AUSTRALIAN ANTARCTIC MAGAZINE

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Instrument Electrician Zach Lockhard took this photo of pancake ice in Newcomb Bay, at Casey, after a blizzard last year. Standing at the wharf he used a DJI Mavic Pro drone to hover about 60 metres above the water, braving the cold for 15 minutes to capture the ice forming. A few hours later the bay was covered in sheet ice.

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).

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From the Director

The new Director of the Australian Antarctic Division, Kim Ellis, took up the reins in February. Mr Ellis is the 13th Director of the Division, replacing Dr Nick Gales who retired in late 2018.

The Australian Antarctic Division is a globally recognised institution delivering amazing scientific capabilities and I am honoured to lead an organisation of such enthusiastic, engaged, committed and skilled people. This is the most exciting job in the world!

I've had a strong interest in Antarctica since high school and I seem to have worked in a succession of jobs that, perhaps unconsciously, have been leading me towards this role.

My journey started when I graduated from the Australian Army's Royal Military College at Duntroon, and went into amphibious logistics; specifically because I wanted to go to the Antarctic.

As a 'LARC-ey'- operating the all-terrain vehicle or Lighter, Amphibious, Resupply Cargo, I led a group of soldiers that undertook the resupply at Mawson, Davis and Macquarie Island research stations. We also worked on the building programs that were underway at the time.

This time on the ice was a remarkable character-forming experience and it gave me a good grounding in the unique operating environment of the Antarctic Division – including the challenges of logistics, weather, getting people in and out, and dealing with emergency situations.

After I retired from the Army in 1997 I spent 16 years running small and large airports in Australia, including leading the Sydney Airport international terminal upgrade and the 2000 Sydney Olympic operations. Again, this gave me a good grounding in logistical challenges.

When I became Executive Director at Sydney's Botanic Gardens and Centennial Parklands in 2014, one of the core elements of my role was collecting data and monitoring and reporting on changes in climate. So I have a strong background in

large-scale public organisations delivering critical environmental science activities.

As you know, the Australian Antarctic Program has a 20 year Strategy and Action Plan, with a strong focus on developing Australia's presence in Antarctica and maintaining and building a strong science capability. For the next five years the Australian Antarctic Division will be focused on enabling world-class science and delivering outstanding infrastructure with the best workforce we can have.

This work will be driven by a significant investment from the Federal Government to provide a new icebreaker (page 6) that will be one of the world's premier scientific research vessels, an overland traverse capability (page 11) to find a million-year-old ice core, and the rebuilding of Macquarie Island research station (page 2).

In February this year the Prime Minister also announced a Federal Government investment of more than $450 million over 10 years to upgrade our Antarctic research station network and supporting infrastructure.

The challenge for the Antarctic Division will come from both managing these new capabilities while delivering our existing operations.

Through all this I will continue to tell the story and build the brand of the Australian Antarctic Program. Not just the understanding of our immense scientific contribution, but also the incredible adventure of working in Antarctica. The ability for a tradesperson, scientist, administrator or communicator to live in one of the world's great frontiers; to work in the character-changing environment and build friendships, skills and experiences that will last a lifetime.

One of my most important personal focuses will be on maintaining a safe operating environment, to ensure that everybody who participates in our activities comes home safely.

The Antarctic continent is huge, imposing and frightening, but it's also one of the most fragile parts of the Earth. The Australian Antarctic Division has an enormous responsibility to develop our science, to keep data and to provide records that will inform government policy, to ensure that Antarctica and the whole Earth's climate is protected. Delivering on our 20 year Action Plan is the most important thing we can do to achieve this.

Kim Ellis
Australian Antarctic Division

Main: Mr Kim Ellis is the 13th Director of the Australian Antarctic Division. (Photo: AAD)

Inset: Kim Ellis (left) with LARC colleagues at Davis station, 1979-80.

Getting the measure of Macquarie Island field huts

Hiking 80 kilometres in 13 days over steep, rough and sometimes boggy terrain, in driving rain, and with more than 20 kilograms on your back, is not for the faint-hearted. But when the weather gods smile and your journey takes you past vast colonies of penguins, seals and seabirds, on your way to six iconic Macquarie Island field huts, it's as good as it gets. Especially if you're already an outdoorsy type.

Ben Woods navigates a steep tussock slope above Hurd Point. (Photo: Aleks Terauds)

For the Australian Antarctic Division's Macquarie Island Infrastructure Project Officer, Paul Farrow, it was the trip of a lifetime to asses each of the six huts for replacement or refurbishment.

The assessment is part of a broader modernisation plan for the island's infrastructure, which includes building a new research station and decommissioning the existing 70 year-old one (see *Australian Antarctic Magazine* 35: 6-7, 2018).

"The field huts are as integral to life and scientific research on Macquarie Island as the actual station, so it's important to get this right," Mr Farrow said.

Antarctic Division spatial ecologist Dr Aleks Terauds, and one of the site foremen for Managing Contractor VEC Civil Engineering, Ben Woods, also joined Mr Farrow.

"The three of us worked together to assess the structural and functional aspects of the six huts, while Aleks also undertook an environmental impact survey of each hut's current location and any proposed new locations, or extensions or renovations," Mr Farrow said.

"Our reports will form the basis for recommendations on which huts should be refurbished or replaced, where new huts might be sited, and how much it will cost."

While assessing the structural integrity of each hut Mr Farrow also undertook a detailed inventory of fixtures, fittings and equipment, including photographs and video. He developed floor plans for each hut, surveyed levels around the hut sites, and marked up site plans with potential staging areas for construction crew and equipment.

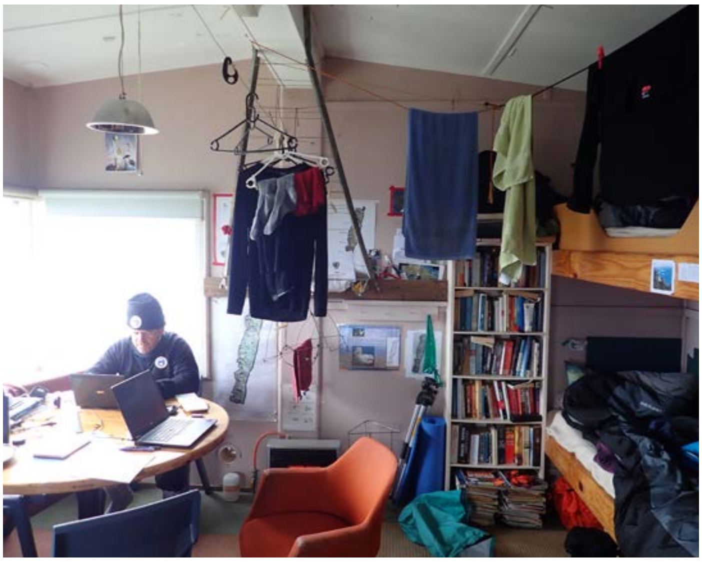
In terms of function, the team looked at what works and what doesn't, based on discussions with past and current users of the huts and Dr Terauds' extensive knowledge from years of seabird and terrestrial research based out of the huts (see page 5).

"Some of the most important functional elements we identified were the need for roomy, ventilated cold porches to dry and store wet gear and other supplies, plenty of natural light, and clever heating," Dr Terauds said.

"Then there are things like access to water and managing grey water disposal, the interaction between spaces inside the huts, and even having a few creature comforts, like bucket showers.

"In my view, the key thing is that any new build, extension or renovation should not be over-engineered, because simple often works best in this environment and generally requires the least maintenance."

Dr Terauds also conducted a flora and fauna survey around each hut and any potential new hut locations, including areas for temporary accommodation, helicopter landings and construction materials.



"Most of my report is about the plants or animals found in the vicinity of the huts or new build sites," he said.

"Fortunately, most of the huts are away from penguin colonies, so wildlife considerations generally relate to helicopter landing or drop sites."

The team's reports will feed into an existing 'functional design brief' for the huts, which sets out the standards required of each hut. These include the number of people each hut should accommodate, the purpose of a cold porch and protected entrance, the tasks that need to be supported by the kitchen and living space, power generation, water supply, heating, lighting and waste management, amongst other things.

Only two of the huts, at Green Gorge and Hurd Point, come close to meeting this brief and are the most likely candidates for renovation or extension. Two prefabricated fibreglass 'googies' at Waterfall Bay and Brothers Point are too small, and poorly suited to the wet subantarctic environment. The old hut at Bauer Bay now has a creek running beneath it, while at Davis Point, a water tank is currently used more as a refuge.

Once decisions have been made on which huts will be replaced or refurbished, the architects and engineers subcontracted by VEC will turn their thoughts to the detailed design of the huts, factoring in the logistics of getting construction materials or flat-packed structures to sites.

"It's exciting to think that the new huts will be designed to respond to their local areas, including the views, wildlife and weather. They will become places people want to visit for the experience of seeing the huts and staying in them."

"It's likely that we'll have to fly everything to site and have construction crews walk in, so the design of the huts will have to be simple," Mr Farrow said.

"We may be able to construct them in Hobart and flat-pack them for transport, re-erect them at Macquarie Island station and then fly them to sites. This will reduce the amount of time the construction team need to spend at each site."

Despite the sentimental values attached to the current huts, expeditioners know it's time for change.

"The reality is that the huts are at the end of their life and, like the station, they have become a cost and maintenance burden," Mr Farrow said.

"This is an opportunity to rectify the issues and make the huts comfortable to work in.

"It's exciting to think that the new huts will be designed to respond to their local areas, including the views, wildlife and weather. They will become places people want to visit for the experience of seeing the huts and staying in them."

For Dr Terauds, who spent years of his life in the huts, and walking the tracks and beaches between while conducting a range of research, it's a bitter-sweet but necessary step.

"This will allow the Australian Antarctic Division to leave a legacy for the next generation of researchers. It will be good for the island and the science that will happen there," he said.

Wendy Pyper
Australian Antarctic Division

Clockwise from top: Picturesque Hurd Point hut at the southern tip of Macquarie Island. The hut is regularly used by albatross monitoring scientists. All the huts have a 'remote area power supply' that includes a wind turbine, solar panels and a generator (visible to left of hut). (Photo: Aleks Terauds)

Spatial ecologist Dr Aleks Terauds on the cold porch outside the Waterfall Bay googie. (Photo: Aleks Terauds)

The Macquarie Island field hut assessment team of Paul Farrow (left), Dr Aleks Terauds and Ben Woods from VEC Civil Engineering (right). (Photo: Paul Farrow)

The inside of Hurd Point hut shows why larger cold porches and better separation of living and working spaces will make for a more comfortable experience. (Photo: Paul Farrow)

Walking on the wild side

Spending 13 days traversing the windy, wet subantarctic Macquarie Island is a hard-won privilege.

While Paul Farrow, Dr Aleks Terauds and Ben Woods were up for the task of assessing the island's network of six field huts for a program of modernisation (see page 4), the experience had its challenges.

On most days the trio traversed densely vegetated 'tracks' on the island's plateau, dodging tussock grasses and seal wallows, and navigating steep scree slopes. Or they walked the coastal route, detouring around large congregations of wildlife. All while carrying the equipment needed to do their jobs – including laptops, hard drives, GoPros, radios, spare batteries, GPS trackers, survival gear and clothes.

Despite extensive hiking experience in Antarctica, Tasmania and elsewhere, Mr Farrow said the island didn't compare.

"While the plateau has defined tracks, you have to avoid wildlife, like skuas, which nest on the track.

"I often found myself knee deep in seal wallows and holes that I couldn't see because of the tussock grass and the slope.

"Then there are steep, loose scree or grassy jump-ups of 300 to 400 metres between the beaches and the huts, which need a level of fitness to navigate.

"By the time we got to our hut we were in that 'hiking holiday' frame of mind and pretty fatigued, but we had to switch into work mode."

Fortunately the team had a number of rest days scheduled to recover their energy for the next leg.

Highlights included uncommonly good weather, which allowed the team to appreciate the views and collect good information from their surveys and observations in and around the huts. The wildlife was "phenomenal", as was the cooking.

"We had some crazy pizzas, including one where we added anything we could find – mostly tins of seafood. I thought we might regret it, but it turned out really well," Mr Farrow said.

Wendy Pyper
Australian Antarctic Division

Paul Farrow (top) and Ben Woods scale a scree slop from Davis Point hut up to the plateau. These steep climbs of up to 400 metres are part of the joy of hiking on Macquarie Island. (Photo: Aleks Terauds)

Living the hut life for science

Main: Caroline Cove hut was Aleks's favourite hut until it was lost to a landslide. (Photo: Aleks Terauds)

Inset: Huts have played an important role in facilitating research on Macquarie Island, including Aleks's many years working with albatrosses and petrels at their remote nesting sites. (Photo: Aleks Terauds)

"After I'd climbed out a small window and dug the door out, I was left to contemplate what might have been, and appreciate the fact that I was there to appreciate the island."

Field huts are an integral part of life for many researchers on Macquarie Island, providing a home away from home and an opportunity to become immersed in a raw, elemental and vibrant environment, with penguins and seals on the doorstep.

The field huts have played a fundamental role in a wide range of research, facilitating daily visits to penguin colonies, sampling and surveying of remote geological features, or long term-multi season monitoring programs like the albatrosses program.

This research has fundamentally changed the way we think about and manage the Macquarie Island environment and ecosystems. From defining the geological values that underpinned the island's World Heritage status, to tracking seabirds to understand their past, current and potential threats, field huts have helped to deliver a range of positive outcomes for the Macquarie Island environment and its biodiversity.

But of course it's not just about the research. The field huts also played a critical role in the Macquarie Island Pest Eradication Program, acting as bases for bait drop operations during the helicopter operations in 2010 and 2011. They were also a welcome respite for the hunters and dogs as they spent three years literally walking their way over every square meter of the island – rain, hail or shine. For those of us who were involved in the early stages of the eradication operation, the announcement in 2014 that the island was rabbit and rodent free was a welcome culmination of over a decade of intense effort. To this day it represents one of the most satisfying conservation outcomes that I have ever been involved in.

Since 1996, when I first went to the island, I have spent many years living and working in the huts. One of my most memorable experiences was waking up to a heavy rainstorm in 2000 at Caroline Cove hut, situated at the base of a mountain in a south-western bay. The flooding river adjacent to the hut was the first sign that something was amiss, but nothing could prepare me for the deep rumbling sound of hundreds of tonnes of rock and dirt, as a massive landslide roared down Petrel Peak later that morning, enveloping the hut (and many of the penguins that were on the beach). After I'd climbed out a small window and dug the door out, I was left to contemplate what might have been, and appreciate the fact that I was there to appreciate the island.

Caroline Cove was condemned soon after, and although it was my favourite hut, I grew to love Hurd Point hut, where I spent many subsequent summer field seasons studying the albatrosses that live nearby. Bauer Bay field hut is also a special place for me, for its stunning location on the north-western featherbed, and for the many great memories of time spent there with friends and colleagues.

Twenty years ago it wasn't uncommon for me to spend significant time alone in field huts. Often weeks would go by without my seeing another person; my only communication with the outside world through the nightly radio 'sked'. But there was always plenty to do, and if I wasn't writing up research or analysing data, I would spend time in the kitchen, baking bread or other treats and trying to think up creative ways of cooking vegetarian food in the field. To this day, lentil and bean pies remain a Macquarie Island hut favourite.

Now the field huts are host to a new generation of researchers, including those undertaking post-eradication monitoring to help understand how the ecosystem is responding to the removal or rabbits and rodents. But for several huts, their time is drawing to a close, as plans are made for rebuilding or major renovations (see page 4). Soon a new era of hut life on Macquarie Island will begin.

Aleks Terauds
Leader - Biodiversity Conservation,
Australian Antarctic Division

More than a ship

RSV *Nuyina* may be the new flagship of Australia's maritime Antarctic operations, but an understated fleet of small watercraft will be an essential support to the icebreaker's scientific and logistic capabilities.

As befits a vessel of the size, strength, purpose and capacity of the *Nuyina*, a series of smaller support craft – a science tender, two personnel transfer tenders, a stern tender and two barges – will form part of the 'ship system'.

Australian Antarctic Division Icebreaker Project Officer Justin Hallock said the system approach means that the *Nuyina* has dedicated facilities to accommodate the smaller support vessels. These include dedicated stowage positions, tailored lifting and securing equipment, power outlets to charge batteries and warm engines, and facilities for refuelling. The tenders will also be the same colour as the mother ship.

"Because the tenders and barges are part of the ship's system they will go through the same testing regime as *Nuyina*," Mr Hallock said.

The two aluminium personnel transfer tenders will be operated by two crew and will transfer up to eight expeditioners and 150 kilograms of baggage from the ship to Antarctic stations. They will be deployed by "certified man-riding davits" (small cranes) over the side of the ship, with people and cargo already loaded.

"The tenders are made to a very robust design by Maritime Partner in Norway, which allows them to operate in rough seas," Mr Hallock said.

"However, at four tonnes and more than eight metres in length, they will be too big to handle in the surf at Macquarie Island, so we'll continue to deploy inflatable rubber boats to get people ashore in the sub-Antarctic."

The tenders have plenty of redundancy built into them in terms of propulsion and navigation, with two five-cylinder diesel engines, separate fuel tanks, radar, GPS, chart plotter and an electronic identification system.

While the stern tender is identical to the personnel tenders, it is located at the stern of the ship for access to the pool of open water behind the ship when it's locked in ice. This is important for safe helicopter operations and to support deployments of some scientific equipment over the stern.

While the stern tender is identical to the personnel tenders, it is located at the stern of the ship for access to the pool of open water behind the ship when it's locked in ice. This is important for safe helicopter operations and to support deployments of some scientific equipment over the stern.

An artist's impression showing the two barges and a personnel transfer tender in the water. The science tender is located mid-ship and the stern tender at the stern of the vessel. (Graphic: Damen/AAD)

Clockwise from left: The barges will sit on the hatch covers at the bow of the *Nuyina*. (Photo: Damen)

One of three personnel transfer tenders constructed in Norway. (Photo: Maritime Partner)

One of the aluminium jet barges under construction by Taylor Bros in Tasmania. (Photo: Wendy Pyper)

The barges are a classic example of a highly complex system made to look simple, with design tweaks that ensure their ramps will cope with frequent heavy loads at a certain gradient in contact with the shore, and various tide heights.

Altogether, the three tenders offer a capability increase on the *Aurora Australis*, which doesn't have dedicated embarked personnel transfer watercraft.

Similarly, the science tender will provide a new research capability that will work independently or in parallel with the *Nuyina*'s scientific systems.

"Its primary mission is to support science activities. It has a moon pool to deploy instruments through the hull, an A-frame to deploy towed bodies and a davit rated to deploy scientific instruments in rough seas," Mr Hallock said.

The 10.3 metre-long, 3.5 metre-wide science tender also has a few mod cons including a heater, defroster, sink and toilet. The vessel will be operated by two Australian Antarctic Division personnel and will accommodate up to six personnel and 500 kilograms of cargo.

At the opposite end of the *Nuyina*, on the cargo holds' hatch covers near the bow, will sit the two 16.3 metre-long, 6.2 metre-wide barges, each capable of carrying more than 45 tonnes of cargo.

Manufactured by Taylor Bros in Hobart, Tasmania, the barges can carry trucks loaded with shipping containers for a 'roll on, roll off' operation, or shipping containers and other cargo for a 'load on, load off' operation, using cranes on the ship and at the station wharf.

Icebreaker Project Manager, Nick Browne, said the aluminium barges can operate in calm seas and up to 50 knots of wind, at a speed of eight knots.

"The barges are not built for the open ocean, but to carry general cargo from ship to shore in Antarctica. They can operate in grease ice and they have rubber fenders that can be used to carefully nudge bergy bits out of the way," Mr Browne said.

Each barge has two 448 kilowatt (600 horsepower) engines and a water jet propulsion system that provides greater manoeuvrability than propellers.

"The water jets are a proven technology in Antarctica," Mr Browne said.

"They draw in water under the hull and push it past the stern, generating thrust. When each jet is operated independently they provide good control for manoeuvring. Because there are no external propellers or protrusions below the hull, it means they can sit flat on the hatch covers of the cargo holds."

The barges are a classic example of a highly complex system made to look simple, with design tweaks that ensure their ramps will cope with frequent heavy loads at a certain gradient in contact with the shore, and various tide heights. They can also fit a 40 foot container while still allowing crew to move between the container and the wheelhouse, rather than having a long walk around.

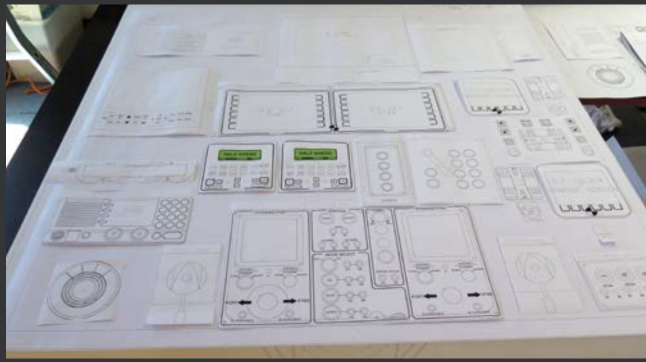
As an added complexity, all the vessels and their associated equipment need to operate in temperatures as low as -30°C and up to 45°C.

"It's a challenge to meet this design criteria," Mr Browne said.

"Fortunately we have in-house experts and naval architects who can provide advice on the performance of equipment and materials at these extreme temperatures, as well as the expertise of Taylor Bros on our landing barges currently in operation.

"As a result, our watercraft will be just as strong, reliable and capable in their roles as the *Nuyina* will be. They will be an integral part of the ship's systems and key to *Nuyina*'s ability to support the Australian Antarctic Program for the next 30 years."

Wendy Pyper
Australian Antarctic Division



Building a bridge

The bridge of Antarctic icebreaker RSV *Nuyina* has come a long way from a scale model on paper to a final functional design boasting cutting-edge technology.

Just as 'form follows function' in modern industrial design, function is a key design driver on the bridge of the *Nuyina*, and critical to the vessel's efficient and safe operation.

So who better to apply this design principle than former ship Captain and Australian Antarctic Division Icebreaker Project Officer, Mike Jackson, and former Captain of Australia's current icebreaker *Aurora Australis*, Scott Laughlin.

To begin, the pair covered walls and work benches with sheets of paper printed with life-size graphic representations of the bridge instruments.

Then, by sitting at the central and side-wing 'conning' (driving) positions, and "using a bit of role play" to move between the different functions of the bridge, they were able to adapt the original bridge design, provided by the Damen ship-builders, to their needs.

"In the central conning position, for example, we looked at what we'd need to do if we were conducting helicopter or boating operations, and then we moved to the side positions and repeated the process," Mr Jackson said.

"On the starboard side of the ship there are two conning positions; one facing forward for icebreaking and cargo operations, and another facing aft for scientific work and stern and side deployments.

"So we looked at things like visibility and radio communications, using windscreen wipers, and ensuring the bridge instrumentation was in the right position for operations facing both ways.

"Printing the shapes of the instruments to scale on individual sheets of paper made it easy to move the pieces around and find the best solution to each operational need."

As they found functional efficiencies, the pair also saved space, with room opened up for the harbour pilot to dock their laptop, and more room for navigation charts.

In November 2018 Mr Jackson travelled to Norway to see the design in action, witnessing the Factory Acceptance Test of *Nuyina*'s bridge systems, before installation on the ship.

"...the pair covered walls and work benches with sheets of paper printed with life-size graphic representations of the bridge instruments... by sitting at the central and side-wing 'conning' (driving) positions, and "using a bit of role play" to move between the different functions of the bridge, they were able to adapt the original bridge design"

Clockwise from left: An earlier version of the *Nuyina* bridge, mocked up with instruments printed to scale and mounted at the same height and distance as they would appear on the ship. This section shows the central console and instruments to its right. (Photo: Mike Jackson)

A 1:1 scale mock-up of the central conning console. (Photo: Mike Jackson)

The central conning (driving) console. The central display monitor shows information from the sensor integrator. The ship can be driven from the wheel, levers and joysticks on this console. Steering and propulsion can also be controlled from levers in an arm rest on the driver's seat. (Photo: Mike Jackson)

The three day trial involved inspecting all the consoles and instruments, and then testing the ship's systems in normal and failure situations using a simulator.

Four critical systems were tested – the bridge navigation system, the 'sensor integrator', the 'dynamic positioning system', which maintains the ship's position, and the 'Seapath 380', which provides positional information to scientific instruments to allow them to adjust for ship movement.

"In one test we checked that the navigation radar changed scale, that it could acquire and track a target, and that an alarm sounded if the target was lost," Mr Jackson said.

"In another test we removed power from one of the thrusters and checked that the dynamic positioning system adjusted the other thrusters to pick up the load."

The sensor integrator is a critical part of bridge operation. It collects information from a swath of navigation sensors, such as the ice and navigation radars, compass and gyros, and provides it to all the multi-function display consoles as required.

"The *Nuyina* has an integrated bridge, which means that information from the sensor integrator is available on all the consoles," Mr Jackson said.

"For example, you can display the ship's navigation and controls, or the radar information, on any or all of the multi-function displays, and you can overlap the radar on the charts."

The Factory Acceptance Test was attended by representatives from Norwegian company Kongsberg Maritime, who supplied most of the consoles and equipment, as well as Damen, Serco and Mr Jackson.

Once the bridge instrumentation is installed on the ship, there will be a Harbour Acceptance Test (HAT).

"The HAT is a repeat of what we've already done but using the ship's sensors rather than a simulation," Mr Jackson said.

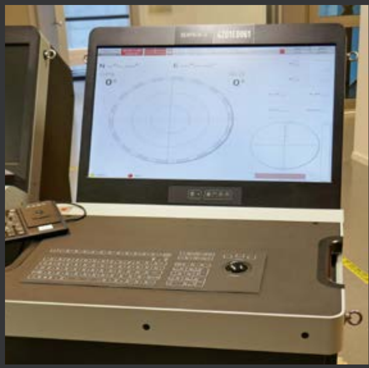
"After that we'll do a Sea Acceptance Trial, where we can use the displays, track radar contacts, and find all the loose nuts and bolts as the ship moves around."

Wendy Pyper
Australian Antarctic Division

"In another test we removed power from one of the thrusters and checked that the dynamic positioning system adjusted the other thrusters to pick up the load."

The front of bridge consoles undergoing a Factory Acceptance Test in Norway in November. At the front right of the image are consoles for the Seapath 380 and dynamic positioning system. At the back on the left is the console that controls internal lighting, the drop keels and a sonar display. (Photo: Mike Jackson)

Ship-shape layout



From left: The ship's dynamic positioning (DP) system will mainly be used to hold the ship (via the thrusters) at a designated position and heading during scientific operations and during resupply. The system can hold the ship in position with an accuracy of ±20 metres. The DP is operated via a 'compact joystick' (visible on the far right of this photo) or a moveable 'compact wing station' on a lead, that can be plugged in to different points on the bridge. (Photo: Mike Jackson)

The Seapath 380 provides positional information (roll, pitch and heading) to scientific instruments to allow them to adjust for ship movement. This will ensure that when mapping the sea floor using sonar, the signal remains pointed downwards rather than rolling with the ship. The Seapath can also act as a back-up for the dynamic positioning system. (Photo: Mike Jackson)

The *Nuyina's* bridge is arranged so that 'driving' happens on the starboard (right) side, and monitoring on the port side. In the centre is the central driving position with access to all the operational and scientific information displays. It also includes the pilot station, drop keel and lighting controls, and the dynamic positioning and Seapath 380 systems – both of which will mainly be used for scientific operations facing aft.

On the port-side wing is a helicopter control console and observation area. On the starboard side is a second dynamic positioning control and an observation area.

Behind the centre bridge are navigation planning and charting consoles, a radio console, and a scientific operations space for a weather radar, ice/wave radar, CCTV and satellite information. There is also a 'safety centre' with controls to shut down the ship's ventilation and fuel systems in the event of fire, activate the 'water mist' and close watertight doors.

Ice core drill construction begins

Engineers at the Australian Antarctic Division have begun work on a drill head for a high-tech ice drill that Antarctic scientists will deploy in their quest for a million year ice core.

The drill head is the first in a series of components that will be machined and assembled at the Division, with input from other polar programs. The component is critical to the ice drill's stability as it descends up to 3000 metres into the ice.

Million Year Ice Core Project Lead, Tim Lyons, said the drill will operate for months at a time, in temperatures below -30°C, which means reliability and precision are key.

"Our aim is to produce a drill that can recover high quality ice cores day after day, and hopefully reach the bottom of Antarctic ice sheet over a four-to-five year period," Mr Lyons said.

"It's not something you can just buy off the shelf, but we are fortunate to have a team of skilled people to machine and fabricate it here at the Australian Antarctic Division.

Instrument technician, Chris Richards (left), and Million Year Ice Core Project Lead, Tim Lyons, begin fabrication of the ice core drill head at the Australian Antarctic Division. (Photo: Simon Payne)

"The international ice drilling community also shares designs and techniques, and we are building on and sharing our experiences with other drilling nations."

Atmospheric information contained in the ice core samples will provide a window into a period in history when a major shift took place in the Earth's climate system, and when the regular pacing ice ages gradually slowed (see *Australian Antarctic Magazine* 33: 6, 2017).

David Reilly
Australian Antarctic Division

Heavy tractors provide pulling power for ice core traverse

Five new heavy tractors will provide the pulling power for the Australian Antarctic Program's new deep-field traverse capability, and the search for a million year ice core.

With a combined 2600 horsepower, the tractors will be capable of towing an entire mobile research station deep inland, with food supplies, accommodation, scientific facilities, power generation and up to 160,000 litres of fuel.

The $5.1 million investment is part of a broader $45 million Australian Government commitment to re-establish an overland traverse capability in Antarctica.

Hobart-based business, William Adams, will supply the Caterpillar Challenger traverse tractors, following an open tender process.

Australian Antarctic Division Traverse Manager, Matt Filipowski, said the first machine had arrived at William Adams for modifications to withstand Antarctica's extreme conditions.

"This is a truly exciting capability upgrade for the Australian Antarctic Program, which opens up the Antarctic interior to big, ambitious science projects like the search for a million year ice core," Mr Filipowski said.

"The traverse and mobile inland station will allow us to deploy scientists and support teams to some of the most remote and extreme parts of Antarctica, in all weather conditions, and for long periods of time."

The traverse will be managed by a team of eight expeditioners and will reach up to 1500 kilometres inland.

The first traverse from Australia's Casey research station is planned for the 2020–21 summer, with jobs on the traverse team expected to be advertised from December this year.

Major items remaining for procurement include sleds, living and accommodation units and fuel storage.

The traverse project team previously spent time on British and French Antarctic traverses to inform the development of Australia's new traverse capability (see *Australian Antarctic Magazine* 33: 4-6, 2017).

David Reilly
Australian Antarctic Division

Main: Australian Antarctic Division personnel went on a fact-finding mission with French (pictured) and British Antarctic traverses in 2016–17, to inform the design of Australia's new traverse model. (Photo: Steve Macaulay)

Inset: One of Australia's new Caterpillar Challenger tractors at the William Adams workshop in Hobart, ready for its Antarctic modification. (Photo: David Reilly)

Casey solar farm

The first Australian solar farm in Antarctica was switched on at Casey research station in March.

Australian Antarctic Division Director, Mr Kim Ellis, said the system of 105 solar panels, mounted on the northern wall of the 'green store', provides 30 kilowatts of renewable energy into the power grid – about 10 per cent of the station's total demand.

Carpenters Conrad Willersdorf and Paulie Hanlon, and Engineering Services Supervisor Doreen McCurdy, with the completed panel installation. (Photo: Mark Pekin)

"This is the first solar power array at an Australian Antarctic research station and amongst the largest in Antarctica," Mr Ellis said.

"It will reduce Casey station's reliance on diesel generators for electricity, cutting fuel costs and emissions, as well as boosting the station's capacity in peak periods."

The project is a collaboration between the Australian Antarctic Division and Masdar, a renewable energy research and development corporation in the United Arab Emirates, to investigate a range of energy efficiency and energy management options at Australia's Antarctic stations (*Australian Antarctic Magazine* 34: 19, 2018).

Mohamed Jameel Al Ramahi, Chief Executive Officer of Masdar, said the project was an opportunity to pool energy-efficiency expertise from the hot deserts of the Middle East and the cold desert of Antarctica.

The project is a collaboration between the Australian Antarctic Division and Masdar, a renewable energy research and development corporation in the United Arab Emirates

"This project will help to build expertise in, and the performance of, solar systems in cold and remote environments," Mr Al Ramahi said.

"It will test the durability and suitability of the solar panels to the strong wind and snow load in Antarctica and help us to determine if it is an efficient way of powering a station."

Masdar sourced the solar panels from Aleo Solar in Germany, while Australian Antarctic Division engineers undertook wind modelling, produced technical drawings, and devised a special mounting system of brackets and rails to fit the corrugated shape of the green store cladding.

While the panel installation is unusual in its flush mounting against a wall, it has been designed to strike a balance between maximum solar gain and stability in the wind, as well as ensuring the panels are easy to install, access and maintain.

Clockwise from top: The solar panel array installed, with a wind deflector visible down the length of the array on the left side of the building, to minimise the effects of high wind speeds during blizzards. (Photo: Doreen McCurdy)

Three carpenters (L-R) Paulie Hanlon, Conrad Willersdorf and Rhys Francis prepare cable ducting for installation. (Photo: Doreen McCurdy)

Two installers use the elevated work platform to attach solar panels to the north wall of the green store. The panels are attached to horizontal and vertical rails by specially designed 'panel keeper brackets'. (Photo: Doreen McCurdy)

The three inverters that convert DC power into 240V AC power. (Photo: Doreen McCurdy)

Engineering Services Supervisor at Casey, Doreen McCurdy, said her six-person team first installed the brackets and rails to hold the panels flush against the wall. Then they installed external cable ducting, internal cable trays, a switchboard, and three inverters to convert the variable direct current (DC) into 240V alternating current (AC).

The team faced some challenging conditions with temperatures as low as -7°C and a number of blizzards.

"The cold was a challenge, as the brackets and bolts are small and fiddly and can't be installed while wearing gloves, so we had to use hand warmers to keep our fingers nimble," Ms McCurdy said.

"On windy days we had to focus on the internal installation, as the elevated work platform we use outside can't operate in winds above 15 knots.

"Once all the rails and brackets were in place though, we were able to install about 15 panels a day."

While the panel installation is unusual in its flush mounting against a wall, it has been designed to strike a balance between maximum solar gain and stability in the wind, as well as ensuring the panels are easy to install, access and maintain.

There are now plans to look at whether solar farms will be suitable for use at Australia's other stations.

"Once we see how the solar farm performs as part of the station's power grid, we can look at how to get more out of the technology in the future," Mr Ellis said.

Wendy Pyper
Australian Antarctic Division

X-rays get to the bottom of biopile success

X-rays have been harnessed to investigate the performance of materials used to help clean up fuel contaminated soils at Casey research station.

Australian Antarctic Division remediation experts, Dr Rebecca McWatters, Mr Tim Spedding and their team*, in collaboration with the Division's Polar Medicine Unit, are using the station's medical X-ray machine to examine the effect of moisture, drying, freezing and thawing, on clay liners used at the base of 'biopiles'.

Biopiles at Casey are about 1.5 metres high and measure between 25-40 metres long by six metres wide. Fertiliser, moisture and air are circulated throughout the pile to assist the native microbes to degrade fuel in the soil resulting from spills. (Photo: Rebecca McWatters)

"Biopiles are mounds of fuel-contaminated soil that rely on native soil microorganisms to break down the fuel," Mr Spedding said.

To contain the soil and prevent fuel leaching out while it is undergoing treatment, a composite liner system is used beneath the biopiles, in a similar design to that used in Australian landfills.

The system consists of a clay liner (a layer of powdered bentonite sandwiched between two geotextiles) which absorbs moisture from the compacted and levelled ground beneath the biopile, and swells to form a barrier against the migration of contaminants from the biopile above. A heavy-duty plastic sits on top of the clay liner and adds an additional barrier against the migration of contaminants from above. Finally, a geotextile helps protect the plastic from being punctured by any rocks in the biopile soil.

"The biopile system has been employed since 2010 to successfully remediate contaminated soil, which is then reused around the station," Mr Spedding said.

"While biopiles have been used in the Arctic and extensively in temperate environments, the Australian Antarctic Program is the first to use large biopiles in Antarctica."

An important part of the team's work is to monitor the liner system throughout the soil remediation process to ensure it is performing as designed in the relatively untested Antarctic conditions.

Through the monitoring process the team, in collaboration with Queen's University in Canada, has been studying different combinations of clay and plastic liner materials to test their long-term performance in containing fuel within the biopiles, and their durability in the Antarctic climate.

"We're looking for the right combination of technologies that will do the job with minimal cost, maintenance and management, and that will outlast the remediation process and allow for long term containment," Dr McWatters said.

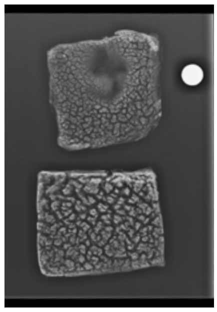
"While the plastic liners are good at stopping fluid migration, they can get punctured by rocks in the soil. The clay liners, on the other hand, self-heal if they're punctured, but they operate best at about 60 per cent hydration. As Antarctica is very dry, the clay liner can often be unevenly hydrated or even desiccated."

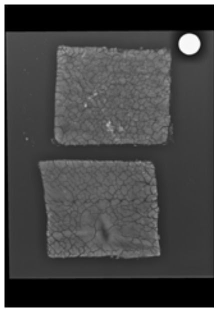
In the first five years of biopile operations the team included small 'coupons' of each material beneath them, which they removed each year to see how they changed in response to freezing, thawing, puncturing by rocks, and exposure to contaminants and ultraviolet (UV) light.

The team also has test plots of the materials on the ground and on top of shipping containers, where materials are exposed to wind, snow and UV. These materials are regularly inspected and tested to see how each is performing.

"The tests are essential to demonstrating that these materials are performing as intended and preventing fuel contaminants from entering the environment," Dr McWatters said.

"They have also allowed us to identify the best combinations of liner materials for Antarctic conditions, which are used in the construction of new biopiles."





The tests include X-ray analysis of the clay liners to see deep into the structure of the clay and understand how it changes with freezing, thawing, wetting and drying.

If the clay has dried out after being hydrated above 60 per cent, for example, hexagonal patterns appear. If the clay has not been hydrated at all, it appears as black areas of powdered bentonite. Hydrated clay appears white.

"We used to send our clay liner samples to Queen's University to X-ray, but it meant we couldn't do the sampling in real time," Dr McWatters said.

"So we approached Polar Medicine to see if we could use the Casey station machine."

Chief Medical Officer, Dr Jeff Ayton, obtained the required approvals from the Australian Radiation Protection and Nuclear Safety Agency, for the station doctors to use the medical diagnostic X-ray equipment to analyse scientific samples.

"Now we can determine the moisture content and structural change in samples immediately, which means greater accuracy," Dr McWatters said.

"Because of the performance testing and monitoring conducted to date, these liners can be confidently reused for new biopiles, which minimises the cost of rebuilding. "

"We can also X-ray clay liner samples from the test plot on a weekly basis to see what happens to them over the summer season, and test other samples under repeated freezing, drying and rehydration."

The team has found that even within one biopile, the clay liner has areas that are frozen, wet, partially hydrated, desiccated (wet and then dried) and dry (never wet) - demonstrating the challenges of an Antarctic site.

"The risk with clay liners is that they don't hydrate in the first place," Mr Spedding said.

"But when they do and then they dry out again, how does that affect performance? And how does freezing compound any changes in performance? These are questions that are very rarely studied in the field."

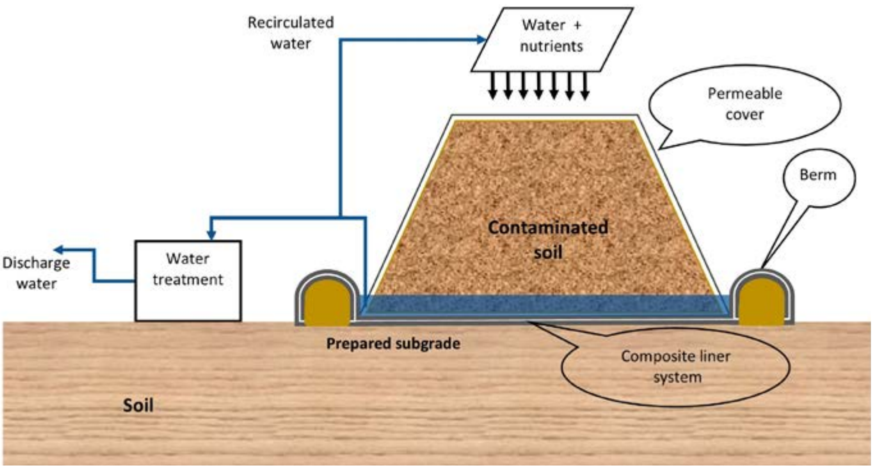
Future testing will help to answer these questions. So far though, the research has shown that the variation in bentonite content in the liner (the amount and type of clay) is more important to its performance than it is in temperate conditions, and that the preparation, hydration and drainage of the subgrade on which the biopiles sit, is critical.

"This is the first and only detailed study of these liners in Antarctic conditions and its showing in real time how these liners are performing," Mr Spedding said.

"Because of the performance testing and monitoring conducted to date, these liners can be confidently reused for new biopiles, which minimises the cost of rebuilding.

"This work is relevant for future clean-up projects and any engineering project where geosynthetics are used in the Antarctic, and it's also contributing to industry development of new products."

Wendy Pyper
Australian Antarctic Division
**Australian Antarctic Science Project 4036*



Clockwise from top: Freeze-thaw conditions in Antarctica pose a challenge to the performance of clay liners beneath biopiles. (Photo: Rebecca McWatters)

The clay liner under X-ray showing variations in hydration (white) and voids (black) from desiccation and cracking. Large voids could allow contaminants to pass through the clay liner. There is also evidence of the protrusion of stones or gravel (dark spot in the top sample) pushing up into the clay liner from the subgrade, due to freeze/thaw. This thins the clay and reduces the protective capacity of the clay liner. A dollar coin (bright circle) provides scale. (Photo: AAD Remediation/PMU)

Finer (smaller) desiccation cracks mean there is a lower risk of contaminants passing through the clay liner. (Photo: AAD Remediation/PMU)

Water and nutrients are recirculated through the biopile to assist the natural microorganisms in the soil to degrade contaminating fuel. The composite liner system sits on clean, compacted subgrade and prevents contaminants leaching from the biopile into the ground. A cover prevents dust from blowing off the biopile, while berms prevent excess meltwater, from snow, leaching away from the biopile. Excess water is treated to remove any contaminants before disposal. (Image: AAD Remediation)

Clockwise from left: Snow petrels have colonised parts of East Antarctica for more than 3600 years. (Photo: Peter Layt)

Field biologist, Marcus Salton, chisels a thick sample of very hard mumijo off rocks outside a nest cavity in the Masson Range near Mawson research station. The layers of mumijo have accumulated over thousands of years. (Photo: Marcus Salton)

Layers of fossilised stomach oil date back thousands of years, providing information on when snow petrels colonised parts of East Antarctica. (Photo: Anna Lashko)

Fossilised spit reveals 3600 years of snow petrel colonisation

Fossilised layers of spit, or 'mumijo', at snow petrel breeding sites, show the birds colonised the southern Prince Charles Mountains in East Antarctica at least 3680 years ago.

The research, led by Dr Sonja Berg of the University of Koln, Germany, and involving Australian Antarctic Division seabird ecologist Dr Louise Emmerson, provides the first dating of snow petrel mumijo deposits in the region.

"Snow petrels regurgitate their stomach oil as a defence mechanism, and over time it solidifies in Antarctica's cold, dry climate to form a waxy deposit called mumijo," Dr Emmerson said.

"By radiocarbon dating these deposits we've shown the birds colonised the southern Prince Charles Mountains several thousand years after the Antarctic ice sheet retreated. This suggests that environmental factors, other than the availability of ice-free nesting sites, are important for snow petrel colonisation."

Most snow petrels (*Pagodroma nivea*) are found within 100 kilometres from the coast, where they nest in cavities created by large boulders, on nunataks, rocky hills or mountains. In the Prince Charles Mountains, however, snow petrels nest up to 440 kilometres from the coastline – the furthest inland of any known populations.

Because the birds only nest in ice-free areas, radiocarbon dating (^{14}C) of the fossilised spit can be used to infer local deglaciation history and the location of ice-free areas during the last glacial period. As the birds usually nest within about one day's flight from feeding grounds, mumijo also provides information on changes in the coastal food web.

The research team collected samples of mumijo from Greenall Glacier and Pagodroma Gorge, 450 kilometres and 260 kilometres inland of Prydz Bay, respectively, near Davis research station.

Radiocarbon dating of three mumijo deposits from Greenall Glacier, one of which was six centimetres thick, provided ages of 3680, 2400 and 895 years. The oldest deposit from Pagodroma Gorge was dated at 2675 years.

"Our results suggest that snow petrels occupied Greenall Glacier at least 3680 years ago and that they have probably inhabited the region continuously since," Dr Emmerson said.

"A comparison of our results to mumijo ages reported at more coastal sites, indicates that colonisation was not directly linked to de-glaciation, but rather enabled by changing environmental conditions, either at the birds' nesting sites or in their foraging range.

"Improved conditions in their foraging range would make it energetically feasible to live in these inland areas."

As part of a broader study looking at the movement and changes in snow petrel populations over geological time scales, this past summer, field biologists Marcus Salton and Dr Anna Lashko collected mumijo samples from rocks outside snow petrel nests in the Masson Range near Mawson research station. The samples were collected while the birds were out foraging at sea, to prevent disturbance when they returned to lay their eggs.

Mr Salton said the mumijo was so hard it has to be chipped off with a hammer and chisel.

"The spit gets a lot of bird foot traffic and is exposed to high winds, so it gets amalgamated with bird poo, dirt and grit, and becomes very hard," he said.

"Once we collected a sample we wrapped it in kitchen foil and stored it in a freezer on station, before returning it to Australia."

A team at Casey research station also searched for mumijo, however they are yet to find layers of any substantial depth.

"The absence of thick mumijo layers may mean the birds haven't been around for as long in this area of Antarctica, and this is consistent with recent genetics studies that suggest that the birds are likely to have moved in from the Davis and Mawson populations," Dr Emmerson said.

Wendy Pyper
Australian Antarctic Division

Technology enhances whale-krill study

Australian Antarctic Program scientists have used submersible and airborne technologies, to investigate the distribution of endangered Antarctic blue whales and their food source, krill.

CSIRO's Marine National Facility, RV *Investigator*, spent seven weeks in the Southern Ocean, looking at the complex relationship between Antarctic blue whales and krill, and their roles in maintaining the health of the Southern Ocean (more details in *Australian Antarctic Magazine* 35: 14-15, 2018).

The first challenge for the 28 scientists on the 13,000 kilometre journey was to find the rare Antarctic blue whales in the vast Southern Ocean.

Lead whale acoustician, Dr Brian Miller, said more than 250 underwater listening devices or 'sonobuoys' were deployed during the voyage to detect the whales' low frequency calls.

Sonobuoys can detect blue whale calls up to 1000 kilometres away and can be used to triangulate the whales' precise location as the ship closes in.

Sonobuoys can detect blue whale calls up to 1000 kilometres away and can be used to triangulate the whales' precise location as the ship closes in.

"We monitored over 750 hours of underwater recordings and measured over 33,000 bearings to blue whale calls, which enabled us to home in on whale 'hotspots'," Dr Miller said.

Over 300 hours of search effort led to 36 encounters with blue whales and 25 individual identifications. One was a whale that had previously been sighted on an expedition six years ago.

Antarctic blue whales almost exclusively eat krill and can eat up to four million krill, or more than three tonnes, in one day.

Australian Antarctic Division krill biologist, Rob King, said krill swarms can be deep or shallow, dense or diffuse, but little is known about the different swarm types and whether some are more attractive to blue whales than others.

To find out more, the ship's echo sounders, which bounce sound off organisms in the water column, were used to locate and characterise krill swarms. The krill team was able to construct three-dimensional pictures of giant krill swarms, with several swarms extending over one kilometre in length and hundreds of metres across. Each swarm contained many millions of krill.

"This voyage has provided much more information about the fine-scale three-dimensional structure of krill swarms, so we can start to get a better idea of the sort of swarms Antarctic blue whales hunt," Mr King said.

Drones were also used in more than 130 missions across a range of scientific applications, including size measurements and 'blow' (exhalation) sampling of blue whales, and a new method for trace metal surface water sampling.

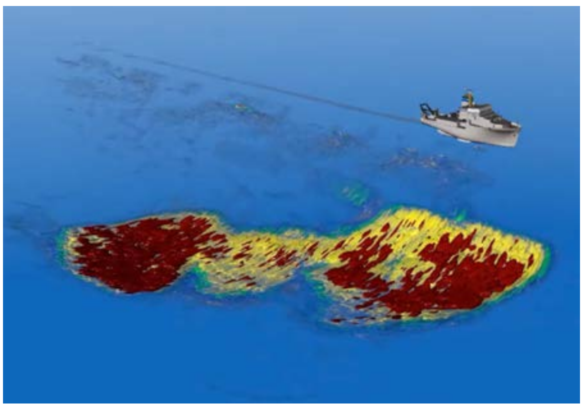
Voyage Deputy Chief Scientist, Dr Elanor Bell, said biogeochemists conducted experiments on these surface water samples, and other samples from various depths, to test the theory that whale faeces is an important source of iron in the Southern Ocean.

"It's thought the whales' iron-rich faeces may stimulate the growth of phytoplankton on which krill feed, which are in turn whale food," Dr Bell said.

The voyage's multidisciplinary research will contribute to the improvement of ecosystem-based management of the Antarctic krill fishery and the conservation of endangered species, including Antarctic blue whales.

The research was supported by a grant of sea time on RV *Investigator* from the CSIRO Marine National Facility. A large number of collaborating institutions and partners also supported the voyage, including the University of Tasmania, Murdoch University, University of Technology Sydney, University of Washington, University of Liverpool, Texas A&M University, University College Cork, the International Whaling Commission's Southern Ocean Research Partnership, and the World Wildlife Fund – Australia.

Mark Horstman
Australian Antarctic Division



Main: The science team onboard the RV *Investigator*. (Photo: AAD/CSIRO)

Inset from left: The ship's acoustic echo sounders were used to characterise the size and density of giant krill swarms. This swarm was 400 metres long, 200 metres wide, and 100 metres deep. (Image: Josh Lawrence)

A drone (top left of photo) is used to take photo measurements of an Antarctic blue whale. (Photo: Charlotte Boyd)

Submarine ventures under Sørsdal Glacier

For the first time an Australian autonomous underwater vehicle (AUV), operated by the Australian Maritime College of the University of Tasmania, has ventured into the ice cavity beneath the Sørsdal Glacier near Davis research station. The trial paves the way for more ambitious missions that will help scientists understand the response of the East Antarctic Ice Sheet to environmental change.

The support vessel RV *Howard Burton* trails the AUV as it prepares for a mission beneath the Sørsdal Glacier. (Photo: Glenn Johnstone)

The Antarctic coast is fringed by ice shelves – extensions of the continent's thick ice cap that float on the ocean. Understanding how the ocean drives the melting of these ice shelves, known as 'basal' melting, is key to determining how Antarctica will respond to future change.

The underside of ice shelves are one of the most elusive regions of the Antarctic continent. Sea ice can impede access to the front of the ice shelves and iceberg calving can make it a dangerous place to be. However, an autonomous underwater vehicle (AUV) named *nupiri muka** ('eye of the sea') can help.

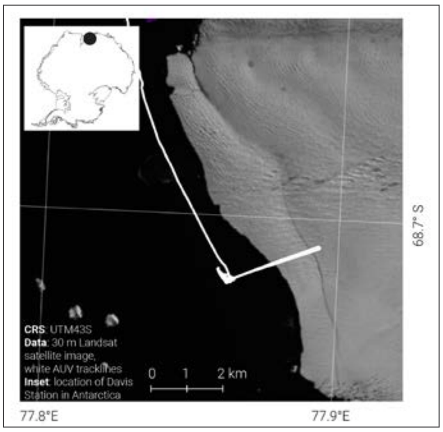
nupiri muka is a 5000 metre depth-rated Explorer class AUV, developed by International Submarine Engineering, which collects data on ocean currents, conductivity (salinity) and temperature. It is equipped with a sonar system that measures the shape and depth of the sea floor ('bathymetry') and sub-bottom profiles (sediment layers beneath the sea floor), as well as a side-scan sonar (high resolution sonar imagery) and a magnetometer (magnetic sensor). To build a map of its surroundings, discern its location and avoid hazards, it uses additional acoustic sensors that ping upwards, downwards and forwards, as well as an inertial navigation system.

Because *nupiri muka* can measure the temperature and salinity of the ocean beneath ice shelves, it allows us to estimate the amount of heat entering and exiting the ice shelf cavity. The AUV also allows us to build a picture of the cavity, from the sea floor to the underside of the ice shelf, using sonar data. Yet these missions are technically difficult as the AUV is out of contact for long periods of time, in an environment with little hope of rescue.

After successfully trialling *nupiri muka* in a Tasmanian alpine lake last year (see *Australian Antarctic Magazine* 35: 12-13, 2018), this year's campaign aimed to deploy the AUV in Antarctic waters, under a floating ice shelf, and have it return safely. The Sørsdal Glacier, like most of the East Antarctic Ice Sheet, is under-mapped and under-sampled. We aimed to collect oceanographic data of the water column, and sonar data of the sea floor and under-ice topography, to determine how these factors may influence basal melting.

The first phase of the campaign involved in-water tests in front of Davis research station, to be sure all the AUV systems were optimal and calibrated and that we could safely and efficiently deploy and retrieve the vehicle from the boat ramp.

With phase one complete, the team progressed to phase two – open water surveying. Once the AUV and its support boats were launched, and all systems were operating correctly, the daily three-hour commute to the Sørsdal Glacier began.



The journey was slow going as *nupiri muka* had to be manually navigated between icebergs, bergy bits and ice slurry. The RV *Howard Burton* followed closely behind, limited to a speed of four knots, while an inflatable rubber boat went ahead to clear a path of open water. The procession was of keen interest to curious skuas and petrels, and the boats made a handy landing spot for Adélie penguins.

Once at the calving front of the Sørsdal Glacier, *nupiri muka* dived to a set depth and its systems were re-checked before missions began. Each mission usually involved either diving to a set altitude above the sea floor and maintaining that altitude over a survey line, or maintaining a set depth beneath the ice shelf.

One of the trickier aspects of the campaign was the lack of knowledge of any bathymetry in front of the glacier. Standard AUV missions usually rely on low resolution maps of hazards and features of interest, previously surveyed by a surface vessel. For our missions, *nupiri muka* was both the exploratory and mapping platform, surveying unknown areas of the sea floor while simultaneously taking measurements of its environment so it didn't collide with any obstacles or venture into situations it could not return from.

nupiri muka had eight operational in-water days, travelling over 342 kilometres, 85 of which were in specific science missions, with the deepest dive over 1200 metres beneath the ocean's surface. Three of the dives took the AUV under the ice, travelling up to 700 metres into the ice cavity.

Standard AUV missions usually rely on low resolution maps of hazards and features of interest, previously surveyed by a surface vessel. For our missions, *nupiri muka* was both the exploratory and mapping platform, surveying unknown areas of the sea floor while simultaneously taking measurements of its environment so it didn't collide with any obstacles or venture into situations it could not return from.

Australia now joins the United Kingdom and Sweden in being the only countries to have successfully deployed an AUV beneath an ice shelf. Now that we have proved *nupiri muka* can operate under an ice shelf, future deployments will see it venture up to tens of kilometres under ice shelves and up to 5000 metres deep.

The data collected this season has contributed to a better understanding of the sub-ice environment of this small ice shelf, and how *nupiri muka* behaves in this dynamic environment.

This campaign also demonstrates the successful operation of *nupiri muka* in Antarctica, delivering rare oceanographic and acoustic results. It serves as a test-case for far more ambitious, long-range deployments beneath other East Antarctic ice shelves, and has delivered vital experience in operating the AUV in very challenging Antarctic environments.

Erica Spain and David Gwyther
Institute for Marine and Antarctic Studies, University of Tasmania
Peter King
Australian Maritime College, University of Tasmania

**nupiri muka* means 'eye of the sea' in *palawa kani*, the language of Tasmanian Aborigines.

This research was supported under Australian Research Council's Special Research Initiative for Antarctic Gateway Partnership (Project ID SR140300001) and Australian Antarctic Science Project 5138.

Clockwise from top: The daily transit from Davis Station to the Sørsdal Glacier meant navigating hazards like these bergy bits. (Photo: Glenn Johnstone)

The AUV team after the successful season (L-R at the back): Jean-Marc LaFramboise, Peter King, Konrad Zürcher, Erica Spain, Isak Bowden-Floyd; (L-R at the front): David Gwyther, Glenn Johnstone, Mick Davidson. (Photo: Andrew Harrison)

AUV *nupiri muka* made three journeys under the Sørsdal. (Image: Erica Spain)

The Law Dome drill site included three drilling areas for three different drill types, extracting ice (and air) of different ages. The modern ice (2010) was drilled in the semi-circular tent on the left, older cores in the white tent on the right, and the century-old ice was drilled from a two-metre deep trench constructed in the centre of the photo. (Photo: David Etheridge)

Hydroxyl hunters

How do you measure the abundance of a molecule that disappears from the atmosphere almost as soon as it is created? Scientists on the hunt for hydroxyl have found a way to measure another trace gas – itself present in minuscule but measureable concentrations – that acts as a proxy for hydroxyl. As a natural 'air purifier' the amount of hydroxyl in the atmosphere is critical to the removal of pollutants, including greenhouse gases and ozone depleting chemicals.

Century-old air extracted from up to 240 metres below the Antarctic ice sheet will help scientists determine how much of a natural atmospheric 'air purifier' is available to scrub the Earth's atmosphere of pollutants.

Samples totalling some 500 litres of air, extracted from five tonnes of melted ice cores, were collected at Law Dome in East Antarctica last season, by an international team of scientists led by Dr David Etheridge of CSIRO* and Dr Vas Petrenko from the University of Rochester in the United States.

The extracted air samples cover about 140 years of the Earth's atmospheric history, back to about 1875. This will allow the team to measure pre-industrial levels of the hydroxyl radical (OH), which chemically destroys gases like methane and ozone-depleting chemicals.

"The majority of greenhouse gas emitted is carbon dioxide, but there are more than 40 other gases that contribute to climate change, ozone depletion and pollution," Dr Etheridge said.

"Hydroxyl radicals act like natural atmospheric scrubbers, by chemically destroying many of these gases. But we don't know how they have withstood the demand of increased emissions.

"Variations in hydroxyl could have implications for future levels of greenhouse gases, so this information is key to improving the accuracy of our climate models and predicting the impact of pollutants in the future."

The air samples will be processed at the University of Rochester, and then analysed at the Australian Nuclear Science and Technology Organisation (ANSTO) to see whether the concentration of the radical has changed over time.

But there's a catch. The hydroxyl radical lasts less than a second in the atmosphere before it reacts with gases. So the analysis will focus on a tracer molecule of carbon-14 monoxide (^{14}CO). ^{14}CO is removed by hydroxyl, so the amount that remains in the atmosphere provides information about the hydroxyl levels – as previously reported in *Australian Antarctic Magazine* 35: 17-18, 2018.

Because the amount of ^{14}CO in the atmosphere is so small (analogous to finding one particular grain of sand on a beach), hundreds of kilograms of ice had to be collected to provide enough air to measure its concentration in each sample. Three different drilling systems were used to drill a total of 1010 metres of ice core at different depths (time periods), by the United States' Ice Drilling and Design Operations. This provided 11 samples spanning from the pre-industrial era to today.

"It's the only known place on the planet to find air for reconstructing hydroxyl trends. After six years of planning and three months of working in one of the highest snowfall areas in Antarctica, it's a huge achievement to get this far."

"The ice samples were melted immediately after drilling on site using a large vacuum tank in a 'melter shelter' to extract the air containing the ^{14}CO," Dr Etheridge said.

"We also took around 240 metres of continuous ice core samples for ice dating and climate reconstructions."

The air samples are now at the University of Rochester where the ^{14}CO will be converted to CO_2. The team at ANSTO in Sydney will then convert the CO_2 into graphite (elemental carbon) and use an accelerator mass spectrometer to count the ^{14}C atoms amongst the 'regular' C atoms.

"Once we've measured these samples across the past 140 years, and quantified the trend in the tracer that tells us how hydroxyl levels have changed, we can begin providing data to Earth systems models that simulate the chemistry and the physics of the atmosphere," Dr Etheridge said.

The unique glaciology of Law Dome continues to provide ice to help scientists understand more about Earth's atmospheric environment.

"It's the only known place on the planet to find air for reconstructing hydroxyl trends. After six years of planning and three months of working in one of the highest snowfall areas in Antarctica, it's a huge achievement to get this far."

Wendy Pyper
Australian Antarctic Division

**Australian Antarctic Science Projects 4167 and 4425*

Watch videos about this research at:
https://blog.csiro.au/past-antarctic-air-informs-our-future/
https://www.youtube.com/watch?v=VOZctOI8sgg

Clockwise from top: The hydroxyl hunters in the first half of the season (L-R): Richard Smith, Vas Petrenko, Andrew Smith, David Etheridge, Peter Neff, Sharon Labudda, Tanner Kuhl, Jose Campos, Grant Boeckmann. (Photo: Richard Smith).

Tanner Kuhl (left) and Grant Boeckmann from Ice Drilling Design and Operations in the trench used to drill 240 metres into 200 year-old ice. (Photo: David Etheridge)

Working in one of the highest snowfall regions of Antarctica was a challenge. (Photo: Sharon Labudda)

Stainless steel canisters of old air extracted from the ice sheet, containing trace amounts of the ^{14}CO tracer. (Photo: David Etheridge)

Co-Chief Investigator Vas Petrenko, from the University of Rochester, melting ice cores to extract the air trapped in bubbles. To prevent contamination of the samples, scientists had to wear 'cleansuits' and gloves. (Photo: David Etheridge)

AIRBOX to study the polar atmosphere

Main: Dr Alan Griffiths of ANSTO, and Professor Clare Murphy of the University of Wollongong, use a high volume air sampler to analyse the composition of aerosols over the Southern Ocean. The work was part of a suite of air chemistry studies supported by the AIRBOX. (Photo: Ryan Osland)

Inset: Some members of the AIRBOX team: (from left) Dr Dagmar Kubistin (Uni of Wollongong), Jared Lewis (Uni of Melbourne), Dr Robyn Schofield (Uni of Melbourne), Dr Ruhi Humphries (CSIRO), Dr Alberto Alberello (Uni of Adelaide), and Dr Alessandro Toffoli (Uni of Melbourne) (Photo: Glenn Jacobson)

A mobile air chemistry laboratory called AIRBOX travelled on the *Aurora Australis* this summer to measure trace gases, aerosols and clouds, as the ship plied the Southern Ocean.

The custom-built containerised laboratory housed nine dedicated instruments, with at least eight other instruments added by project collaborators.

Project Leader Dr Robyn Schofield, of the University of Melbourne, said one of the main goals of the project* was to understand where the aerosols that influence cloud formation come from, how many there are, how reflective they are, and how big they are.

"Aerosols are important in cloud formation over the Southern Ocean and affect the amount of solar radiation reaching and heating the Earth's surface," Dr Schofield said.

In the relatively unpolluted air above the Southern Ocean, the major source of aerosols is sea salt, from wind shearing the tops off waves. However, there are also chemical processes in the ocean and in the sea ice that influence aerosol concentrations.

"To help interpret our measurements we will use atmospheric modelling to disentangle the roles of these local chemical processes and transport," Dr Schofield said.

"This is an innovative approach that has not been used before in this region of the world and will hopefully help us resolve some issues that climate models have over this region – including the contribution of Southern Ocean clouds in regulating Earth's temperature."

Instruments in the AIRBOX (Atmospheric Integrated Research Facility for Boundaries and Oxidative Experiments) included:

- a lidar that emits a micro-pulsed green laser to measure aerosol and cloud profiles up to 10 kilometres;
- an ozone monitor;
- a trace gas analyser to measure greenhouse gases such as carbon dioxide, nitrous oxide and methane;
- a spectrometer measuring ultraviolet and visible light to see reactive trace-gases, including bromine monoxide, nitrogen dioxide and ozone; providing information on how chemically reactive the atmosphere is;
- sonic anemometers to measure energy and moisture fluxes; and
- cameras to record the sea state and cloudiness of the atmosphere.

"This is an innovative approach that has not been used before in this region of the world and will hopefully help us resolve some issues that climate models have over this region – including the contribution of Southern Ocean clouds in regulating Earth's temperature."

In addition, a range of instruments measured aerosol properties, including optical properties, how readily they form clouds, their concentrations and sizes, and their chemical make-up.

Dr Schofield said the four teams that rotated through the four voyages were happy with how the AIRBOX performed, with the instruments running well most of the time, despite some challenges.

"The big seas and ice-breaking weren't kind on our instruments but they stood up to the rolling and battering fairly well," she said.

"We have a lot of data coming in now, so managing that is going to be the next challenge."

Also involved in the AIRBOX project are the Australian Antarctic Division, University of Tasmania, University of Melbourne, Queensland University of Technology, Macquarie University, University of Wollongong, CSIRO, Monash University and the Australian Nuclear Science and Technology Organisation (ANSTO).

Read more at:
http://airbox.earthsci.unimelb.edu.au/#tab179

Wendy Pyper
Australian Antarctic Division

**Australian Antarctic Science Project 4431*

Main: Scientists sampling in a geothermal area for the project *Keeping it cool when the temperature is rising*, led by the Australian National University. (Photo: Ceridwen Fraser)

Inset: L-R: ASF Executive Director Chrissie Trousselot, Australian Antarctic Division Program Leader Dr Dirk Welsford, and Founding Donor Dick Smith, at His Excellency Sir Peter Cosgrove's patron's event for the ASF, Admiralty House, 2018. (Photo: Aran Anderson Photography)

Science and philanthropy

Philanthropy has long played a role in Australian expeditions to the Antarctic. Douglas Mawson's Australasian Antarctic Expedition relied on funds not only from the Australian and British Governments, but also from industry backers and philanthropists. Sir Hugh Denison, of Cape Denison fame, was a wealthy philanthropist and businessman with interests in tobacco and broadcasting, who generously backed the pivotal Mawson expedition. Aside from its endurance and heroism, the expedition resulted in important scientific discoveries, including the mapping of 3000 kilometres of coastline and the collection of specimens and data about Antarctica's geology, biology, oceanography and meteorology.

More than 100 years later the Antarctic Science Foundation (ASF) is bringing together tomorrow's science leaders, entrepreneurs and philanthropists in partnership to support Antarctic, sub-Antarctic and Southern Ocean ecosystems and climate research, the polar technology that enables it, and the public outreach and education required to achieve global understanding of the importance of this region and what it tells us about our planet.

The ASF is an independent environmental charity that evolved from an initiative in the 2016 *Australian Antarctic Strategy and 20 Year Action Plan*, to reinvigorate Antarctic science by building private-public partnerships. Its establishment in 2018 has been aided by an injection of funds from a generous philanthropist, its founding Board, support from the Australian Government, and the hard work of Australian Antarctic Division staff.

We have launched two founding donor initiatives to help build the ASF: the *32/107 Founding Donors' Club*, for individuals who join in 2019, and *Trailblazers10 Corporate Sponsorship*, for the first 10 companies to support the Foundation. Both initiatives bring with them lifetime recognition and involvement in future activities and events. The *Trailblazers10* also offers an opportunity for businesses to work jointly with the Foundation in Antarctic endeavours.

There are also a number of projects that are ready for funding. *Unlocking the secrets of the seabed using ancient DNA; Keeping it cool when the temperature is rising*; and *Using bacterial hitchhikers to better understand Antarctic krill*, are three of the projects identified through our expressions of interest process, undertaken by our science committee on behalf of the Board. Our database of potential projects is growing strongly, but the quality of the science and the interests of donors will determine which get funded.

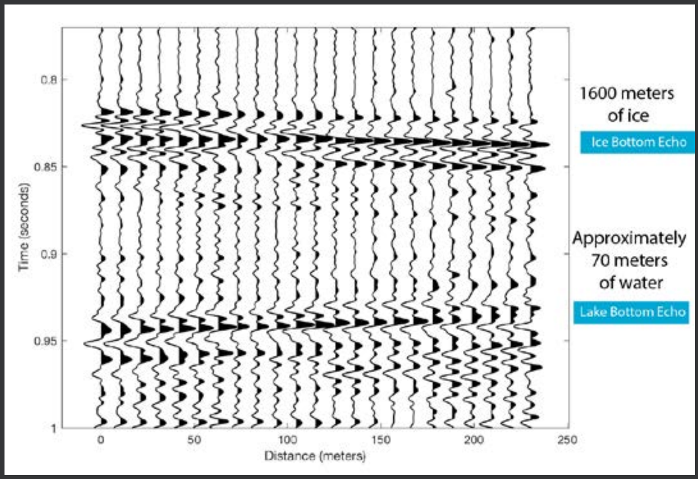
The ASF is open to funding a range of quality science projects that align with our purpose and that do not duplicate work already funded under the Australian Antarctic Science Program. The more ground (or ice) breaking the better!

The Foundation is developing strategic partnerships with aligned research, professional and corporate organisations, but the Australian Antarctic Division remains our major public partner. We rely on its reputation and resources, and particularly its people. As in all good partnerships the ASF is important to the Antarctic Division too, particularly at this critical time when Government investment and focus is on modernisation of infrastructure. The ASF can play a role in investing in, and promoting the importance of science - which many describe as the "currency" of influence in Antarctica.

To find out more about how you can get involved contact info@asf.aq or visit www.antarcticsciencefoundation.org

Chrissie Trousselot
ASF Executive Director

Seismic survey sees beneath Totten Glacier



Controlled explosions across the largest glacier in East Antarctica have revealed a network of lakes beneath the ice.

The seismic study* led by Dr Ben Galton-Fenzi of the Australian Antarctic Division, used a series of small explosions about two metres below the surface of the Totten Glacier. The explosions sent out sound waves, which echoed off different layers in the ice and bedrock (see figure).

The international team spent 160 days working on the glacier, near Casey research station, to find out if there is bedrock or water – as subglacial lakes or ocean – under the ice.

"We placed geophones along the surface of the glacier to listen to the reflected sound, giving us a picture of what lies beneath the ice," Dr Galton-Fenzi said.

"This study has shown, for the first time, that there are substantial amounts of water under the Totten Glacier, contained in subglacial lakes, not far from the ocean."

The flow of water in and out of these lakes could exert a powerful control on the rate that the ice flows into the oceans. Understanding this water flow is critical to helping predict how the melting of Antarctic glaciers will change the world's oceans into the future.

"If there's bedrock under a glacier, it's sticky and the glacier will move more slowly. But if there's water or soft sediments, the glacier will move faster," Dr Galton-Fenzi said.

The Totten Glacier drains a catchment of 538,000 square kilometres, containing enough ice to raise sea level by seven metres. However, the area of the glacier thought to be vulnerable to a warming climate has the potential to raise global sea level by about 3.5 metres (*Australian Antarctic Magazine* 28: 13-14, 2015). More research is needed to accurately predict the rate at which this melting could occur.

Nisha Harris and Wendy Pyper
Australian Antarctic Division

**Australian Antarctic Science Project 4287, supported by the Australian Research Council Antarctic Gateway Partnership, Antarctic Climate and Ecosystems Cooperative Research Centre, and Australian Antarctic Division.*

An example of seismic data showing the presence of a subglacial lake beneath the Totten Glacier. Each vertical line, or 'trace', is a recording from one of 23 geophones placed 10 metres apart, as the sound from an explosion travels down through the ice to the lake surface and lake bottom, and back up again. The first significant change in the seismic signal occurs at the base of 1.6 kilometres of ice, where the lake begins, and then again 70 metres later, when the base of the lake is reached. Altogether, the lines record the seismic signal across 230 metres of the glacier's surface. (Figure: Paul Winberry)

Jade iceberg mystery

Researchers may have solved the century-old mystery of why some Antarctic icebergs are green.

Experiments on ice samples collected from the Amery Ice Shelf suggest that iron oxides in seawater are the likely explanation.

The research, led by Professor Steve Warren from the University of Washington, and involving Australian Antarctic Division Glaciologist Dr Mark Curran, was published in JGR Oceans in January.

"The remarkable jade colour is likely the result of yellow-tinted iron oxide in seawater, combining with the crystalline blue of the ice – much like mixing yellow and blue pigments together," Dr Curran said.

The most commonly sighted Antarctic icebergs are made from blue-white glacial ice, which forms when snow falls on the Antarctic plateau and becomes compacted over thousands of years.

Jade icebergs are formed beneath the ocean, when mineral-rich seawater freezes to the underside of an ice shelf in layers, then eventually breaks off. These jade bergs contain layers of the blue-white glacial ice, and greener frozen seawater below. Green-striped icebergs form when seawater freezes into basal crevasses in glacial ice.

The scientists also believe that these mineral-rich ice blocks could play a role in promoting biological activity in the Southern Ocean, by transporting nutrient-rich water to areas where iron is in short supply.

Read more at https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2018JC014479

David Reilly
Australian Antarctic Division

Jade icebergs are thought to originate from iron-rich frozen seawater beneath ice shelves. (Photo: Doug McVeigh)

World-first radio broadcast from the ice

The world's first ever talkback radio from Antarctica was hosted at Casey research station this summer, with science communicator Dr Karl Kruszelnicki heading south as part of the Australian Antarctic Division's media program.

Dr Karl spent 11 days on the ice and hosted 13 half-hour live radio programs, crossing to ABC Cairns, Perth, Brisbane, Hobart, Gold Coast, Melbourne, Sunshine Coast, regional Victoria, Triple J and the BBC.

Dr Karl said the marvel of modern technology ensured there was only a split-second delay in the broadcast.

"The sound goes from my microphone at Casey station into the internet, 36,000 kilometres up to the satellite, down from the satellite into Perth, but it doesn't stop there," Dr Karl said.

"It then goes through a specially encrypted tunnel across to Hobart, where it's decrypted and then shot across to ABC master control in Sydney. From there it's sent to the broadcast station we are talking to; how incredible is that?"

During his broadcasts Dr Karl fielded listener questions on all aspects of Antarctic science, with a little help from guest scientists Dr Ben Galton-Fenzi, Dr Cath King, Dr Dan Wilkins and Phoebe Lewis.

He also had some curly questions about the more mundane aspects of life on the ice, such as "do farts freeze?" He was able to answer these with some confidence, thanks to the assistance of Station Leader Chris MacMillian, Field Leader Sharon Labudda and Chef Justin Chambers.

Dr Karl's enthusiasm for Antarctica and the expeditioners at Casey knew no bounds.

"The sound goes from my microphone at Casey station into the internet, 36,000 kilometres up to the satellite, down from the satellite into Perth... through a specially encrypted tunnel across to Hobart, where it's decrypted and then shot across to ABC master control in Sydney. From there it's sent to the broadcast station we are talking to"

"Everyone working there for the Australian Antarctic Program, whether they were a dieso, plumber or doctor, seemed to have so many levels to them," he said.

"Yes, they all are leaders in their specific field of work, but they also had a depth to their life experience and personality, which was quite profound."

At the same time as Dr Karl's visit, ABC TV's Behind the News (BTN) Program was also at Casey, with journalist Emma Davis and cameraman Peter Curtis.

The BTN crew gathered a large number of television, print and digital stories, which have been broadcast to more than one million primary school children across Australia. They also filed several stories for ABC News.

Emma said it was the trip of a lifetime, with visits to the Shirley Island Adélie penguin colony, Vandeford Glacier and Robbo's field hut.

"The Casey crew warmly welcomed us into their lives and made us feel part of the community, sharing their insights and love of Antarctica," Emma said.

Nisha Harris
Media Manager, Australian Antarctic Division

Main: Dr Karl (second left) broadcasting from Casey, with station chef Justin Chambers, Dr Cath King, and Sharon Labudda. (Photo: Nisha Harris)

Inset: Behind the News team, Peter Curtis and Emma Davis. (Photo: Nisha Harris)

Jane and Jesse take inspiration from the scenery as they ponder plot problems. (Photo: Amy Chetcuti)

Mawson provides backdrop for Antarctic drama

Two writers, four months, five thousand penguins, one big red shed and no way home. What could possibly go wrong? So started our pitch to spend the 2018–19 summer at Mawson station as Antarctic Arts Fellows. Our plan was to research and write an Antarctic adventure novel for young readers and develop a television drama about life on an Antarctic research station.

'We' are author Jesse Blackadder, and television screenwriter Jane Allen. Before last summer we were both already Antarctic tragics: Jesse round-tripped as a previous Arts Fellow in 2011 and visited the Antarctic Peninsula as a tourist. Jane has been obsessed by Scott since childhood, and also voyaged to the Antarctic Peninsula.

Plenty could go wrong in Antarctica, it appeared, from the pre-departure briefing at the Australian Antarctic Division headquarters in Hobart, in which Dr Clive Strauss warned us of the many ways we could be killed or maimed in the far south. There were too many graphic pictures for a couple of writers with overactive imaginations.

"It's all great material," we told each other. Nervously.

None of our previous experiences prepared us for the reality of station life. Everything was bigger, brighter, more intense, scarier, more exhilarating, and more exciting than we could have dreamt.

Like the day of survival training, when we traversed the eggshell blue of the Antarctic ice cap on quad bikes, standing up on the pedals to look out for hazards, the sky a brilliant blue overhead, the mountains sticking up out of the ice, the sun making dazzling pinpoints in every direction. Or the time we climbed Mount Henderson, scrambling up the scree slope and then roping up to clamber to the summit, with its 360 degree view of ice sheet, mountains, frozen sea and icebergs. Or the time we slept at the foot of a cliff in yellow plastic bags. Or when we headed by Hägg out to the Auster Rookery and spent hours lying on the ice, surrounded by emperor penguins and their chicks, against a backdrop of towering blue ice cliffs. Or roped up in full climbing kit to stand on the ruins of an old Russian plane lodged in the ice.

It's not what you imagine when applying for an Arts Fellowship. Knots, navigation, mountain climbing, quad bike riding, crampons, bivvies, ice rescues and swimming in sub-zero waters aren't the usual fare of writers-in-residence. We were privileged to have the full experience of being summer expeditioners, with survival training, lending our hands to any projects needing help, and living as part of the summer population, immersed in station life.

Over summer we largely kept to the station's working hours, heading up to the aeronomy building each workday. For our book project, we dreamed up ways that four kids could get to Antarctica, stumble on an evil corporation, and save Antarctica from its clutches. Once we'd mapped out the plot on whiteboards and covered the walls of the building with index cards, we settled in and wrote, working side by side on alternating chapters, stopping to read aloud to each other.

It has been the most extraordinary summer of our lives, and a wrench to sail away from Mawson at the end of the season. Since living at Mawson, we've graduated from Antarctic tragics to Antarctic obsessives and our plotting conversations include improbable plans for how we might return.

Draft of the book done and dusted, we turned our attention to the TV series. It was back to whiteboards, index cards and long conversations in different locations. This was harder – our experience of life at Mawson was largely harmonious – exactly the opposite of what's needed for a television drama. We wanted to create a story about a female leader and her challenges in keeping a station functioning and happy in an extreme location, in the face of the 'A-Factor' (Antarctica's extreme version of Murphy's Law). Our immersion in station life was perfect for Antarctic authenticity, but we needed to go way outside our own experiences to devise a strong and completely fictional storyline. By the end of the voyage home, we had completed a blueprint for the first season of the series – and now we're exploring options for the next stage of development.

In a writing collaboration, in a place like Antarctica, you never really go off duty. We thought, talked and wrote in places as varied as the Dog Room (home to Mawson's husky memorabilia), the ship's bunker door, the blue Hägg, the West Arm outcrop encircling Horseshoe Harbour. On warm days we'd sit on the rocks outside the cosray building at the station's highest point, looking down at the ice cliffs – a good place to gnaw on knotty plot problems.

An Arts Fellowship of this scope is a cause for deep gratitude. To our fellow expeditioners for making us welcome, and their interest in our work. To the Australian Antarctic Division for sending us south for an entire season, and for supporting our work in such a respectful way. To Create NSW for development funding to help pay for our time. And to the people who bid for the right to name a character in the charity auction on our way home, raising a few extra dollars for Camp Quality. Plus those who offered to do their own stunts when it comes to filming – we'll be in touch.

It has been the most extraordinary summer of our lives, and a wrench to sail away from Mawson at the end of the season. Since living at Mawson, we've graduated from Antarctic tragics to Antarctic obsessives and our plotting conversations include improbable plans for how we might return. The book and the TV project are both progressing through the journey of getting out into the world – watch this space.

Jesse Blackadder
Australian Antarctic Arts Fellow

Clockwise from left: Jesse (left) and Jane were immersed in station life, including survival training, which allowed them to participate in outdoor activities, such as a visit to the ruins of a Russian plane. (Photo: Mark Savage)

Jane (left) and Jesse map out the plot of their television drama. (Photo: Jane Allen & Jesse Blackadder)

Jesse (left) and Jane spent three months at Mawson research station researching and writing an adventure novel and television drama. (Photo: Amy Chetcuti)

The *Wyatt Earp* arriving in Hobart for her final voyage with American explorer Lincoln Ellsworth on February 4, 1939. (Photo: AAD)

The Antarctic ship with seven names

"*Natone* aground near Double Island, freighter breaking up under heavy pounding" was the headline in Queensland's *The Gympie Times* on Tuesday 27 January 1959.

The wooden ship was travelling back from Port Moresby via Cairns, having for the past six months been converted to carry cattle from Queensland ports, following her purchase by the Sydney–Ulverstone Shipping Company of Sydney. She had struck the tail end of Cyclone Beatrice and was leaking badly, which had put out her engines. Despite hoisting her sails, she drifted ashore on the Mudlow Rocks at Rainbow Beach on Saturday 24 January 1959, to become a total loss. The heavy seas persisted for many days, during which the ship started to break up, and it was only on the sixth day that a local fisherman was able to gain access and salvage the ship's papers and the last of the three ship's cats.

As if an after-thought, the newspaper reporter was able to squeeze in a few words to bring to light the significance of the loss of the ship under a sub-heading; "Did service in Antarctic", mentioning that the ship's former name was *Wongala*, and before that *Wyatt Earp* – "an Antarctic exploration ship".

Such was an inglorious end to a proud little Norwegian ship, which made her name in Antarctic exploration and discovery for both Norway and Australia, and was associated with the first flight across the Antarctic continent.

The ship was the former Norwegian fishing/coastal trader, MS *Fanefjord*, named after the long fjord which extends inland eastward past the town of Molde, the major town in the county of Romsdal. Commissioned by the Romsdal/Fanefjord Shipping Company for owner Edv. Christensen, building had commenced at the Bolsoense Shipyard and Mechanical Workshop close to the town in 1918. With the Norwegian merchant shipping fleet being decimated during WWI, the unavailability of steel meant that she was built of wood (pine and oak). The ship was 136.6 feet long (41.6 metres), with a beam of 29.2 feet (8.2 metres) and weighed 408 tonnes. She was one of the two largest ships built in the shipyard, which finally closed after nearly 100 years in 1984.

After her launch on 27 September 1919, the ship sailed to Tronheim to load timber marine props for the English coal mines. From then on she was involved in the North Sea and Norwegian coastal trade, including the Greenland and Icelandic fishing industry.

In June 1932 MS *Fanefjord* was purchased by Australian aviator Sir Hubert Wilkins and the famous Norwegian aviator Bernt Balchen, for the American adventurer Lincoln Ellsworth. The trio had already made names for themselves in polar exploration, but Ellsworth wanted a ship to support the first flight across the Antarctic continent. After some modifications to enable her to carry two aircraft and survive the tempestuous seas of the Southern Ocean, MS *Fanefjord* sailed to Oslo to load Ellsworth's plane and voyage south to the Ross Sea for the first of what would be four private expeditions, between 1933 and 1939.

During Ellsworth's first expedition (1933-34), the ship was renamed the MV *Wyatt Earp*, after Ellsworth's fascination with the gun-slinging Marshal of the same name, in an American wild-west frontier town. She retained the name until 1939, when she was bought by the Australian Government for the Royal Australian Navy as an ammunition and stores carrier, and re-named HMAS *Wongala*. She made one voyage to Darwin before being employed as an examination vessel at Port Adelaide, spending the remaining war years as a guard ship in South Australia.

Awaiting disposal, she was loaned to the South Australian Branch of the Boy Scouts Association by the Minister for the Navy, who took her over as a Sea Scout Training Ship and named her SSTS *Wongala*. The loan was short lived as in February 1947 the Australian Government informed the Navy that Antarctic exploration was now being

From left: The *Wyatt Earp* in Buckles Bay, Macquarie Island, 1948. (Photo: Laurence Le Guay)

The HMAS *Wyatt Earp*, photographed here in 1948, was used to transport aircraft for Antarctic and sub-Antarctic use. (Photo: Alan Campbell-Drury)

considered and extensive work was required to make the ship ready for Antarctic voyages planned later that year.

For the 1948 *Wyatt Earp* Expedition she was commissioned HMAS *Wyatt Earp* on 17 November 1947; the Navy Board having decided that in view of her impending Antarctic voyage, and that she had achieved international fame for exploration work there, she should be renamed accordingly.

Her 1947–48 voyage to Antarctica was part of a trilogy of Australia's post war expeditions; to establish sub-Antarctic stations at Heard Island (1947) and Macquarie Island (1948) and to survey the coastal regions around Commonwealth Bay, with a view to establishing a continental station. This resulted in Australia's first postwar continental station, Mawson, being established in 1954, followed by Casey and Davis.

After problems encountered during the voyage, in part due to her fitting out in Adelaide, the HMAS *Wyatt Earp* was found to be unsuitable for further Antarctic voyages. Accordingly, she was paid off at Williamstown Dockyard in Melbourne on 30 June 1948, and after two years growing barnacles was sold to the Arga Shipping Company of St Helens, Tasmania. She was registered under her former name, *Wongala*, for the Bass Strait trade and to carry explosives. In 1956 she was bought by the Sydney-Ulverstone Shipping Company of Sydney and re-named the *Natone*, after the potato growing district of north east Tasmania.

The Antarctic history of this little Norwegian fishing vessel has never been properly recognised in the annals of Australian and Norwegian Antarctic expedition history, and the 60th anniversary of the ship's sinking provides an opportunity to reflect upon her Antarctic voyages.

David Dodd
ANARE Club

Celebrating the Wyatt Earp

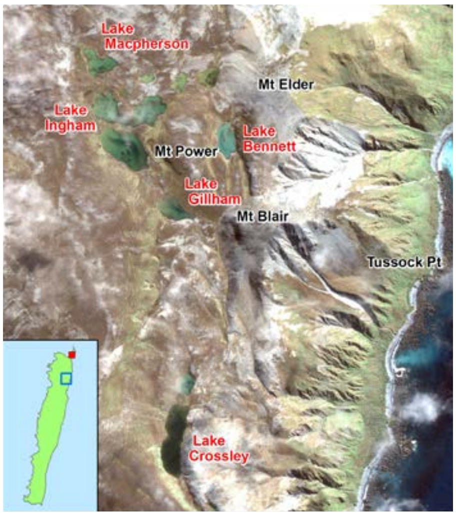
This ship's bell, which reads H.M.A.S Wyatt Earp 1947 on the opposite side, will be a feature at the ANARE luncheon in September. (Photo: ANARE)

Although inanimate objects, ships inspire high emotions amongst mariners, and in the *Wyatt Earp*'s case, are fondly remembered by all those associated with her voyages.

To celebrate the ship's contribution to Antarctic exploration, and commemorate her loss 60 years ago, a living crew member of the 1948 *Wyatt Earp* Expedition will be honoured at a special Australian National Antarctic Research Expeditions (ANARE) Club luncheon in Hobart in September this year.

Australia also has in its possession the original ship's bell with the names of *Fanefjord* 1919 and the HMAS *Wyatt Earp* 1947 engraved upon it, which will take pride of place at the luncheon.

At Rainbow Beach the remnant timbers of the *Natone* are exposed from time to time by the tropical cyclones that took her to her grave. Recently, her keel was exposed beyond high tide level and enquiries have brought to light artifacts souvenired from the ship at the time of her breakup. It is hoped that some of these artifacts will be available for display.



Lake names recognise pioneering scientists

Several lakes on sub-Antarctic Macquarie Island have been named after the first four female scientists to travel south with the Australian Antarctic Program.

Hope Macpherson, Susan Ingham, Isobel Bennett and Mary Gillham went to the World Heritage listed island 60 years ago to undertake field research on the unique flora and fauna.

Chief Scientist of the Australian Antarctic Division, Dr Gwen Fenton, said the hard work and dedication of these researchers has paved the way for female scientists who have followed.

"Each of these scientists' work has had lasting impact, increasing and deepening our understanding of sub-Antarctic ecosystems," Dr Fenton said.

Dr Bennett's pioneering research on tidal zone species on Macquarie Island provided an early understanding of the island's coastal ecosystems.

Ms Macpherson's work on marine invertebrates laid the foundations for her later ground-breaking work on molluscs in southern Australia.

Dr Gillham's studies analysed the effects of seabirds on the island's vegetation, while Ms Ingham's scientific papers on southern elephant seals provided some of the earliest studies of their colonies on the island.

"Naming the lakes after these trail-blazing women will hopefully inspire other young women who might be interested in pursuing a career in science," Dr Fenton said.

The lakes are located at the northern end of Macquarie Island (see map).

The names were recommended by Australia's Antarctic Place Names Committee to the Nomenclature Board of Tasmania, to formally recognise the scientific contributions of these women.

Australian Antarctic Place Names Committee

Main: Susan Ingham (left), Mary Gillham, Hope Macpherson and Isobel Bennett, headed for Macquarie Island on the *Thala Dan*. (Photo: Museum Victoria)

Inset: This map shows the location of lakes on Macquarie Island, named after five pioneering women. The inset shows the location of Macquarie Island research station (red square) and the location of the lakes detailed on the satellite image (blue square). (Map: AADC; satellite image ©DigitalGlobe Inc., All Rights Reserved)

Naming honour for former Station Leader

Former Antarctic Station Leader Louise Crossley in Melbourne in 1987. (Photo: Swinburne University of Technology)

A lake south-west of Tussock Point on Macquarie Island (see map) has been named after former Station Leader, Louise Crossley. The Australian Antarctic Place Names Committee recommended to the Nomenclature Board of Tasmania that Dr Crossley's significant contribution to the Australian Antarctic Program be formally recognised.

In 1991 Dr Crossley was appointed Station Leader at Mawson station; the second woman to lead an Australian Antarctic station.

Louise Crossley (1942–2015) was an eminent Tasmanian scientist, community leader, environmentalist and author, whose leadership supported scientific work in Antarctica and at sub-Antarctic Macquarie Island.

Graduating from Cambridge University with a science degree, she worked as a research assistant at various universities in the United States and Australia. In 1980, she gained her PhD in the history and philosophy of science at the University of New South Wales.

Following her career working in a variety of roles as a science educationalist, in 1991 Dr Crossley was appointed Station Leader at Mawson station; the second woman to lead an Australian Antarctic station. She also served as Station Leader at Macquarie Island in 2000, and again in 2003, supporting the successful feral cat eradication program.

Highly respected for her inclusive leadership style, Dr Crossley was a role model for women working in extreme environments.

A passionate advocate for the Antarctic and sub-Antarctic, she continued to pursue her love of the Southern Ocean region by working as a specialist lecturer on tourist voyages to Antarctica until 2011.

Australian Antarctic Place Names Committee

School of rock

Two boulders of Mawson Charnockite, collected near Mawson research station, will go on display at the National Rock Garden in Canberra this year. The rock garden is a collection of unique rock samples gathered from around Australia and its territories.

Two boulders of Mawson Charnockite being loaded on to the *Aurora Australis*, destined for the National Rock Garden in Canberra. (Photo: Katrina Beams)

Mawson Charnockite is named after Sir Douglas Mawson, the legendary Australian Antarctic explorer and geologist who mapped large areas of Antarctica and greatly enhanced our knowledge of the frozen continent.

The boulders will serve as a permanent reminder of Australia's links to Antarctica when the two continents were joined as part of the supercontinent, Gondwana. Their inclusion in the garden was originally proposed by eminent geologist and palaeontologist, the late Professor Pat Quilty.

The rock type is also found in Western Australia, including near Cape Leeuwin and Cape Naturaliste near Albany, Esperance Bay, Eyre Peninsula, and the Musgrave Ranges.

The rock is typically composed of quartz, K-feldspar, plagioclase and orthopyroxene, but its exact origin has been a matter of debate amongst geologists. Once thought to be igneous rock crystallised from cooled magma, it is now generally considered metamorphic rock, formed by high temperatures and pressures deep below the Earth's crust.

The boulders were collected under a permit authorising their removal for the purpose of public education, via display at the National Rock Garden.

David Reilly

New Centre for Antarctic, Remote and Maritime Medicine

Highly specialised medical skills honed in the extreme Antarctic environment will be shared through a new Centre for Antarctic, Remote and Maritime Medicine (CARMM), based at the Australian Antarctic Division in Hobart.

The Centre is a partnership between the Australian and Tasmanian Governments and the University of Tasmania. It will draw on expert knowledge developed by the Australian Antarctic Program to inform medical care providers in other remote and maritime settings across Australia.

Chief Medical Officer of the Antarctic Division's Polar Medicine Unit, Dr Jeff Ayton, said his team has developed a unique remote healthcare system over decades.

"Our doctors provide support for expeditioners up to 5500 kilometres away on Australian Antarctic stations and on ships plying the Southern Ocean," Dr Ayton said.

"We use advanced telehealth systems for remote diagnosis and treatment of patients, for example we are able to monitor the vital signs of an ill expeditioner from back here in Hobart.

"We also have a well-established network of specialists in Tasmania and around the country to support healthcare delivery.

"CARMM will bring all this acquired knowledge together to help provide highly specialised care in other isolated and extreme environments, such as off-shore islands and remote communities."

Professor Ben Canny from the University of Tasmania said, through the College of Health and Medicine, CARMM will provide accredited training and education pathways for generalist health practitioners.

"This year we are starting a new Graduate Certificate in Healthcare in Remote and Extreme Environments, a one-stop shop to up-skill medical professionals for care-giving in remote areas," he said.

Read more on the CARMM website
https://www.carmm.org.au/

Nisha Harris

Dr Jeff Ayton (second left) explains some of the medical equipment used at Antarctic stations to the Tasmanian Minister for Health, Michael Ferguson (left), while doctors from the Antarctic Division's Polar Medicine Unit, Roland Watzl and Clive Strauss look on. (Photo: Simon Payne)

Upgrading Australia's Antarctic stations

The Australian Government will invest more than $450 million over the next 10 years to upgrade Australia's Antarctic research stations and supporting infrastructure. The funding is additional to recently announced investments in new shipping, aviation and inland transport capabilities, and a new sub-Antarctic research station at Macquarie Island.

Australia's Antarctic research stations are set for an upgrade. (Photo: Jenny Wressel)

The last time a major renewal program was undertaken at Mawson, Casey and Davis research stations was in the 1980s and early 1990s.

Priorities for the upgrade program include:

- modernising fuel storage, water supplies, energy provision, and communication technology;
- upgrading the heavy vehicles and mobile equipment that maintain our daily operations;
- providing Antarctic doctors with access to cutting-edge medical technology;
- enhancing the environmental sustainability of Australia's research stations;
- improving operational assets such as boats, field huts, and aerodromes; and
- providing new science equipment to support leading-edge research and development.

Corporate Communications

Australian Antarctic Program Partnership

The Australian Antarctic Division welcomes the opportunity to work with core partners, the University of Tasmania, CSIRO and the Bureau of Meteorology, as part of the new Australian Antarctic Program Partnership (AAPP) announced in April.

The AAPP will be funded through the Antarctic Science Collaboration Initiative (ASCI), which will provide $5 million a year for 10 years to support Antarctic researchers.

The Partnership brings together leading Australian science agencies to better understand the role of the Antarctic region in the global climate system and the implications on marine ecosystems.

Correction

On page 32 of Issue 35 (December 2018) we incorrectly used the date 2013, rather than 1913, in paragraphs five and six relating to Sidney Jeffryes' time in Antarctica.

Director Kim Ellis (right) presents a 50th anniversary photograph to Casey Station Leader Christine MacMillian. (Photo: Jordan Smith)

Casey turns 50

Casey research station hit a half century in February.

The station was officially opened on 19 February 1969, and named 'Casey' after the then Governor-General Sir Richard Casey, a staunch supporter of Australia's early Antarctic program. Since then it has been home to more than 1000 over-wintering expeditioners.

Australia's presence in the region began a decade earlier in January 1959, when Australia took over the United States-built Wilkes station, on the Clarke Peninsula. However it soon became clear that Wilkes would be buried by deepening snow drifts, which threatened the structural integrity of the buildings.

In 1964, Australia commenced work on a replacement station, cleverly named 'REPSTAT', located nearby on the Bailey Peninsula. REPSTAT had a unique design, with a 260 metre-long corrugated-iron 'tunnel' connecting 13 buildings, elevated on stilts to minimise snow drifts.

REPSTAT was used for 19 years before it was decommissioned. Construction of a new Casey station began in 1979, providing a greater degree of comfort and safety, and incorporating state-of-the-art facilities.

Casey has continued to develop and change, particularly since 2007, with the opening of Wilkins Aerodrome increasing the number of expeditioners staying at and passing through the station.

Mark Horstman

JUSTIN CHAMBERS

Freeze Frame

Justin Chambers has spent the past seven years working in Antarctica, wintering at Davis, Mawson and Macquarie Island. He also spent six months at Scott base and a summer at Casey. He has worked as a chef, deputy station leader, lay medical assistant, emergency responder and station photographer. He is 'classically trained' in restaurants and hotels internationally and has travelled the world working as a chef for rock 'n' roll greats including Madonna, Queen, Prince, Bon Jovi, Beyonce and Shania Twain.

Macquarie Island has an abundance of wildlife and an aesthetically diverse landscape. I would often sit for hours at a time with music playing through headphones and watch the animals go about their business. This particular elephant seal seemed content knowing he was not ready to be a Beach Master. But as a captive to his primal instincts, he would casually wait near a harem for an opportunity. I watched for over two hours in the 5 degree drizzle as he slowly moved up the beach. I took this photo when I was sure he would go no further, using a Canon 5D3, with 50 mm lens set at f1.4.

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AUSTRALIAN ANTARCTIC PROGRAM

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