assist in the planning and coordination of activities, avoid possible conflicts, improve cooperation, or minimise environmental impacts.
- Provides protection for plants and animals.
- Prevents or regulates discharge of pollutants to the marine environment.
- Puts in place arrangements for liability associated with environmental emergencies (yet to enter into force).

1. *Plants and animals are protected under the Protocol on Environmental Protection to the Antarctic Treaty. (Phil Tracey)*

2. *The Australian delegation to the Antarctic Treaty Consultative Meeting and Committee for Environmental Protection in Santiago, Chile this year. (AAD)*

3. *The Protocol on Environmental Protection to the Antarctic Treaty establishes Antarctica as a natural reserve devoted to peace and science. Mining and mineral resource activities are prohibited indefinitely, and all activities, such as tourism (pictured), must be planned and conducted to minimise impacts. (Phil Tracey)*

IWC appointment

The Government appointed Australian Antarctic Division Director, Dr Nick Gales, as Australia's new Commissioner to the International Whaling Commission (IWC) in June.

Dr Gales takes up the position at a critical time in Australia's efforts to maintain the global moratorium on commercial whaling. This year (2016) is the 30th anniversary of the moratorium and it is as important today as it was 30 years ago.

For over a decade, Dr Gales led Australia's delegation to the IWC's Scientific Committee — a role that culminated in him serving as a key witness in Australia's successful case at the International Court of Justice against whaling by Japan in the Southern Ocean (*Australian Antarctic Magazine* 26: 6, 2014).

Dr Gales will ensure that Australia continues to be a leading voice in the IWC, advocating for a permanent end to all forms of commercial whaling, and so-called scientific whaling. Australia maintains that all information necessary for the management and conservation of whales can be obtained through non-lethal methods.

Dr Nick Gales is Australia's new Commissioner to the IWC. (Glenn Jacobson)

La Trobe University marine biologist Dr Jan Strugnell helped coordinate the publication on Wikipedia of more than 100 biographies of high achieving female scientists, from 30 countries. (Rachel Malinowski)

Wikibomb celebrates women in Antarctic science

Women in Antarctic research were celebrated at this year's meeting of the Scientific Committee on Antarctic Research (SCAR) through a 'Wikibomb' event.

A team of volunteers, led by Latrobe University marine biologist, Dr Jan Strugnell, and Wikipedia expert and protein engineer Dr Thomas Shafee, created and updated more than 100 biographies of high achieving women in Antarctic science.

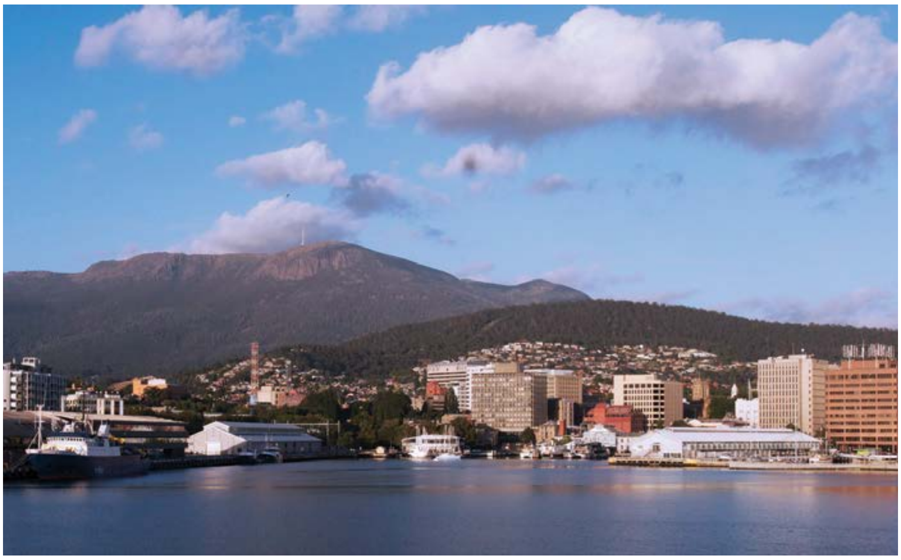
Dr Strugnell said it was important that senior women scientists were visible to younger female scientists, so that they understood that careers in science were possible. She said some 60% of early career Antarctic researchers are women, with strong reputations in the scientific community, but only about 10% of awards, prizes and papers at scientific conferences were presented to, or given by, women.

Of the 18 Australian women now profiled through the Wikibomb, four are from the Australian Antarctic Division. For the full list of women nominated by SCAR, and their Wikipedia entries, see the Women of the Antarctic Wikibomb page https://en.wikipedia.org/wiki/Wikipedia:Meetup/SCAR_2016.

Tasmania to host key Antarctic meetings

Tasmania will host two major Antarctic meetings in 2020, bringing together the world's experts in Antarctic research and operations and further cementing the state's role as a key Antarctic Gateway.

The Scientific Committee on Antarctic Research (SCAR) will hold its Delegates' Meeting and Open Science Conference in Hobart in mid-2020, with more than 700 Antarctic scientists and academics from over 40 countries expected to attend. The Council of Managers of National Antarctic Programs (COMNAP) will also host its Annual General Meeting in Hobart, with more than 100 Antarctic program managers and operational experts to attend.



Tasmania will host two major Antarctic meetings in 2020. (Jessica Fitzpatrick)

Low winter sea-ice coverage bucks trend

Winter sea-ice coverage around Antarctica was noticeably reduced in September this year, with sea ice extent starting its annual retreat early and setting new daily record lows.

The result comes two years after winter sea ice extent around Antarctica reached a record high in September 2014, when it exceeded 20 million square kilometres for the first time since satellite measurements began in 1979.

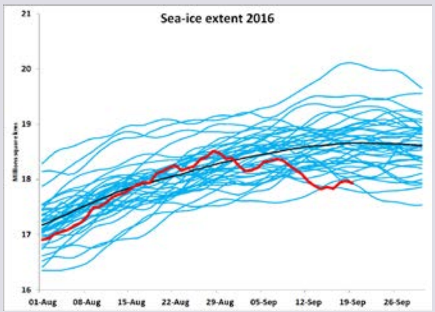
This year, Antarctic sea ice began its annual spring retreat roughly four weeks earlier than average, after peaking at 18.5 million square kilometres on 28 August 2016, which was close to the lowest winter maximum on record.

Dr Jan Lieser from the Antarctic Climate and Ecosystems Cooperative Research Centre (ACE CRC) and the Australian Research Council-funded Antarctic Gateway Partnership said it was a surprising finding, given the trend in recent years.

"Within the space of just two years we have gone from a record high winter sea-ice extent to record daily lows for this point in the season. This is a great reminder that we are dealing with an extremely variable component of the climate system," Dr Lieser said.

"It's also a reminder of why it can be unwise to leap to conclusions about the link between Antarctic sea ice and climate change on the basis of one or two years of data. It is the long-term trends that are most important, as well as the regional variability, which is high around Antarctica."

DAVID REILLY, ACE CRC



Antarctic winter sea-ice extent peaked at 18.5 million square kilometres on 28 August 2016, which was close to the lowest winter maximum on record. The red line shows the sea ice extent between August and September this year. The light blue lines show the maximum/minimum recorded extent between 1979–2015 and the black line represents the average extent between 1979–2015. (Phil Reid/BOM)

Antarctic Circumnavigation Expedition

The proposed voyage legs of the Antarctic Circumnavigation Expedition. (Swiss Polar Institute)

In April 2016 the newly created Swiss Polar Institute announced its first ambitious project; an international scientific expedition circumnavigating Antarctica.

Twenty-two research projects were selected for the expedition, involving 55 scientists from 30 countries. Australia will conduct seven projects during the voyage, with the Australian Antarctic Division leading two of those.

The 90 day expedition will be supported by the Russian icebreaker RV *Akademik Treshnikov*. The ship will sail from Cape Town, South Africa, in December 2016, visiting four sub-Antarctic islands, including Heard and McDonald Islands, on its way to Hobart (Tasmania). From there it will sail south via Macquarie Island and make its way along the West Antarctic coastline to Punta Arenas (Chile). The final leg will conclude in Cape Town in March 2017, after visiting South Georgia and the South Sandwich islands.

The expedition is a unique opportunity to obtain a circumpolar perspective on scientific questions in a single summer season.

First midwinter airdrop

Medical supplies, mail and tractor parts formed part of the very first midwinter airdrop of supplies to an Australian Antarctic station in June.

In complete darkness and with temperatures below -30°C, a Royal Australian Air Force (RAAF) C-17A Globemaster III dropped 1500 kg of cargo for the Australian Antarctic Division onto the Casey plateau.

The Antarctic Division's Future Concepts Manager, Matt Filipowski, said that until now, access to Australia's Antarctic stations has been limited to the summer months between October and March.

"We can't reach our stations by sea or air in winter, due the darkness, sea ice and extreme temperatures," Mr Filipowski said.

"But this capability test with the RAAF C-17A has shown we can now drop essential supplies and equipment year round."

RAAF Flight Lieutenant Doug Susans said the aircraft routinely undertook airdrops across the globe, but this was the first time in winter in a polar region.

"We undertook training in the simulators before the mission to make sure we were familiar with the locations, timings and observations," he said.

This is phase two of a trial using the RAAF planes in Antarctica. Last season the C-17A made six successful trips to Australia's Wilkins Aerodrome to provide heavy-lift cargo for the Australian Antarctic Program (*Australian Antarctic Magazine* 30: 24-25, 2016).

NISHA HARRIS
Australian Antarctic Division

The cargo was deployed from the C-17A at 3500 ft. The aircraft slowed to a speed of 145 kts (270 km/h) to conduct the drop. ©Chad Griffiths/RAAF

Freeze Frame

Kym Newbery has worked as an electronics engineer with the Australian Antarctic Division's Science Technical Support team for 17 years. He designs, modifies and maintains a diversity of electronic equipment for use by scientists and non-technical personnel in support of the Australian Antarctic Program (see page 26).

This photo was taken using a Hasselblad 50 megapixel camera installed underneath a helicopter as part of the RAPPLS system (see page 27). The photo was taken on the return of a mission to the Prydz Bay region near Davis, and is one of many thousands taken. The placement of the companion helicopter below the aircraft and the iceberg was an idea we had on the flight, to take an interesting photo showing the scale of machines and nature.

ANTARCTICA
valued, protected
and understood

www.antarctica.gov.au

Australian Government
Department of the Environment and Energy
Australian Antarctic Division